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Colin Hinson
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RESTRICTED

AIR PUBLICATION

114M-0200-1

(Formerly A.P.2891J, Vol. 1)

GROUP 114: AIRBORNE RADAR EQUIPMENT

SUB-GROUP M: TAIL WARNING RADARS

ARI.5919

GENERAL AND TECHNICAL INFORMATION

BY COMMAND OF THE DEFENCE COUNCIL

Henry Hardman

(Ministry of Defence)

FOR USE IN THE
ROYAL AIR FORCE

(Prepared by the Ministry of Aviation)

(A.L.29, Nov. 65)

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 airframe 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.

NOTE TO READERS

The subject matter of this publication may be affected by Defence Council Instructions, Servicing Schedules or "General Orders and Modifications" leaflets in this A.P. in the associated publications listed below, or even in some others. If possible, Amendment Lists are issued to correct this publication accordingly, but it is not always practicable to do so. When an Instruction, Servicing Schedule, or leaflet contradicts any portion of this publication, the Instruction, Servicing Schedule, or leaflet is to be taken as the overriding authority.

The inclusion of references to items of equipment does not constitute authority for demanding the items.

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. New or amended technical matter will be indicated by triangles positioned in 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.

The reference number of this publication was altered from A.P.2891J, Volume 1 to A.P.114M-0200-1 in November, 1965. No general revision of page captions has been undertaken but the code number appears in place of the earlier A.P. reference on new or amended leaves issued subsequent to that date.

◀Revised material issued after September 1969 has been brought into line with current practice as follows:

(1) Frequencies are given in Hz, kHz and MHz instead of c/s, kc/s and Mc/s. Since only parts of the manual are revised c/s and Hz may be treated as synonymous.

(2) Semiconductor diodes are referred to in the text by the letter D as opposed to V in earlier material. Since component locations painted on chassis are unchanged, the references on revised circuit diagrams and component layouts are given in the new form followed by the old form in brackets e.g. 5D3 (5V8)

Certain earlier material contains the reference MR for semiconductor diodes and this has not been revised; D and MR are to be treated as synonymous.▶

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PART I

LEADING PARTICULARS AND GENERAL INFORMATION

SECTION I

GENERAL INFORMATION

Chapter 1

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GENERAL

1. ARI 5919 is a 130kW X-band search radar system designed for installation in all V-bombers. It is a light-weight and compact equipment consisting of a tail-mounted radar unit and an indicator in the cockpit. The indicator combines the functions of indicator and control unit.

2. The equipment is intended to form part of the ◀ECM▶ equipment of a V-bomber to give warning of the presence of other aircraft within a 90° cone to the rear. At a range of 10 miles, there is a 75% probability that a following aircraft of Hunter size will be detected.

3. When airborne, the equipment will normally be maintained in a stand-by condition (i.e. not transmitting) for most of the time. This is because the other ◀ECM▶ equipment in the bomber includes ARI 18105. When required ARI 5919 can be switched to transmit in order to find the exact range and bearing of the attacking fighters.

4. Information is provided to the Air Electronics Officer in the form of an "inverted" X-scope display. In this, the following aircraft appears as a bright arc whose radius varies inversely as the range of the following aircraft so that range is measured from the rim of the display.

5. Two timebase ranges are available; these are

(1) 0 to 5 nautical miles

(2) 0 to 18 nautical miles

SCANNING

6. The equipment transmits a radar beam which is made to trace out a cone whose apex angle varies in a cyclic manner. The result of this is a spiral scan pattern consisting of an inward and an outward spiral. To do this, the scanner mirror rotates at approximately 1,000 rev/min about the roll axis of the bomber and at the same time the angle between the scanner mirror axis and the bomber roll axis is made to vary at a slow rate (1 cycle in $2\frac{1}{4}$s). The spiral commences with the beam centre at 2° from the bomber roll axis and, since the beam width is 5.5° at half power points, this covers the dead-astern direction. The total cover is a cone of semi-angle 45°. Fig. 1 gives an impression of this scanning action though the spiral pattern is drawn with only a few lines for the sake of clarity. Actually, the pattern contains 36 lines and the inward and outward spirals (18 lines each) are interlaced. The lines are deliberately cramped slightly at the extreme angles to improve the illumination of aircraft at the edge of the cover.

DISPLAY

7. In the situation shown in Fig.1, a following aircraft is within the cover of the ARI 5919 equipment. Echo pulses are obtained from this aircraft, each time the radar beam passes over it, and a paint appears on the display tube in the indicator.

8. The direction of the echo blip from the centre of the display tube is the direction of the following aircraft from the bomber roll axis in the vertical plane containing the bomber chord axes. ▸◂ . Aircraft approaching from the starboard side of the bomber will always appear on the ◂left-hand▸ side of the display and those approaching from port on the ◂right▸ . This will apply whatever the mounting position chosen for the indicator in the bomber and the operator must ignore his particular position and merely refer to right and left as indicated. Aircraft below the bomber roll axis will be indicated in the lower half of the display and those above in the upper. It should be noted that the whole display is relative to bomber axes.

9. The echo blip always appears as an arc of a circle varying between a complete ring when the following aircraft (or missile) is dead astern, and being uniformly illuminated by the innermost turn of the scanning spiral, and a short arc subtending

about 5° at the centre of the display tube when the following aircraft is at the maximum angle of 45° off. Interpretation of the display to obtain the angle accurately is a difficult matter depending on the type of aircraft and the gain setting of the equipment. The following list gives a rough guide.

Angle subtended by echo blip (degrees)	Angle off of following aircraft (degrees)
360	0
180	3
90	5
30	10
15	20
10	30
5	45

10. Generally, it should be sufficient for the pilot to be informed of the range and direction of the attacker for him to start taking evasive measures.

Effect of roll

11. If the bomber rolls, the equipment rolls with it. Since the scan pattern is generated about the roll axis, the scan pattern will still cover the same portion of space as previously but any echo blip on the display will move round in a direction opposite to the direction of roll.

Effect of pitch

12. Since there is no stabilization in pitch or roll, bomber pitch will alter the elevation of the scan pattern and hence the apparent elevation of any following aircraft.

Typical display

13. A typical display is given in Fig. 2. The echo blip indicates that the attacker is on the ◀left▶ of the bomber and slightly above it. The blip subtends about 30° at the display tube centre indicating that the attacker is about 10° off the bomber roll axis. The second trace ground returns, which are sometimes present, show that the bomber is banked with ◀left-wing▶ down.

Range markers

14. Fixed marker circles, at 2 or 4-mile intervals depending on the timebase range in use, are available.

IN-FLIGHT TESTING

15. In order to test the equipment when airborne, a Radar Signal Cartridge is fired from the Very Pistol. This falls astern of the bomber and, if the equipment is transmitting and working correctly, it should pick up an echo from the cartridge and give a corresponding blip on the display. This will increase in range at the bomber true air speed and should be visible out to 5 miles range.

POWER CONSUMPTION

16. The power consumption of ARI 5919 is approximately

(1) 2A at 28V d.c.

(2) 1.3kW at 200V, 400Hz three-phase a.c. (power factor 0.9)

WEIGHT

17. The weight of the complete pressurized tail assembly will vary with the bomber type but should be approximately 200 lb (including the radome and mounting ring). The weight of the indicator is 12 lb.

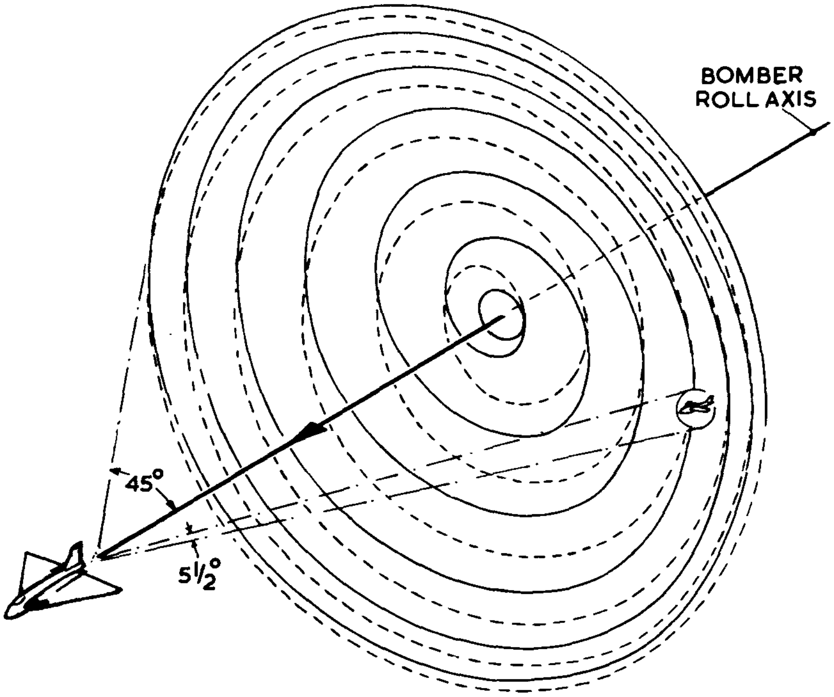

Fig.1 Scan Pattern

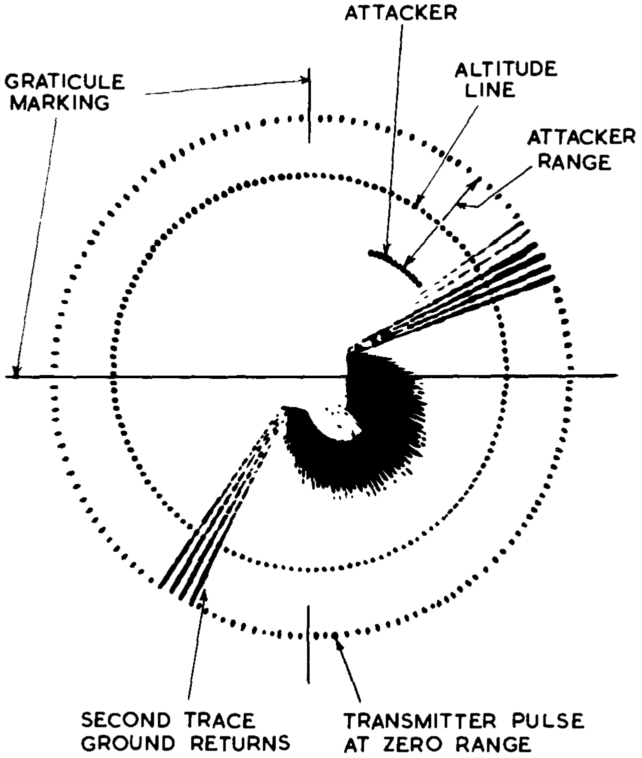

Fig.2 Display

Chapter 2

GENERAL DESCRIPTION

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Introduction

1. ARI.5919 consists of the following items:—

(1) Radar unit 6934

(2) Indicator c.r.t. 6935

(3) Radome

(4) Mounting ring

(5) Backplate assembly

(6) Friction damper assembly

(7) Thermostat assembly (cooling air)

(8) Connectors

2. The radar unit, when fitted to a mounting ring and radome, becomes known as a radar head. The ring and radome vary with the type of aircraft and there are normally two types; one for the Victor Mk. 2 and the other for the Vulcan Mk. 2. A third type, for Valiant aircraft, is possible. A view of the radar head for the Vulcan aircraft is given in Fig. 1.

3. Radar units, rings and radomes are separately delivered to units where they must be assembled into complete radar heads. The various radar heads are known as:

(1) Radar head 6931—for Victor

(2) Radar head 6932—for Vulcan

(3) Radar head 6930—for Valiant.

Once assembled, radar units and mounting rings will not normally be separated except for major repairs.

9. The unit is normally pressurized to 20 lb/in² (absolute) from an aircraft source (air bottles). When compressed air is applied, the seals inflate first and seal the unit. When the pressure in the seals rises to 3 lb/in² above the air in the main compartment, a differential valve opens and the unit pressure starts to rise but it always remains 3 lb/in² below the seal pressure. When the unit pressure reaches 20 lb/in² the seal pressure is 23 lb/in².

10. The method of construction ensures that the pressure sleeve is subjected to radial loading only. The end thrust is borne by the two main decks of the framework.

11. The electrical components within the radar unit are disposed in such a manner that those generating the most heat occupy the centre section while those requiring closer control of temperature are arranged round the outside of the box section (i.e. in the space between the decks and the pressure sleeve).

12. The air inside the unit is circulated by a blower. Cooled air emerges from the heat exchanger and passes towards the radome round the outside of the box framework. It then passes through the centre section and through the blower back into the heat exchanger. The external cooling air supply to the heat exchanger is obtained from the aircraft system.

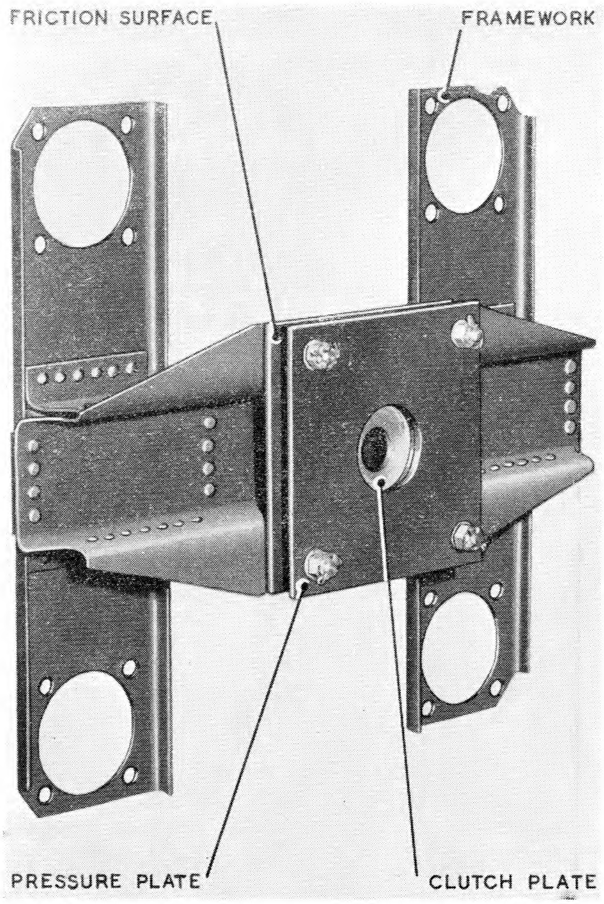


Fig. 2. Friction damper assembly

13. The unit incorporates a switch which may be used to switch off the main blower (so reducing noise level) when running the equipment on the bench. This switch (S1) is shown in Fig. 7. It is so arranged that the pressure sleeve cannot be fitted with the switch set to off.

14. With the pressure sleeve off and the main blower on, the quipment may be run on the bench for several hours provided that the rear tray assembly (Fig. 9) is fitted. If the blower is switched off, the quipment should not be allowed to transmit for more than ten minutes if it is not to overheat. Removal of the rear tray will allow hot air to rise more easily and the equipment may then be run on the bench with the transmitter on, for approximately thirty minutes without overheating.

Friction Damper Assembly

15. A friction damper assembly (Ref. No. 10AR/4648) is provided for fitting to the end panel of the heat exchanger. The purpose of the assembly is to reduce the amplitude of vibration at the mechanical resonance frequency of the radar head.

16. A view of the friction damper is given in Fig. 2. It consists of an 'H' form frame which can be bolted to the four axial air ports (Chap. 6). The assembly does not interfere with the use of the ports.

17. The cross-member of the frame carries a friction surface at its centre. A clutch plate, faced with Ferodo material, is pressed against this friction surface by a spring loaded pressure plate. When the radar head is mounted in position in the tail of the aircraft, a spigot, mounted on a bracket fixed rigidly to the aircraft structure, engages a central hole in the clutch plate. Thus, any vibration in a plane at right-angles to the axis, is opposed by friction between the clutch plate and the friction surfaces.

Thermostat assembly (cooling air)

18. This assembly is included to prevent over-cooling of the radar equipment under conditions of low ambient temperature. Over-cooling might cause loss of air from the equipment due to cracking of the rubber seals at low temperatures. The thermostat assembly controls the d.c. supply to a motor driven valve in the air feed from the aircraft system; it is mounted on one of the unused ports of the heat exchanger in such a matter that its temperature sensitive element (the thermostat) projects into the low-pressure compartment of the heat exchanger.

19. A diagram, showing the details of the thermostat assembly, is given in Fig. 4. Variations of temperature cause axial movement of a shaft which has a block, carrying two adjusting screws, mounted on it; the block moves towards the thermostat when the temperature falls, and away when it rises. The adjusting screws engage the ends of leaf-spring actuators which transmit the movement of the block to the plungers of two micro-switches S1 and S2.

20. The adjusting screws are set so that, when the temperature is between the operating limits, S1 is operated (i.e. the moving contact is made to the normally open contact) and S2 is released. This cir-

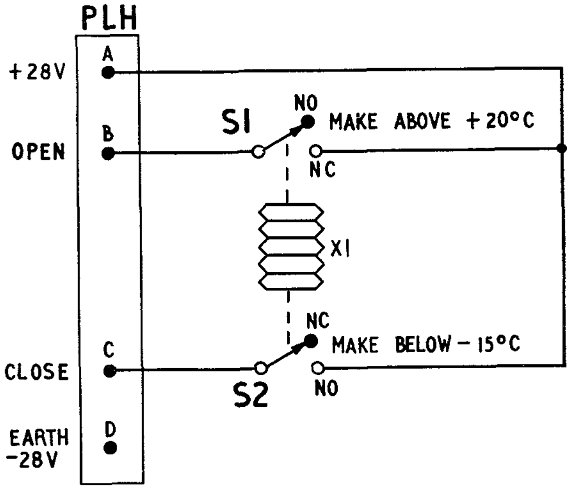


Fig. 3. Thermostat assembly—circuit

cuit configuration is shown in the circuit diagram (Fig. 3).

21. ◀When the temperature falls to —15°C, switch S2 operates and connects the 28V d.c. supply to the 'closing' circuit of the motor driven air valve in the aircraft system; the valve closes and remains closed until its 'opening' circuit is energized. Switch S1 releases on rising temperature at +20°C connecting the 28V d.c. supply to the 'opening' circuit of the motor valve.▶

FUNCTIONAL DESCRIPTION

22. A block diagram of the equipment is given in Fig. 5.

23. ◀The scanner aerial system rotates about the aircraft roll axis at 1000 rev/min. The pulse repetition frequency is 2000 c/s and is derived from a free running oscillator in the waveform generator. An output from the free running oscillator is amplified and used to drive trigger circuits.▶

24. One trigger circuit drives a circuit which generates the c.r.t. timebase waveform for the indicator. This waveform consists of a sawtooth followed by a sinusoildal overswing; the energy contained in the overswing is approximately equal to that during the sawtooth. The sawtooth portion represents movement of the spot on the indicator c.r.t. from the centre out to the edge and back again; the subsequent overswing represents movement from the centre to the opposite edge and back again. A bright-up waveform, also produced by the waveform generator, ensures that the c.r.t. spot is only seen making an excursion from the tube edge to the centre during the sawtooth portion of the timebase waveform.

25. The timebase waveform is applied to an output stage which produces a current waveform. This is connected to the rotor of a synchro which is mounted on the scanner and driven at the aerial spin speed. Resolved outputs are obtained from the synchro and these are applied to the indicator c.r.t. deflection coils so that a rotating radial timebase is obtained. This timebase starts at the edge of the tube and runs to the centre giving a display of the form known as 'inverted' X-scope. Range is measured from the tube edge.

26. ◀Since the repetition frequency of the timebase is 2000 c/s and the scanner speed is 1000 r.p.m., it follows that approximately 120 strokes are displayed for each scanner rotation. The timebase is not locked to the scanner and there is a tendency for the picture to have a spoking effect.▶

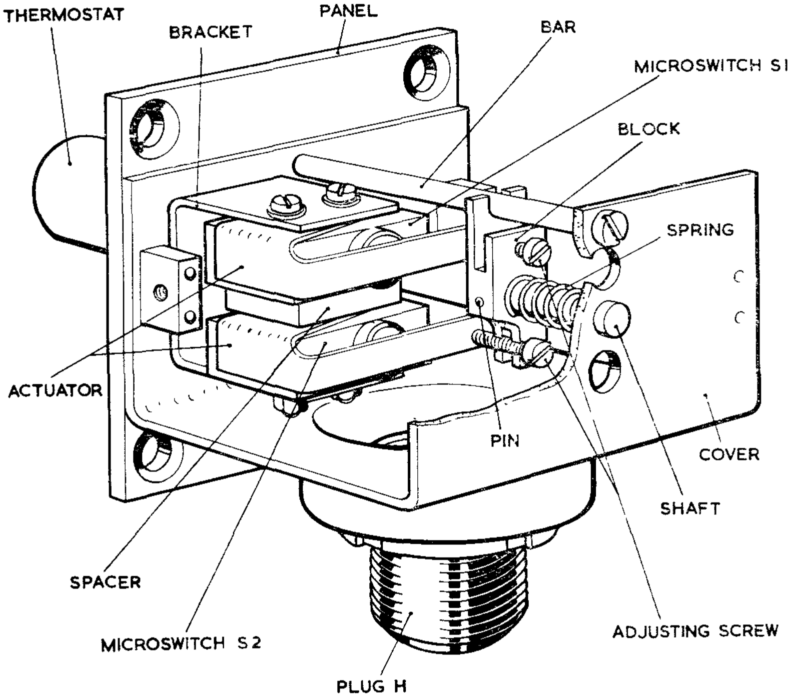


Fig. 4. Thermostat assembly—general view

27. Another trigger circuit in the waveform generator drives a circuit which produces 7 μS pulses known as prepulses; the trailing edges of these ultimately determine the triggering of the transmitter. The prepulse must occur just before the c.r.t. spot reaches the edge of the tube face on its outward journey in order that zero range (the instant at which the transmitter pulse occurs) appears just after the start of the inward journey.

28. In the transmitter section of the equipment, a trigger pulse is generated from the trailing edge of the prepulse; this trigger pulse is used to drive a thyratron valve which causes the discharge of an artificial line through the primary of a pulse transformer to provide a driving pulse for the magnetron transmitting valve. The $\frac{1}{2}$ μS r.f. pulses from the magnetron are connected to the r.f. unit (*fig.* 9).

29. The r.f. unit includes the r.f. block. This consists of two matching, machined aluminium-alloy sections which are bolted together to form a waveguide labyrinth. The labyrinth forms a common T and R system employing hybrid 3 dB slot couplers in such a manner that energy from the magnetron is passed to the scanner and the signal echoes reaching the scanner are passed via a signal mixer to an i.f. strip. The r.f. block forms a mounting for the i.f. unit; the klystron local oscillator and the a.f.c. system are also part of the r.f. unit and are mounted on the block.

30. A sample of the transmitter pulse is taken in the r.f. unit and is connected to an a.f.c. mixer together with the oscillations from the klystron local oscillator. The resulting i.f. output from the a.f.c. mixer is applied to a frequency discriminator (frequency control unit 12131). This gives an output of magnitude and polarity depending on the degree and direction of the frequency difference between the a.f.c. mixer output and the correct i.f. of 30 MHz.

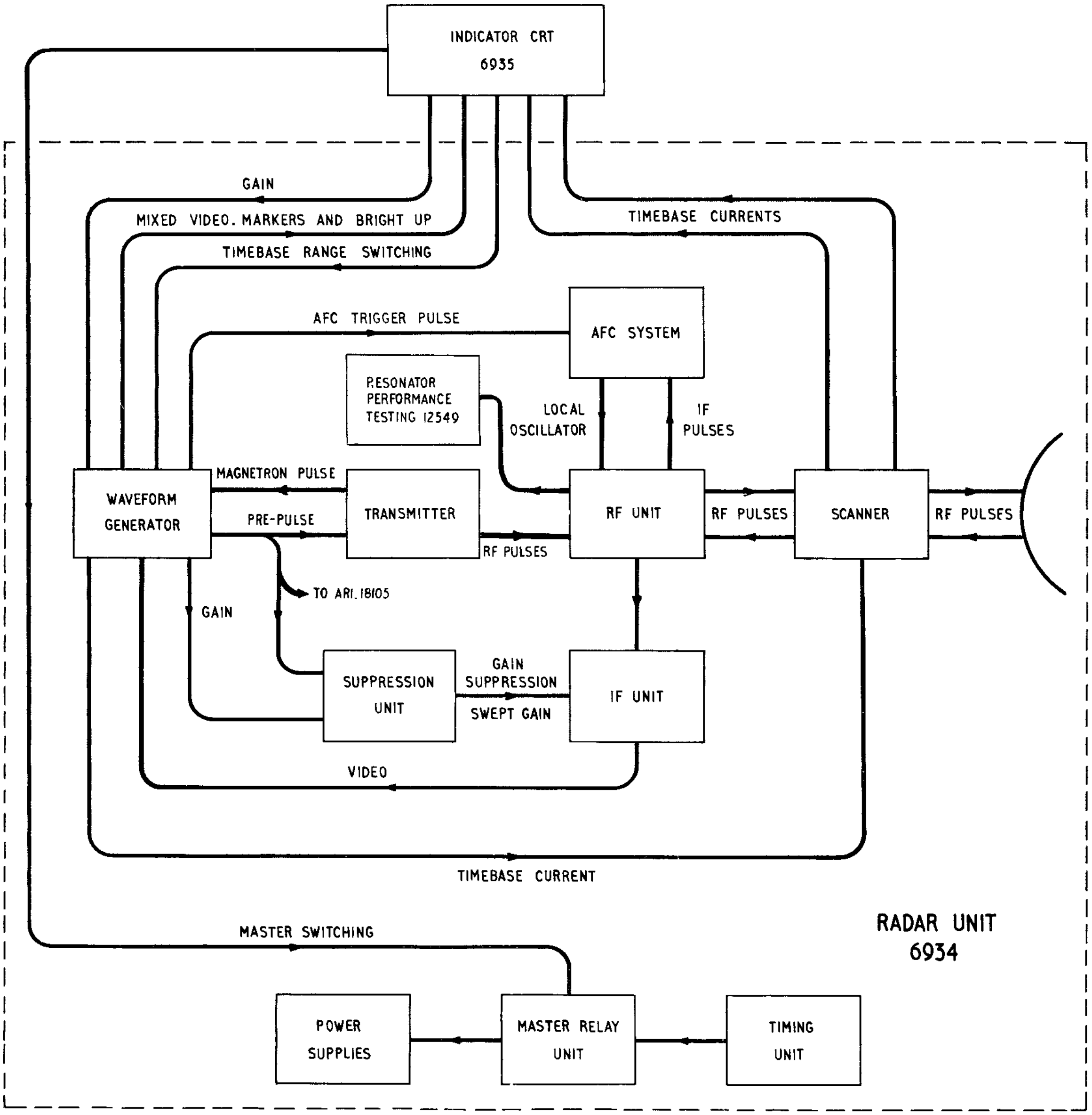


Fig. 5. Block diagram

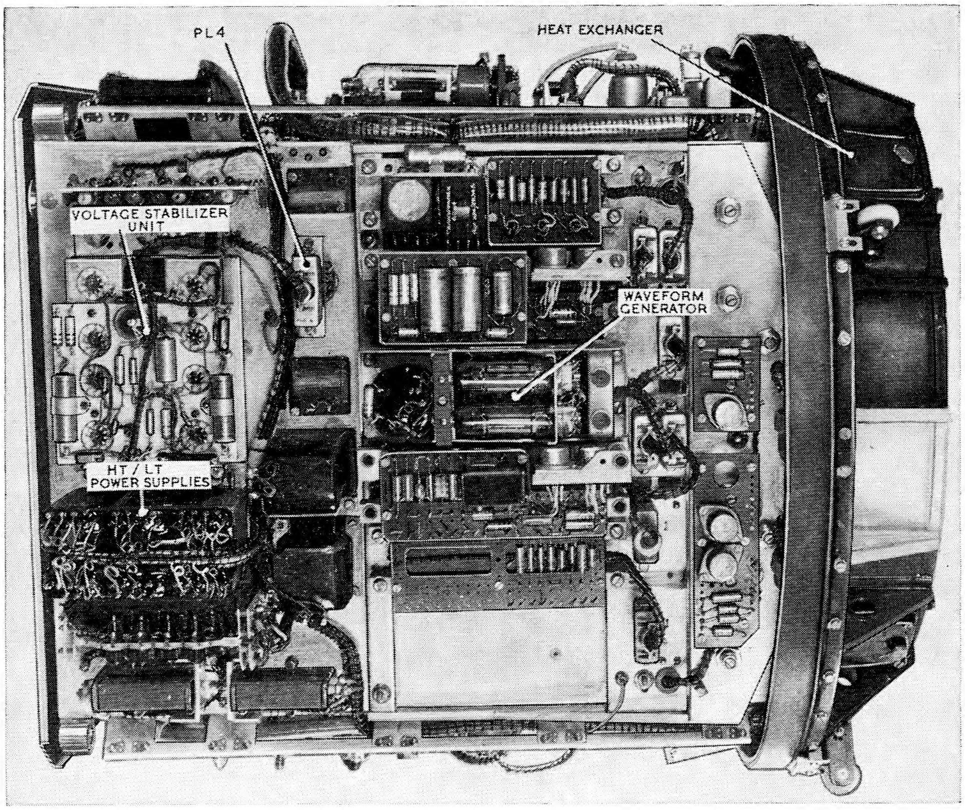


Fig. 6. Radar unit 6934: side view (1)

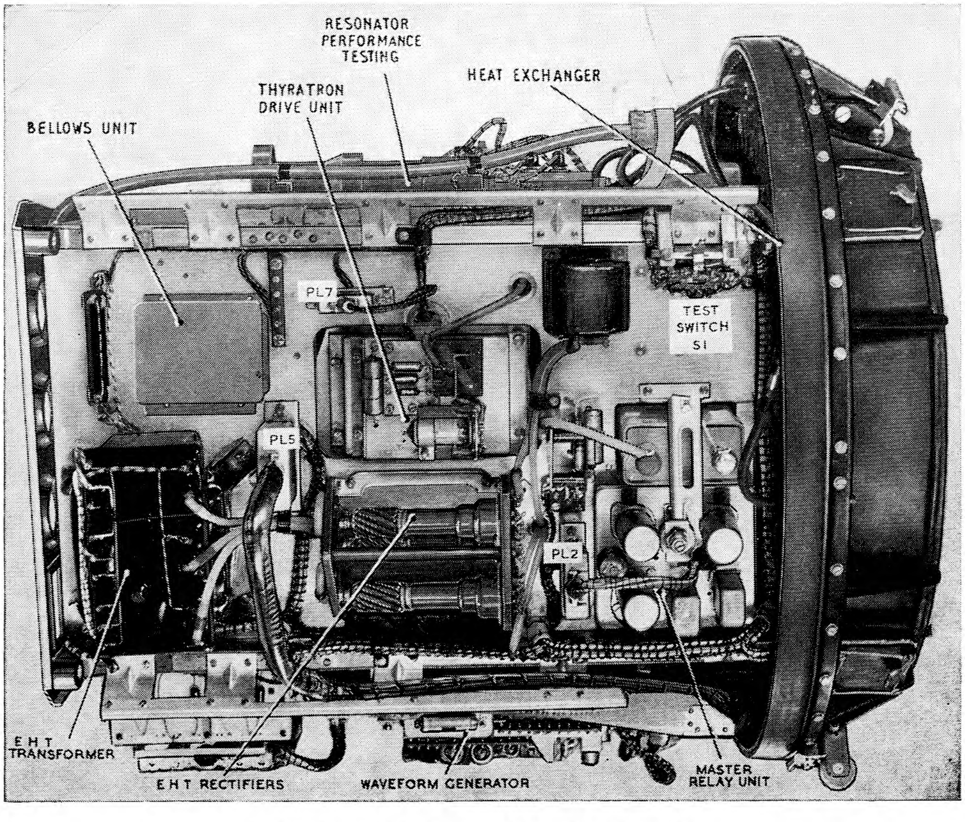


Fig. 7. Radar unit 6934: side view (2)

31. The a.f.c. system also incorporates a search feature which causes the klystron frequency to vary in a cyclic manner until the i.f., as indicated by the frequency discriminator output, is close to the correct value. An a.f.c. lock system then operates placing the klystron under automatic control which maintains the klystron frequency at 30 MHz above the magnetron frequency. Since the klystron output also feeds the signal mixer, the signal mixer output must then be at a frequency of 30 MHz as well.

32. In addition to maintaining the klystron frequency correct, the a.f.c. system also ensures that the klystron always operates in the centre of the correct oscillation mode (i.e. at maximum power). This is done by impressing a sinusoid (one cycle of a sinusoidal waveform) on the klystron reflector. By this means, the klystron power output is made to vary and so give a variation of a.f.c. crystal current during the sinusoid. The crystal current waveform is examined in a discriminator circuit (in the klystron control unit). The amplitude and polarity of the time discriminator output depend on the degree and direction of the departure from mode-centre operation. This output is made to alter the klystron conditions in the direction of mode centre operation.

33. The sinusoid generating circuit is triggered by a pulse from the waveform generator. This pulse, known as the a.f.c. trigger pulse, occurs before the prepulse so that the mode-centring activity takes place during the dead period between the reception of the longest range echoes and the occurrence of the following transmitter pulse; the a.f.c. trigger pulse is the first pulse to occur in the system.

34. The output of the i.f. unit consists of video signals which are connected to amplifying and gating circuits in the waveform generator. The output from the waveform generator consists of the amplified video signals mixed with range markers and bright-up pulses; the composite waveform is applied to the indicator. After further amplification in the indicator, the waveform is applied to the c.r.t. to provide brightness modulation of the display.

35. The i.f. amplifier is supplied with suppression and swept-gain waveforms; these are developed in the suppression unit from the prepulse. The purpose of the waveforms is to suppress the i.f. strip during the transmitter pulse and to allow the gain of the strip to increase steadily after the transmitter pulse; this prevents the strip from being saturated by the transmitter pulse or by short-range echoes. The i.f. strip is also supplied with a gain control voltage. This is obtained from a potentiometer network including the GAIN control on the indicator and resistors in the waveform generator. The gain control voltage is fed to the suppression unit and is applied to the i.f. strip together with the suppression pulses.

36. The power supplies to the various circuits are switched by means of the master switch on the indicator in conjunction with a master relay unit (*fig.* 7) and timing unit (*fig.* 9) in the radar head. The purpose of the timing unit is to hold back the application of h.t. supplies to the transmitter until a period of five minutes has elapsed after the master switch is moved from the OFF position.

Overall performance testing

37. A sample of the transmitter pulse is taken in the r.f. unit and is connected to the resonator performance testing (*fig.* 8) where it causes an echo box to ring. This ring is used during servicing as a signal source for the receiver and enables the overall performance of ARI.5919 to be measured by the gating unit (*Part* 2, *Chap.* 6). Under normal operating conditions, to prevent the echo box feeding an output into the receiver, a dummy socket fitted to an output test plug (PLD on the heat exchanger, para. 46) causes the echo box to be driven off tune.

Indicator c.r.t. 6935

38. The indicator is a rack mounting unit situated in the aircraft pressure cabin. It provides the display for the Aircraft Electronics Officer and carries all the controls necessary for operating ARI.5919 in the air. The controls are listed in Chap. 12.

CIRCUIT DESCRIPTION

39. A complete circuit diagram, showing all the components of the main frame circuit, and the interconnections between the main frame and various sub-units, is given in *fig.* 13. Details of the interconnections between the radar head and the indicator, and the aircraft system cabling, are given in the cabling diagram (*fig.* 12).

40. In the spares breakdown for the equipment, only the assemblies held as complete spares are considered as sub-units. The sub-units are shown simply as blocks in *fig.* 13; circuit details are given in other chapters of this Section as follows:—

Sub-unit	Chapter
Waveform generator	3
◀Transmitter chassis assembly	4 ▶
Thyratron drive unit	4
Master relay unit	5
Timing unit	5
Scanning unit 6923	7
RF unit 6926	
RF Block	8
I.F. unit 6927	9
Suppression unit	9
Frequency control unit 12131	10
Klystron and tuning mechanism	10
Klystron control unit	10
Relay unit (klystron) 6928	10
Stabilizer unit	11
Resonator performance testing 12549	13

◀**41.** Certain assemblies of the radar unit are not considered as sub-units and components in these assemblies are not prefixed by identifying numbers but are referenced in the main frame series. An exception to this rule is the transmitter chassis assembly (Fig. 10). This carries components referenced in the main frame series, namely magnetron V33, magnetron blower X2, diodes V23, V24, heater transformer T5 and pulse transformer T4. Despite its method of component referencing the transmitter chassis assembly is held as a spare sub-unit. Connections to the main frame wiring are made via plug PL8 (*fig.* 10), SK10 and SK13.▶

42. The various parts of the main frame circuit are described together with their associated systems in other chapters of this Section. A guide to the various descriptive paragraphs is given in the following list.

Components	Chapter	Remarks
T1	4	High-voltage heater supplies
T2 and D1 to D18 (V5 to V22)	11	H.T./L.T. power supplies
T3, V2 to V4	4	Transmitter e.h.t. supply
V25 to V32	10	Klystron reflector supply
Blower X1	5	Main blower
X3, X4, S2, S3	5	Protection against loss of air pressure

Wiring conventions

43. The following colour code is observed in the equipment:

Supply	Wire colour
200V, 400 c/s 3-phase	
White phase	White
Blue phase	Blue
Red phase	Red
+285V	Red
+175V	Red/Blue
+150V	Red/green
−175V	Violet/green
−300V	Violet
−1000V	Orange
6·3V a.c.	Brown
+28V	Red

44. Where wires are soldered to numbered terminals (as on transformers T1, T2, T3) the wire terminations carry coloured markings corresponding to the terminal numbers; the colour code is the same as that used for resistor values. For example, the wire connected to terminals 24 on T2 is marked with a red band and a yellow band, the red band being the one nearest the terminal. Where choke terminals are numbered 1 and 2, 1 always refers to the input end.

Plugs and sockets

45. All plugs and sockets on the heat exchanger panel (those carrying services external to the radar unit) have a letter suffix e.g. PLA. All internal plugs and sockets have number suffixes.

46. Two test plugs are provided to enable the monitoring of various quantities without the need for releasing the unit pressure and removing the pressure sleeve. Plug PLD is a 25-pole plug for the connection of a piece of special test gear known as meter unit (Monitoring) 6415. When the test gear is not attached, the plug must be fitted with a dummy socket which makes the connections marked with asterisks in *fig.* 13. Plug PLE provides a monitoring point for the video output of the i.f. strip, the mixed video output of the waveform generator, the prepulse and the magnetron pulse. When ARI.5919 is installed in Victor and Vulcan aircraft, the prepulse output from PLE (pole A) is used to suppress the E.C.M. equipment ARI.18105 for duration of the transmitter pulse of ARI.5919.

Note on photographic illustrations Fig. 6–10

47. Illustrations in other chapters of this publication have been revised and reissued to conform with the modifications state of the equipment as at September 1969. The photographic illustrations in this chapter will be revised and reissued with a later A.L. In the meantime the following points should be noted.

(1) Fig. 6 Radar Unit 6934—side view 1.
(a) The waveform generator now appears as in Part 1, Sect. 1, Chap. 1, Fig. 20.
(b) Components between the voltage stabilizer unit and the waveform generator are now as in Part 1, Sect. 1, Chap. 11, Fig. 1.

(2) Fig. 10. Radar Unit 6934—, end view. The two upper valves visible in the voltage stabilizer unit, in this view, are replaced by semiconductor rectifier diodes (see Part 1, Sect. 1, Chap. 10).

NOTES ON INITIAL ASSEMBLY

48. The radar unit, as delivered by the manufacturer, is packed in a storage case (*Ref. No.* 10D/21450). The storage case consists mainly of a sealed cylindrical container enclosed in a metal-bound wooden crate.

Unpacking

49. The procedure for opening the crate is as follows:—

(1) Remove the twelve nuts securing the four lifting straps to the upper half of the crate and hinge the straps downwards.

(2) Remove the locking clips and release the six fasteners.

(3) Lift off the upper half of the crate. The inner, sealed container, which encloses the radar unit is now accessible. Do not attempt to remove it from the crate.

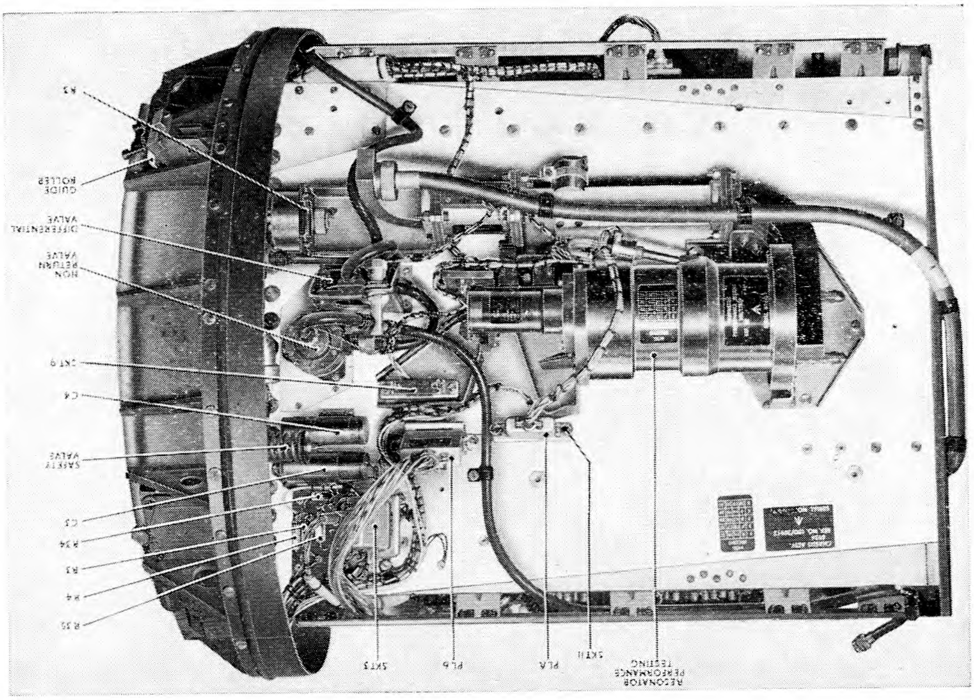


Fig. 8. **Radar unit 6934: side view (3)**

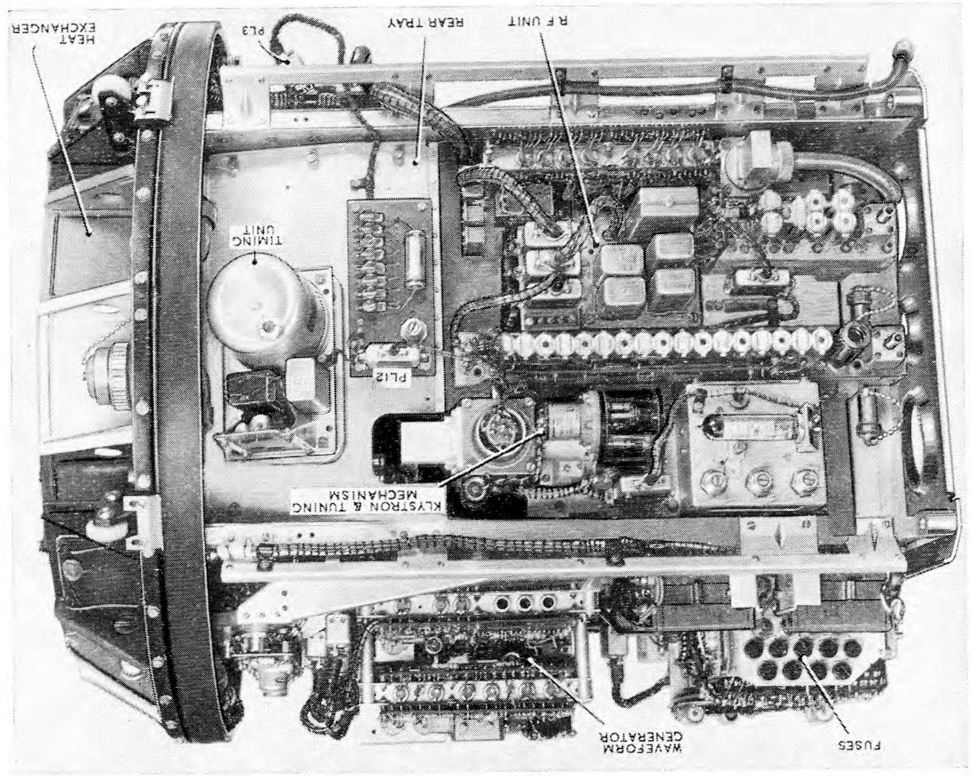


Fig. 9. Radar unit 6934: side view (4)

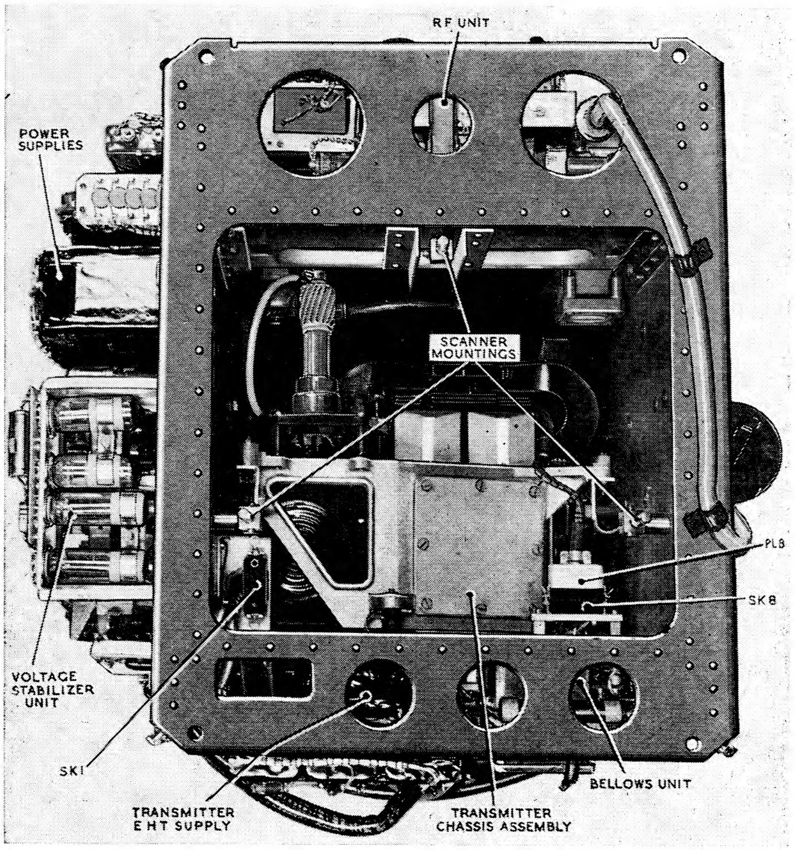


Fig. 10. Radar unit 6934: end view

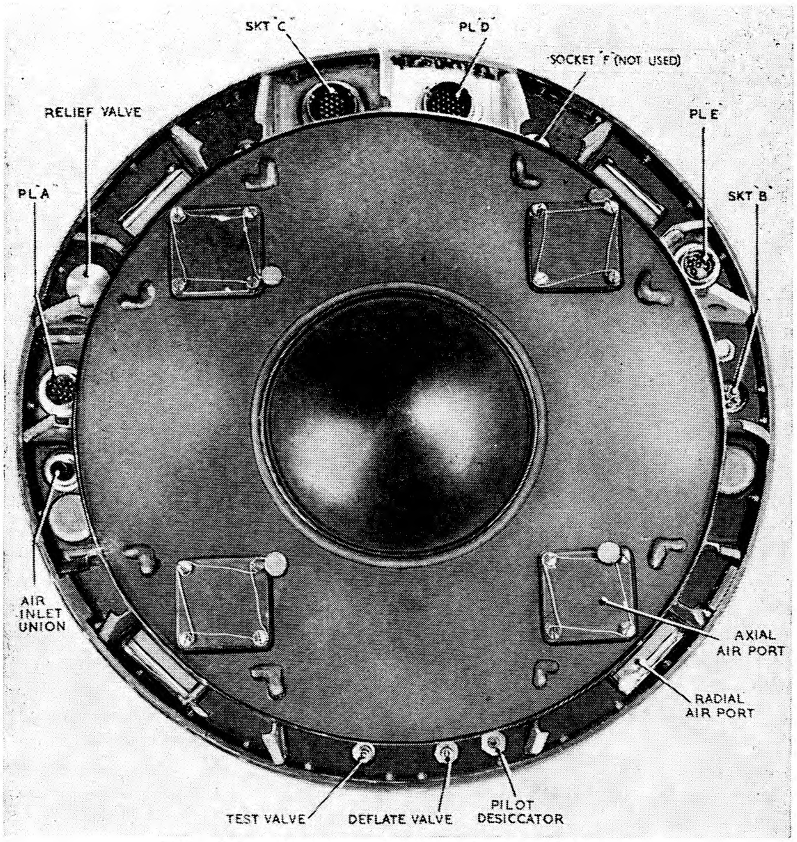
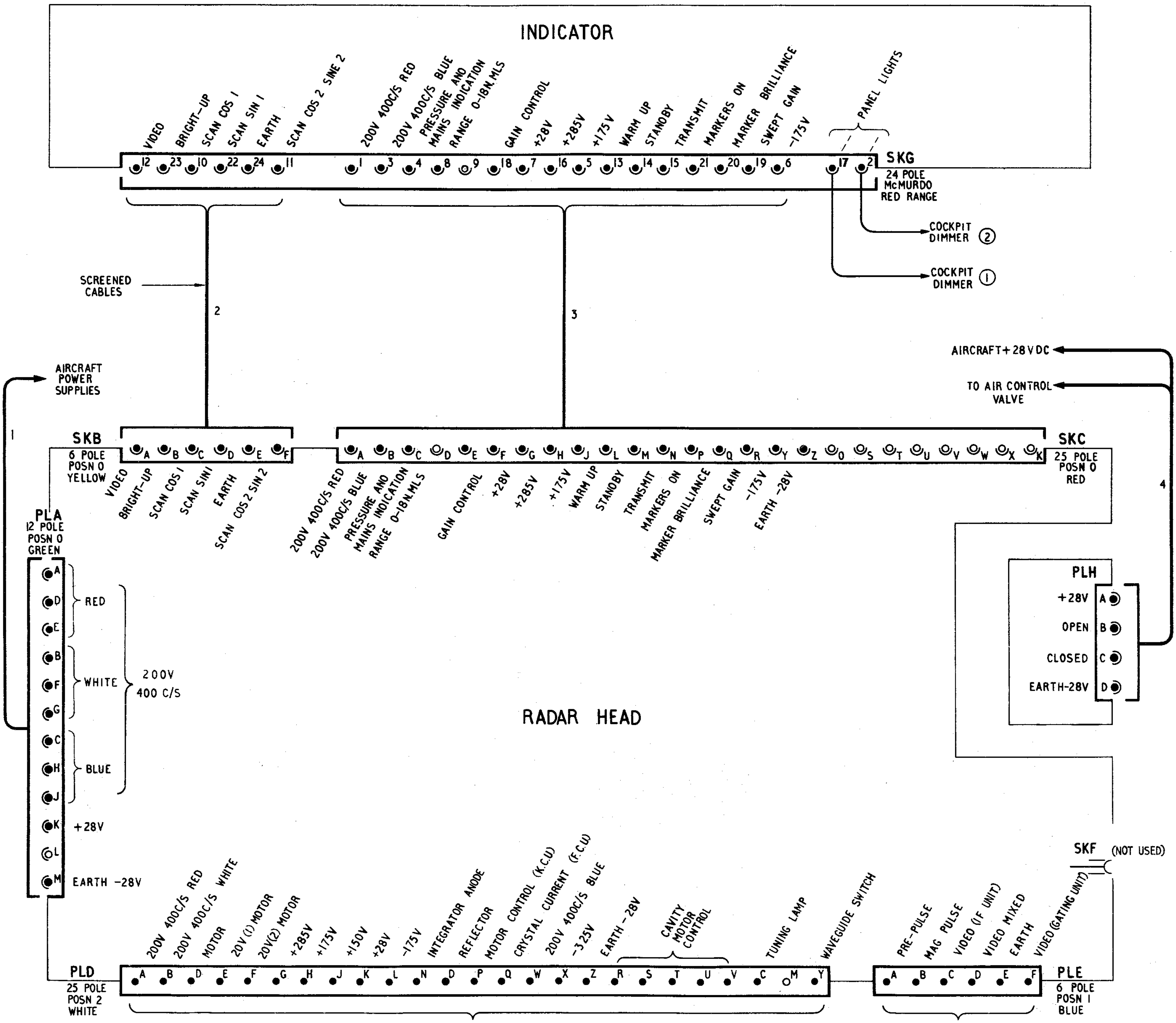


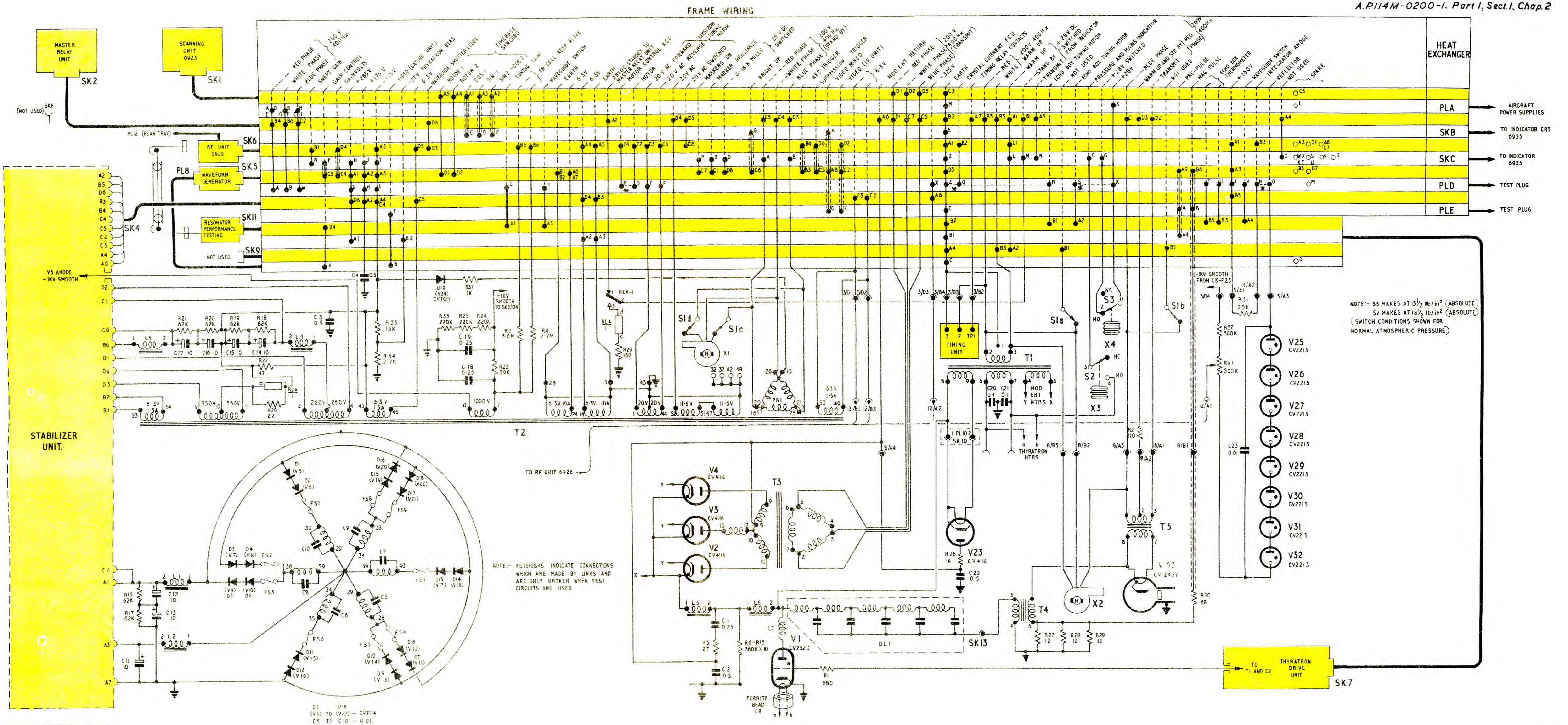
Fig. 11. Radar unit 6934: heat exchanger



AIR DIAGRAM
6166T/MIN.
ISSUE 2 | PREPARED BY MINISTRY OF SUPPLY FOR PROMULGATION BY AIR MINISTRY

ARI 5919-cabling diagram

Fig 12



NOTE:- S3 MAKES AT 13½ lb/in² (ABSOLUTE)
S2 MAKES AT 18½ lb/in² (ABSOLUTE)
(SWITCH CONDITIONS SHOWN FOR NORMAL ATMOSPHERIC PRESSURE.)

NOTE:- ASTERISKS INDICATE CONNECTIONS WHICH ARE MADE BY LINKS AND ARE ONLY BROKEN WHEN TEST CIRCUITS ARE USED

AIR DIAGRAM-MIN
6166S
BY COMMAND OF THE DEFENCE COUNCIL FOR USE IN THE ROYAL AIR FORCE
ISSUE 4 Prepared by the Ministry of Technology

A L 36 May 74

ARI. 5919-Main frame-circuit

Fig 13

50. A cavity, inside the crate, provides stowage for a polythene envelope. The envelope contains brief instructions for packing and unpacking the equipment, and a drawing which gives details of the packing case and special pack items.

51. Proceed to remove the radar unit from the cylindrical container as follows:—

(1) Open the pressure equalizing valve by turning it in a counter-clockwise direction. The valve is located at the centre of the upper half of the container drum.

(2) Unfasten the closure ring that secures the flanged joint half-way up the container. Allow the ring to drop on to the cushion round the lower part of the container.

(3) Lift off the upper half of the container, taking care to keep it clear of the radar unit inside. Place it in the upper part of the outer crate.

(4) Unhook one end of the each of elastic cords and remove the loops from the scanner balance weights.

(5) Remove the red-painted bolts securing the angle-iron bearers to the lower part of the container.

(6) Place the lifting beam (supplied in the crate) across the guard bars taking care to keep it clear of the scanner and dipole. Attach the lifting beam shackles to the ends of the angle-iron bearers.

(7) Secure a hoist to the lifting beam. Lift the radar unit from the container and remove the lower part of the packing case.

(8) Lower the radar unit to the floor, allowing it to rest on the special baseboard attached to the heat exchanger.

(9) Remove the lifting beam.

(10) Remove the four stiffnuts securing the angle iron bearers to the radar unit. Lift off the bearers and the guide ring for the radar unit pressure sleeve.

(11) Release the baseboard retaining hooks from the radar unit guide rollers.

(12) Hinge back the guide rollers and lower the pressure sleeve as far as it will go.

(13) Remove the bearer studs from the radar unit.

(14) Refit the various pack items to the angle iron bearers and stow them in the lower drum for future use.

Radar head assembly

52. It is assumed that the radar unit has been unpacked from its sealed container and that it is standing on the floor with the scanner uppermost and the heat exchanger protected with the wood and felt baseboard from the packing case.

(1) Remove the fibreglass pressure sleeve by lifting it upwards over the scanner assembly. Be very careful not to damage the pressure sleeve end rings in the process.

(2) Separate the radome from the aircraft mounting ring.

(3) The aircraft mounting ring is supplied complete with the necessary bolts, nuts, split pins, nylon bushes, nylon washers and metal washers for fixing it to the radar unit. The diagram of fig. 14 shows the method of assembly at each of the four fixing points. The procedure is as follows:—

(*a*) Offer the mounting ring to the radar unit in such a manner that the centre holes for the lifting attachment (*fig.* 1) are at the same side as the Schrader valves on the heat exchanger (i.e. the side shown in *fig.* 7). Allow the mounting ring to rest on the radar unit and register the mounting holes in the ring with the lugs on the radar unit.

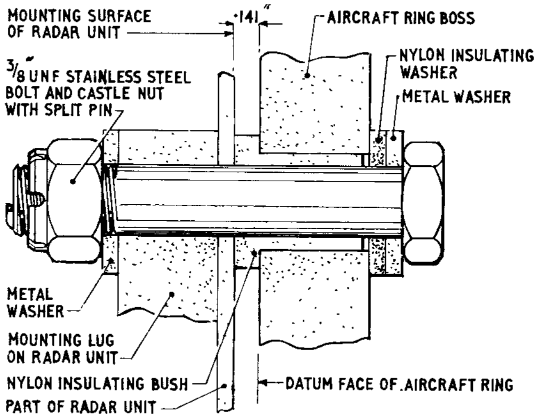


Fig. 14. Mounting ring attachment

(b) Lift the edge of the ring, at a point near one of the fixing holes. Fit a nylon bush to the mounting ring in such a manner that the the bush flange is between the ring and the radar unit lug. Fit the other three bushes in a similar manner.

(c) Pass a bolt, fitted with a metal washer followed by a nylon washer, through each nylon bush in the mounting ring. Make sure that the threaded ends of the bolts pass correctly through the mounting lugs of the radar unit.

(d) Fit a metal washer and a castle nut to each bolt. Tighten the nuts in rotation, a little at a time, until all are secure. Do not overtighten them to the point where distortion of the nylon bushes and washers is likely to occur.

(e) Lock the castle nuts with split pins.

(4) Fit the flexible pressurized air connection on the radar unit to the pressurizing connection on the mounting ring.

(5) Fit the radome to the mounting ring.

(6) Fit a lifting attachment, radar head, 12166 (Ref. No. 10S/17399) to the radar head. A special point to note about this attachment is that the two side bolts (one can be seen in fig. 1) are not on a common axis. If the attachment is allowed to swivel about the side bolts, the bolts will become bent and impossible to remove. In consequence, when fitting the attachment, the top bolts must be fitted first. Conversely, when removing the attachment, the side bolts must be withdrawn first.

(7) Fit the hook of a hoist to the lifting attachment. Lift the radar head to a horizontal attitude and fit it into the radar servicing trolley or storage trolley as required (*fig*. 15). The unit must be steadied during the lifting operation to prevent damage during the change from vertical to horizontal.

(8) Remove the lifting attachment (side bolts first).

(9) Stow the protective wooden base in the lower half of the packing case.

(10) Fit the fibreglass pressure sleeve to the radar head and restore the nylon rollers to the operating condition.

(11) Fit together the two halves of the cylindrical packing container and secure them with the closure ring.

(12) Close the air valve at the top of the container.

(13) Refit the top section of the wooden crate.

Pressure checks

53. The pressure checks required after initial assembly are given in Chapter 6.

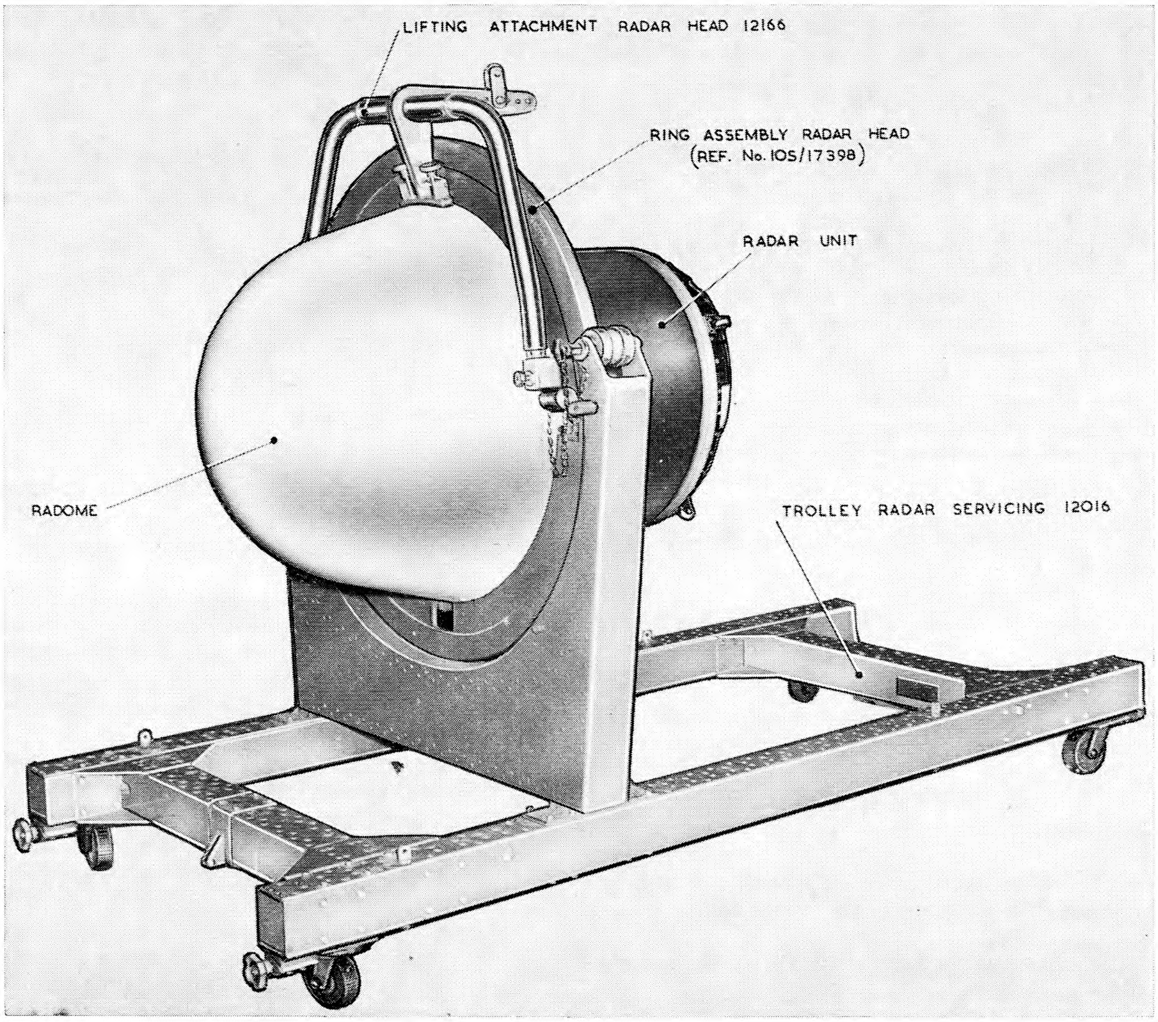


Fig. 15. Radar head in servicing trolley

Chapter 3

(*Completely revised*)

WAVEFORM GENERATOR

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Introduction

1. The waveform generator consists of seven sub-units mounted on a sheet metal tray. The tray carries inter-sub-unit wiring together with various preset potentiometers and relays. Connections between the tray and the sub-units are made via micronector plugs and sockets.

2. The unit develops the following output waveforms.

(1) The prepulse. This is used to trigger the modulator and to initiate the i.f. strip suppression waveform.

(2) A bright-up waveform for the indicator.

(3) The indicator timebase waveform.

(4) The a.f.c. trigger pulse.

(5) The mixed video waveform for the indicator display. This includes signal echoes and range markers.

GENERAL DESCRIPTION

3. A simplified block diagram of the waveform generator is given in *fig.* 1.

Oscillator and stagger circuit

4. The repetition frequency of the equipment is determined by the frequency of a 2 kHz oscillator. The output of this oscillator is applied to a stagger circuit which provides a train of rectangular pulses. The positive-going edges of these pulses ultimately determine the start of the timebase sweep on the indicator, the timing of the a.f.c. trigger pulse, the occurrence of the prepulse and the firing of the magnetron. The stagger, or variation in interpulse period is achieved by mixing the 2 kHz waveform with the output of a 100 Hz oscillator.

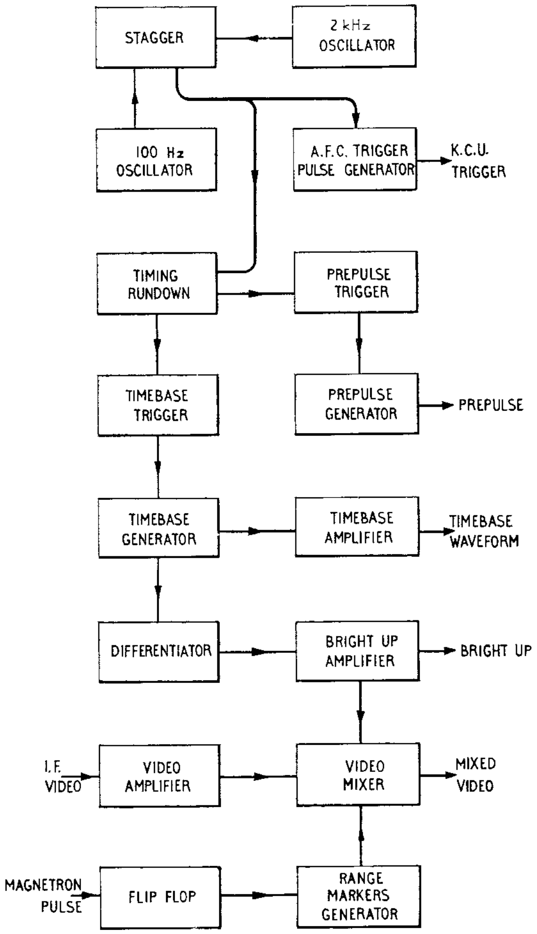


Fig. 1. Waveform generator: block diagram

A.F.C. trigger

5. The a.f.c. trigger pulse is generated by a blocking oscillator which delivers a 1 μS negative-going pulse coincident with the leading edge of the timing pulse from the stagger circuit. The a.f.c. trigger pulse is the first pulse in the system ensuring that the mode centering activity (*Chap.* 10) is completed before the occurrence of the magnetron pulse.

Timing run-down

6. The timing pulse from the stagger circuit is applied to a circuit which generates a linear voltage run-down commencing at the onset of the timing pulse. There are two trigger circuits associated with this run-down voltage; one of these determines the timing of the prepulse and the other the timing of the start of the timebase.

Timebase generator

7. Two timebase ranges are available, range 1, 0-5 n.m. and range 2, 0-18 n.m. Both ranges require triggering before the prepulse since the c.r.t. spot normally rests near the centre of the tube face and has to run out to the edge before the magnetron pulse occurs. The required timing of the timebase trigger is determined by selecting the point on the timing run-down at which the timebase trigger operates.

8. The timebase generator commences operation at the onset of the timebase trigger waveform. The generator consists of a Miller integrator having a tuned circuit as part of its anode load. The integrator is fed first with a positive voltage so that a linear voltage run-down is obtained. This corresponds to spot movement from the centre to the edge of the display. When the spot reaches the edge of the display, the voltage at the integrator grid is changed to a negative one and a linear voltage run-up is obtained corresponding to the timebase sweep. At the end of the run-up, the integrator is cut off and the tuned circuit is allowed to oscillate for one half cycle giving a voltage overswing at the integrator anode. The waveform so obtained, after passing through a.c. couplings, will be balanced about a voltage such that the energy during the sawtooth portion is equal to the energy during the overswing. The amplitude of the overswing therefore determines the position of the spot on the c.r.t. at the end of the timebase sweep. This is arranged to be such that an open centre display is obtained.

9. The timebase voltage waveform is applied to an amplifier which employs current negative feedback. The current waveform obtained from the amplifier is applied to the timebase synchro on the scanner where it is resolved into components, proportional to the sine and cosine of the angle turned through by the aerial, for application to the deflecting coils of the indicator c.r.t.

Prepulse generator

10. The prepulse generator is a blocking oscillator which generates a 7μS rectangular pulse. The voltage point on the timing run-down at which the prepulse trigger circuit operates is arranged to be such that the prepulse starts a few microseconds before the end of the timebase run out, and therefore finishes a few microseconds after the start of the timebase sweep. The magnetron pulse is initiated by the trailing edge of the prepulse and defines the point of zero range on the timebase.

Bright-up

11. A waveform, consisting of the timebase waveform without the overswing, is obtained from the timebase generator stage and is applied to a differentiator. The output of this consists of a positive-going rectangular pulse lasting for the duration of the integrator run-down followed by a negative-going pulse lasting for the integrator run-up. This waveform is applied to an amplifier stage which provides two outputs coincident with the negative-going part of the differentiator output —a negative-going one from the cathode circuit and a positive-going one from the anode. The pulse from the cathode is applied to the video circuit in the indicator ultimately providing a negative-going excursion of the c.r.t. cathode to the point where beam current is just cut off. Any further depression of the c.r.t. cathode thus causes beam current to flow and provide a spot on the c.r.t.

Video amplifier and mixer

12. The positive-going bright-up output from the bright-up amplifier is used to gate the video mixing circuit. The video output from the i.f. strip (*Chap.* 9) is applied to the video mixing stage together with the range markers and both quantities are gated by the bright-up pulse. The video output from the mixer is applied via a coaxial cable to the indicator where the signals are developed across a 100 ohms CONTRAST control.

13. The application of the bright-up pulse to the video mixer causes a voltage pedestal to be developed in the output and the video signals rise from this. The pedestal drives the cathode ray tube in the indicator sufficiently to lift the screen brightness to the threshold of visibility when the indicator CONTRAST control is adjusted for optimum signal brilliance. If the incident illumination on the tube face changes, the CONTRAST control will require adjustment. The amplitude of the pedestal is subject to the setting of the CONTRAST control. Consequently, if optimum signal brilliance, is the criterion for setting the CONTRAST control, the threshold brilliance of the picture will be correct for all settings and it will not be necessary for the user to adjust the BRILLIANCE control (which sets the "black" level) during operation.

14. The intensity of the range markers can be adjusted independently of the signal echoes by means of the MARKER BRILL control on the indicator.

Range markers

15. The magnetron pulse, obtained from a small resistor in series with the pulse transformer in the transmitter, is used to trigger a flip-flop circuit. The negative-going rectangular pulse output from this is applied to the range markers generator and allows a train of short duration pulses to be generated for a period corresponding to about 20 miles of range. The circuit is switched by the range switch on the indicator to give pulses at 2-mile intervals on range 1 and 4-mile intervals on range 2. These pulses are fed to the video mixing stage to provide 2 or 4 mile range rings on the display as appropriate to the timebase range. The range markers circuit is made to operate by the MARKERS switch on the indicator.

CIRCUIT DESCRIPTION

General

16. A complete circuit diagram of the waveform generator system is given in Fig. 27. This circuit includes the associated parts of various other units in the radar head (e.g. scanner and indicator). The following points should be noted with regard to the convention used for circuit references.

(1) All components on waveform generator sub-units are prefixed with the sub-unit number (e.g. 1R1 refers to R1 on waveform generator (sub-unit 1).

(2) Components prefixed "w" are on the waveform generator tray assembly (e.g. wRV1 is RV1 on the tray)

(3) Plug and socket poles are prefixed with their location reference and an oblique stroke. Plugs and sockets on the main framework of the radar unit are prefixed G/. Note that 5/ refers to the plug and socket connection between waveform generator unit 5 and the tray but G5/ refers to the plug and socket connection between the tray and the radar unit main framework wiring.

17. The complete circuit diagram of Fig. 27 is intended for use in following the circuit description and for fault finding on a sub-unit basis. Separate circuit diagrams of the individual sub-units, and the tray are given on Fig. 22 to 26. Views of the various sub-units and tray are given in Fig. 4 to 19. Views of the complete waveform generator are given in Fig. 20 and 21.

2 kHz oscillator

18. Valve 5V7 is a Hartley oscillator generating a sinusoidal voltage at a frequency of approximately 2 kHz. The anode circuit consists of coil 5L1 in parallel with capacitors 5C9 and 5C10; these resonate at 2 kHz. The output is taken from 5V7 anode and is fed via 5C8 and 5R16 to the grid of valve 1V5.

100 Hz oscillator

19. Valve 1V4 is a resistance-capacitance coupled oscillator generating a sinusoidal voltage at a frequency of approximately 100 Hz. The theory of such an oscillator is given in A.P.1093E(2), Chap. 8, Sect. 20. In order to prevent spurious pulses being generated, 1V4 is cut off, by a circuit involving 1D2 and 1D3, until such time as the output from 5V7 has reached a maximum amplitude. Valve 1V4 is cut off by about −16V from the chain consisting of 1V12 and 1R33 to 1R35 connected across the −175V bias supply. The resulting negative voltage across 1C15 is offset by the 2 kHz output from valve 5V7 fed into the circuit by 1C16, shunt rectified by 1D3 and used to charge 1C15 via 1R33; the process takes about 16 sec. The diode 1D2 prevents 1V4 bias becoming positive when the output from valve 5V7 reaches maximum amplitude.

2 kHz staggered pulse generator

20. The 2 kHz sine waveform output from valve 5V7 is applied to the grid of 1V5 via 5R16. Negative d.c. bias is applied to the valve from the junction of 5R16 and 1R14. The valve is driven into grid current by the positive peaks of the 2 kH waveform and is cut off by the negative peaks. A rectangular waveform is obtained in the anode circuit. The mark-to-space ratio of this waveform depends on the points at which the 2 kHz waveform passes through the grid base of the valve; these points are varied regularly by the presence of the 100Hz waveform from 1V4 fed via 1C8 and 1R13. The main purpose of 1R13 is to prevent 1V5 grid current from charging 1C8 and clamping the positive peaks of the 2 kHz waveform at earth potential.

21. The output from the anode of 1V5 may be considered as consisting of a train of positive-going rectangular pulses at a repetition frequency of 2 kHz having pulse-width modulation at 100 Hz (waveform 2, Fig. 2). Since the time intervals between the centres of consecutive pulses are equal (the centres coincide with the negative peaks of the 2 kHz waveform), it follows that the time intervals between the leading edges of consecutive pulses vary at 100 Hz. The maximum difference between one interval and the next occurs when the rate-of-change of the 100 Hz voltage is a maximum; that is, as it passes through zero. The greatest interval occurs at the start of a positive half-cycle of the 100 Hz wave and the smallest at the end. The mean interval, equal in duration to one cycle of the 2 kHz voltage, occurs at a positive or negative peak of the 100 Hz voltage.

22. The leading edges of the positive-going pulses at 1V5 anode ultimately determine the instants at which the magnetron pulses occur. The interpulse period of the equipment thus varies at 100 Hz resulting in the spreading of any second trace echoes on the display. This prevents echoes from objects at ranges greater than those represented by the interpulse periods from appearing on the display as discrete echoes which would confuse the user. This is the only effect of the interpulse period variation or 'stagger'. The stagger may be neglected completely when considering the action of the rest of the circuits.

A.F.C. trigger

23. The a.f.c. trigger pulse, which initiates the sinusoid for the mode centering feature of the a.f.c. system (*Chap.* 10) is generated by valves 1V1 and 1V2.

24. The timing pulse from the anode of 1V5 is connected to the control grid of 1V1 via a differentiating circuit consisting of 1C1 and 1R2. The valve is normally cut off by a negative voltage from the junction 1R2, 1R1. The sharp positive-going pulse, resulting from the differentiation of the leading edge of the timing waveform, drives a pulse of current through the valve and through the primary of the pulse transformer 1T1 in the anode circuit of 1V2. The negative pulse which occurs at 1V1 grid, coincident with the end of the timing pulse, has no effect on the valve since it is already cut off by the negative grid bias.

25. Valve 1V2 is a blocking oscillator. The theory of this type of oscillator is given in A.P. 1093E (2), Chap. 10, Sect. 8. The circuit is triggered by the current pulse from 1V1 and the output, consisting of a negative-going 1μS pulse (waveform 4, Fig. 2), is taken from a tertiary winding on the pulse transformer 1T1. The diode 1D1 prevents any positive-going overswing from occurring after the output pulse.

Timing run-down

26. Valve 1V7 is connected as a Miller timebase valve similar to that described in A.P.1093E (2) Chap. 11, Sect. 10. The rectangular positive-going timing pulse (waveform 3, Fig. 2) from 1V5 anode is connected to 1V7 suppressor grid via 1C9. The diode 1D4 clamps the positive level of this pulse at earth potential and 1V7 is therefore cut off during the periods between pulses.

27. When the leading edge of a timing pulse arrives at 1V7 suppressor grid, anode current starts to flow through the valve and the normal Miller run-down voltage occurs at its anode. The rate of this run-down is determined by the time constant 1C11, 1R20. At the end of the timing pulse on the suppressor grid, anode current is cut off by suppressor grid bias and the anode voltage rises exponentially as 1C11 charges via 1R19 and the grid-cathode impedance of the valve. This voltage rise stops at about +100V since, at this level, valves 1V8 and 5V1 start to draw grid current.

Prepulse generation

28. The prepulse, which determines the timing of the magnetron pulse, is generated by the action of valves 5V1, 5V2 and 5V4.

29. Valves 5V1, 5V2 are connected in a cathode coupled trigger circuit. The action of this is as follows.

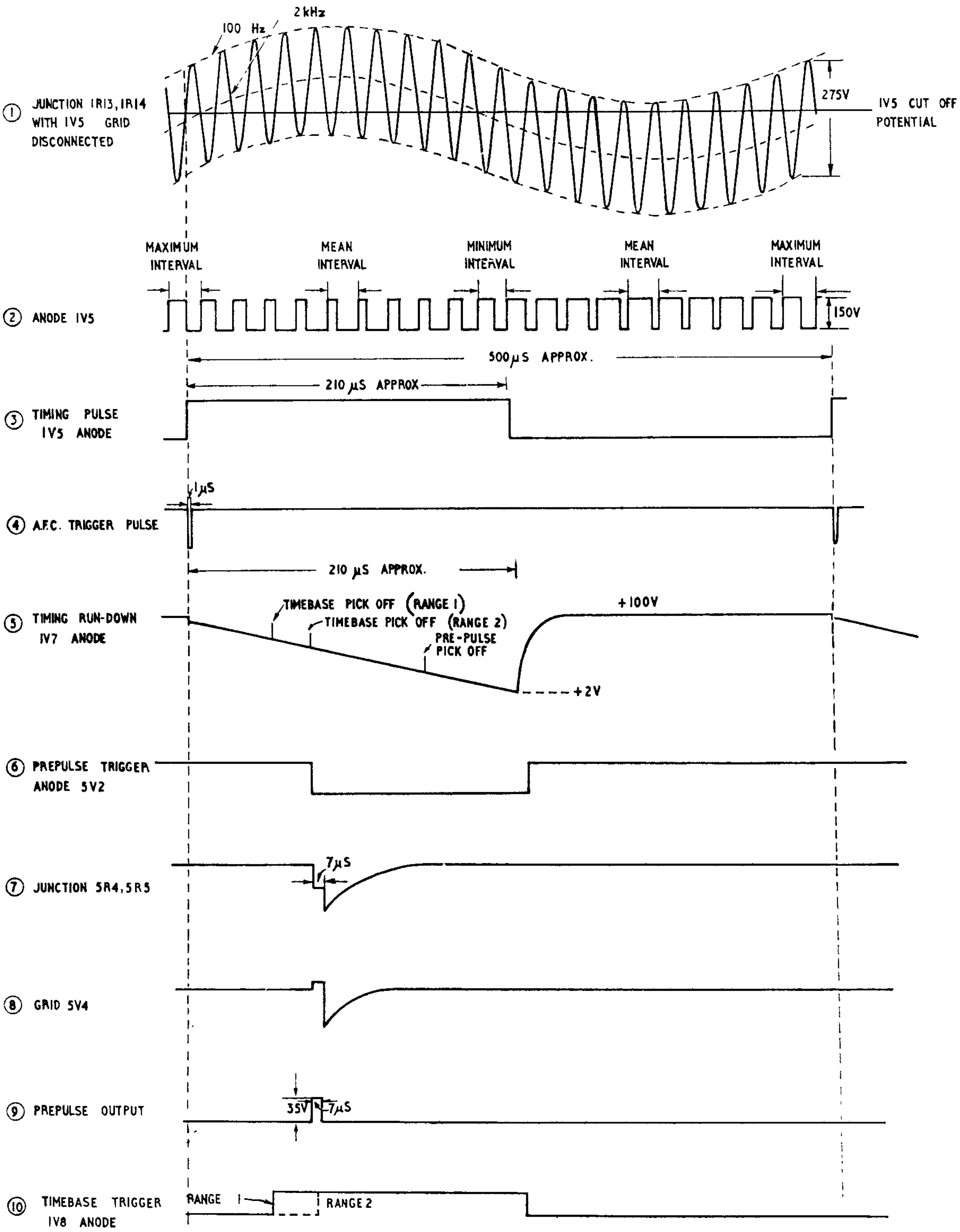


Fig. 2. Timing, a.f.c. trigger, prepulse and timebase trigger: theoretical waveforms

30. The grid of valve 5V2 is caught at the voltage of the junction wR8/wR6 by the diode 5D1. The grid of 5V1 is connected to the anode of 1V7 and it therefore follows the timing run-down voltage. At the start of the timing run-down, 5V1 grid voltage is high and 5V2 is cut off by cathode bias.

31. At the point in the run-down when the run-down voltage (and therefore the common cathode voltage of 5V1, 5V2) approaches 5V2 grid potential, 5V2 starts to conduct taking some of the current from 5V1. 5B1 anode potential rises and with it the grid potential of 5V2 by coupling via 5C1. 5V2 anode current increases still further and, because of the common cathode coupling 5V1 current decreases by the same amount. The action is cumulative and ceases when 5V2 is fully conducting and 5V1 cut off. The common cathode potential is now determined by 5V2 grid potential which has been lifted by the rise in 5V1 anode potential. The time constant 5C1, 5R6, is long enough (about 250μS) for the effect of the charging of 5C1 on the grid potential to be ignored.

32. Valve 5V2 remains conducting with 5V1 cut off until 5V1 grid rises at the end of the timing run-down. As 5V1 grid passes through the common cathode potential, the cumulative action takes place in the opposite direction cutting off 5V2 and driving 5V1 on. The resulting fall in 5V1 anode potential, coupled via 5C1 drives 5C2 grid down to the voltage at the junction wR8, wR6 where it is caught by 5V3.

33. The output from the trigger circuit is taken from the anode of 5V2. It consists of a negative-going rectangular pulse which starts at some point in the timing run-down (known as the prepulse pick-off point) and ends at the end of the timing run-down (waveform 6, Fig. 2).

34. Valve 5V4 operates as a blocking oscillator whose output pulse length is determined by a delay network 5DL1 in the grid circuit. The valve is normally biased beyond cut off by a voltage derived from the junction 5R4, 5R5.

35. The leading negative-going edge of the pulse from 5V2 is applied via 5C4 to the anode of 5V4. This edge is applied in antiphase, by the action of the pulse transformer 5T1, to 5V4 grid where it drives the valve into grid current. The voltage at the grid end of the grid winding on the transformer is limited at earth by the grid current and a sharp negative edge therefore appears at the other end. This is propagated along the delay network and is reflected from the open circuit termination with the same polarity. Since the delay time of the network is 3·5 μS in each direction, a further negative edge, of the same amplitude as that applied but 7 μS later appears at the input terminals of the network and thus cuts off 5V4. The network then discharges via 5R4 and the voltage across it decays exponentially to the steady voltage at the junction 5R4, 5R5. The waveforms generated at 5V4 grid and at the junction 5R4, 5R5 are given in *fig*. 2 (waveforms 7 and 8). The h.t. supply to 5V4 is switched by contacts of relay wZ/1; the operating coil of the relay is connected in series with wR7 across the −175V bias supply. The reason for this is that the +285V h.t. supply is derived from silicon diode rectifiers whereas the −175V supply was originally generated by valves. Thus if the bias circuit were not allowed sufficient time to warm up, (as when switching straight from WARM UP to TRANSMIT) the prepulse generator could run free at a high repetition rate which would cause the transmitter overload circuit to trip. Relay wZ/2 prevents this effect by ensuring that the 285V h.t. supply cannot appear at 5V4 anode until the −175V supply is present.

36. The prepulse output (waveform 9, *fig*. 2) is taken from a winding on the transformer. Diode 5D2 is included to prevent any overshoot, or ringing from the transformer, from appearing on the prepulse. Another pulse, coincident with the prepulse, is taken from a further winding to operate the i.f. strip suppression circuit.

Timebase trigger circuit

37. Since the rest position of the spot on the indicator display tube is near the centre of the tube face, the spot has to move out to the edge before starting the timebase sweep. On both ranges the timebase trigger must occur before the prepulse trigger. On range 1 (0–5 n.m.) the timebase trigger occurs 70 μS before the prepulse trigger and on range 2 (0–18 n.m.) the timebase trigger occurs 30 μS before the prepulse trigger. The magnetron pulse occurs about 1 μS after the end of the prepulse (8 μS after start) and this instant is required to be about 5 μS after the start of the timebase sweep.

38. Valves 1V8 and 1V9 are connected as a cathode coupled trigger circuit similar to that already described for the prepulse trigger (para. 29). The time-base pick-off points on the timing run-down (waveform 5, *fig*. 2) are determined by the settings of wRV1 (range 1), wRV3 (range 2) and the condition of relay 0. Relay contacts 10A operate on range 2. Valve 1V10 clamps the negative excursion of 1V9 grid to the pick-off voltage. The voltages set by wRV1 and wRV3 are both more positive than the prepulse pick-off so that the timebase trigger occurs before the prepulse on both ranges (waveform 5, Fig. 2).

39. The output from the timebase trigger circuit is taken from the anode of 1V8 via 1C13. It consists of a positive-going rectangular pulse which starts at the instant determined by the pick-off voltage on the timing run-down and ends at the end of the timing run-down (waveform 10, Fig. 2).

Timebase generator

40. Valve 2V8 is connected in a Miller integrator circuit. The anode voltage of the valve is required to execute a linear run-down, followed by a linear run-up, followed by a voltage overswing. The run-down period ultimately provides a c.r.t. spot movement from near the centre of the tube face to the edge. The run-up provides spot movement from the edge back towards the centre for the timebase sweep. The voltage overswing ensures that the timebase origin will be situated near the centre of the tube face.

41. Valves 2V2, 2V3 form a cathode coupled trigger similar to that used for the prepulse trigger (para. 32). The operation of this circuit is initiated by the leading edge of the timebase trigger waveform from 1V8 fed via 1C13. It is terminated when the run-down voltage from 2V8 anode reaches a particular level; the action of 2V8 is then made to change from run-down to run-up.

42. Immediately before the leading edge of the timebase trigger pulse, valve 2V8 rests at cut off since its grid is connected via 2V6 to a negative voltage at the junction wR4, wR5 via pole 2B3. Valve 2V9 will be conducting via 2R26 and, although no anode current flows through 2V8, there is a current flowing in the choke 2L1 as will be explained later (para. 49). Valve 2V10 is conducting holding the potential at 2V9 anode to 80V derived from the junction 2R28, 2R29. The cathode coupled trigger circuit rests with 2V2 cut off and 2V3 conducting.

43. When the leading edge of the timebase trigger pulse from 1V8 (waveform 10, *fig.* 2) arrives at 2V2 grid, the valve conducts and cuts off 2V3 by coupling via 2C2. The anode potential of 2V3

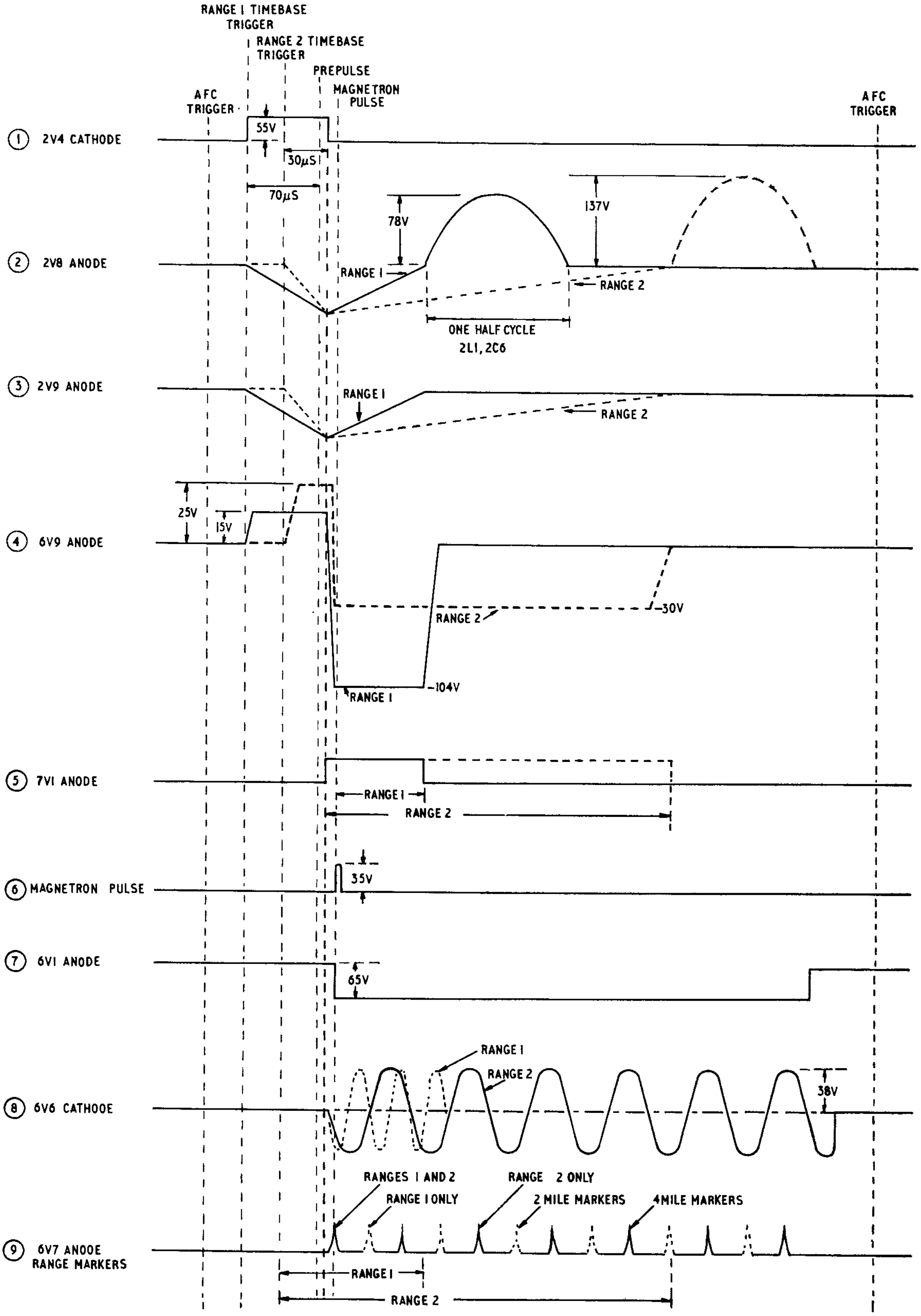


Fig. 3 Timebase, bright-up, range markers: theoretical waveforms

rises sharply taking the grid (and hence the cathode) of the cathode follower 2V4 to the clamping potential at the junction 2R1, 2R2 by the action of 2D1. The voltage step (about +55V) at 2V4 cathode forms a low impedance voltage source which drives the Miller integrator 2V8 via 2V5 and 2R15 (waveform 1, Fig. 3).

44. Valve 2V8 starts to conduct as a result of the voltage rise at 2V4 cathode and the current flowing through 2R15 (or 2R15, 2R34) discharges the feedback capacitor 2C5. The anode voltage of 2V8 therefore executes a linear run-down. Immediately the run-down starts, 2V10 cuts off.

45. At some point on the run-down voltage (approximately +45V) valve 2V7 conducts and the run-down voltage appears at its anode. This linearly falling voltage, applied to 2C3, 2R30, causes an exponentially falling voltage (*A.P.* 1093*E*(2) *Chap.* 2, *Sect.* 3) to appear at 2V2 grid and this eventually cuts off 2V2. The voltage rise caused at 2V2 anode is coupled to 2V3 grid which rises to approximately +22V where it is caught by 2V1. Valve 2V3 conducts resulting in a fall in the voltage at 2V4 cathode which cuts off 2V5. The input current to the Miller integrator 2V8 now reverses since it flows from the −175V line via 2R21, wRV4 (range 2) or 2R23, wRV5 (range 1). The feedback capacitor 2C5 commences to charge and 2V8 anode voltage starts a linear run-up. The rate of this run-up is determined by the condition of contacts 20B (relays 0 operate on range 2). At the point when the run-up voltage passes through +45V, 2V7 cuts off.

46. When the run-up voltage reaches +100V, 2V10 conducts preventing any further voltage increase and 2V9 cuts off breaking the feedback circuit via 2C5. The grid of 2V8, deprived of feedback, now moves quickly negative to the clamping level, determined by 2V6, and 2V8 cuts off.

47. During the Miller action, the anode load of 2V8 consists of the tuned circuit 2L1, 2C6 in parallel with the anode load resistor 2R26. If a voltage is applied across the terminals of a choke, the current driven through the choke will depend on the voltage and the length of time for which it is applied. The current change in the choke during the Miller action is therefore proportional to the integral of the Miller waveform. Also, although the voltage across the choke varies during the waveform, it has uniform polarity and the resulting current change will be in the same direction throughout the waveform. It was stated in para. 42 that some current flows in the choke at the start of the Miller waveform. This current is in opposite direction to that induced during the waveform and the amount of current flowing when 2V8 cuts off is the increase in current during the waveform less that which was flowing at the start.

48. When valves 2V8 and 2V9 cut off, the resistor 2R26 is disconnected allowing the resonant circuit 2L1, 2C6 to oscillate at its natural frequency. At the start of this action, there is a current flowing in the choke and there is also a small voltage across it (approximately −10V since one end of the choke is connected to +90V at the junction 2R27, 2R28 and the Miller run-up terminated at +80V). At the start of the oscillatory action, the voltage increases positively to zero as 2C6 discharges causing a slight increase in current. Then follows a complete positive half-cycle of voltage; at the end of this, the voltage across the circuit is again zero the current being a maximum in the opposite direction. The voltage then moves sinusoidally negative until it is about −10V when the potential at 2V8 anode falls to +80V and 2V9 conducts providing a path through 2R26 for the current. The current is less than that normally drawn by 2V10 so that the current passing through that valve, when 2V9 conducts under these conditions, is reduced but the voltage at 2V9 anode (and hence at 2V8 anode) remains at +80V.

49. The voltage across 2L1 is now fixed at −10V and this figure determines the current through it. Since the voltage is constant, the rate of change of current must be constant also and it follows that the current decreases in a linear manner. Before the current decreases to zero, the next trigger pulse edge arrives at 2C2 grid and the next Miller run-down action commences. This explains why there is current flowing in the choke at the start of the Miller run-down (para. 42).

50. The amplitude of the positive-going voltage overswing at 2V8 anode, after the valve cuts off, is determined by the current in the choke at the cut off point; this, in turn, depends on the current in the choke at the start of the Miller action which, in turn, depends on the rate of change during the period between the end of the overswing and the next trigger pulse.

51. The waveform at 2V8 anode (waveform 2, Fig. 3) will be balanced about a voltage level such that the energy represented by voltage excursions above the level will balance the energy represented by those below. Thus, the larger is the positive overswing, the greater will be the difference between the balance level and the voltage (+80V) at the end of the Miller run-up, and the larger will be the open centre obtained on the indicator display. The resistor 2R28 determines the size of the open centre since it determines the voltage across the choke at the end of the overswing and hence the current in the choke at the start of the Miller action.

52. The waveform at the anode of 2V8 is connected via 2C7 to the network consisting of 2C12, 2R25, 2R24 and either wRV6 or wRV7 depending on the setting of the range switch on the indicator. Potentiometers wRV6 and wRV7 are included only to adjust the circuit for component tolerances and to give a fine control of the timebase amplitude on the display. Part of the timebase waveform is connected from the junction 2R24, 2R25 to the input grid of the timebase amplifier circuit. Capacitor 2C12 is included in parallel with 2R25 to balance the input capacitance of the amplifier circuit so preventing distortion of the waveform.

Timebase amplifier

53. The timebase amplifier consists of a push-pull voltage amplifier circuit 3V1 and 3V2 followed by a push-pull output circuit 3V3, 3V4.

54. The circuit of the voltage amplifier is similar to that described in A.P.1093E(2) Chap. 7, Sect. 23. The output stage follows normal practice and should require no further explanation. Current negative feedback, from the output circuit, is applied to the cathode circuit of 3V1. The voltage waveform across 3R2 is similar to waveform 2, Fig. 3. and represents the current waveform obtained in the c.r.t. deflector coils. Resistor 3R14, across the output of the circuit is included to assist in damping any tendency to high frequency oscillation.

Bright-up circuit

55. Valve 2V9, in the timebase generator circuit, is cut off during the period of the positive-going—overswing on the timebase waveform. The waveform at the anode of 2V9 therefore consists of a triangular wave, formed by the run-down and run-up voltages from 2V8 anode (waveform 3, Fig. 3). This waveform is applied to a differentiating valve 6V9.

56. Valve 6V9 is a high gain amplifier and a 'virtual earth' may be considered to exist at its grid since a large change of output voltage will be obtained for an infinitesimal grid voltage excursion. Any input voltage applied to the grid circuit is developed across the input capacitor 6C10. The current flowing through 6C10 will be proportional to the rate-of-change of input voltage and, if grid current is not to flow, this current must flow through the feedback network 6R18, 6V12, 6R24 and 6C12. 6V9 anode voltage therefore follows the rate-of-change of the voltage applied to 6C10 (i.e. it is a differentiated version of the input voltage).

57. In order that the differentiator circuit may always work within the anode voltage swing of 6V9, an asymmetric time constant is used in the feedback arm 6R18, 6D4, 6R24 and 6C12; the asymmetry is due to the diode 6D4. At the onset of the run-down voltage from 2V9 anode, 6V9 anode moves sharply positive. It remains steady during the period of the run-down. At the—transition from run-down to run-up, 6V9 anode moves to a level more negative than its starting point, where it remains until the end of the run-up voltage, and returns to the quiescent level. The asymmetric time constant reduces the amplitude of the positive-going waveform due to the run-down voltage, since 6D4 conducts under this condition and the feedback arm is virtually 6R18 alone. Conversely, on the run-up voltage 6D4 is non-conducting and the feedback arm becomes 6R18 and 6R24 in series thereby increasing the amplitude of the negative-going waveform due to the run-up voltage.

58. The output from 6V9 is applied via 6C11 to the grid circuit of 7V1. The positive-going part of the waveform is developed across 7R2 and has no effect on the valve since the grid potential is prevented from rising by grid current. The following negative-going portion of the waveform cuts off 7V1 and a positive-going rectangular pulse, lasting for the duration of the timebase sweep, is obtained from the anode of the valve (waveform 5, Fig. 3); an antiphase version of this is obtained at the cathode. At the end of the driving pulse, 7V1 returns to grid current. The positive-going pulse from the anode circuit is used to gate the video mixer circuit (para. 69). The negative-going pulse from 7V1 cathode circuit is used to define the 'black' level for the indicator c.r.t. (para. 71).

Range markers

59. The range markers circuit produces a train of short duration pulse at intervals corresponding to 2 miles on range 1, and 4 miles on range 2. The train lasts for about 20 miles of range and is initiated by the magnetron pulse.

Starting and sustaining circuit

60. Valves 6V1 and 6V3 are connected as cathode coupled flip-flop circuit. In this, 6V3, is normally conducting and 6V1 cut off since their grid potentials are determined by the voltages at the junctions 6R1, 6R2 and 6R2, 6R3 respectively. The grid of 6V3 is prevented from rising above the voltage at the junction 6R1, 6R2 by the action of the clamping diode 6V2.

61. The magnetron pulse, obtained from a small resistor in series with the pulse transformer in the transmitter (*Chap.* 4), is connected via 6D1 and 6C2 to 6V1 grid and drives the valve into conduction. The diode 6D1 is included to prevent any negative-going rings following the magnetron pulse from cutting 6V1 off again. When a magnetron pulse arrives, 6V1 anode voltage falls and cuts off 6V3 by coupling through 6C4. Valve 6V3 remains cut off after the end of the magnetron pulse until 6C4 discharges via 6R8. The time taken for this corresponds to about 20 miles of range.

Oscillator

62. Valve 6V5 is a series fed Hartley oscillator having one of the tuned circuits 6L1, 6C6 (range 2) or 6L2, 6C7 (range 1) in its grid-cathode circuit. The appropriate tuned circuit is selected by contacts 60D and 60E which operate accordingly to the postion of the range switch on the indicator.

63. The rectangular waveform (waveform 7, *fig*. 3) at 6V1 anode is applied via 6C3 to the grid circuit of 6V4 where its positive level is d.c. restored to earth potential by a diode 6D2. Valve 6V4 conducts during the positive-going portion of the waveform, damping the oscillatory circuit and preventing it from operating. During the negative-going portion of the waveform from 6V1, 6V4 cuts off allowing 6V5 to oscillate for a period corresponding to about 20 miles of range following the magnetron pulse (waveform 8, *fig*. 3).

Output circuit

64. Valve 6V7 is normally in grid current since its control grid is connected via 6R14 to the +150V line. The negative-going half cycles of the oscillation from 6L1, 6C6 or 6L2, 6C7 are connected to the grid of 6V7 via the diode 6V6 and cut off the valve. The diode 6V6 prevents 6V7 grid current from damping the tuned circuit. Each time 6V7 cuts off a positive-going voltage pulse is obtained across the choke 6L3 in its anode circuit. Each time the valve conducts again a negative voltage pulse would occur at the anode but it is removed by the diode 6D3. The resulting waveform at 6V7 anode thus consists of a train of positive-going sharp pulses each pulse being coincident with the start of a negative-going half-cycle of voltage at 6V7 grid (waveform 9, Fig. 3).

65. The anode circuit of 6V7 is connected to the h.t. line via contacts of relay wQ; the range markers are thus available when relay wQ is not operated. The relay is controlled by the MARKERS switch on the indicator.

Video amplifier

66. Valve 4V3 is the partner of the output valve in the i.f. unit (*Chap.* 9). Resistors 4R6, 4R7 form the common cathode load. Positive-going video signals on the control grid of the i.f. unit output valve cause positive-going video signals to appear at 4V3 anode; these are limited by the action of 4V3 which cuts off at large signal amplitudes.

67. The positive-going limited output from 4V3 is applied via 4C1 to the grid of a cathode follower valve 4V2. The diode 4D1 is a d.c. restorer which ensures that the signals and noise at 4V2 grid rise from earth potential. The video output at 4V2 cathode is connected via poles 4/D4 and 7/D3 to the grid of 7V4 (where it forms the video input to the video and marker mixing stage) and via G8/B to GE/F (video test).

Video and marker mixing stage

68. Valves 7V3 and 7V7 are connected as a long-tailed pair whose cathode circuit includes valves 7V4 and 7V8. The grid of 7V3 is connected to a more positive point on the potential divider 7R14, 7R15, 7R16 than is the grid of 7V7. In the static condition, with no inputs to any of the valve control grids, 7V3 conducts and the common cathode potential of 7V3, 7V7 is determined by the potential at the junction 7R14, 7R15 and 7V7 is cut off by cathode bias. The grid of 7V8 is returned to a negative voltage at the junction 7R20, 7R19 so that, in the static condition, 7V4 conducts and 7V8 is cut off. It is convenient to regard 7V4, 7V8 as current generators, 7V3 as a gate valve, and 7V7 as a 'sink' taking any surplus currents.

69. The positive-going bright-up pulse from 7V1 (para. 58) is applied via 7C2 and 7R7 to the grid circuit of 7V3. The diode 7D2 clamps the peak of this pulse to the potential at the junction 7R14, 7R15. Valve 7V3 can thus only conduct during the bright-up pulse since, when the pulse is not present, the valve grid falls in potential by an amount equal to bright-up pulse amplitude. When the bright-up pulse is absent any current passed by 7V4, 7V8 flows through 7V7 and 7R21.

70. The voltages appearing at the anode of 7V3, as a result of current through the valve during the bright-up period, form the video input to the indicator. The connection is made by means of a coaxial cable terminated by the 100 ohms CONTRAST control in the indicator. The bright-up pulse (para. 58) lasts for the duration of the timebase sweep and the magnetron pulse (para. 37) occurs a few microseconds after the start of the timebase sweep. To prevent signals and noise from appearing before the transmitter pulse, the prepulse is applied to the grid of 7V7 from the pulse transformer in 5V4 anode circuit. The connection is made via 7C7 and 7R18. The amplitude of the prepulse is great enough to hold 7V7 on, even though the bright-up pulse has started at 7V3 grid. 7V3 therefore starts to conduct at the end of the prepulse and cuts off at the end of the bright-up pulse; this applies on both ranges.

71. The current turned on in 7V3 by the bright-up pulse generates a negative-going voltage pedestal and the negative-going video signals and markers fall from this. During the periods between bright-up pulses, the indicator c.r.t. operates beyond beam cut off. The negative-going bright-up pulse from 7V1 cathode is applied to the indicator and the indicator BRILLIANCE control is adjusted so that this pulse is just sufficient to depress the tube cathode potential to beam cut off or 'black' level. The video pedestal from 7V3 depresses the c.r.t. cathode potential still further lifting the picture brightness to the threshold of visibility. Since this pedestal is adjusted by the CONTRAST control, the picture threshold will be correct for all levels of incident illumination on the tube face if the CONTRAST control is adjusted for optimum signal brightness.

72. Positive-going video signals from 4V2 are applied via 7C4 and 7R11 to the grid of 7V4. The negative level of these signals is clamped at earth potential by the action of the d.c. restoring diode 7D3. The current which flows in 7V4 thus consists of standing current (or steady state current) plus video current.

73. In the absence of video signals, the current flowing through 7R10 (the cathode load of 7V4) consists of standing current plus about 1·5 mA which flows via 7R6 and the diode 7D1. For video signals which cause an increase of less than 1·5 mA through 7V4, the cathode load is decoupled by 7C3 and the valve operates at high gain. When the video current exceeds 1·5 mA, the current passed by 7D1 falls to zero and 7D1 cuts off disconnecting the decoupling capacitor 7C3. Valve 7V4 then works with negative current feedback and the gain is reduced in consequence. The circuit thus operates at high gain for small signals and at reduced gain for large ones. The gain obtained for large signals is determined by the value of 7R10 which determines the amount of negative feedback. This resistor also determines the bias on the valve when the diode is conducting. In order to ensure that the valve works at a point on its characteristic where high gain can be obtained for small signals, the bias is adjusted by the current which flows from the −175V line via 7R9. It should be noted that the cathode-screen grid voltage of 7V4 is high to enable it to handle a large signal input without running into control grid current.

74. The current turned on in 7V3 by the bright-up pulse is the standing current of 7V4 less the current by-passed through 7R21. In the absence of 7R21, all the standing current of 7V4 would be available and this would generate too large a video pedestal. The current turned on in 7V4 by the video signals is an increase above the pedestal level and pulses of video current therefore flow through 7V3 during the bright-up. The cathode-screen grid voltage of 7V3 is low and the valve therefore limits large signals. The common cathode potential then falls allowing 7V7 to conduct and bleed away the excess video current. Valve 7V7 has a high cathode-screen grid voltage to enable it to behave as an efficient 'sink'.

75. Marker information is added to the video signals by the action of 7V8. The 2 or 4 mile range markers are connected to 7V8 grid from the anode of 6V7 via 6C9.

76. The range markers are of sufficient amplitude to drive 7V8 into grid current setting a limit to the anode current which they turn on in the valve. The value of the limited anode current is determined by the screen potential of the valve. This can be varied, so carrying the brightness of the markers on the display, by means of the MARKER BRILL knob on the indicator.

77. Assuming the bright-up pulses to be present at 7V3 grid, the current turned on by the markers in 7V8 flows through 7V3. Any excess current, beyond that necessary to cause limiting in 7V3, flows through 7V7. Any marker pulses occurring after the end of the bright-up pulse have no effect on 7V3 and flow entirely through 7V7.

Gain control

78. The gain control voltage in this equipment is obtained from the indicator and is ultimately added to the suppression waveform before application to the i.f. strip.

79. A circuit consisting of the indicator GAIN control, wRV8, 4R9, 4R10 is connected between earth and the −175V line. The gain voltage for the suppression unit is taken from the junction wRV8, 4R9 and is adjustable by either wRV8 or the indicator control. Potentiometer wRV8 is the preset control and its setting determines the minimum gain control voltage and therefore the maximum gain of the i.f. strip.

80. A connection is also made from the junction wRV8, 4R9 to pole U of the 26 pole test plug D via poles G11/B3, G11/B4 (resonator performance testing). This enables the receiver gain to be set at the gating unit 10D/23451 during overall performance testing.

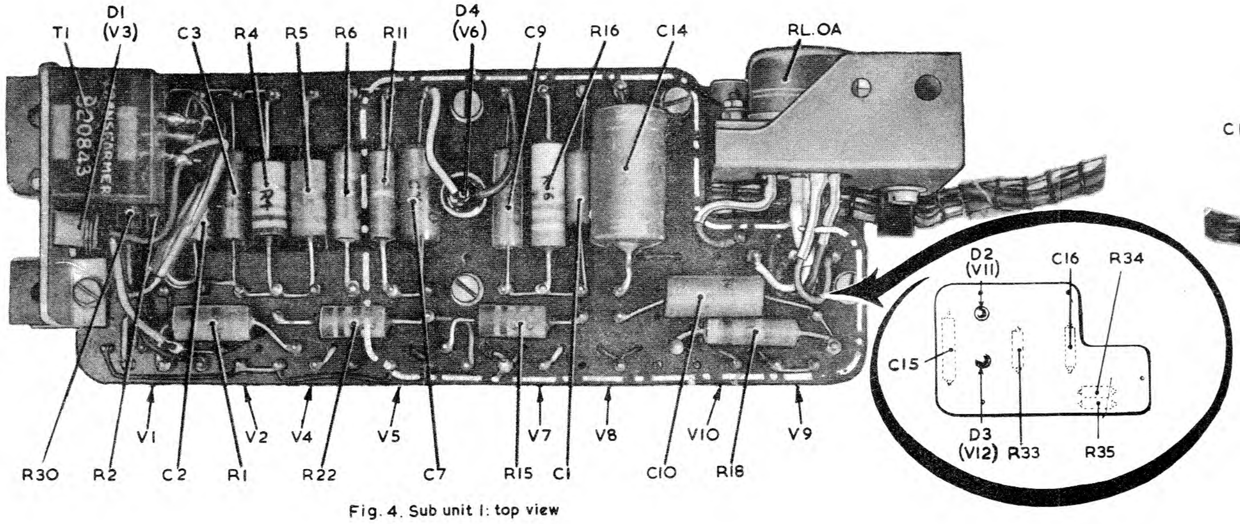


Fig. 4. Sub unit 1: top view

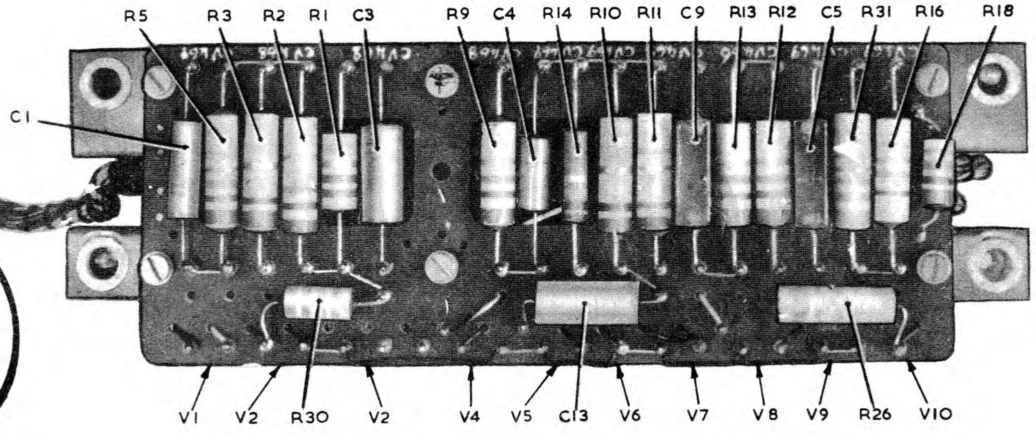


Fig. 7. Sub unit 2: under view

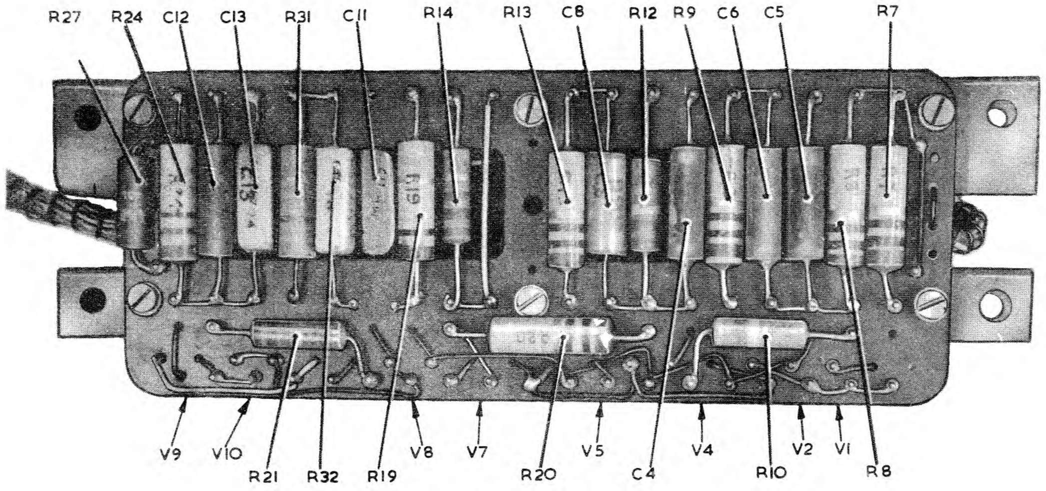
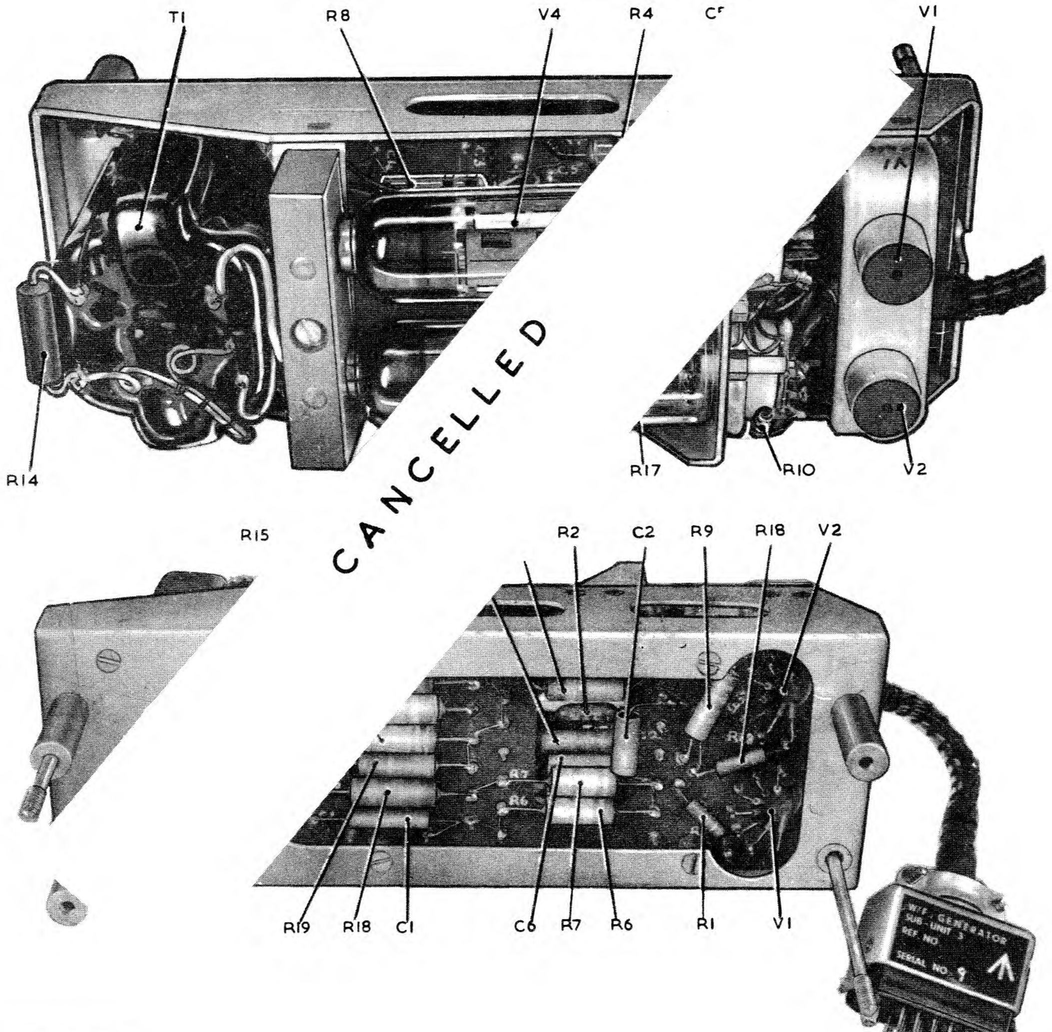


Fig. 5. Sub unit 1: under view



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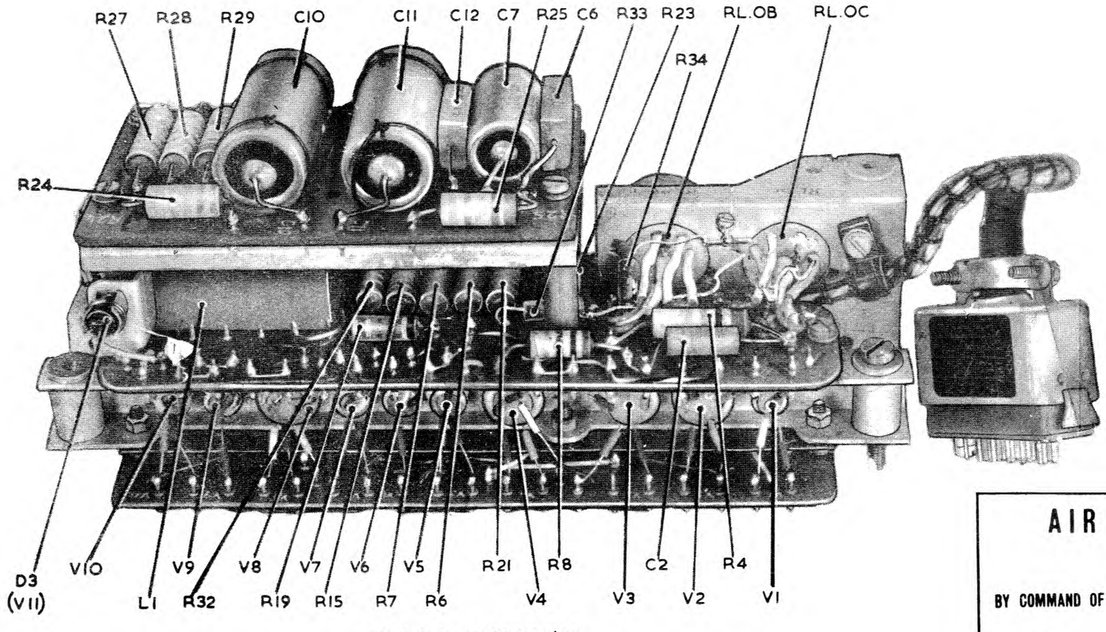

Fig. 6. Sub unit 2: top view

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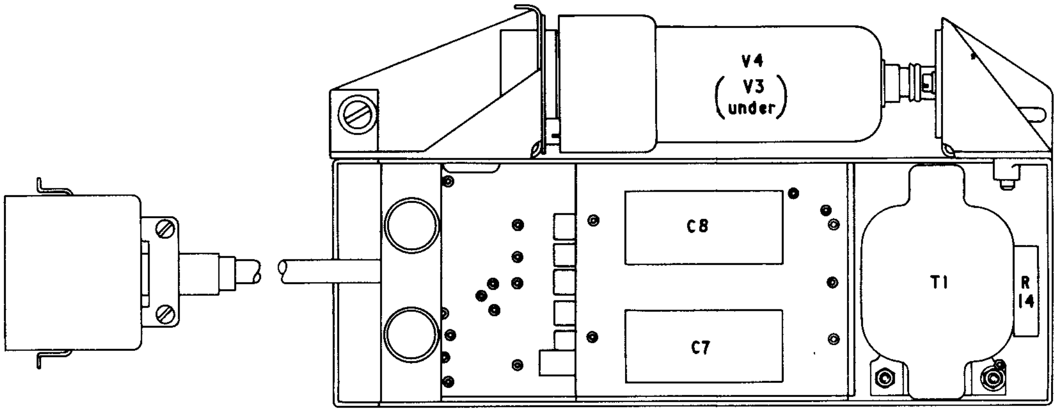

Fig. 8. Sub Unit 3. Top view.

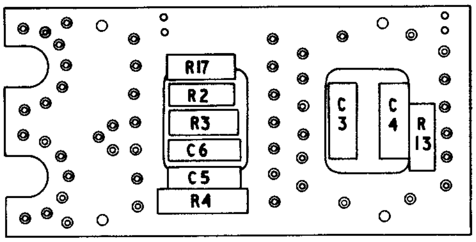

Fig. 9A. Sub Unit 3. Component location upperside of board.

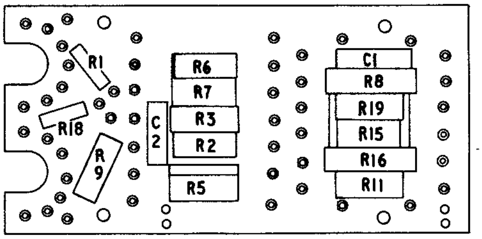

Fig. 9B. Sub Unit 3. Component location lowerside of board.

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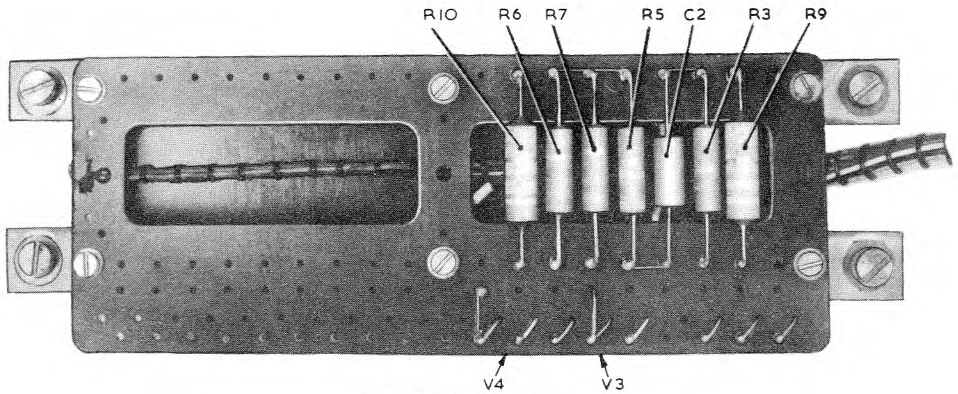

Fig.10. Sub unit 4: top view

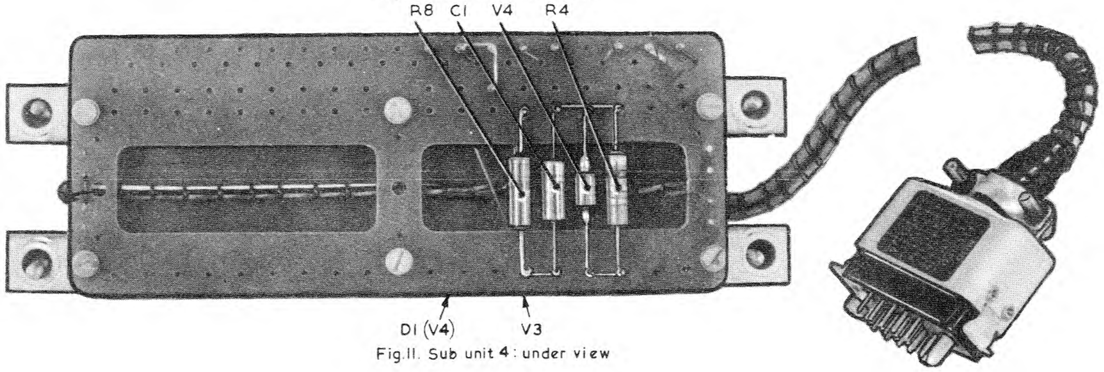

Fig.11. Sub unit 4: under view

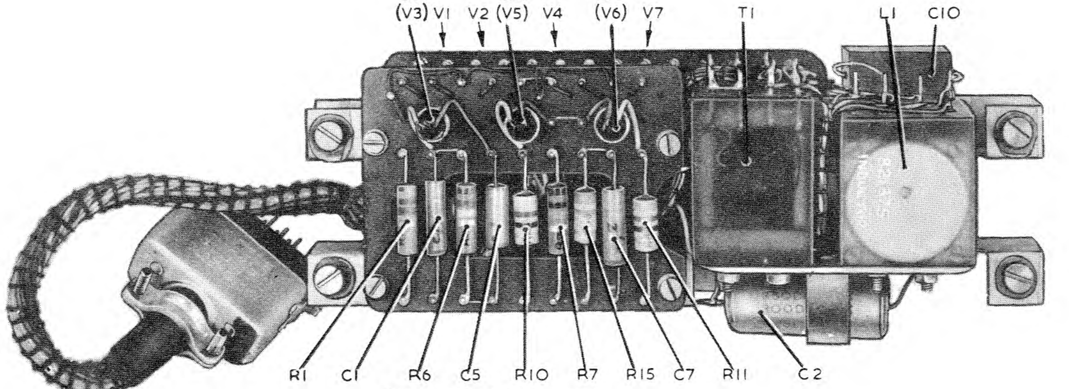

Fig.12. Sub unit 5: top view

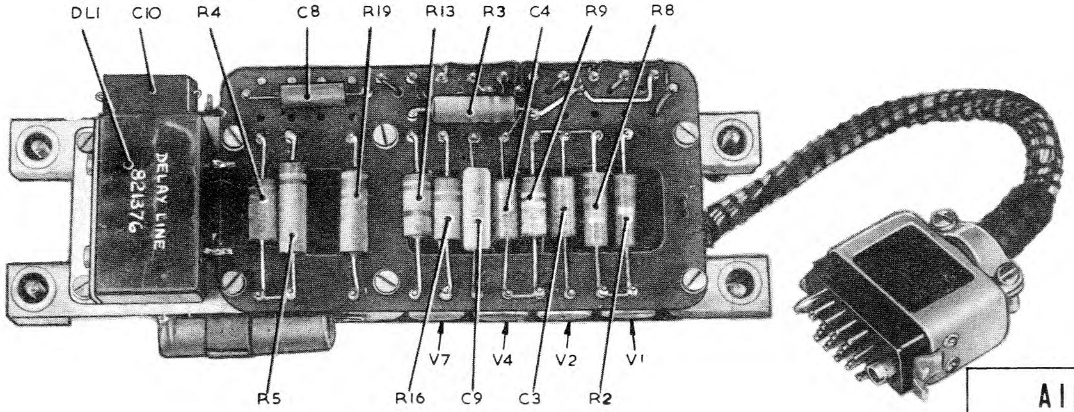

Fig.13. Sub unit 5: under view

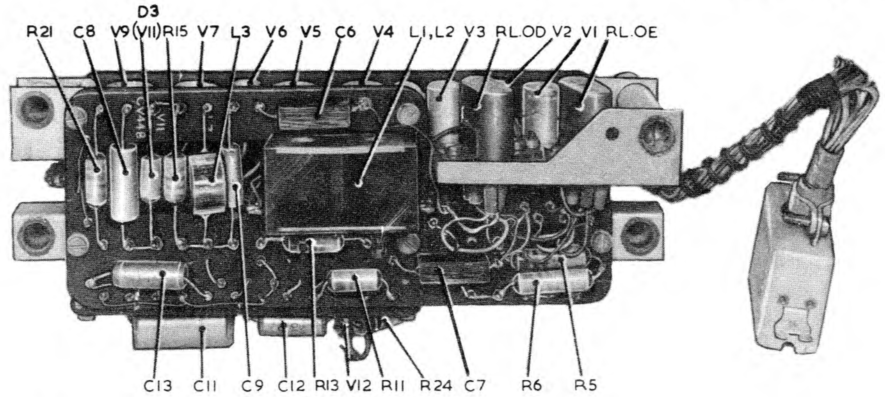

Fig.14. Sub unit 6: top view

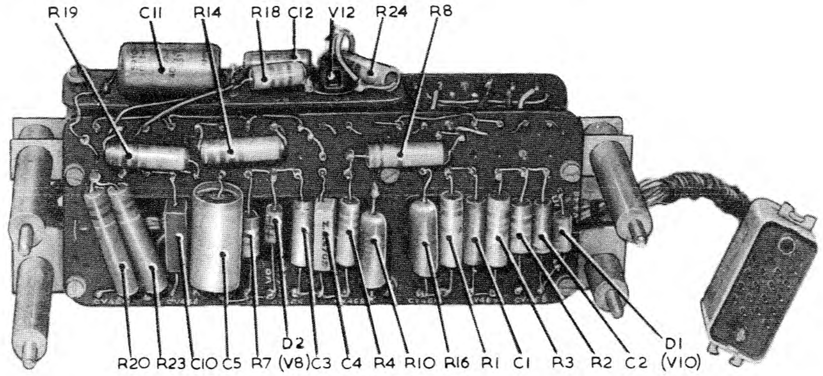

Fig.15. Sub unit 6: under view

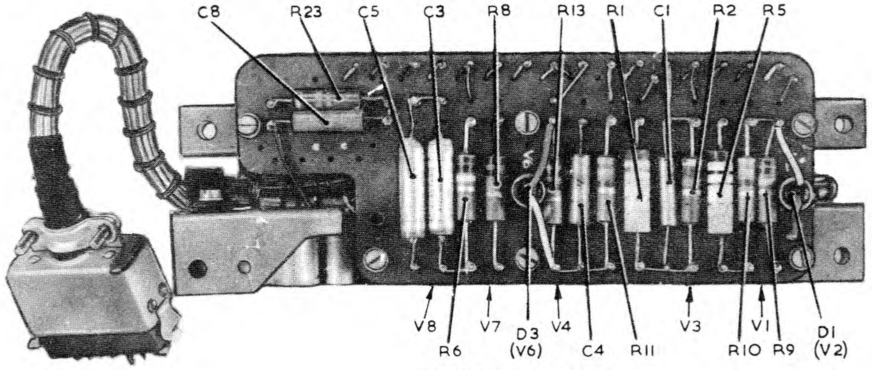

Fig.16. Sub unit 7: top view

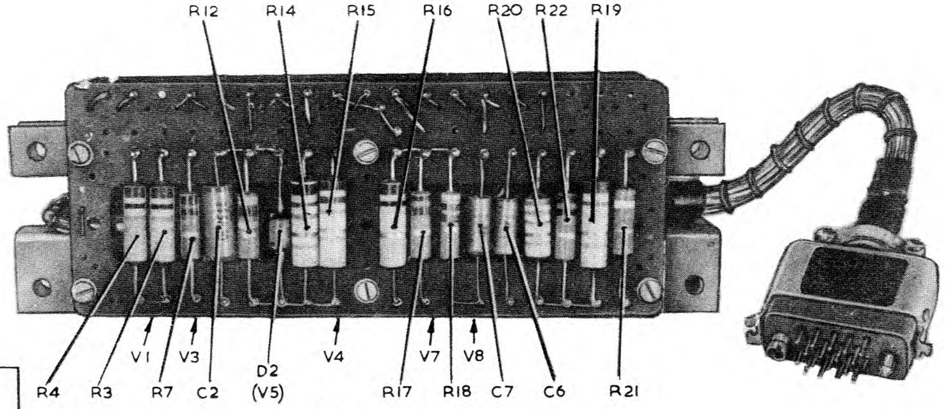

Fig.17. Sub unit 7: under view

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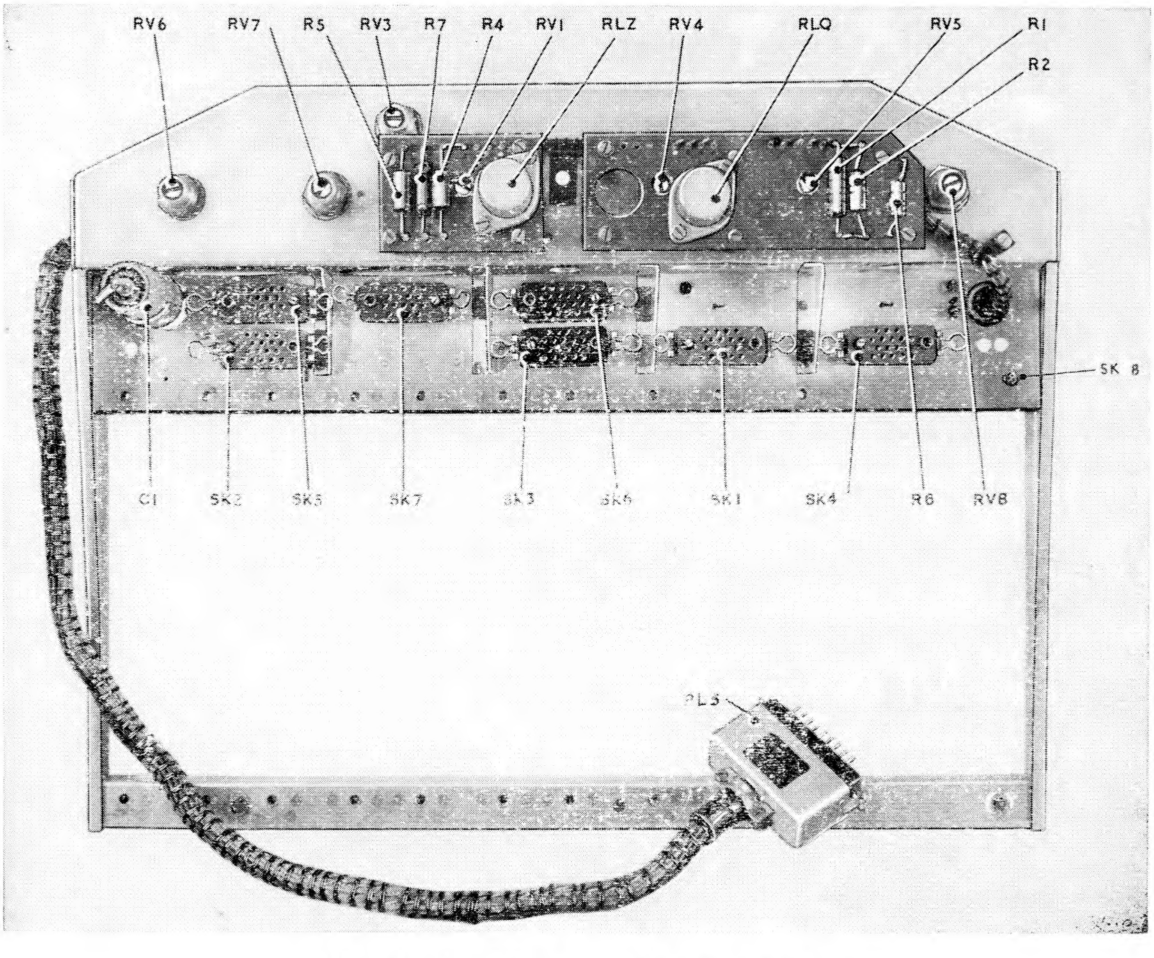


Fig. 18. Waveform generator tray: top view

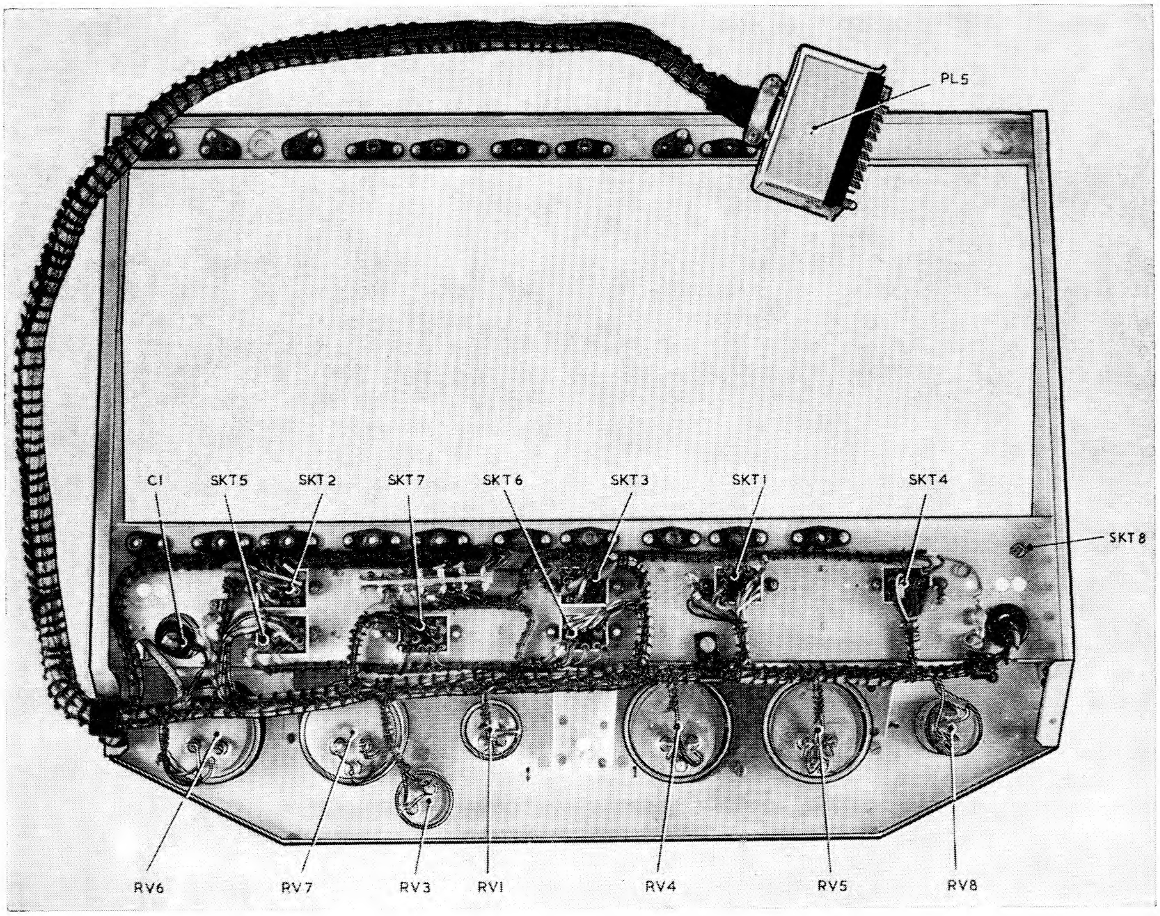


Fig. 19. Waveform generator tray: under view

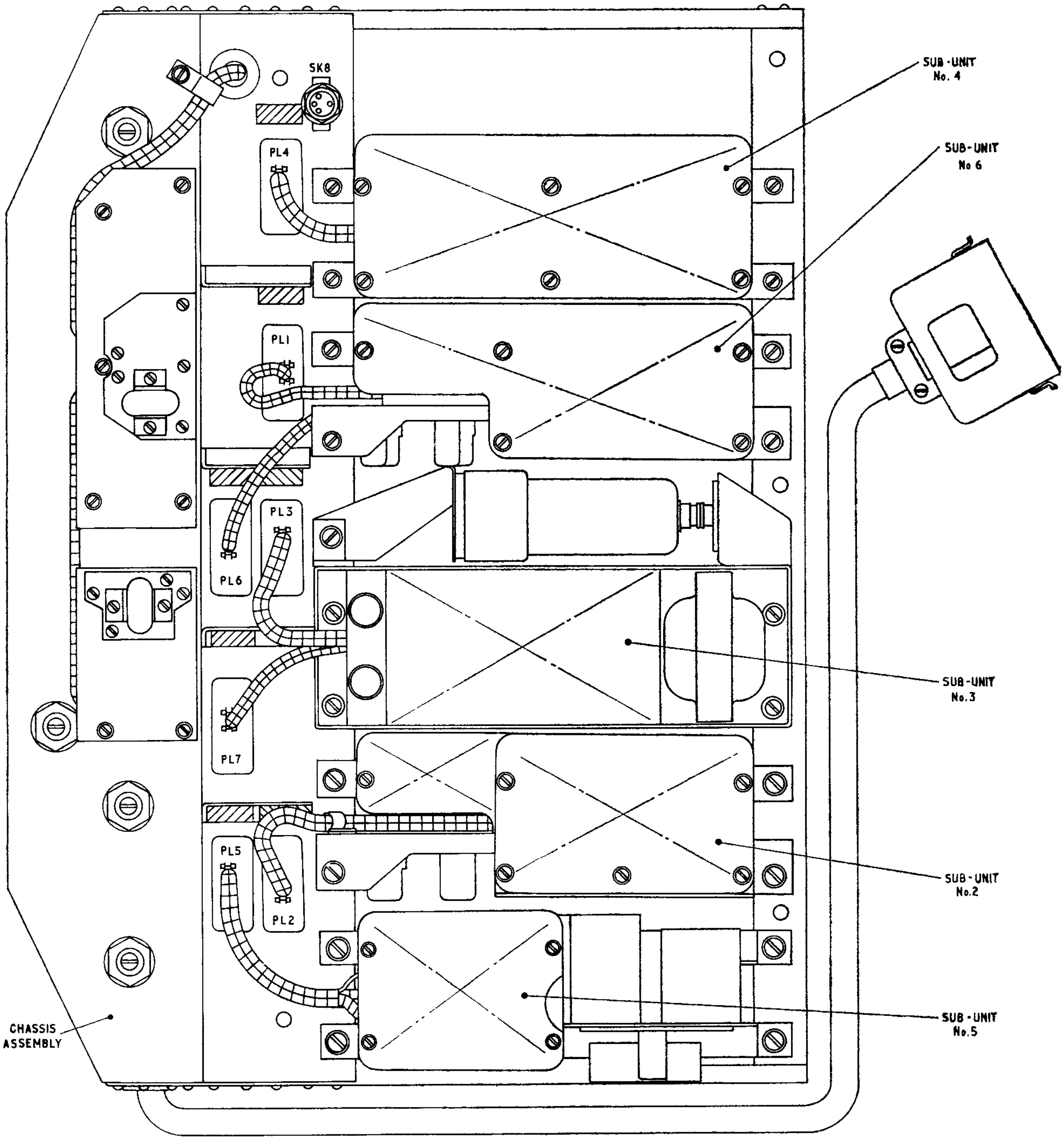


Fig. 20. Waveform generator complete: top view

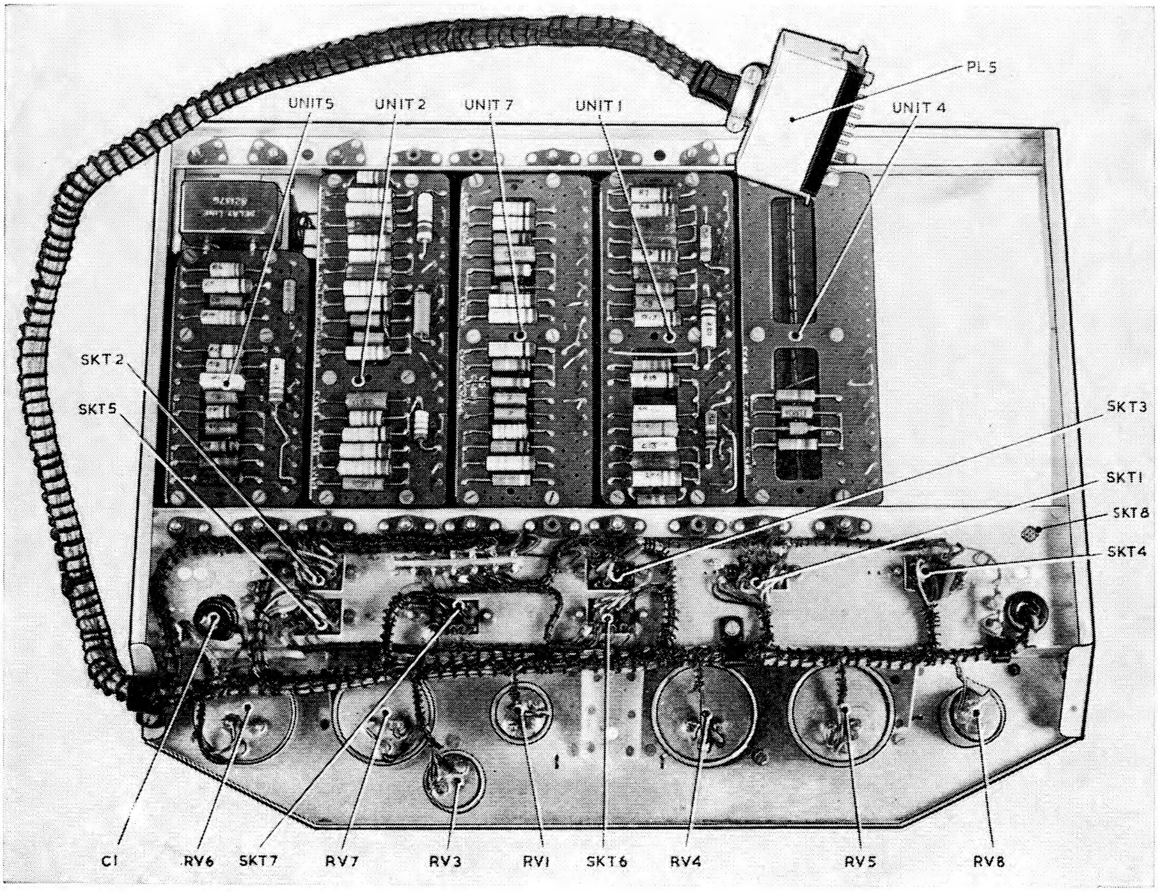
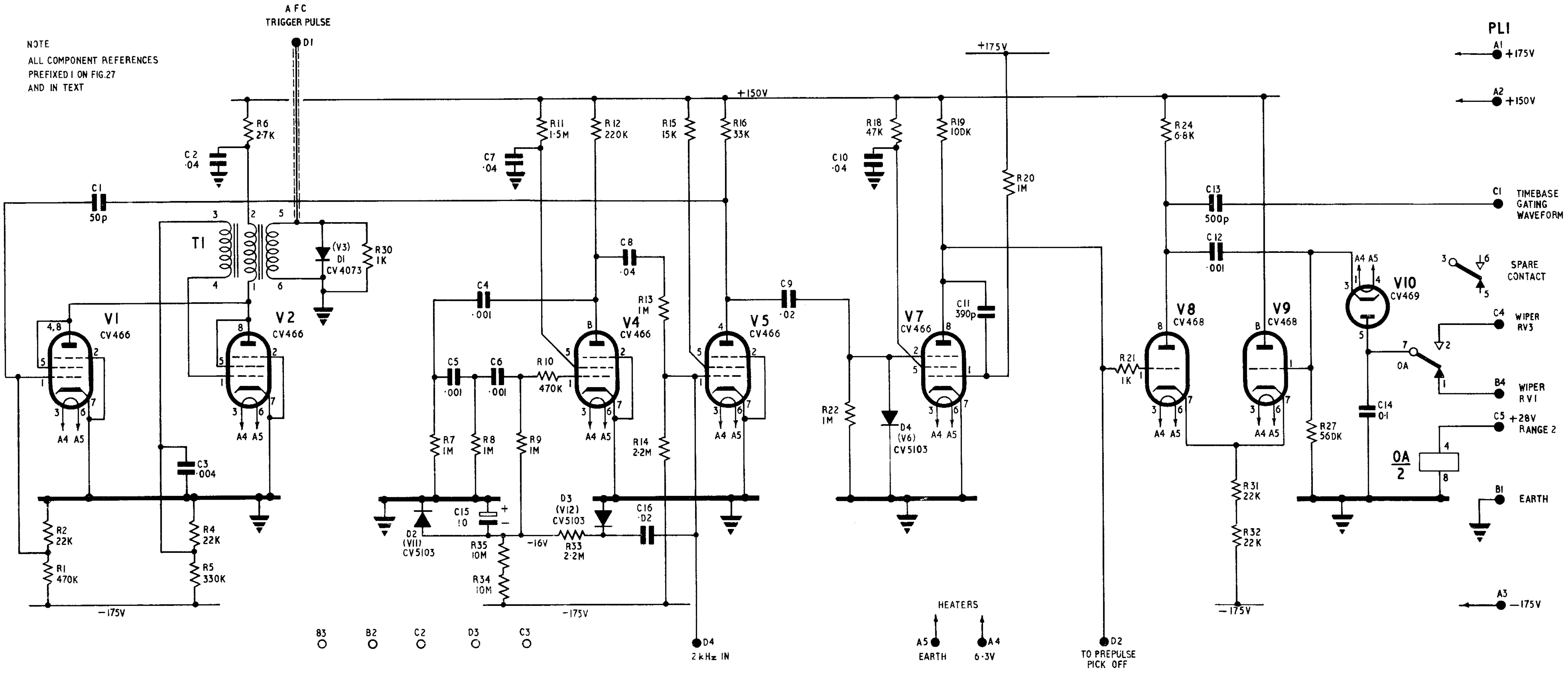


Fig. 21. Waveform generator complete: under view

NOTE
ALL COMPONENT REFERENCES
PREFIXED 1 ON FIG.27
AND IN TEXT



ARI 5919
Waveform generator (unit 1): circuit

Fig. 22

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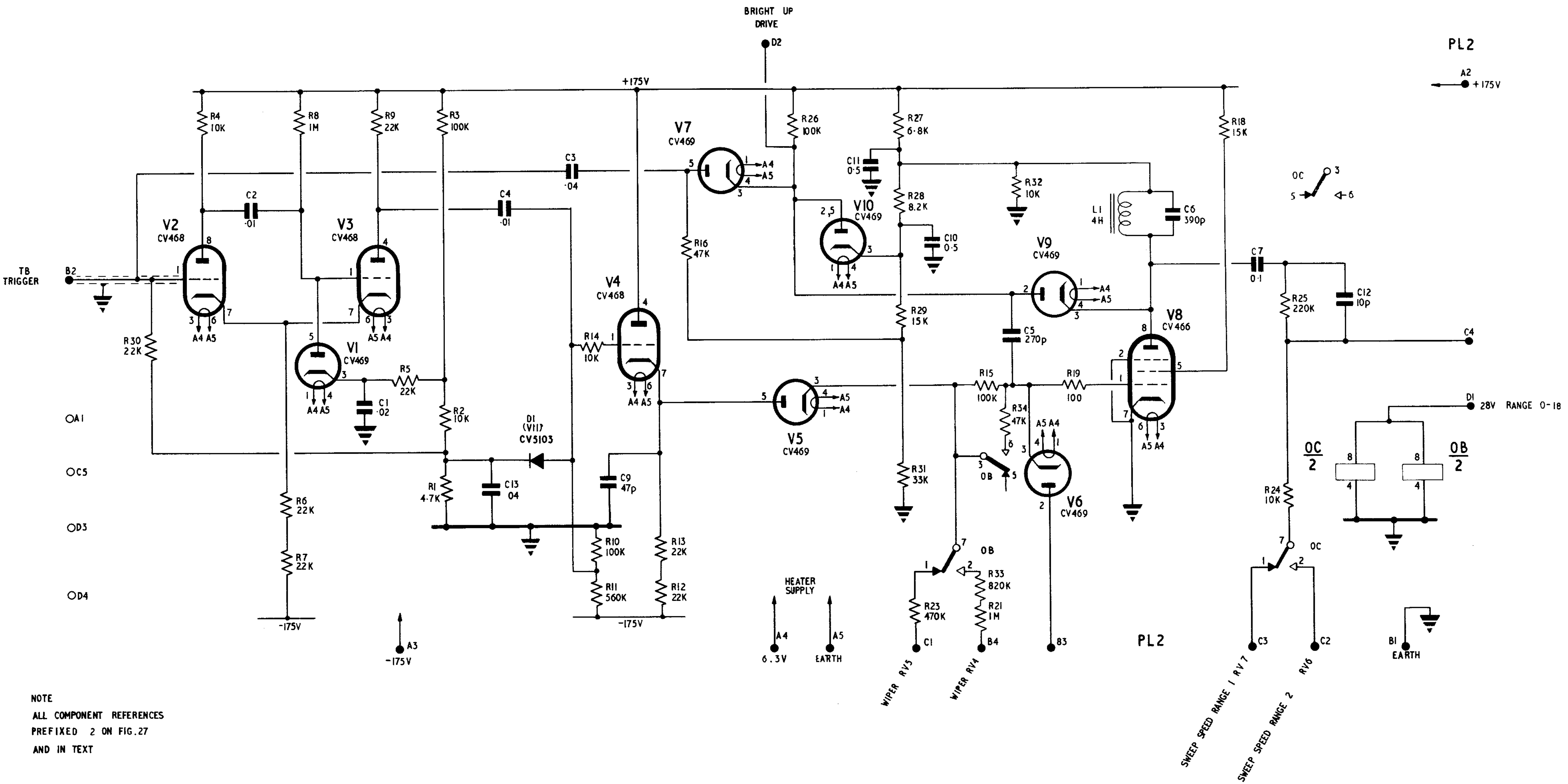

NOTE
ALL COMPONENT REFERENCES
PREFIXED 2 ON FIG.27
AND IN TEXT

AIR DIAGRAM-MIN
6166C
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ARI 5919
Waveform generator (unit 2): circuit.

Fig. 23

NOTE
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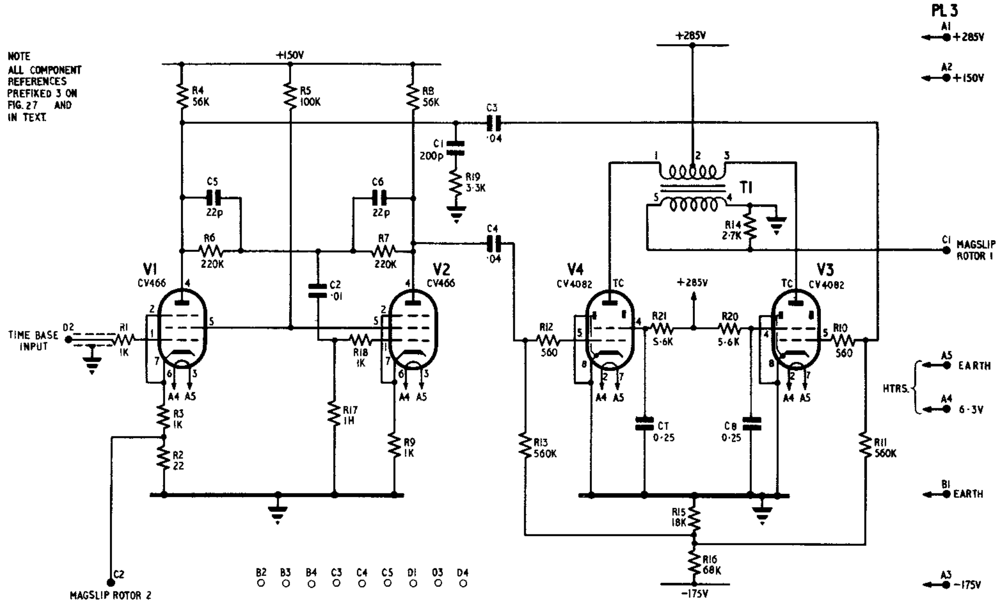

UNIT 3

NOTE
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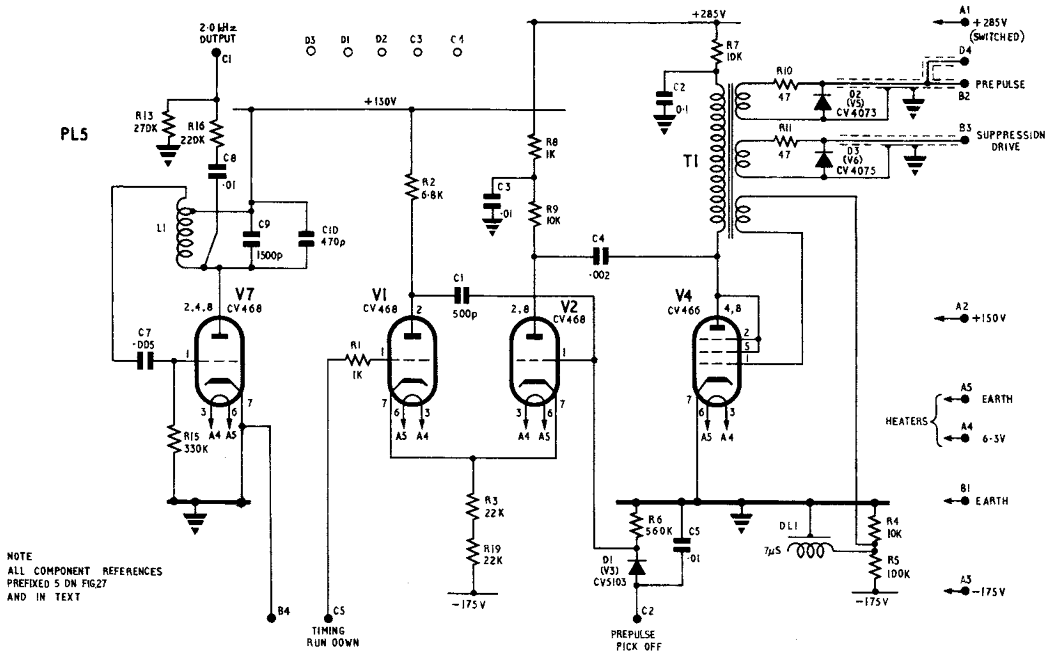
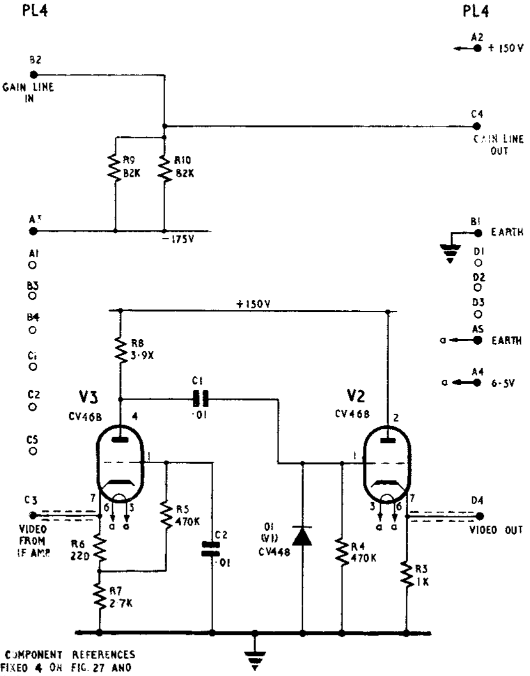


UNIT 5



ALL COMPONENT REFERENCES PREFIXED 4 ON FIG. 27 AND IN TEXT.

UNIT 4

NOTE
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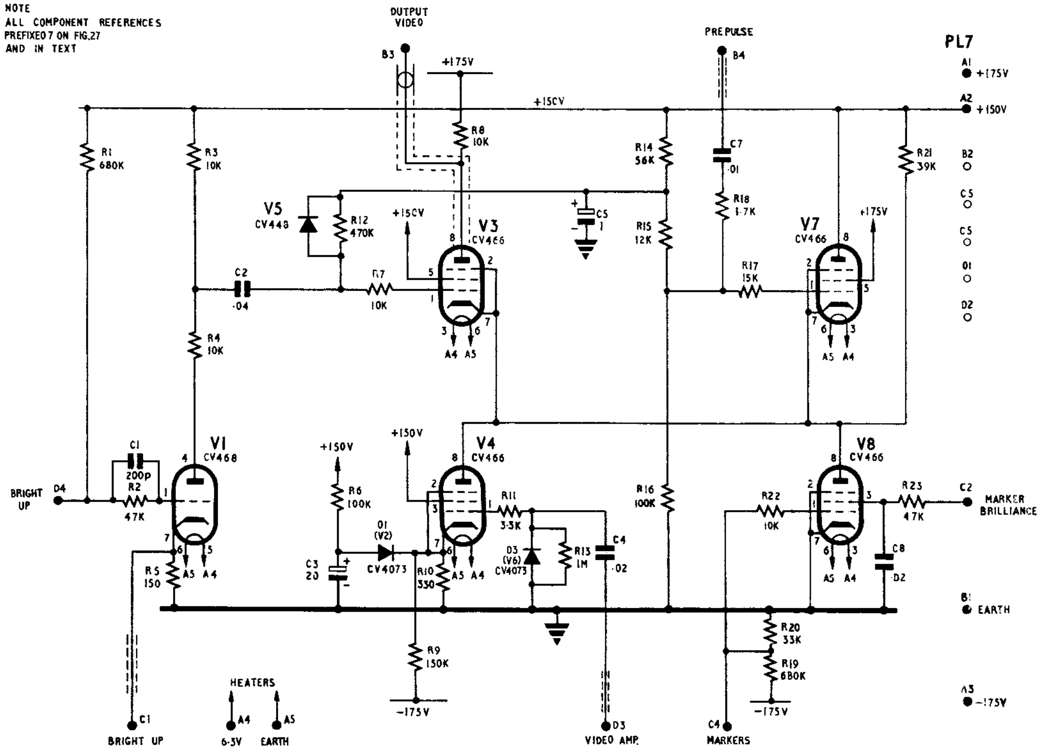

UNIT 7

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ARI 5919 waveform generator (units 3,4,5 and 7): circuit

Fig. 24

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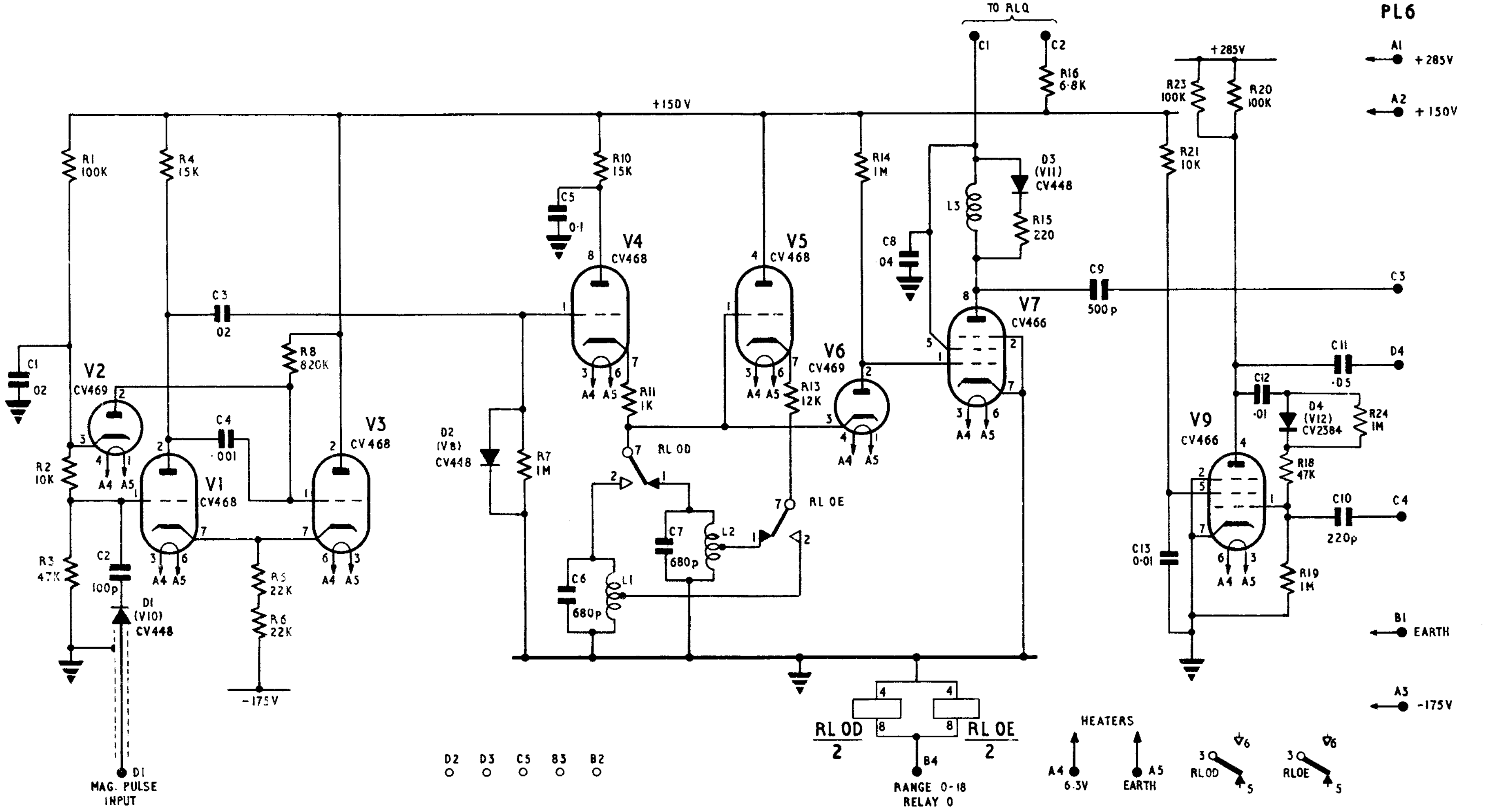
NOTE
ALL COMPONENT REFERENCES
PREFIXED 6 ON FIG.27
AND IN TEXT



ARI 5919
Waveform generator (unit 6): circuit.

Fig. 25

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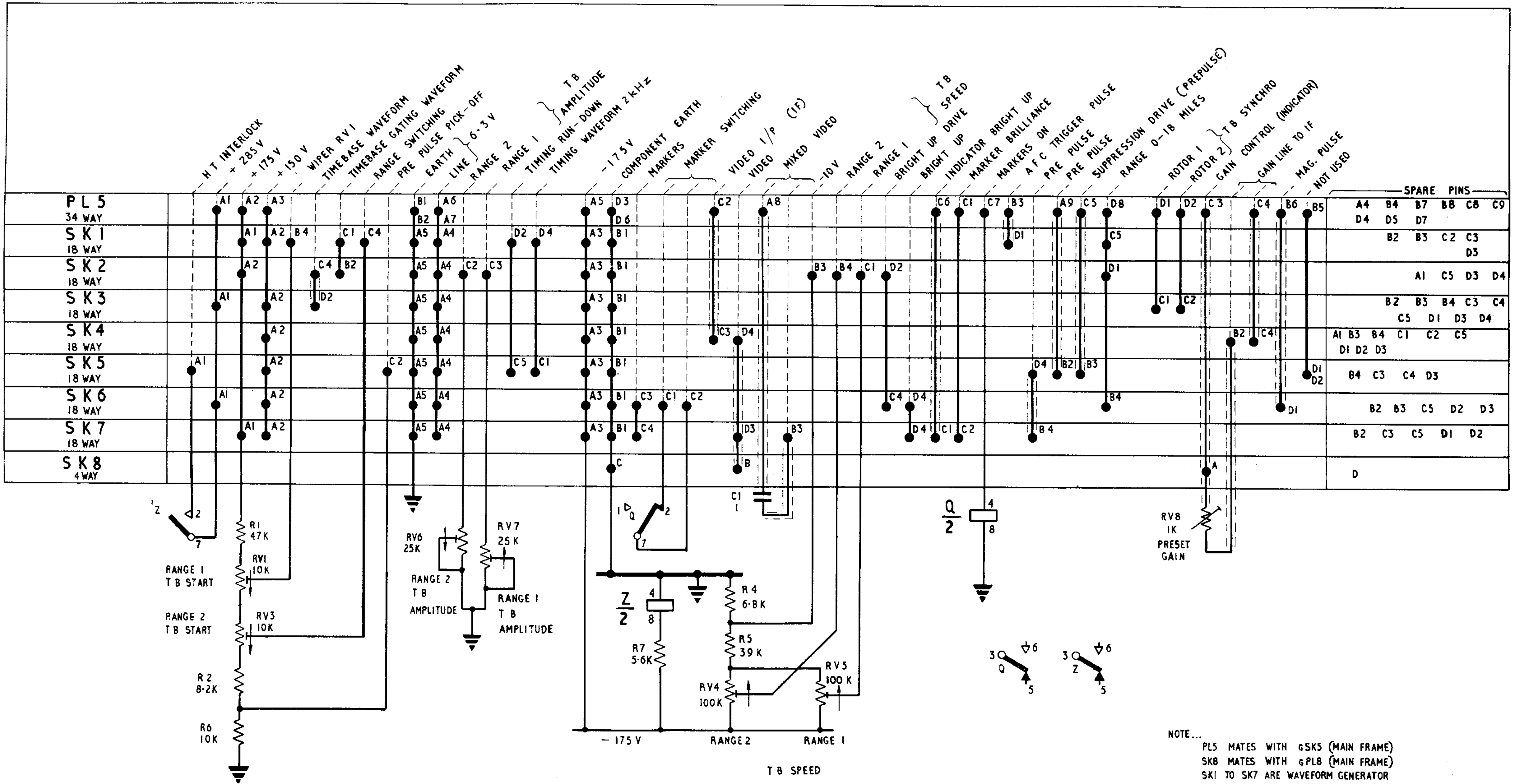

NOTE...
PL5 MATES WITH GSK5 (MAIN FRAME)
SK8 MATES WITH GPL8 (MAIN FRAME)
SK1 TO SK7 ARE WAVEFORM GENERATOR FIXED SOCKETS ACCEPTING SUB-UNIT PLUGS

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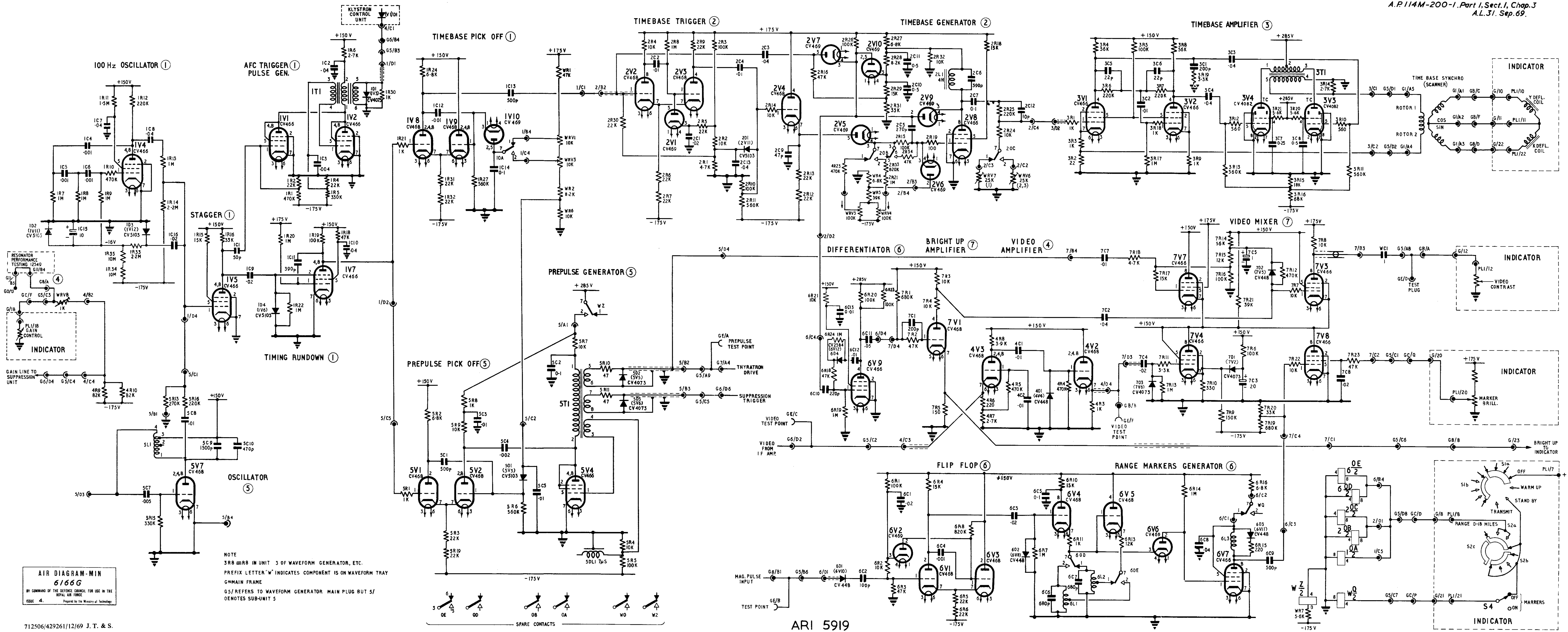
AL.37, Jan.75

ARI 5919
Waveform generator tray : circuit

Fig.26



NOTE

3R8 ≡ R8 IN UNIT 3 OF WAVEFORM GENERATOR, ETC.

PREFIX LETTER "W" INDICATES COMPONENT IS ON WAVEFORM TRAY

G ≡ MAIN FRAME

G5/ REFERS TO WAVEFORM GENERATOR MAIN PLUG BUT 5/ DENOTES SUB-UNIT 5

AIR DIAGRAM-MIN
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ARI 5919
Waveform generator system: circuit

Fig. 27

Chapter 4

TRANSMITTER

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INTRODUCTION

1. The transmitter produces $\frac{1}{2}$ us pulses of X-band r.f. energy having a peak power of 130kW. It is triggered by the prepulse which determines the repetition frequency (2kHz) of the r.f. pulses. As described in Chapter 3, the interpulse periods vary in a cyclic manner in order to produce a pulse "stagger" which minimizes the effects of second trace echoes.

2. The r.f. pulses are generated by a magnetron valve whose output connection is a No. 15 waveguide section. The output is connected via a taper section (to reduce to No. 16 waveguide) and then through a waveguide run to the r.f. block (Chap. 8). The transmitter energy, emerging from the r.f. block, is connected to the scanner through another waveguide run (Chap. 6).

3. An e.h.t. power pack generates a 4.5kV supply which is used to charge a delay line during the interpulse periods. The charging circuit includes a choke which resonates with the delay line. The pulse repetition frequency is more than twice the resonant frequency of the circuit formed by the choke and delay line and "constant current" operation is obtained. The delay line charges to twice the value of the e.h.t. supply during an inter-pulse period and it is then discharged through the primary winding of a pulse transformer to provide the drive pulse for the magnetron.

4. The discharge action is brought about by the operation of a thyratron valve. This is triggered by a thyratron drive unit which, in its turn, is triggered by the trailing edge of the prepulse from the waveform generator (Chap. 3).

5. A description of the use of a delay line for the pulse modulation of transmitters is given in AP1093E(2), Chapter 14, Sections 23 and 24. The waveforms given there (Fig. 625) are applicable to the ARI 5919 circuit.

6. The magnetron starts to conduct at some point on the leading edge of its driving pulse and ceases to conduct at some point on the trailing edge. The load, formed by the magnetron, pulse transformer and associated stray capacitance, is matched to the delay line only when the magnetron is conducting. ▸◂ An overswing diode is included in the circuit to permit dissipation of the energy remaining in the magnetron drive circuit after the end of the r.f. pulse from the magnetron.

CIRCUIT DESCRIPTION

7. A complete circuit of the transmitter system is given in Fig. 7. The various components in the circuit are distributed in the main framework of the radar unit as described in para. 26 to 34. It should be noted that the thyratron drive unit is a sub-unit having its own series of circuit references. A separate circuit diagram of the drive unit is given in Fig. 2.

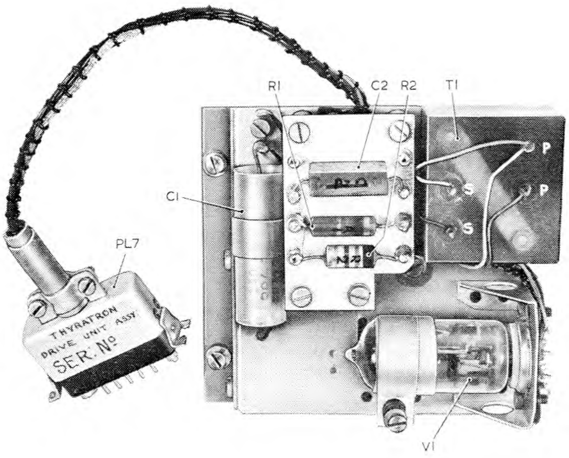


Fig. 1. Thyratron drive unit: top view

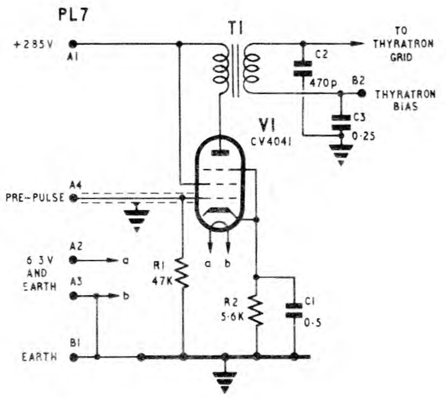


Fig. 2. Thyratron drive unit: circuit

THYRATRON DRIVE UNIT (Fig. 2)

8. The positive-going, 35V, 7us prepulse from the waveform generator (Chap. 3) is applied via pole PL7/A4 to the control grid of a pentode valve V1. This valve is driven into grid current by the prepulse and the anode current turned on in the valve is independent of prepulse amplitude owing to the stabilizing effect of the cathode circuit. During the interpulse periods, the valve is cut off owing to the charge accumulated on the cathode decoupling capacitor C1 during the prepulse.

9. The cutting off of anode current in V1 at the end of the prepulse causes transformer T1 in the valve anode circuit to ring with its self-capacitance and C2. The output from the transformer secondary winding is connected to the grid circuit of the thyratron (Fig.7); the first half-cycle of the ring is positive-going and subsequent cycles do not occur because of heavy damping by thyratron grid current. The rise rate of the initial positive-going edge depends on the natural frequency of the transformer circuit and is such that the thyratron strikes when the rising voltage at its grid reaches 150V. T1 secondary winding is returned to the junction R34, R35 (main frame) where the potential is -27V. This assists de-ionization of the thyratron after the end of the pulse.

TRANSMITTER EHT SUPPLY (Fig. 7)

10. When the function switch on the indicator is set to TRANSMIT, the action of the master relay unit (Chap. 5) connects the 200V 400Hz three-phase supply to the primary of transformer T3. The secondary windings of this transformer feed the anodes of three half-wave rectifier valves V2, V3, V4. The output from the common cathode connection of the rectifiers is at +4.5kV and this is smoothed by a choke input filter consisting of L5 and C1.

A 5 megohms bleed chain R6 to R15, ensures the discharge of Cl when the equipment is switched off.

11. There is a certain amount of stray capacitance in parallel with the charging choke L6 (para. 12). When the thyratron strikes, voltage pulses are sent through this capacitance to the smoothing circuit. A decoupling network formed by R5 and C2, prevents the pulses from being developed across the overload relay in the master relay unit (para. 24). Another purpose of R5 is to prevent destruction of C2 and the overload relay if a short circuit occurs across the E.H.T. output. Such an event would place Cl (charged to +4.5kV) in parallel with the relay and C2.

MAGNETRON DRIVE CIRCUIT

12. The +4.5kV e.h.t. supply is connected across the circuit consisting of the charging choke L6, the delay line DLl and the primary of the pulse transformer T4. Immediately after each transmitter pulse the line is discharged and commences to recharge via L6. Owing to the oscillatory action of L6 in combination with DLl, the line voltage does not stop rising when it reaches +4.5kV but overshoots and continues to rise up to +9kV at which point the next discharge is made to occur.

13. The discharge action is brought about by the thyratron Vl. The trigger pulse from the thyratron drive unit is applied to the thyratron grid where it lifts the bias (-27V from the junction R34, R35) causing the gas in the valve to ionize. A heavy anode current flows and the anode potential falls to near earth. During the extremely short period of time required for complete ionization, the delay line voltage (+9kV) appears at the thyratron grid as a very brief high-voltage spike. A 680 ohms resistor Rl is included in the grid circuit to prevent this spike from damaging the thyratron drive unit. The current pulse through the thyratron generates a voltage spike at the thyratron cathode. To prevent this spike from being coupled into the power supplies via the high-voltage heater transformer Tl, the thyratron heater leads pass through a ferrite bead L8 which forms a filter circuit in conjunction with C20, C21.

14. The striking of the thyratron earths the input terminal of the delay line so that a negative voltage appears at the output terminal; this is connected across the load represented by the impedance of the magnetron and associated stray capacitance reflected into the primary winding of the pulse transformer T4. The delay line may be considered as a source of e.m.f. having an internal impedance of 45 ohms and an open circuit voltage of -9kV. The load impedance, when the magnetron is conducting, is also 45 ohms and the -9kV voltage is shared equally between line and load. The terminal voltage of the line becomes -4.5kV and the difference between this and -9kV (i.e. +4.5kV) is propagated along the line. The reflected wave in the line is in the same sense and when this arrives back at the pulse transformer primary, $\frac{1}{2}$us after the thyratron strikes, it reduces the voltage across the transformer to zero and the discharge of the line is complete. The

thyratron deionizes and the line commences to recharge via L6. During the $\frac{1}{2}$us discharge of the line, the charging choke L6 behaves as an insulator preventing short circuit of the e.h.t. power supply.

15. The delay line has five sections each containing inductance and capacitance. The end section is loosely coupled to the others. The transit time of the line is $\frac{1}{4}$us in each direction. The assembly is cast into an Araldite block.

16. The -4.5kV pulse, developed across the primary of the pulse transformer is stepped up to between 20 and 23kV in the transformer secondary winding and is applied to the magnetron cathode. In order to ensure satisfactory operation of the magnetron, the rise rate of the pulse applied to it must be restricted. The rise rate is restricted by :

(1) A choke L7 in the anode circuit of the thyratron.

(2) The loosely coupled end section of the delay line.

(3) Pulse transformer stray capacitance and leakage inductance.

(4 The capacitance of the magnetron heater transformer T5.

All these quantities form a low pass filter which is matched approximately to the conducting impedance of the magnetron. The LC product of this filter determines the rise time of the drive pulse.

17. Stray capacitances, between the delay line and earth, are charged to 9kV immediately before the thyratron strikes. When the trigger pulse arrives at the thyratron grid, these capacitances are discharged through the thyratron only and not through the pulse transformer primary. The presence of L7 reduces the amplitude of any rings which the discharge current produces in the thyratron current pulse so preventing the thyratron from being over-run.

Overswing diode

18. At a point on the trailing edge of the magnetron drive pulse, where the voltage falls to about 90% of the operating voltage, the magnetron stops conducting. At this time, there is still some energy remaining in the circuit. This energy is bypassed by the overswing diode V23 and is dissipated in a resistor R26.

19. ▶◀

Magnetron current pulse

20. Three carbon resistors R27, R28, R29 are connected in parallel in the pulse transformer secondary circuit. A voltage pulse is obtained across these coincident with the transmitter pulse. The voltage pulse is not a true representation of the magnetron current pulse since the currents from stray capacitance and leakage inductance pass through the resistors but not through the magnetron.

21. The◂positive-going▸pulse obtained across R27, R28, R29 is about 65V to 70V in amplitude. It is connected via R30 and a length of screened cable to the waveform generator (Chap. 3) where it triggers the range markers circuit. The purpose of R30 is to match the impedance of the screened cable.

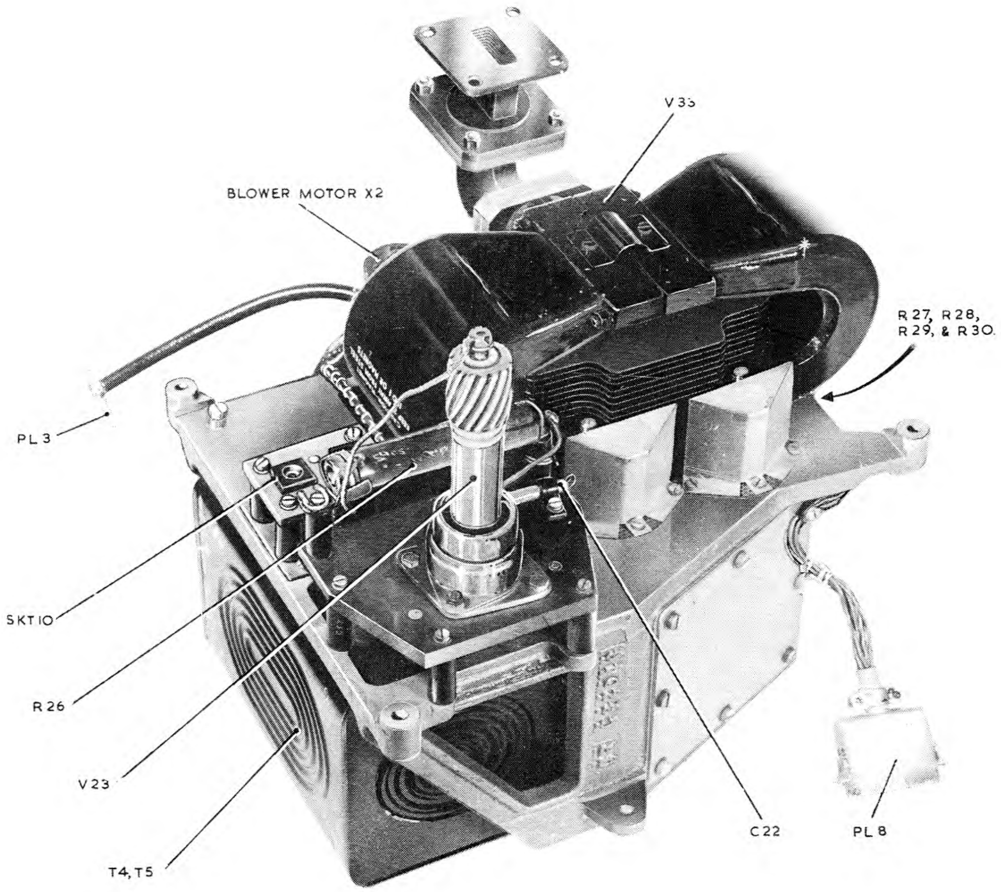


Fig. 3. Transmitter chassis assembly

Magnetron heater

22. As described in Chap.5, the voltage between the red and blue phases (200V) of the 200V three-phase supply is connected to the magnetron heater transformer T5 immediately the function switch on the indicator is set to WARM UP. This voltage is connected only to part of T5 primary and the magnetron heater warms up with 13V across it. A 110 ohms wire-wound resistor R2 is included in the circuit to reduce the current surge when switching on to a cold magnetron.

23. When the TRANSMIT function is selected at the indicator, contacts C4 in the master relay unit (Chap.5) close and connect the supply voltage across the whole of the magnetron heater transformer primary so that the output voltage falls to 8V. The heater current is reduced under transmitting conditions since some heat is contributed by electron bombardment of the magnetron cathode.

OVERLOAD PROTECTION CIRCUIT

24. The negative line of the e.h.t. supply and the anode circuit of the overswing diode (para.18) are returned to earth via coil a-b of the overload relay D/1 in the master relay unit (Chap.5). A preset potentiometer in parallel with the relay coil, provides a means of adjusting the circuit to operate at a given total current.

25. A severe mismatch on the pulse transformer will not effect the e.h.t. drain very much but will give heavy current pulses through the overswing diode; these operate the overload relay. The pulses are smoothed by C22 which prevents the appearance of large voltage pulses across the relay coil.

COMPONENT LAYOUT

Transmitter chassis assembly

26. The basis of this structure is an alloy casting which is carried on four mountings in the centre section of the main framework (Fig.5). The chassis assembly is illustrated in Fig.3. It carries the magnetron V33, the overswing diode (V23)⧓ , the magnetron blower motor X2 and a transformer assembly consisting of an oil filled container housing the pulse transformer T4 and the magnetron heater transformer T5.

27. Connections to the transmitter chassis assembly are made via micronector plug and socket (PL8, SK8). Although the unit is considered to be a sub-assembly for spares purposes, the various circuit references are in the main frame series.

E.H.T. supply

28. A view of the main frame, with sub-units removed, showing the layout of the e.h.t. supply is given in Fig.4. This view includes the circuit as far as the output end of L5.

29. The charging choke L6 is mounted in the centre section. It can be seen in Fig.6 which is a top view of the radar unit with the r.f. block, rear tray assembly and transmitter chassis assembly removed.

High-voltage heater transformer

30. Transformer T1 is mounted in the centre section of the main framework (Fig.5 and 6). Capacitors C20 and C21, which decouple the thyratron heater, are mounted between tags on the transformer. ▶◀ The overswing diode V23 heater is supplied via a two pole plug PL10 which plugs into socket SK10 on the transmitter chassis assembly (Fig.3).

Thyratron and delay line

31. The thyratron V1 plugs into a base socket carried in a sheet metal bracket bracket which is on anti-vibration mounts (Fig.5 and 6). The grid resistor R1 is mounted at the side of the valve; the connection from the thyratron drive unit is made by soldering.

32. The thyratron heater choke L8 consists of ferrite bead through which both heater leads pass. This bead can be seen in Fig.5 and 6. The thyratron cathode connection is made by an earth clip on the transmitter assembly.

33. The delay line DL1 is mounted in the base of the centre section (Fig.5). The output connection from the line is made to the transformer assembly on the transmitter chassis via socket SK13 which is mounted on a small folded metal bracket secured to the delay line; insulation against the high-power pulse voltage is provided by the Araldite moulding of the block.▶◀

Thyratron drive unit

34. The underside of the transmitter chassis casting has an aperture which catered for an early design requirement now obsolete. To prevent the escape of cooling air from this aperture, it is covered with a sheet metal cover. When the transmitter chassis is mounted in the centre section, this cover appears in the rectangular aperture shown in Fig.4. The thyratron drive unit (Fig.1) is secured to the cover by means of captive screws.

DISMANTLING AND ASSEMBLY NOTES

35. Access to the transmitter chassis assembly can be obtained by removing the pressure sleeve (Chap. 6) the rear tray assembly (Chap. 10) and the r.f. unit (Chap. 8). If it is required to remove the transmitter chassis complete, the radome and scanner must also be removed (Chap. 2).

To change the magnetron

36. This may be done without removing the complete transmitter chassis.

(1) Remove the rear tray assembly and r.f. unit.

(2) Remove the four $\frac{1}{4}$in. UNC Nyloc nuts securing the magnetron body to the casting.

(3) Remove the magnetron complete with three waveguide sections. It may appear to be rather tight and a firm straight pull is essential.

(4) Remove the three waveguide sections and fit them to a new magnetron.

(5) Offer the new magnetron, complete with waveguide sections, to its fixing studs on the casting. Press it home with care making sure that it is straight. Do not force it otherwise the cathode connector may be damaged.

(6) Fit four $\frac{1}{4}$in. UNC Nyloc nuts.

Magnetron blower

37. Remove the rear tray assembly and r.f. unit.

(1) Release the two red-painted, spring-loaded, slotted, hexagon head captive bolts securing the motor and blower assembly to the casting.

(2) Turn the assembly to clear the fixing lugs on the transmitter casting and lift it clear.

(3) Unsolder the electrical connections.

(4) When reconnecting the wires to a replacement motor, note that the red, blue and white wires connect to tags A, B and C respectively.

To remove the transmitter chassis assembly

38. Remove the radome, scanner, rear tray assembly and r.f. unit. Remove the thyratron drive unit (para. 40).

(1) Remove the magnetron blower and motor assembly (para. 37) but do not unsolder any wires.

(2) Remove the 9-pole micronector PL8.

(3) Remove the two-pole plug PL10.

(4) Remove the single pole plug PL13.

(5) Remove the earthing clip near to the thyratron support bracket.

(6) ▶◀

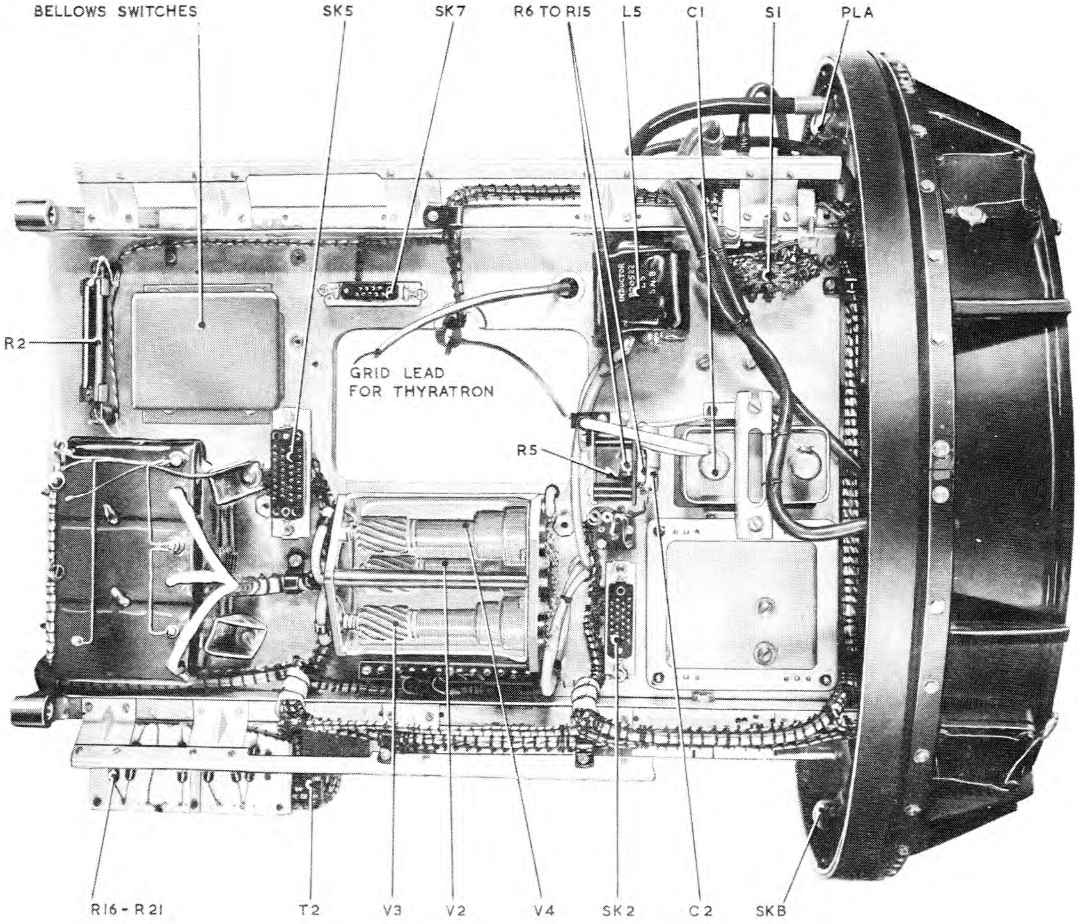


Fig. 4. Main frame : underside view

(7) Release the four 4 B.A. slotted hexagon head captive bolts at the upper corners of the casting and remove the two 2 B.A. nuts and locknuts at the fixing feet.

(8) Lift out the complete assembly taking great care not to damage the transformer assembly - it is fragile since the material of the oil filled container is only 0.010in. thick.

39. The refitting of the transmitter chassis assembly is straight-forward and merely involves doing the various fitting operations in the reverse order to that detailed for stripping in para.38.

Thyratron drive unit

40. To remove the thyratron drive unit, first remove plug PL7 and then unsolder the green wire from the potted transformer on the sub-unit. Finally, release the three captive 6 B.A. securing screws and lift off the unit.

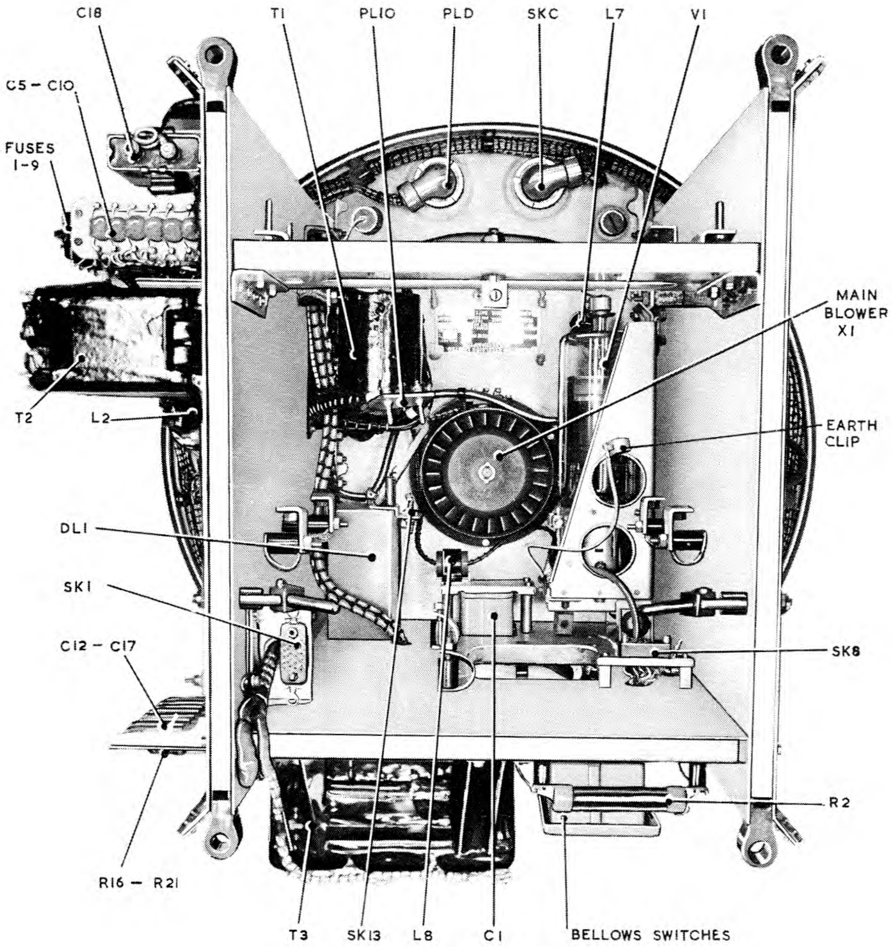


Fig.5. Main frame : centre section

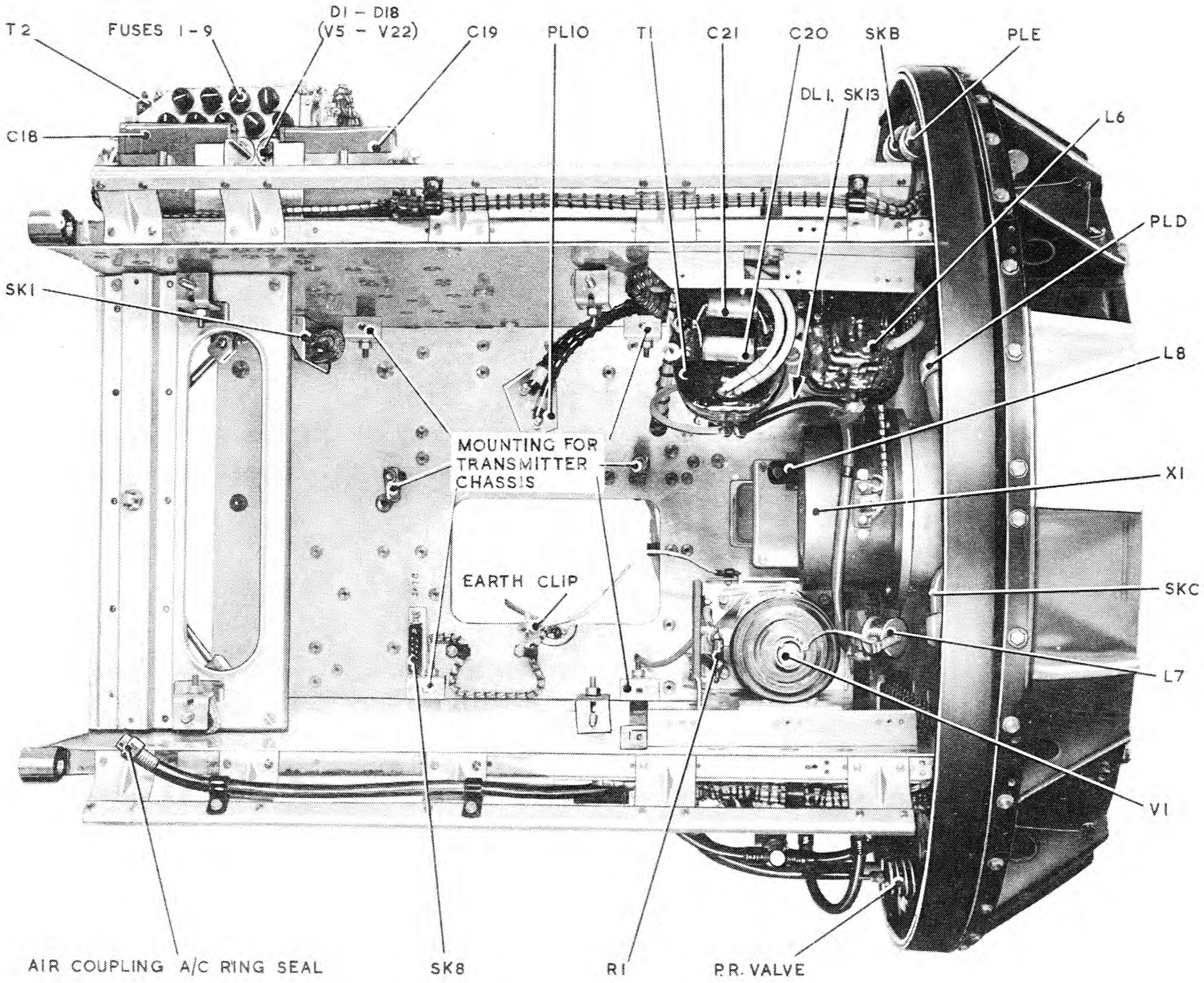
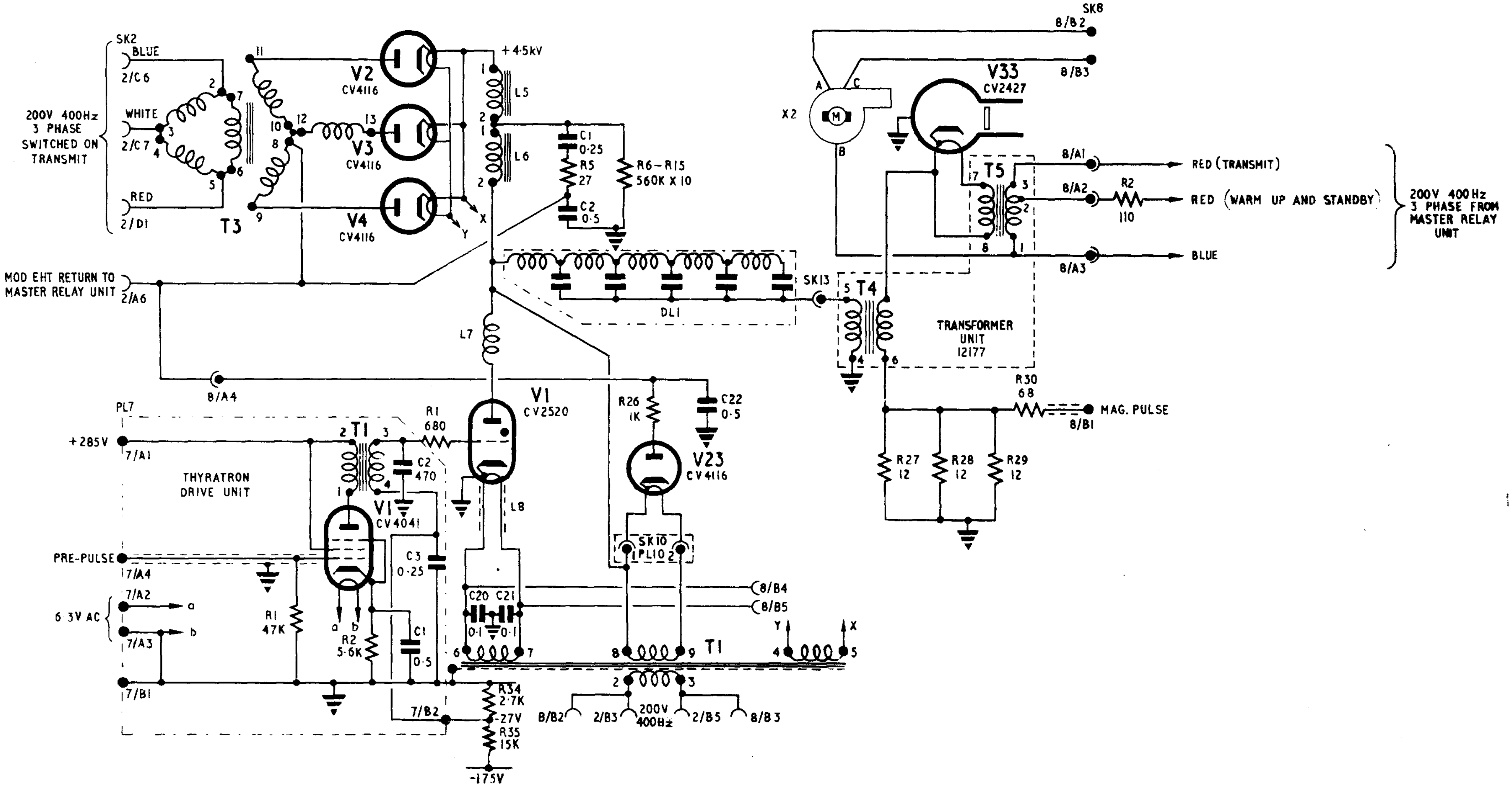


Fig. 6. Main frame : top view



AIR DIAGRAM-MIN

6166A

BY COMMAND OF THE DEFENCE COUNCIL FOR USE IN THE ROYAL AIR FORCE

ISSUE 4

Prepared by the Ministry of Technology

ARI. 5919 Transmitter circuit

Chapter 5

MASTER SWITCHING SEQUENCE

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Introduction

1. This chapter describes the events which occur when the function switch on the indicator is moved through its WARM UP, STANDBY and TRANSMIT position; it also describes the transmitter overload circuit, the −175V line protection circuit and the low pressure warning system.

2. The units involved in this description are as follows

(1) Indicator CRT 6935 (*Chap.* 12).

(2) The master relay unit (mounted on the underside of the main framework) (*Chap.* 2).

(3) The timing unit (mounted on the rear tray assembly.)

(4) The two pressure bellows and micro-switches mounted on the underside of the main framework.

Timing unit

3. The purpose of the timing unit is to prevent the modulator EHT from being applied until a period of five minutes has elapsed after moving the indicator function switch to WARM UP. A circuit diagram of the timing unit is given in *fig.* 5; two views of the unit, showing the layout of components, are given in *fig.* 1 and 2.

4. The timing unit is mounted on the rear tray assembly by means of four captive bolts. Connections are made to the unit via soldered joints on a three-pole tag strip.

Circuit description (*fig.* 5)

5. When the indicator function switch is turned to WARM UP, the red phase (115V) of the 200V three-phase supply appears across transformer T1 An output is taken from a tap on the transformer where the voltage is about 85V RMS and this is connected via C1 to the silicon diodes D1a and D1b. The diodes DC restore the AC waveform so that the negative-going peaks are clamped at earth potential and a positive-going waveform of about 240V peak amplitude is obtained. This waveform is peak rectified by the silicon diodes D2a, D2b giving 240V DC across the reservoir capacitor C2.

6. The 240V DC output from the rectifier circuit is connected across the circuit consisting of RV1, R1, R2, C3. Thus, as soon as the WARM UP function is selected at the indicator, C3 starts to charge via R2 towards the voltage at the slider of RV1. The junction C3, R2 is connected via R3 to the trigger electrode of a cold cathode triode V1. The time taken for C3 to charge to the striking voltage for V1 is adjusted to 5 min. by means of RV1.

7. The cold cathode triode V1 conducts abruptly at a closely defined trigger potential (between 128 and 132 volts). This trigger potential is affected by light intensity and, in order to minimize the effect of light on the valve, a stabilizing electrode is included which is connected via R4 to the output of the rectifier circuit. In order to ensure that the action of the timing circuit is consistent, high-grade components are used and R2, R3, R4, C3 and V1 are enclosed in a sealed container fitted with a desiccator.

8. When V1 conducts at the end of the five minutes, relay A/2 operates in the anode circuit of the valve. Contacts A4, 5 provide a holding circuit for the relay via R5. The current flowing in the holding circuit pulls V1 anode potential down to a level such that the gas in the valve deionizes and anode current ceases. Contacts A1, 2 connect an earth to terminal 1 of the three-pole tag strip on the rear tray assembly; this earth is regarded as the output of the timing unit.

Master relay unit

9. The master relay unit includes relays which route the 200V three-phase supply to various circuits in the radar head. The operations of the relays are determined by the indicator function switch and the timing unit as described in *para.* 12 to 19.

10. An individual circuit of the master relay unit is given in *fig.* 6; views showing the layout of components are given in *fig.* 3 and 4.

Master switching sequence (*fig.* 7)

11. An overall circuit, which includes the whole of the master relay unit together with relevant parts of the indicator, timing unit and main frame, is given in *fig.* 7.

Warm up

12. When the function switch (indicator) is set to WARM UP, the +28V DC is connected to pole PL2/A1 (master relay unit) provided that the air pressure inside the radar unit is above 13½ p.s.i.a. so that the circuit is made through the bellows-operated switch S3.

13. Relay A/3 (master relay unit) operates connecting the 200V, 400Hz three-phase supply as follows.

(1) All three phases to the magnetron blower motor.

(2) Red and white phases to the high-voltage heater transformer T1 (main frame). This supplies the heaters of the thyratron, over-swing diode, damping diode and EHT rectifier valves (*Chap.* 4). The 6·3V winding which supplies the thyratron heater also supplies a warning lamp on the indicator via a microswitch S2. The microswitch is operated by a pressure bellows when the air pressure in the radar unit is above 18½ p.s.i.a. The indicator lamp thus gives an indication that the pressurizing is adequate and that the mains supply is present. When the equipment is operated on the bench (normal pressure = 15 p.s.i.) the lamp will not light since the bellows will be expanded and the circuit broken by the microswitch.

(3) Red phase to the timing unit (*para.* 5); this initiates the five minutes delay timing action.

(4) Red and blue phases to part of the magnetron heater transformer primary via contacts C1, 2 (master relay unit) and a 110-ohm resistor R2 (main frame). The magnetron heater starts to warm up at high current.

Standby

14. Selection of the STANDBY position of the function switch (indicator) connects the 28V DC supply to pole PL2/A2 (master relay unit) as well as to PL2/A1. Relay B/3 operates connecting the 200V, 400 Hz three-phase supply as follows.

(1) The primary of the main HT/LT transformer (*Chap.* 11) is energized and the various HT supplies throughout the equipment become present a short while later.

(2) The red and blue phases are connected via sections S1c and S1d of the TEST switch to the main blower motor. The purpose of the TEST switch is to enable the main blower to be switched off when operating on the bench. The circuit including switch wafers S1a and S1b is not used. It was originally included for feeding a built-in pump assembly.

(3) The red and blue phases are connected to the primary winding of the valve heater transformer in the indicator.

Transmit

15. When the function switch (indicator) is set to TRANSMIT, the 28V DC supply is connected to pole PL2/A3 (master relay unit) as well as to PL2/A1 and PL2/A2. Assuming that the five minutes delay period has elapsed, relay A/2 (timing unit) will be operated and an earth exists at pole PL2/A7 (master relay unit). Relays C/4 and E/2 (master relay unit) operate via contacts D1, 2.

(1) The three-phase supply is connected to the primary of the modulator EHT transformer T3 (*Chap.* 4) and to the scanner motor (*Chap.* 7).

(2) Contacts C2, 3 connect the red and blue phases across the whole primary of the magnetron heater transformer T5 (main frame) so reducing the magnetron heater current.

(3) Contacts E2, 3 complete the 20V AC circuit to the klystron tuning motor (*Chap.* 10).

(4) Contacts E22, 23 complete the 28V DC circuit to the crystal protection shutter solenoid (*Chap.* 8).

Overload protection circuit

16. The modulator EHT current, from the star point of transformer T3 (main frame), enters the master relay unit at pole PL2/A6; it is augmented by the overswing diode current fed via pole PL8/A4 and the combined currents pass through a circuit consisting, of RV1, R3, R2 and the operating coil *a*, *b* of the overload relay D/1. RV1 is adjusted so that the overload relay operates when the combined current entering PL2/A6 exceeds 200mA. Resistor R3 is a wire-wound component using copper wire; the temperature coefficient of this is such that the proportion of the total current passing through the shunt remains approximately constant with variations of ambient temperature.

17. When a transmitter overload occurs, relay D/1 operates with the following results.

(1) The *c*, *d* coil of the relay is energized via contacts D2, 3 providing a holding circuit for the relay (the 28V DC supply is present at PL2/A3 on transmit).

(2) Relays C/4 and E/2 are released by the breaking of contacts D2, 1 cancelling the effects of *para.* 15.

Resetting

18. The resetting action after an overload consists merely of turning the function switch (indicator) to STANDBY and then back to TRANSMIT. When the switch is turned to STANDBY, the +28V DC supply disappears from pole PL2/A3 de-energizing the c, d coil of relay D/1. Contact D2 then makes to D1 and the action detailed in *para.* 15 can proceed when the TRANSMIT function is selected.

−175V line protection circuit

19. The +28V switched supply from the indicator with the selector switch at STANDBY passes from contact M of SKC to contact B1 of SK2 which acts only as a terminal. From this terminal the circuit is made via contacts 2 and 1 of relay RLA on the main chassis to contact A2 of SK2 and then to relay B/3 of the master relay unit as in para. 14.

20. The operate coil of relay RLA on the main chassis (coil *a*, *b*) is connected in series with the −175V supply line but shunted by a fixed resistor whose value is such that under normal load conditions the relay does not operate. Excessive current due to a short circuit on the −175V line in the aircraft wiring causes relay RLA to operate and disconnects the 28V supply from relay B/3 of the master relay unit so that the equipment reverts to the WARM UP condition. At the same time the 28V supply passes through the hold coil (*c*. *d*) of relay RLA.

21. If the selector switch on the indicator is set to WARM UP, the hold coil of RLA is de-energized and the relay releases. If the fault on the −175V line is a permanent one the relay will again operate and hold as soon as the selector switch is reset to STANDBY. The power transformer T2 on the main chassis is therefore safeguarded from damage due to overheating.

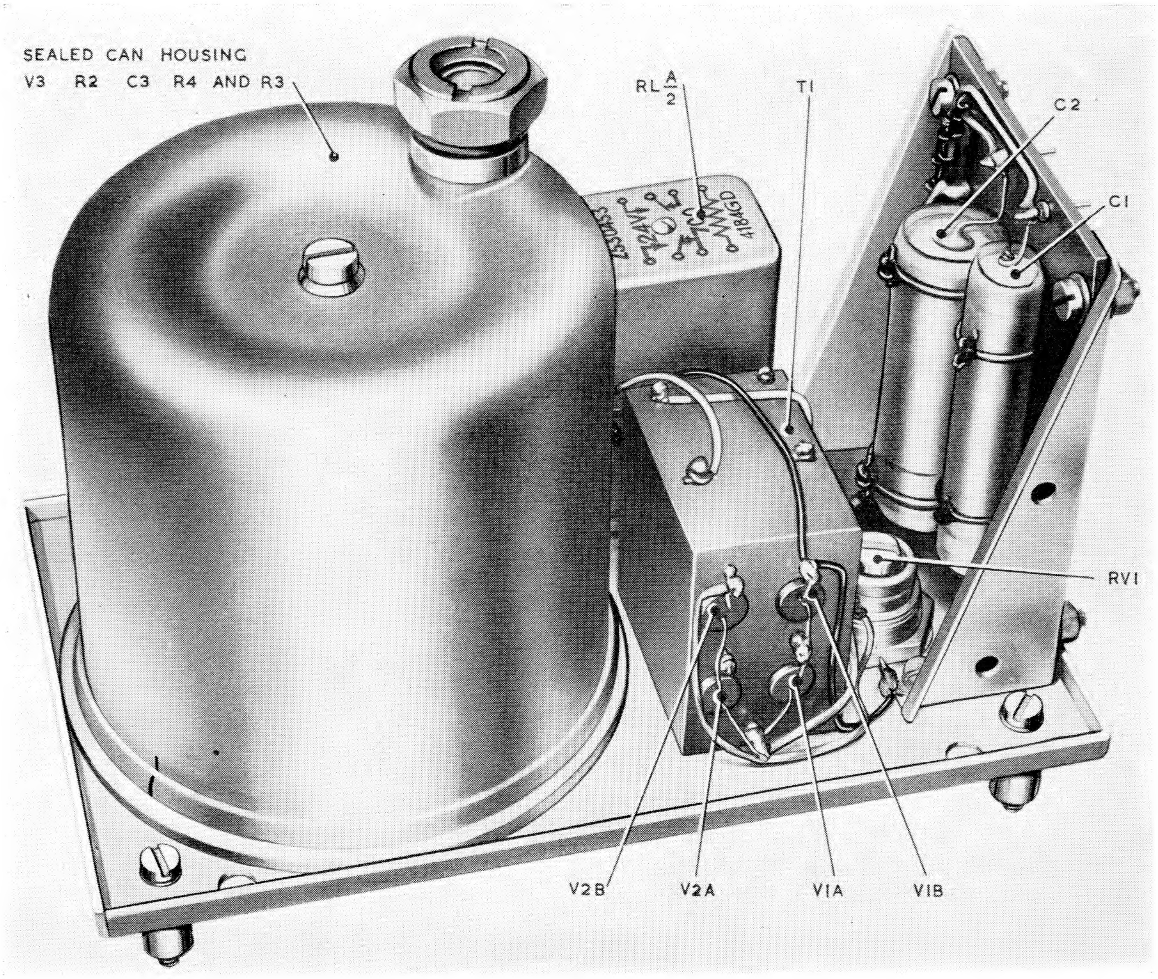


Fig. 1. Timing unit : top view

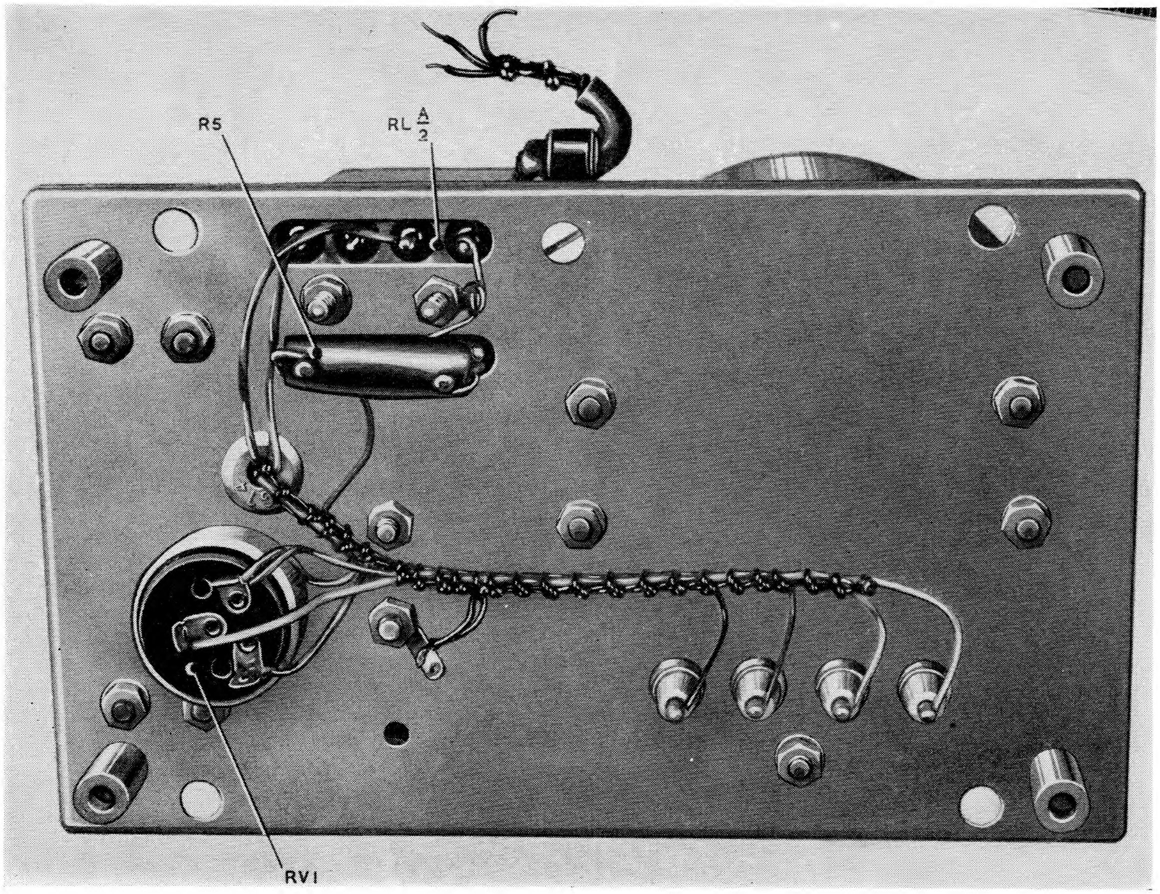


Fig. 2. Timing unit : under view

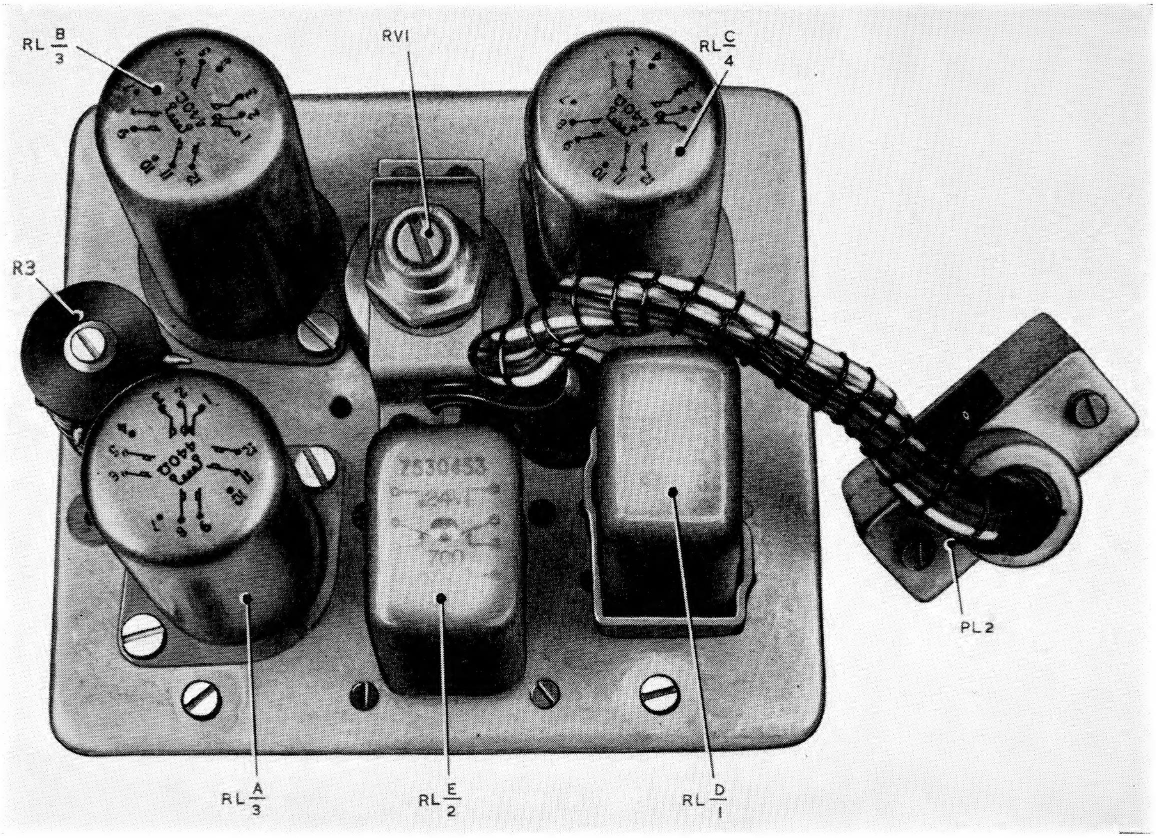


Fig. 3. Master relay unit : top view

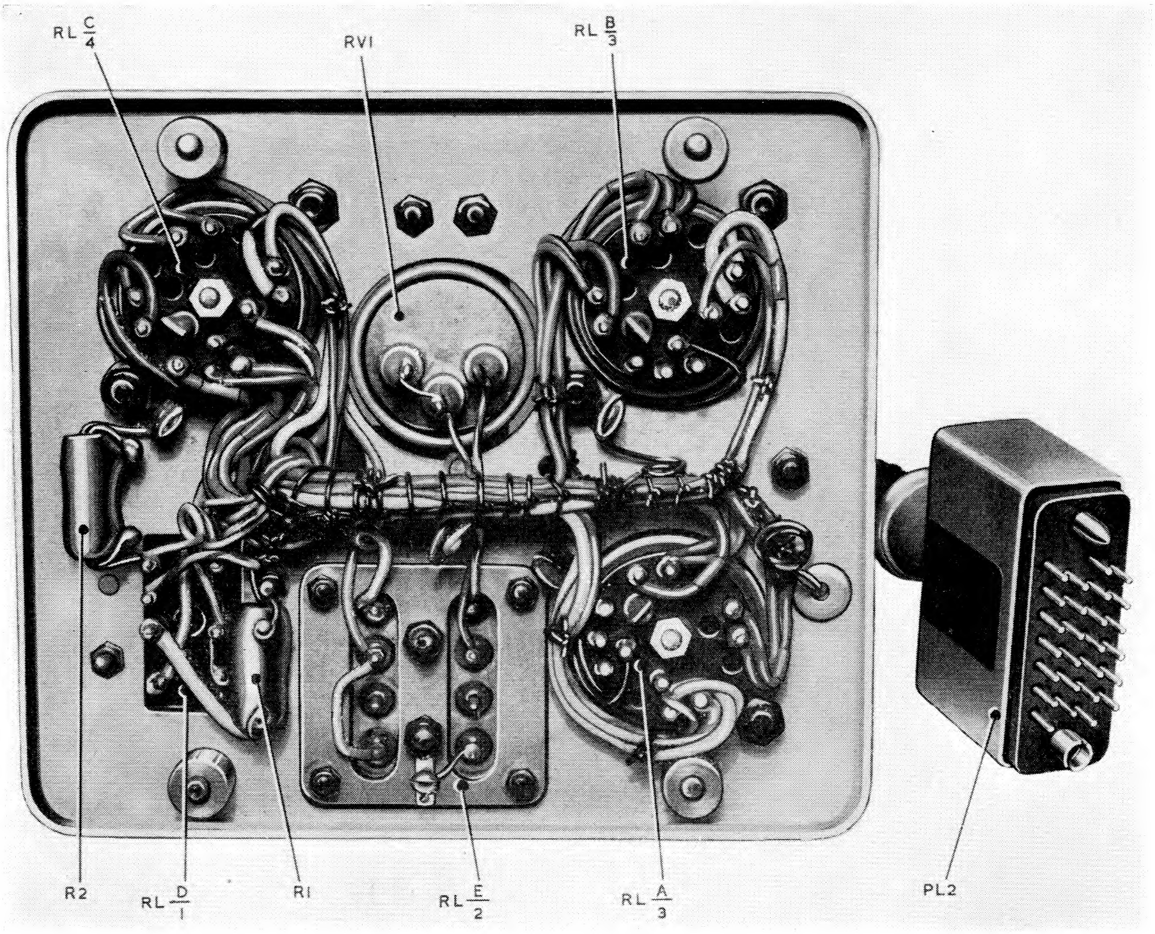


Fig. 4. Master relay unit : under view

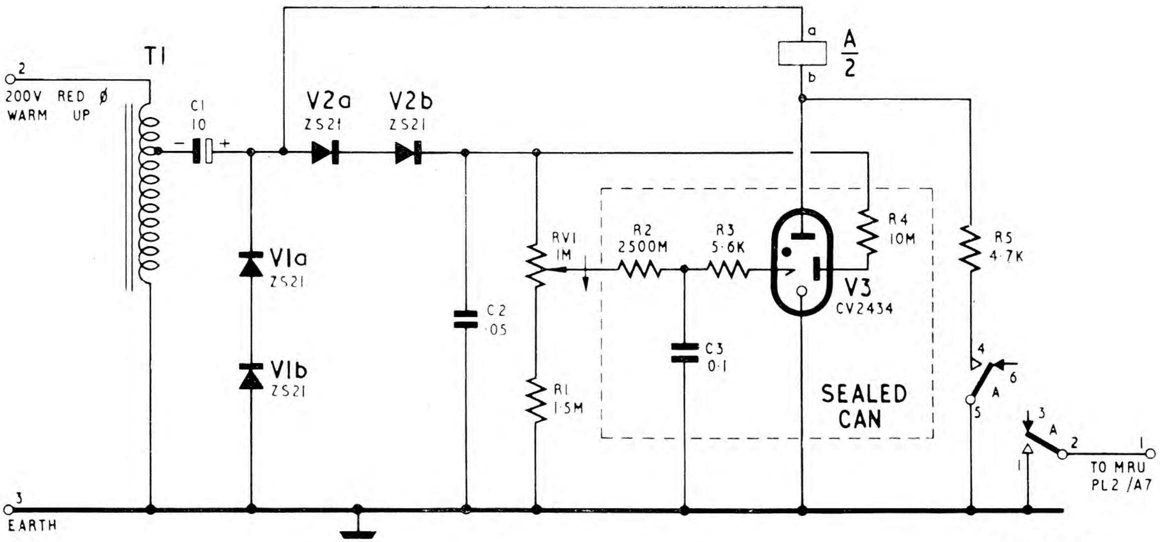
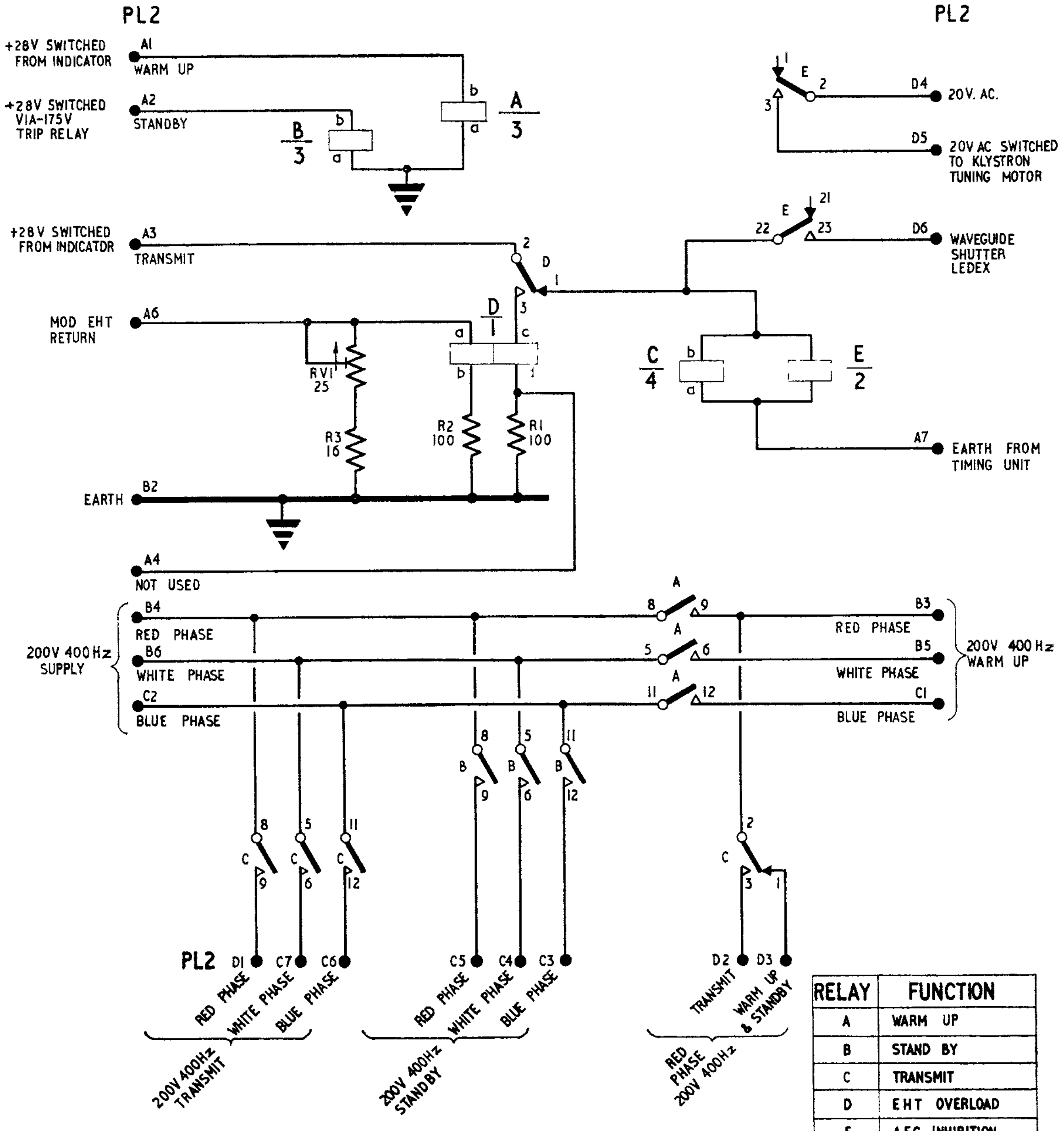


Fig. 5. Timing unit : circuit



RELAY	FUNCTION
A	WARM UP
B	STAND BY
C	TRANSMIT
D	EHT OVERLOAD
E	AFC INHIBITION

Fig. 6. Master relay unit: circuit

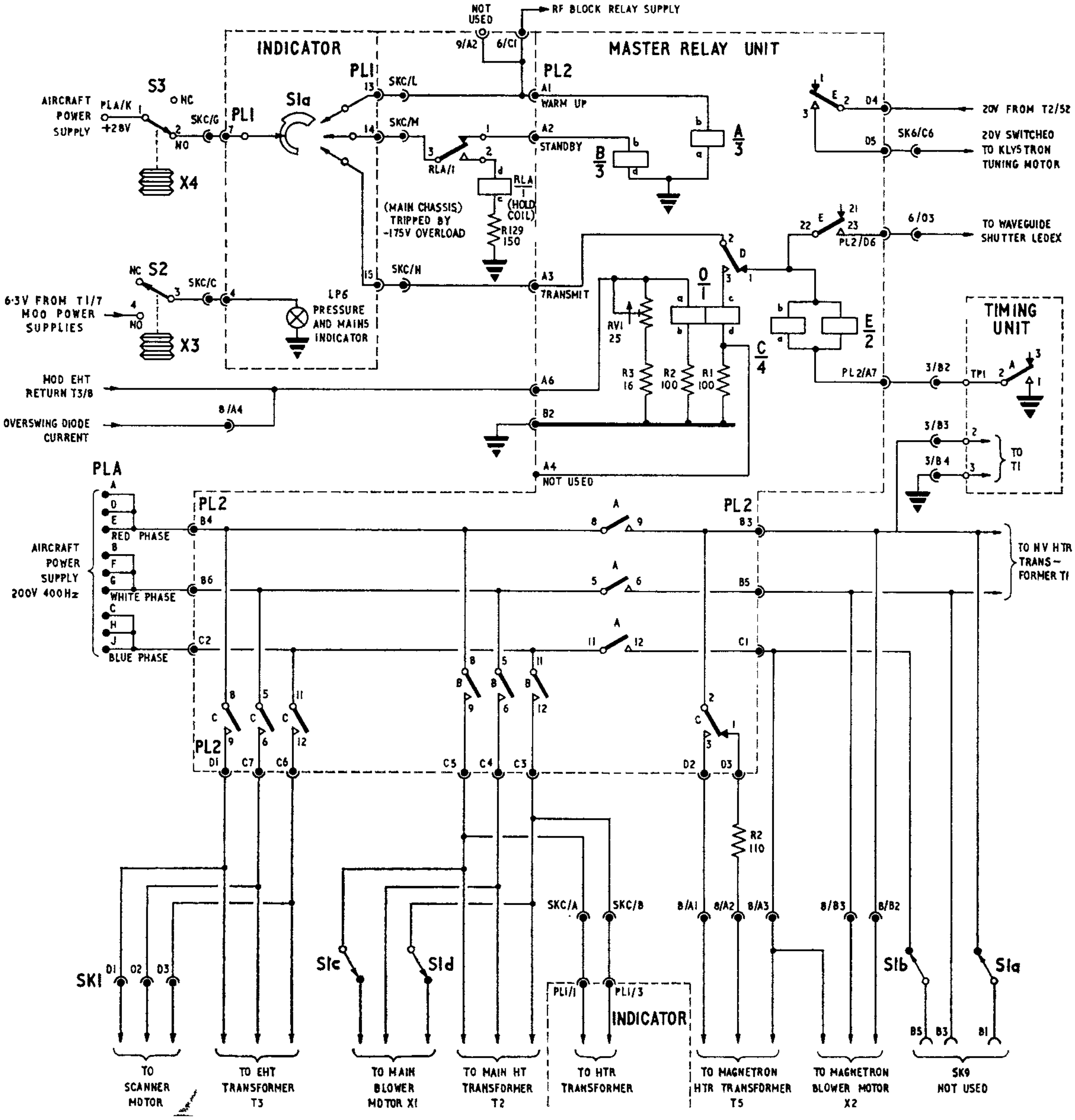


Fig. 7. Master switching sequence: complete circuit

Chapter 6

PRESSURIZING AND COOLING SYSTEM

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Cooling system 2

Introduction

1. The main structure of the radar head consists of a ring casting (forming the aircraft mounting) the heat exchanger and two main decks. The scanner is bolted to the front edges of the main decks and is enclosed by the radome. The two main decks are of honeycomb construction faced with sheet aluminium; they are extremely strong and light.

2. The pressure sleeve is made from fibreglass bonded with a polyester resin and having aluminium end rings bonded to it. The sleeve is cylindrical in form and extends from the ring casting to the heat exchanger which forms the rear panel of the radar unit. The end rings of the pressure sleeve seat on inflatable rubber seals which are pumped up to a greater pressure than the air in the unit so preventing air leakage. The sleeve is subjected to circumferential stress only since the end rings have axial freedom on the rubber seals; the end thrust exerted by the air in the unit is taken by the main decks. These are secured to the ring casting by two bolts each and to the heat exchanger by eighteen bolts each.

3. When the rubber seals are deflated, the pressure sleeve can easily be withdrawn from the unit. It is extremely important that the inner edges of the end rings are free from scratches parallel to the axis and great care must be taken when fitting or removing the sleeve. Even the scratches made by a fine grade of emery cloth will render the assembly liable to leakage,.

4. The high pressure air for filling the radar head is obtained from air bottles via a pressure reducing valve in the aircraft; this controls the pressure delivered to the radar head at 23 lb/in^2.

5. In order to dissipate the heat generated, the high pressure air is circulated in the unit and passes through the heat exchanger.

Pressurizing system

6. A schematic diagram of the system is given in Fig. 1. Air pressures quoted in the text are absolute pressures.

7. A supply of dry air from the compressed air bottles enters the unit via an inlet union at a controlled pressure of 23 lb/in^2.

8. The differential valve has an outlet at the supply pressure and a second outlet at 3 lb/in^2 below this

(1) The first of these outlets is connected through a non-return valve to a "T" junction. One outlet branch of the junction conveys air at 23 lb/in^2 to the front inflatable seals. The second branch of the "T" junction is connected to another "T" junction secured to the heat exchanger panel. One of the two outlet branches of this second "T" provides air at 23 lb/in^2 for the rear inflatable seal and the other branch is connected to a Schrader valve on the heat exchanger panel. This valve provides a means of deflating the seals.

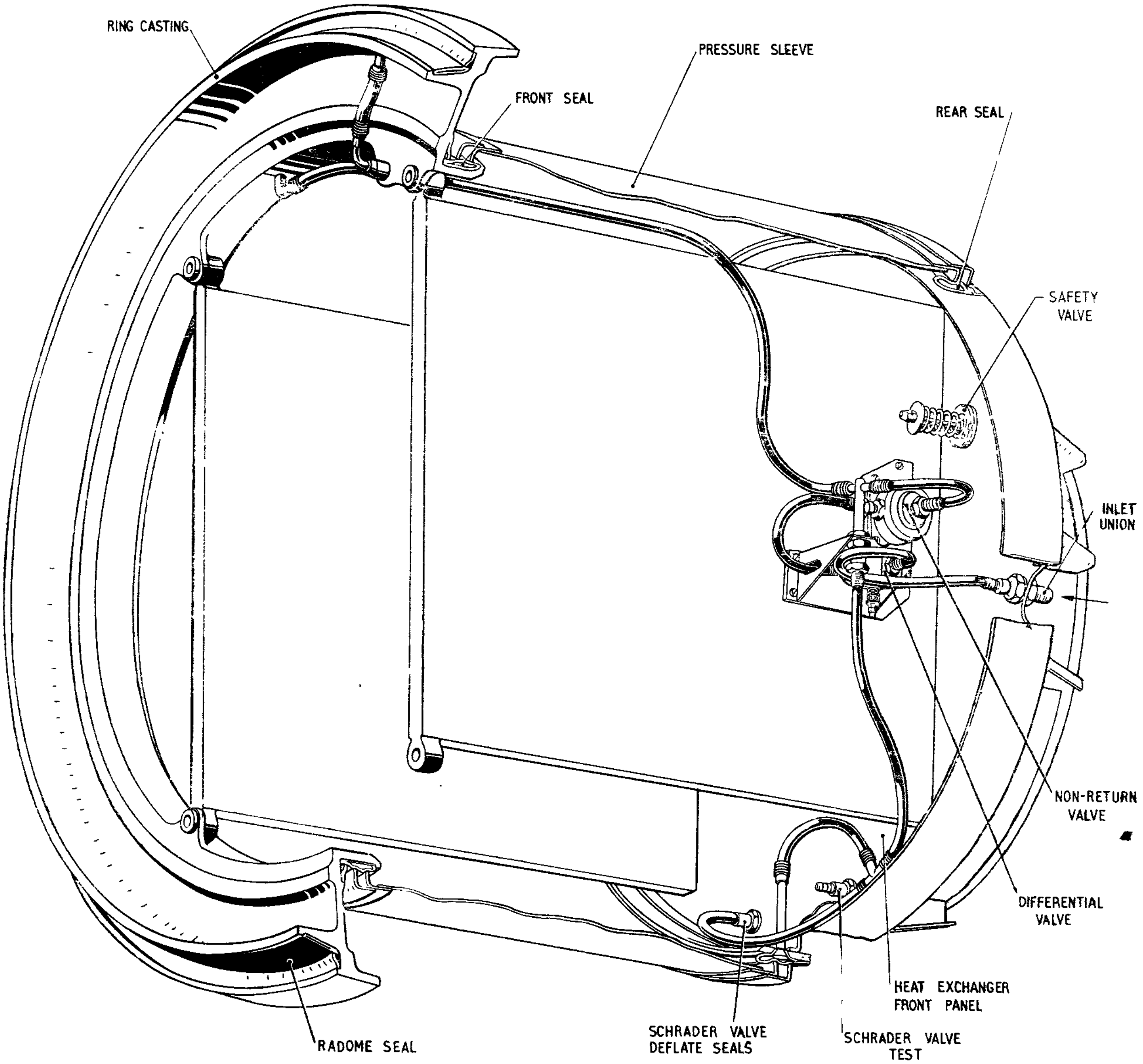

Fig. 1. Pressurizing system

(2) The second outlet from the differential valve is via a spring loaded seat into the main body of the radar head. The spring pressure is adjusted so that the valve lifts from the seat when the pressure of the feed to the non-return valve rises to 3 lb/in^2 above the pressure in the unit. When the supply air is turned on to an un-pressurized equipment, the seals start to inflate and the unit becomes air tight. When the seal pressure reaches 3 lb/in^2 the unit pressure starts to rise and follows 3 lb/in^2 behind the seal pressure. The action ceases when the seal pressure reaches the supply pressure (23 lb/in^2) and the unit pressure then remains at 20 lb/in^2.

9. Because of the arrangement of valves and tubing, the action is not reversible. The seals, once inflated, remain so since the non-return valve provides an effective stop. Any leakage which takes place from the main unit will only cause the unit pressure to fall while the seals remain at the full pressure in which condition they are best able to provide a good seal and minimize the rate of leakage from the unit. The system includes a safety valve which is set to prevent the pressure difference between the unit air and the external air from exceeding 26 lb/in^2. This is to guard against a failure of the aircraft pressure controlling valve or against the application of excessive pressures from other sources on the bench.

10. A Schrader valve marked TEST is provided for deflating the unit, or for checking the pressure using a pressure gauge. When deflating the unit, the TEST valve must be opened first to release the unit pressure and then the DEFLATE SEALS valve is opened to deflate the seals.

WARNING . . .

The pressure in the unit must be

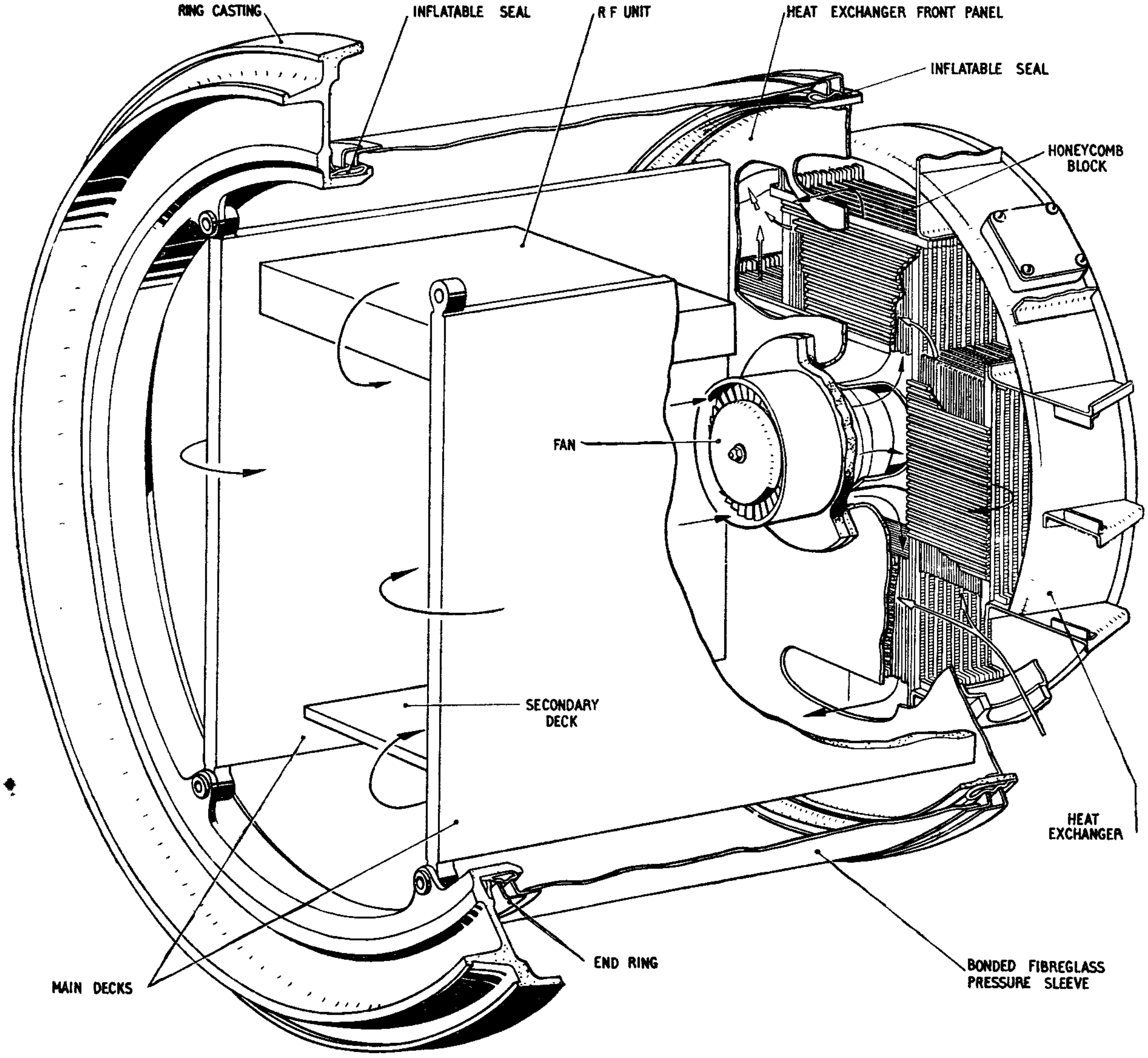

Fig. 2. Cooling system

released before attempting to deflate the seals otherwise the seals may be blown out by the unit pressure. When this happens, the rubber seals become jammed between the pressure sleeve and the outer surfaces of the heat exchanger and ring casting, making it very difficult (if not impossible) to remove the pressure sleeve without damage to the equipment.

Cooling system

11. The construction of the heat exchanger and the circulation of air through the system is given in Fig. 2.

12. The heat exchanger is fabricated from sheet metal and consists of a short cylindrical section containing four honeycomb blocks. The front panel of the heat exchanger carries various interconnecting plugs and sockets which carry the electrical services between the radar head, indicator c.r.t. 6935 and the aircraft wiring. These plugs and sockets are not shown in Fig. 2; the various electrical connections are given in Chapter 2.

13. The cooling air, from the aircraft system, passes through layers of tubes in each honeycomb block, each tube layer being formed by a corrugated metal sheet sandwiched between two flat sheets. The high pressure air in the radar head passes through similar tube layers interleaved with the cooling air layers and at right angles to them.

14. The various electrical components in the radar head are so arranged that those generating the most heat are concentrated in the centre section while those requiring closer control of temperature (waveform generator and r.f. unit) are arranged round the outside of the box formed by the two main decks.

15. The high pressure air is circulated by an axial-flow fan driven by a 3-phase motor and mounted in a cylindrical duct in the front panel of the heat exchanger. The air, heated by its passage through the radar head, passes through the heat exchanger in four radial streams (one through each block) and emerges, with its temperature reduced, through four apertures equally spaced round the edge of the panel. It then passes forward through the space between the component decks and the pressure sleeve and is drawn by the fan through the centre section and back to the heat exchanger.

16. The cylindrical outer surface of the heat exchanger casing contains four equally spaced ports for connecting the cooling air from the aircraft system; these occur in the spaces between the honeycomb blocks. They provide two possible arrangements for the cooling air flow. A series parallel flow is obtained by admitting cooling air through one port and exhausting it through the diametrically opposite one, the other two ports being covered by blanking plates. The four blocks can be fed in parallel by connecting the supply to two diametrically opposite ports and allowing it to emerge from the other two. Axial ports are also provided as an alternative to the radial ones where this is more convenient in the particular aircraft. These are shown in the end view of the equipment given in Chapter 2. All unused ports are covered by blanking plates.

17. The heat exchanger is required to cool air at a maximum charge temperature of 80 C to a maximum discharge temperature of 70 C when the air has a pressure of 20 lb/in^2 and flows at the rate of 13 lb/min. The quantity of cooling air required for this is given by 40/(52-T) lb/min where T is the cooling air inlet temperature in deg. C (i.e. for a cooling air temperature of 12 C, the quantity required is 1 lb/min.)

18. Under conditions of very low ambient temperature, overcooling of the equipment could cause trouble due to a cracking of the rubber seals. To prevent this, a thermostat switch is fitted which actuates a motor driven air valve in the aircraft cooling system. The arrangement ensures that the cooling air is shut off when the temperature in the heat exchanger falls to -15 ± 5°C and is restored when the temperature rises to $+25$°C ± 5°C.

19. The thermostat is mounted on one of the spare ports of the heat exchanger in such a manner that the temperature-sensitive bulb projects into the heat exchanger casing. The electrical function of the unit is associated with the aircraft system only.

Pressure checks after initial assembly

20. When a radar head is first assembled (Chap. 2) the pressurizing system must be checked. For the check, the unit must be mounted in a trolley, radar servicing, Type 12016 to allow complete inspection of seals.

(1) Remove the radome and pressure sleeve.

(2) Examine the three pressure seals for correct fitting. Ensure that there is no foreign matter (e.g. paint or Bostik) on the outer surface of the seals; clean them if necessary. ◀Paint can be removed with acetone, and Bostik with stabilized 1.1.1-trichloroethane, (available under various proprietary names, e.g. Inhibisol, Genklene).▶

(3) Fit a pressure gauge (leak indicator CT160) to the DEFLATE SEALS valve on the heat exchanger.

(4) Connect a supply of compressed air or nitrogen, through a pressure regulating unit, to the air inlet union on the heat exchanger. Inflate the seals until the differential valve operates.

(5) Check that the seals are not stuck down with paint or Bostik by observing that the free edges curl up evenly all round. Correct any defect.

(6) Disconnect the pressurizing supply and check that there is NO drop in the pressure indicator on the gauge.

(7) Remove the pressure gauge and deflate the seals.

(8) Fit the radome and secure it.

(9) Fit the pressure sleeve carefully and secure it.

(10) Connect the pressure gauge (CT106) to the TEST AND DEFLATE valve.

(11) ◀Pressurize▶ the radar head via the pressure regulating unit to 15 lb/in^2 (as read on the pressure gauge) and then disconnect the supply. Allow a period of 20 min to elapse and then check that the pressure has not fallen below 14·5 lb/in^2. Locate and correct any leak that becomes apparent.

(12) Remove the pressure gauge. Operate the TEST AND DEFLATE valve to release the unit pressure.

(13) Operate the DEFLATE SEALS valve to release the seal pressure.

(14) Connect the pressure gauge (CT106) to the TEST AND DEFLATE valve. Pressurize the unit to 5 lb/in^2 (as read on the pressure gauge) and leave it in this condition. Disconnect the pressure gauge and the pressurizing supply.

21. The unit should be pressure checked daily. If the pressure in the unit falls to 1 lb/in^2, it must be re-pressurized to 5 lb/in^2.

Chapter 7

SCANNING UNIT 6923

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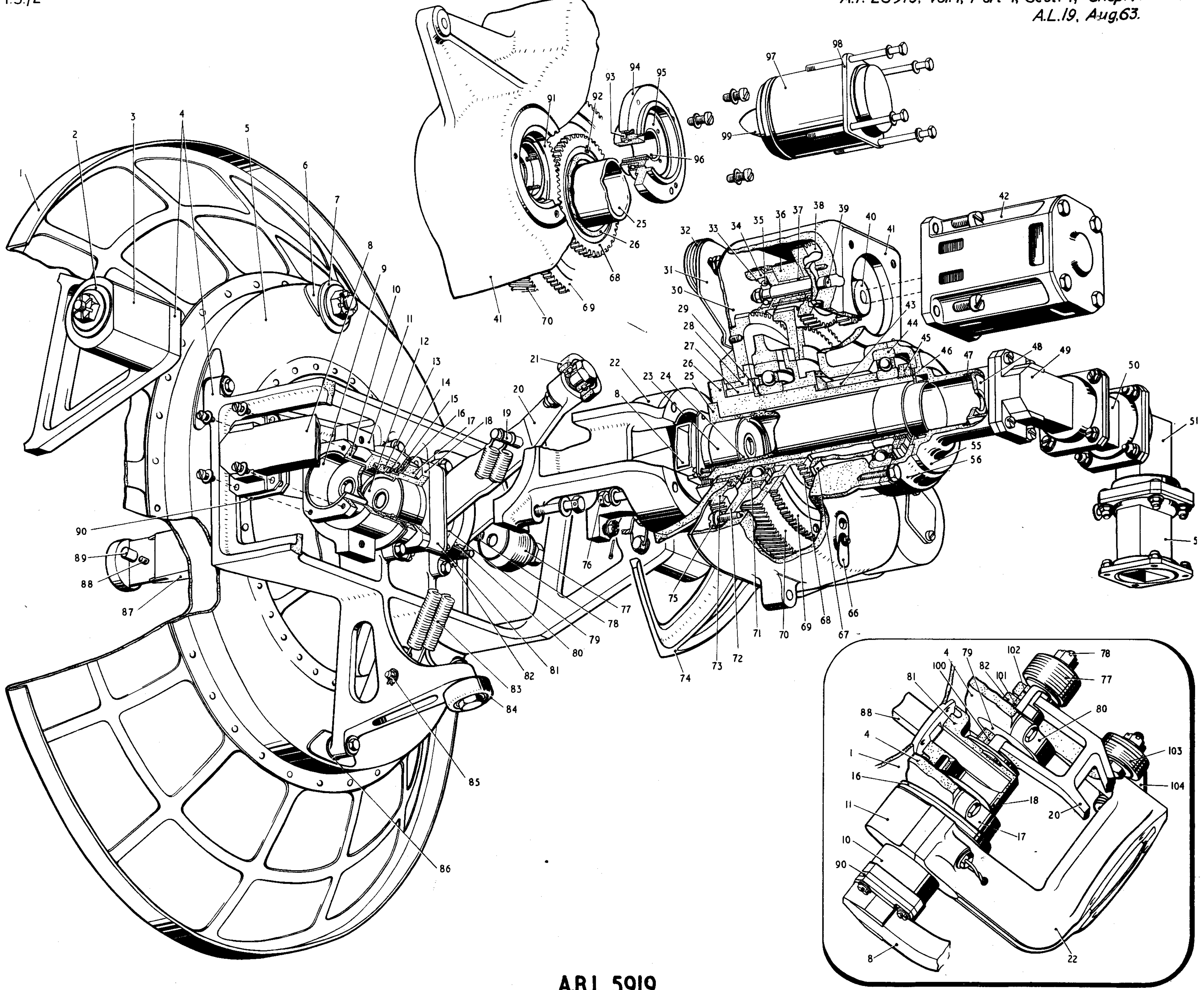

Fig. 1

A.R.I. 5919
Scanning unit 6923: mechanical details

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KEY TO FIG. 1

1	REFLECTOR 117
2	LEAD WASHERS
3	BALANCE WEIGHTS
4	REFLECTOR CASTING
5	REFLECTOR MOUNTING ASSEMBLY
6	PLATES
7	LEAD WASHERS
8	WAVEGUIDE 898
9	FILTER AND SLEEVE
10	HOUSING (BEARING)
11	CLAMP
12	FILTER
13	BUSH 376
14	RINGS (CLAMPING) 722
15	BALL BEARING
16	COVER
17	CLAMP
18	INNER SLEEVE
19	PIN LOCATING 124
20	ROLLER ARM
21	BALL BEARING
22	YOKE
23	FILTER
24	RING 737
25	WAVEGUIDE 897
26	SHAFT 137
27	BEARING BUSH
28	GEAR HUB
29	WASHER 701
30	COVER 1779
31	BRACKET
32	LEAD WASHERS
33	CIRCLIP
34	GEAR (22T)
35	BALL BEARING
36	GEAR (22T)
37	BEARING BUSH
38	GEAR (40T)
39	SHAFT 138
40	GEAR WHEEL 787 (17T)
41	GEARBOX CASTING
42	MOTOR A.C.
43	SPACER 406
44	BALL BEARING
45	NUT SPECIAL
46	WASHER
47	RING 737
48	FILTER RING
49	WAVEGUIDE ELBOW
50	WAVEGUIDE 858
51	WAVEGUIDE 867
52	WAVEGUIDE 868
55	BODY
56	CLAMP
66	COVER 1780
67	SPACER 407
68	GEAR (80T)
69	GEAR (144T)
70	GEAR (105T)
71	BALL BEARING
72	BEARING HOUSING
73	GEAR (108T)
74	CAM
75	BOLT
76	BOLT
77	LEAD WASHERS
78	PIVOT (WAVEGUIDE)
79	BUSH 391
80	CLAMP
81	COUPLING
82	CLAMP
83	SPRING TENSION 354
84	BALL BEARING
85	ANCHOR PIN
86	PLATE
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89	SCREEN (DIPOLE) 349
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93	BALL BEARING
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95	COUPLING (SHAFT) 404
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104	ARM

Introduction

1. Scanning unit 6923 is a directional aerial system which allows the radiation of the ½ μS radio energy pulses from the r.f. block and the collection of reflected pulses. The connection between the r.f. block and the scanner is made by means of a waveguide run. A view of the scanner is given in Fig. 2.

2. The aerial consists of a waveguide feed which terminates in a dipole and splash plate; this is mounted axially in an 18 in. dia. parabolic reflector. The system produces a radar beam with a width of 5·5° at half power.

3. The reflector is driven through gearing by a three-phase motor in such a manner that it spins about the aircraft roll axis at approximately 1000 rev/min. The angle between the reflector axis and the axis of rotation is made to vary continuously from 2° to 45° and back again; this variation is achieved by a cam and roller system. The action, which is known as nodding, takes place at approximately 28 cycles per minute and the spiral scan so generated therefore contains 36 lines. The inward and outward spirals (eighteen lines each) are interlaced. In addition, the lines are compressed slightly at the larger nod angles in order to improve the illumination of objects at the limits of the field of cover.

4. A synchro, mounted on the scanner and driven from it at the spin speed, is fed with the current sawtooth timebase waveform from the waveform generator (chap. 3). This synchro provides two current sawtooth waveforms; the amplitude of one of these varies as the sine of the angle turned through by the dish from the *up* position and the amplitude of the other varies as the cosine of the same angle. The waveforms feed the deflecting coils in the indicator (chap. 12).

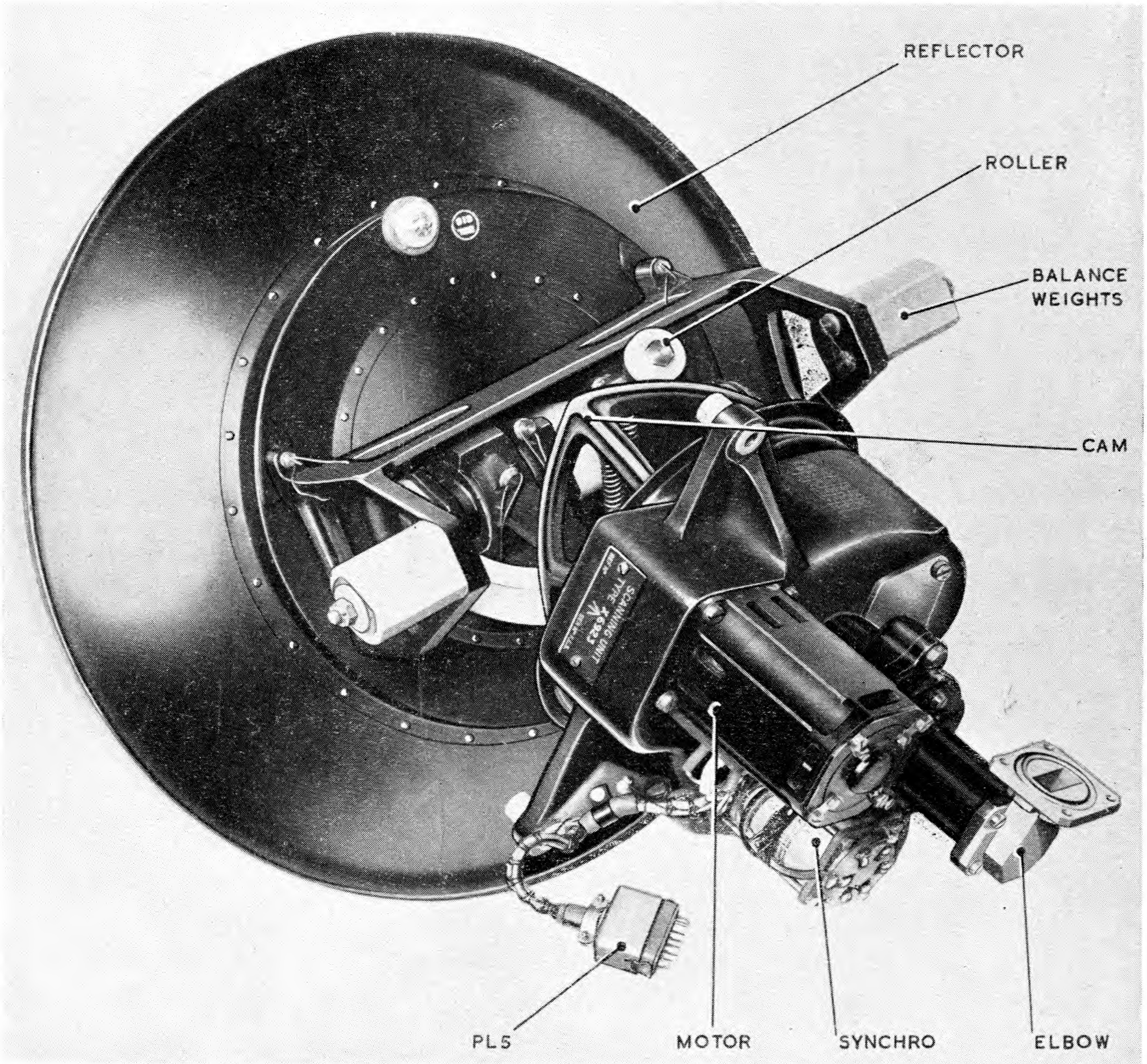

Fig. 2. Scanning unit 6923: general view

MECHANICAL DESCRIPTION

5. A diagram showing the component parts of the scanner is given in Fig. 1.

Gearbox

6. The gearbox (41) contains all the scanner gearing and carries mounting feet for securing the scanner to the main framework of the radar head.

Dish rotating mechanism

7. A hollow mainshaft (26) is carried in two ball bearings (44) and (71). The outer race of the rear bearing (44) is secured in the rear end of the gearbox by the clamp (56). A flanged gear (68) is spaced from the inner of the rear bearing (44) by the spacer (43) and spacer (67) and is fixed to the shaft by a key (92). The inner race of the front bearing (71) locates against the rear face of a thrust washer (29). The thrust washer (29), the gear (68), the spacer (43), the spacer (67) and the inner races of both bearings are clamped against a shoulder at the front end of the shaft (26) by two locknuts (45). The outer race of the front bearing (71) rests in the cylindrical bore of a square bearing housing (72); the outer corners of this housing are bolted to the front end of the gearbox casting. The arrangement ensures that the location of the shaft in the gearbox is determined by the rear bearing (44) only; this has its outer race securely clamped.

8. A laygear cluster, consisting of gears (34), (36) and (38) riveted together, runs free on a "dead" shaft (39) which is bolted to the gearbox casting. The bearings are provided by a bush (37) pressed into the rear end of the cluster and a ball bearing (35) pressed into the front end. The outer race of the bearing (35) is retained in the gear (34) by a circlip (33) and the inner race is clamped up to a shoulder on the shaft (35) by means of a nut and washer. The ball bearing prevents end float and determines the location of the cluster.

9. The laygear cluster is driven by the motor (42) which carries a pinion (40) meshing with the gear (38).

10. The mainshaft is driven from the layshaft by the gear (36) meshing with the gear (70) which is riveted to the flange of gear (68) together with the gear (69).

11. The gear (34) meshes with a gear (73) which is riveted to a gear hub (28) and has the cam (74) fixed to it by peened bolts. The bearing is provided by a bush (27) pressed into the hub (28) and running free on the main shaft (26) between a flange at the front end and the thrust washer (29).

12. Gears (34) and (36) both have 22 teeth. The gear (70) driving the main shaft has 105 teeth and the gear (73) driving the cam has 108 teeth. The speed ratio between the cam and main shaft must therefore be 105/108 or 35/36. Because of this, the cam lags behind the main shaft by one revolution in 36 and the roller (84) which controls the nodding action of the reflector makes a complete excursion round the cam profile in 36 revolutions of the main shaft and generates the 36 line interlaced spiral scan. The end thrust on the cam, caused by the spring loading of the rollers (21) and (84) is taken between the rear face of the bush (27) and the front face of the thrust washer (29).

Synchro drive

13. The timebase synchro (97) is driven by the gear (91) meshing with the gear (68) keyed to the main shaft (26).

14. The gear (91) and the coupling (95) are bolted together and clamp the inner race of a ball bearing (93) between them. A bearing retainer (94), secured by bolts, holds the outer race of the bearing in a counterbore in the gearbox casting. The synchro is held in a counterbore in the retainer (94) by means of four bolts and a clamping plate (98); it is driven by a driving pin (96) in the coupling (95) engaging with a drive moulding (99) on the end of the synchro shaft.

Aerial system

15. The yoke (22), bolted to the front end of the shaft (26), carries a waveguide rotating joint with its axis at right-angles to the axis of the shaft. The reflector casting (4) is mounted on the rotating portion of this joint providing a means of varying the angle between the centreline of the reflector and the axis of the main shaft. The amount of tilt, or nod, is controlled by the roller (84) which mounts on a fixed pivot on the reflector casting (4) and bears on the profile of the cam (74). Contact between the roller (84) and the cam is maintained by the action of the roller (21) which bears on the cam profile at a point diametrically opposite the roller (84). The roller (21) is mounted on an arm (20) and is loaded against the cam profile by springs (83).

16. The housing (10) of the rotating joint is held in one arm of the yoke by the clamp (11). The housing incorporates an iris which locates a filter and sleeve (9); this is clamped in position by the spacer (90) and the flange of the wave-guide (8).

17. The rotating joint inner sleeve (18) works in an oilite bearing (13), pressed into the housing (10), and a ball bearing (15). The inner race of the ball bearing is clamped against a shoulder on the inner sleeve by locknuts (14). The outer race is clamped in a counter bore in the housing by the cover (16); this determines the axial location of the assembly. The reflector casting (4) is fixed to the rotating joint inner sleeve (18) by the clamp (17). The bearings (13) and (15) which permit radial movement between the inner sleeve (18) and the housing (10) therefore permit radial freedom between the yoke (22) and the reflector casting (4).

18. The inner sleeve incorporates an iris. A filter (12) is clamped against the iris by the wave-guide coupling (81). A pivot (78) locates in the coupling (81) by means of a spigot and has a flange which is bolted to the coupling in such a manner that the pivot (78) the inner sleeve (18) and the housing (10) have a common axis.

19. The pivot carries three bearing bushes (viz. (100), (101) and (102)) and it is free to rotate within them. The bush (101) is clamped in the yoke by the clamp (82) forming a second support for the rotating joint system. The bush (79) is held in the reflector casting (4) by the clamp (80) giving a second support for the tilting part of the assembly. The bushes (100) and (102) are pressed into the arm (20) allowing it to rotate relative to the pivot.

20. The outer end of the pivot provides a mounting for balance washers (77).

21. The reflector is an aluminium alloy spinning; this is chemically etched to form a light structure with strengthening ribs. The reflector is riveted to a mounting (5) which is bolted to the casting (4); plates (86) and (6) are used at the bolting points to provide additional strength. The location for the mirror is provided by the circular flange of the waveguide feed (87); this is bolted to the coupling (81).

22. Balancing. The reflector casting (4) extends into two brackets which carry balance weights (3). These weights are in the plane containing the nod axis (the axis of the rotating joint system) and the axis of symmetry of the dish. The centre of gravity of the nodding system is arranged to lie on this plane by the adjustment of lead washers (7) mounted on the plate (6). Adjustment of the weights (3) by addition of lead washers (2) then locates the centre of gravity of the nodding system accurately on the nod axis so ensuring that the nodding action will not disturb the balance of the aerial system as a whole about the spin axis.

23. If it were true that the spin and nod axes intersected exactly, the adjustment of lead washers (77) would suffice to bring the centre of gravity of the whole rotating system on to the spin axis. The result cannot normally be ensured in practice owing to manufacturing tolerances on the various components. For this reason, further balance weights (103) mounted on each end of an arm (104) fixed to the yoke (22) are adjusted in combination with the washers (77) in order to achieve the required result.

24. There are also lead washers (32) mounted on a bracket (30) bolted to the gear (73) to which the cam (74) is bolted. These washers balance the eccentric load of the cam.

R.F. system

25. R.F. energy from the magnetron, leaves the r.f. block (Chap.8) via an H plane waveguide bend which incorporates a special reversible flange. The purpose of this is to facilitate the connection of a dummy load or r.f. noise source to the block for setting up or testing purposes. The power is then connected via a waveguide run incorporating a flexible section (52), an elbow (51) and another flexible section (50) to the elbow (49) on the scanner.

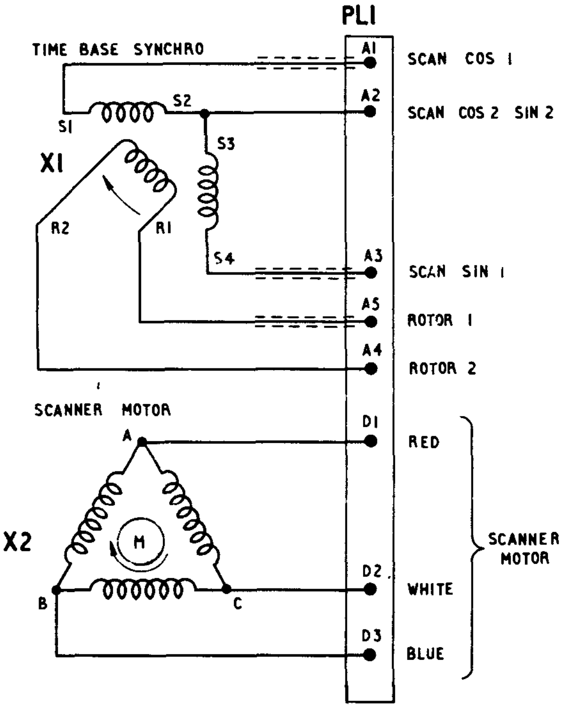

Fig.3. Scanning unit 6923 : circuit

Note... When the scanner is removed from the radar unit, the waveguide components (50) (51) (52) should be taken off by unbolting at the flange joint between items (50) and (49). This is to prevent accidental damage to the assembly.

26. The elbow (49) is bolted to a body (55) which forms the static portion of an E_{01} rotating joint system; this is bolted to the clamp (56) which is bolted to the gearbox. The body includes an iris (47) and a filter (48); these are clamped in a counterbore by the attachment of the elbow (49). The rotating part of the joint system is formed by an alloy sleeve (25) which passes through the bore of the main shaft (26) and enters the bore of the body (55) with a small clearance. Leakage of energy from the system is prevented by an r.f. choke formed by an annular ditch in the body in conjunction with a washer (46) pressed into the clamp (56).

27. The front end of the sleeve (25) carries a shoulder which is clamped between the yoke (22) and the main shaft (26). The waveguide band (8) is bolted to this shoulder and the yoke is slotted to provide a clearance for the guide. The waveguide flange retains a filter (23) and a matching iris (24) in a counterbore in the sleeve.

28. The other end of the waveguide (8) is bolted to the housing of the rotating joint system and retains a filter as described in para.18. R.F. leakage from the rotating joint is prevented by a choke system formed by the end of the inner sleeve, a ditch in the housing and the bearing bush (12). The inner sleeve (18) incorporates a machined iris. A filter (12) is retained against this by the flange of the coupling (81). The output from the coupling passes into the waveguide feed (87). The tapered mouth of this feed contains a flat plate whose plane is that of the broad axis of the feed. The plate carries the dipole (88) and a reflector disc which directs the r.f. energy back into the reflector (1). The dipole ends are insulated by p.t.f.e. covers (89) to prevent arcing between the dipole and the mouth of the waveguide feed (87).

CIRCUIT DESCRIPTION

29. A circuit diagram of the scanner is given in Fig.3.

30. The scanner motor X2 is energized by the 200V 400Hz three phase supply fed via contacts of relay C/4 in the master relay unit when the master switch (indicator) is set to T.X.

31. The rotor of the timebase synchro X1 is supplied with the timebase current waveform from the waveform generator (Chap.3) and is driven at the scanner spin speed. The resolved outputs obtained from the stator winding are applied to the scanning coils in the indicator (Chap.12).

Chapter 8.—RF UNIT 6926

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Introduction

1. The main structure of the RF unit consists of two aluminium alloy blocks which form the upper and lower halves of the RF block. The following sub units are mounted on the block.

(1) IF unit 6927 and suppression unit

(2) Frequency control unit 12131

(3) Klystron control unit

(4) Relay unit (klystron) 6928

Item (1) is described in chap. 9, and items (2) to (4) in chap. 10. Also mounted on the block assembly are the signal and AFC mixers, klystron and tuning mechanism. These are considered as part of the block assembly and component references are in the series relating to the block assembly. Connections between the units are made by means of micronector plugs and sockets; another plug and socket connection (PL6, SK6) carries wiring between the RF unit and the rest of the equipment. An interconnection diagram for the RF unit is given in fig. 5.

2. The upper and lower halves of the RF block contain machined channels of rectangular cross section; the channel pattern in one half is a mirror image of that in the other. When the upper and lower halves are bolted together, a system of waveguides is formed the broad dimensions of the waveguide being at right angles to the mating faces of the two halves.

3. The waveguide system has the following functions:

(1) To connect transmitter signals from the magnetron to the scanner.

(2) To connect received signals from the scanner to the signal mixer.

(3) To sample the magnetron energy for test and AFC purposes.

(4) To connect the klystron output *(chap. 10)* to the signal and AFC mixers.

4. A common T and R system is used which incorporates hybrid 3db slot couplers. The general principle of these is given in para. 5.

Hybrid 3db slot couplers

5. Fig. 1 is a schematic diagram showing two waveguide sections AB and CD coupled by slots EF and GH. The waveguide sections are spaced by $\lambda_g/_4$; the slots are spaced by $\lambda_g/_4$.

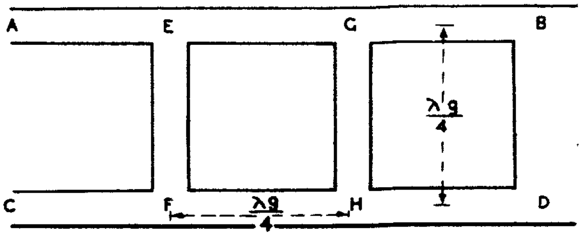


Fig. 1. 3db Slot coupler

6. Some of the energy entering the coupler at A is coupled via the slots EF and GH into the guide CD; the remainder passes to B. Energy reaching point H via slot GH is in phase with energy reaching point H via slot EF since the path lengths AGH and AEFH are equal. A quantity of energy equal to the sum of the quantities passing via the slots therefore passes to D.

7. Energy reaching point F via slot GH is in antiphase with that reaching point F via slot EF since the path lengths AGHF and AEF differ by $\lambda_g/_2$. A quantity of energy equal to the difference between the quantities passing via the slots passes to C.

8. In the couplers used in this equipment, three slots are used whose widths are such that 3db coupling is obtained (i.e. the entrant energy is split into two equal parts half emerging at B and the other half at D). No energy passes to C since the energy passing to C via the first slot is completely cancelled by the resultant signal passing to C via the other two slots. The signal emerging at D lags that emerging at B by 90 deg. since the path length AGHD is $\lambda_g/_4$ greater than AB.

9. The following general results should be noted:

(1) If a quantity of energy enters one arm of a hybrid 3db slot coupler, no energy emerges from the adjacent arm but equal energy quantities emerge from the other two arms. These equal energies differ in phase by 90 deg. the leading quantity emerging from the guide to which the entrant energy is applied.

(2) If a quantity of energy enters one arm of a coupler and an equal quantity differing in phase by 90 deg. enters the adjacent arm, the two quantities add in the coupler and emerge from the other end of the guide having the lagging energy input.

WAVEGUIDE SYSTEM

10. A diagram, showing the lower section of the RF block, is given in fig. 2. Two views of the complete RF unit including the last three waveguide sections of the run from the magnetron *(para.* 11*)* are given in fig. 3 and 4.

Transmission

11. The magnetron output *(chap.* 4*)* is coupled to the RF block via the following components:

(1) A taper section to reduce from No. 15 to No. 16 waveguide.

(2) A 90 deg. waveguide bend.

(3) A flexible waveguide section.

(4) A 90 deg. waveguide bend.

(5) A flexible waveguide section.

(6) A 90 deg. waveguide bend.

12. The last waveguide bend is connected by a flange to the RF block and magnetron energy enters the waveguide section A *(fig.* 2*)*. The energy is split by the duplexer hybrid; half passes towards guide B and half towards guide C. The broad faces of guides B and C are bridged by the pre-TR cell which is inserted through a hole drilled in the block.

13. The pre-TR cell consists of a glass tube which is filled with silica wool and argon gas. When the magnetron energy reaches the cell, the gas ionizes making the tube into a conductor which short circuits both waveguides causing almost complete reflection of the magnetron energy.

14. RF leakage between the surface of the cell and the block metal is prevented by a system of annular ditches which form RF chokes. The outer ends of the cell are surrounded by cylindrical sleeves which are secured to the block by means of flanges. The sleeves form cut off waveguides which prevent RF leakage. The sleeves are fitted with springs which retain the cell in the correct position. Normally the pre-TR cell is a tight fit in the block and great care must be taken when removing or inserting it. If a cell is broken in the block; the block will need dismantling in order to remove the glass fragments.

15. Before reaching the pre-TR cell, the magnetron energy in each guide encounters two P.T.F.E. windows which completely seal the guide. The purpose of the windows is to prevent ultra violet rays, emitted from the pre-TR cell when struck, from ionizing the air at the duplexer hybrid and causing arcing there. The presence of a single window in each guide would cause an impedance mismatch. Two windows are used forming a $\lambda_g/_2$ sandwich which gives satisfactorily matched conditions.

16. The gas in the pre-TR cell ionizes during the transmitter pulses placing a short circuit across guides B and C; the energy in the guides is almost totally reflected back towards the duplexer hybrid. Since the reflected energy in guide C lags that in guide B, the energies combine in the hybrid and the total passes into guide F which is connected to the scanner via a waveguide bend. The main power outlet includes a special flange; this can be reversed to facilitate the connection of test equipment (e.g. dummy load).

17. A small amount of energy leaks past the pre-TR cell in guides B and C. The leakage along guide C lags that in guide B by 90 deg. and the two quantities combine in the combination hybrid; the total passes to guide D where it is absorbed in a lossy ceramic load. The action of the combination hybrid is not perfect and some of the leakage energy continues along guide E; this necessitates the TR cell in the receiver section *(para.* 20*)*.

18. In its passage along guide F to the scanner, the main transmitter energy encounters a 26dB slot coupler; a sample (26 dB down on the main power) passes via this coupler into guide H; a small amount also passes into guide G and is absorbed by a resin load. The 26dB sample passes along guide H and turns through a right angle to emerge at the top of the duplexer block. From here it is connected via a waveguide/coaxial transformer and a length of coaxial cable to the resonator performance testing (Chap. 13).

19. The guide H is connected via a 32 dB slot coupler (the a.f.c. sampling coupler) to guide J. This gives another sample of the transmitter output (58 dB down on the main power) for the a.f.c. system (para. 33). A small amount of energy also passes into guide K where it is absorbed in a resin load. Guide J contains an adjustable resistive attenuator vane X2 which provides a means of varying the a.f.c. sample for setting up. The range of adjustment is from 6 to 18 dB. A resistive attenuator is used to minimize the harmonic content of the sample since it will attenuate harmonics much more than the wanted frequency. It should be noted that the 32 dB and 26 dB slot couplers may attenuate harmonics less than the wanted frequency.

Reception

20. Received signals from the scanner enter the duplexer block and pass into waveguide F (fig. 2). The energy splits at the duplexer hybrid giving a signal in waveguide C and another equal signal lagging by 90° in waveguide B. The pre-TR cell is de-ionized on reception and has no effect. The signals in waveguides B and C are combined by the action of the combination hybrid and the combined signal passes into guide E. It then passes through the crystal protection shutter and out of the block. A waveguide bend and a TR cell connect the received signal back into the block where it enters waveguide L.

Crystal protection shutter

21. The crystal protection shutter consists of a metal cylinder located in a hole bored through the r.f. block. The cylinder is driven by a Ledex mechanism (fig. 4) and contains a rectangular hole which is aligned with the waveguide section E when the equipment is operating. When the equipment is switched off, the cylinder automatically rotates through a right angle so blanking off waveguide E. This is to prevent the signal crystal from being burnt out by radiation from other equipments in the absence of the TR cell "keep-alive" supply (para. 23). The shutter Ledex is supplied with +28V fed via relay contacts E/2 in the master relay unit (Chap. 5) and a 470 ohms resistor R6 in the r.f. block wiring (fig. 5). The Ledex is normally released but operates when the function switch (indicator) is set to T.X. The resistor R6 (r.f. block) is normally shorted by a microswitch S1 so that the Ledex solenoid receives full current from the 28V supply. When the Ledex operates and the shutter opens, S1 opens as well so reducing the current through the solenoid to a safe value for holding.

TR cell

22. The waveguide bend and the TR cell have flanged connections to the r.f. block. There is always a gap (·005 to ·010 in) between the TR cell and the block to allow for tolerance in the manufacture of TR cells. A machined ditch in the block at the TR cell coupling forms an r.f. choke which prevents signal leakage at the joint.

23. The TR cell has two "keep-alive" electrodes which are supplied via series resistors from the unfiltered − 1 kV supply (Chap. 11). These maintain a small degree of ionization within the cell ensuring that complete ionization will be obtained immediately the transmitter pulse occurs. Ionization of the TR cell is brought about by the small amount of energy which passes the combination hybrid during transmission (para. 17), so preventing this energy from entering waveguide L and damaging the signal crystals.

Klystron local oscillator

24. The output from the klystron local oscillator (Chap. 10) is iris coupled to a short waveguide terminated by a waveguide/coaxial transformer and then via a coaxial cable to a coaxial/waveguide transformer bolted to the underside of the r.f. block. The klystron output then enters guide P and encounters the klystron hybrid.

25. The klystron hybrid serves to split the local oscillator output into two giving one feed via guide R to the signal hybrid and another via guide Q to the a.f.c. hybrid. The arrangement provides isolation between signal and a.f.c. channels while maintaining matched conditions for the klystron itself. Any reflected energy from the signal and a.f.c. hybrids passes into guide S and is absorbed by a resin load; the klystron coupling provides a load for energy returning to the klystron via guide P.

26. When setting up the system, it is necessary to adjust the level of local oscillator signal in both the signal and a.f.c. channels. The guides R and Q include adjustable resistive attenuators X3 and X1. The setting technique involves setting the attenuators in guides R and Q to give correct a.f.c. crystal current and signal crystal currents.

Signal mixer

27. The signal energy in guide L is split into two equal parts by the action of the signal hybrid; this gives a signal in guide M and an equal signal lagging by 90° in guide N. The oscillations from the klystron in guide R are similarly split by the signal hybrid giving one local oscillator signal in guide N and another equal signal lagging by 90° in guide M.

28. Consider an instant when the signal in guide L is in phase with the local oscillation in guide R.

Then:—

In guide M, the local oscillation will lag the signal by 90°.

In guide N, the local oscillation will lead the signal by 90°.

Thus, when the two energies in guide M are applied to a crystal mixer, and the two energies in guide N are applied to another crystal mixer, the i.f. outputs from the two mixers will be in antiphase.

29. Energy at i.f. may also be produced by local oscillator noise frequency. Since the noise frequency reaching guides M and N originate from the same source, quantities which are in phase in guide R will be in phase in guides M and N. The noise i.f. from one crystal will therefore be in phase with that from the other.

30. The two crystal mixers are mounted in waveguide stubs which are bolted to the ends of guides M and N by means of a flange. The crystals are connected in opposite sense so that the antiphase i.f. signal outputs add together in the common connection at the input of the i.f. amplifier (Chap. 9). Conversely, the in-phase noise i.f. outputs cancel in the common connection.

31. The method of extracting the r.f. power from the waveguide to feed the crystal is known as bar and post matching from the waveguide to the coaxial section containing the crystal. In this, the post may be regarded as a vertical aerial, placed in the field in the waveguide, having a crystal detector at one end with the bar as capacitance loading offsetting the capacitance of the post with the backing plate formed by the end wall of the waveguide. The bar provides an output path for the i.f. signals resulting from the mixing operation.

32. The bar passes out of the waveguide as the inner conductor of a coaxial section. The dimensions of this coaxial section are so arranged that a very low impedance portion, surrounded by a quarter wave ditch, is followed by a high impedance porton terminated with a washer of lossy material. This provides a choke for the r.f. but has little effect on the i.f. The inner conductor of the coaxial section terminates in an "S" shaped phosphor bronze strip which mates with the special connector on the i.f. strip (Chap. 9).

A.F.C. mixer

33. The arrangement or the a.f.c. mixing system is similar to that of the signal mixer. The local oscillation in guide Q is split by the a.f.c. hybrid and the a.f.c. sample in guide J (para. 19) is also split by the a.f.c. hybrid. The a.f.c. mixer uses only one crystal which is coupled by a bar and post arrangement to guide U. Guide T is terminated by a stub which includes a resin load. The output from the a.f.c. crystal is connected to the a.f.c. system (Chap. 10).

DISMANTLING AND ASSEMBLY NOTES

34. Access to the r.f. unit can be obtained by removing the pressure sleeve (Chap. 6). Any sub-unit may be removed from the unit without removing the complete block.

Sub-units

35. Removal of sub-units is quite straightforward. In each case withdraw the connecting plug and release the appropriate securing bolts (painted red).

Klystron resonator and drive mechanism

36. (1) Unbolt the waveguide/coaxial transformer from the klystron cavity. Do not attempt to unscrew the coaxial cable from the waveguide.

(2) Make a note of the colour coding and unsolder the cableform from the three motor terminals and the 470 pf capacitor (C1) feeding the klystron reflector.

(3) Remove the four 6 B.A. screws securing the klystron resonator and drive mechanism to the r.f. block.

To remove the r.f. unit complete

37. (1) Remove the rear tray assembly.

(*a*) Withdraw PL3.

(*b*) Withdraw PL12 from the tray itself.

(*c*) Release the six 6 B.A. bolts securing the tray to the main frame.

(*d*) Lift up the edge nearer the r.f. block an withdraw the tray.

(2) Break the waveguide run to the magnetron by releasing four bolts marked with red paint.

(3) Remove the klystron control unit (withdraw PL4 and release two 6 B.A. captive screws).

◀(4) Disconnect the waveguide run to the scanner by removing the four bolts securing the output waveguide bend to the scanner.▶

(5) Withdraw the 26 pole plug PL5 connecting the block to the main frame wiring.

(6) Remove the waveguide/coaxial transformer from the resonator, performance testing outlet by removing the four securing screws.

(7) Remove the four 2 B.A. Nyloc nuts at the corners of the r.f. block.

(8) Lift off the complete unit. When placing it on the bench, do so very carefully—it is best stood on edge.

TR cell

38. The TR cell is removed complete with the waveguide bend by removing the two screws securing the bend to the block. After removing the two-pole cap from the "keep-alive" electrodes, the TR cell may be unbolted from the bend. Note that when fitting a new cell, it must be bolted to the bend with the 'A' electrode nearer the bend and pointing out.

Pre-TR cell

39. To remove the pre-TR cell simply deflect the two springs and withdraw the cell carefully. When fitting a cell deflect the springs before attempting to insert the cell. Be careful to push the cell in straight and do not apply any force otherwise the cell may break in the block.

Note . . .

It is not anticipated that the service will attempt to separate the two halves of the block.

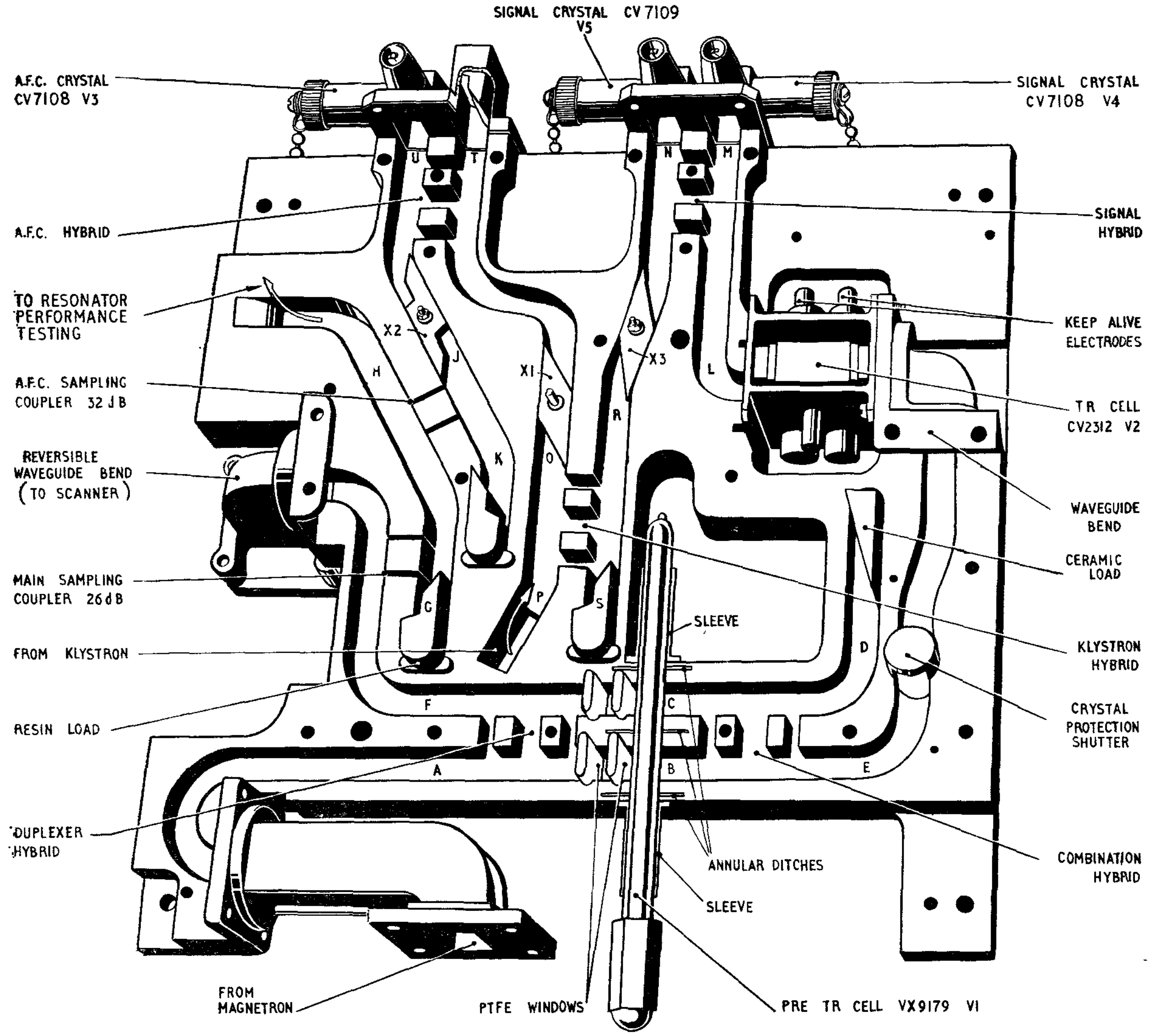


Fig. 2 RF Block: lower section

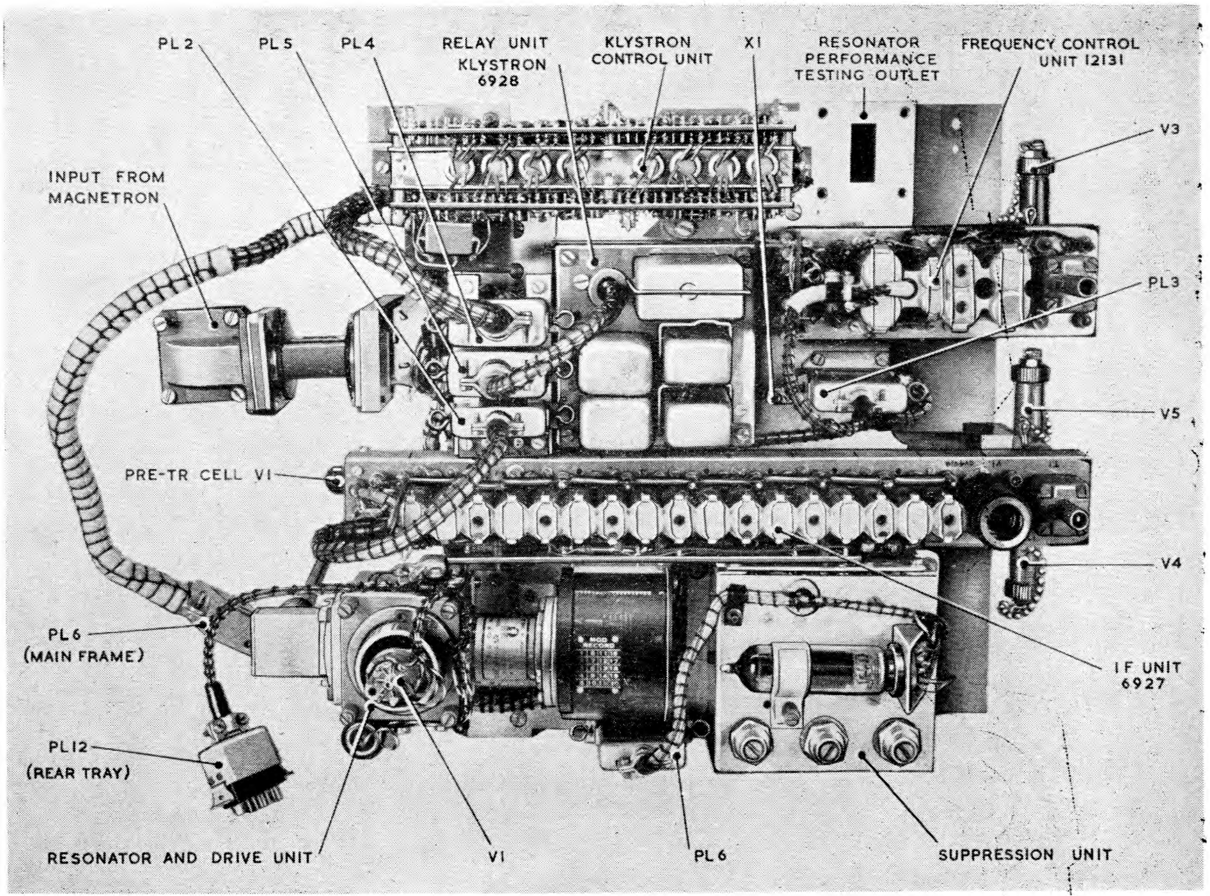


Fig. 3 RF unit: top view

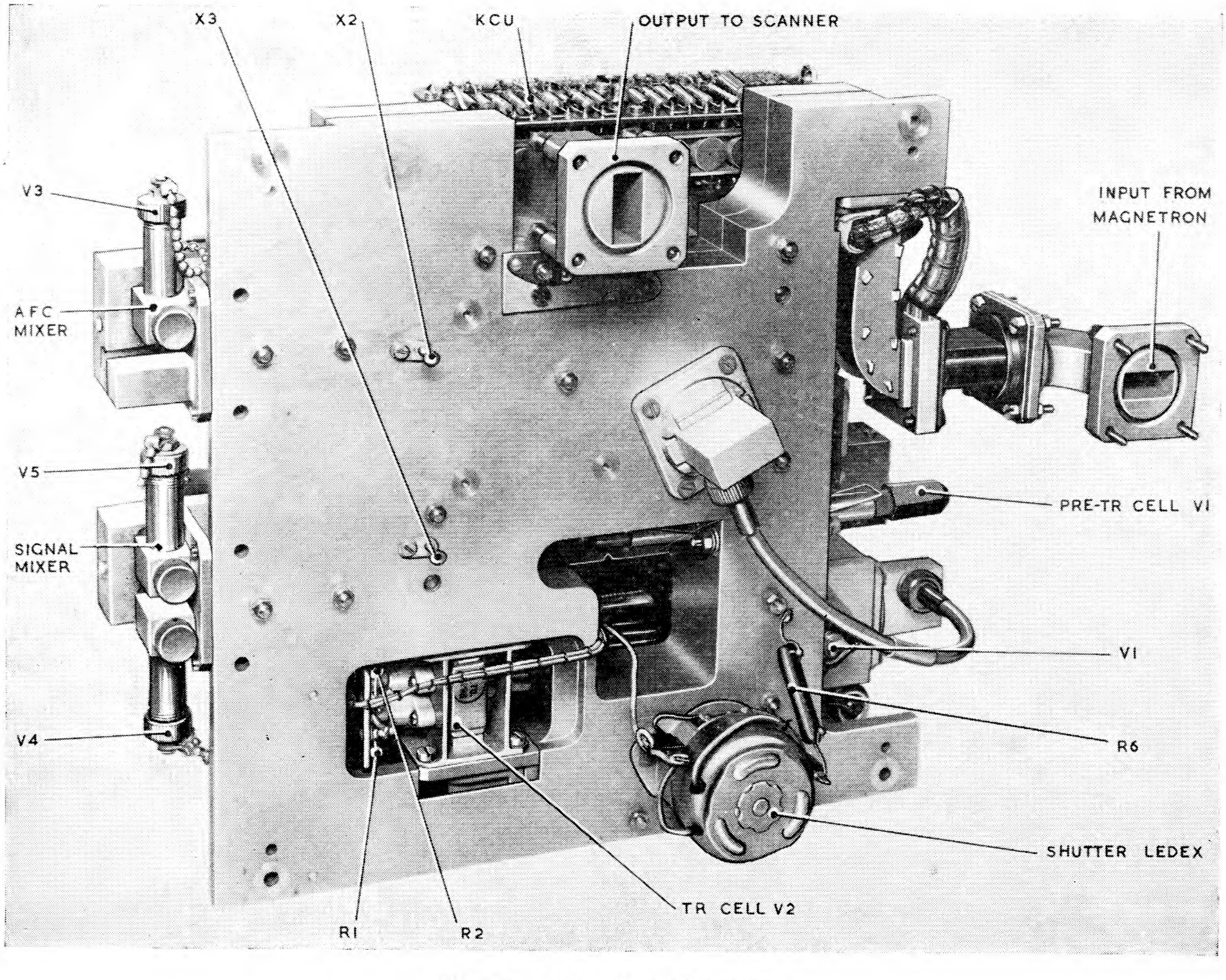
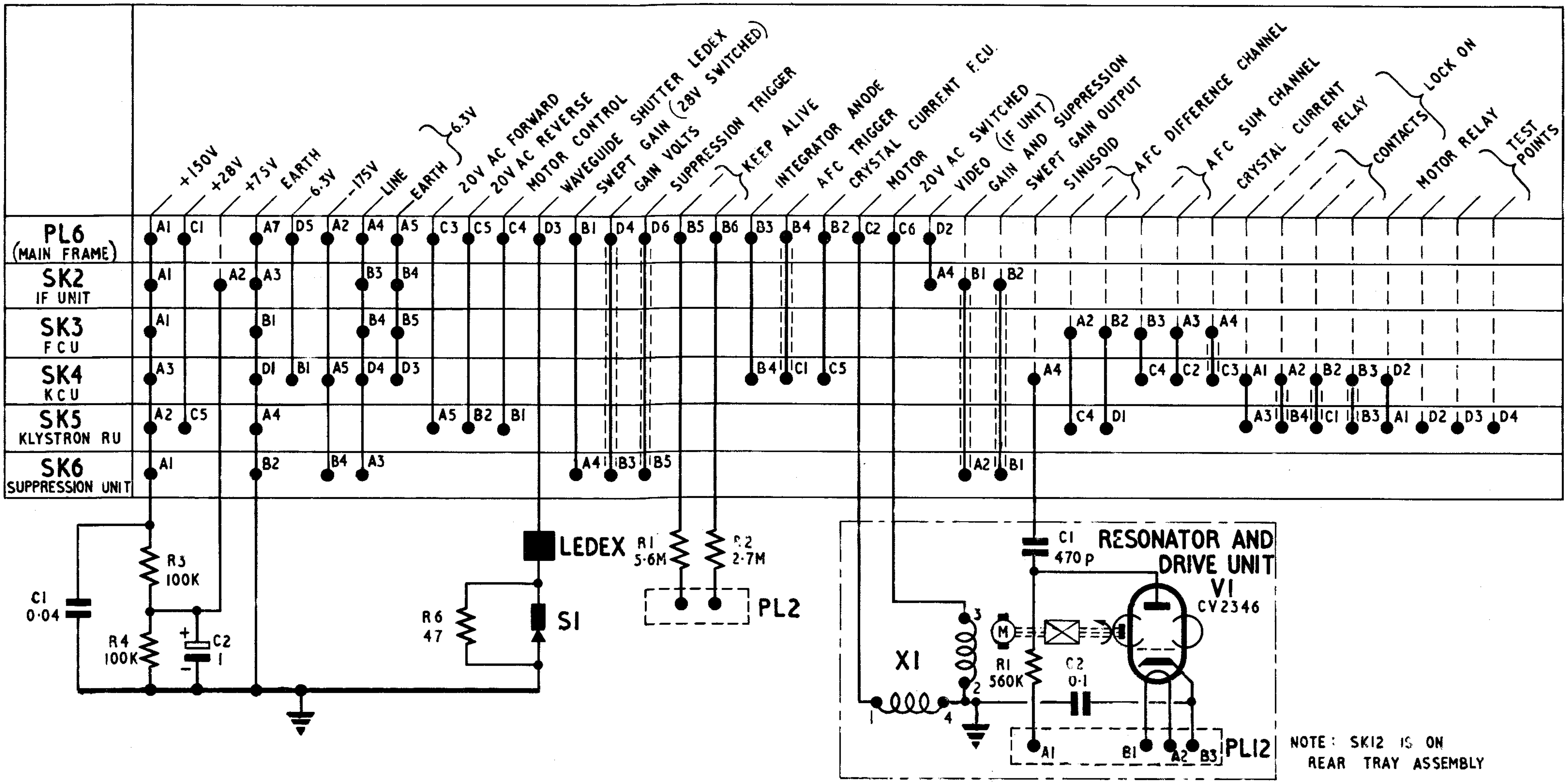


Fig. 4. RF unit: under view



NOTE: SK12 IS ON REAR TRAY ASSEMBLY

AIR DIAGRAM
6166L/MIN.

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AR1 5919 RF unit 6926 : interconnections

Fig. 5

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Chapter 9

(*Completely revised*)

IF UNIT 6927 AND SUPPRESSION UNIT

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IF UNIT 6927

Introduction

1. The IF unit is a high gain, low noise amplifier operating on a centre frequency of 30 MHz with a bandwidth of between 4 and 5 MHz at 3dB down. The noise factor of the unit is less than 2½dB and the noise output at maximum gain is equivalent to a sine wave having 5V peak-to-peak amplitude.

2. The unit is mounted on the RF block (*Chap.* 8) in such a manner that the amplifier input connections mate directly with the signal mixer output connections. The inner conductors of the signal mixer stubs consist of "S" shaped phosphor-bronze strips forming spring contacts. This method of connection gives a very small amplifier input capacity owing to the elimination of connecting leads. The IF unit chassis is fixed to the RF block by means of three pillars and captive screws. Power connections to the unit are made by means of a 9-pole micro-nector plug which mates with SK2 on the RF unit.

Construction

3. Three views of the IF unit are given in *fig.* 1, 2 and 3.

Chassis

4. The chassis consists of an aluminium die-casting in the form of a flat plate carrying screening cans for the various IF coils and sub-miniature valves. The die-casting contains all the holes necessary for feed-through capacitors and the mounting of various components. The under side of the chassis is covered by a brass screening can whose long sides are slit to form spring contact fingers; the fingers engage "V" grooves in the long edges of the chassis. The can is secured by a single screw at the front end and two screws at the rear.

IF coils

5. The coil formers are of moulded Nylon and include a ferrite core bonded to a brass screw. The bore of the former has a diameter slightly less than the diameter of the brass screw and the screw is allowed to cut its own thread in the former. The screw friction is sufficient for normal use but tuning adjustments should be kept to a minimum otherwise the screws become loose in the formers and adjustments cannot be held under vibration.

6. The upper ends of the die-casting screening cans are machined to locate the tops of the formers which are held in position with wire clips. The formers are colour-coded for frequency by means of a spot. The spots are all in the same positions relative to their formers and this feature gives a quick check, when looking at the IF unit, that all coils are correctly in position. The screening cans are tapered as demanded for die-casting; the lower ends contain nylon spiders which prevent vibration, centre the coil formers in the cans and provide separation of connecting leads.

Valves

7. Valve V1 is a CV 4010 which is triode-connected and neutralized to provide a low noise input stage. This valve has a conventional base and separate screening can. Valves V2 to V10 are sub-miniature valves which are mounted in die-cast cans. The spaces between the valves and their cans are filled with silicone grease to assist in the conduction of heat so restricting valve temperature below the allowed maximum (120 deg. C). The tops of the valve cans are fitted with nylon caps which are retained by wire clips; the caps serve to retain the silicone grease.

Chokes

8. The chokes used in the heater, HT and swept gain circuits consists of ferrite beads surrounding short lengths of wire. A low frequency grade of ferrite is used and this, although having a high "Q" at low frequencies, is extremely lossy at 30 MHz. This type of choke is not used in the suppression circuit since the short duration suppression pulses cause ringing; wire-wound chokes are used instead.

Feed-through capacitors

9. Feed-through capacitors are used for decoupling in some cases. These capacitors are retained in stainless steel clips which pass through holes in the aluminium chassis. When servicing, the capacitors should be treated as fragile items otherwise the steel clips wear holes in the chassis and may cause intermittent contact trouble.

CIRCUIT DESCRIPTION

10. A circuit diagram of the IF unit is given in Fig. 7.

IF stages

11. The input transformer T1 is moulded in polythene and enclosed in a square section screening can. The input tapping on the coil is brought out to two contacts connected in parallel and projecting through the surface of the moulding. These contacts mate with the spring contacts in the signal mixer output stubs. The input tapping on the coil is arranged to give the best possible noise factor not maximum signal transfer. The input is shunted by R19 and JK1 giving facilities for connecting test gear.

12. Valve V1 is an RF pentode which is connected as a triode. The valve is neutralized by the IF voltage fed via the neutralizing capacitor VC1 from the secondary winding of T2 in the valve anode circuit. Transformer T2 is bifilar wound at wire diameter spacing to minimize the capacitive coupling between the windings. The secondary connections are such that 180 deg. phase shift is obtained from V1 anode to V2 grid; the voltage at V2 grid is therefore in phase with the voltage at V1 grid and is suitable for neutralizing purposes.

13. Valves V2 and V3 are connected in cascade for IF signals but are in DC series across the HT supply. The grid circuit of the top valve is returned via a filter circuit to the junction of two resistors connected across the +150V stabilized supply in the RF unit wiring (*Chap.* 8); the potential at this junction is +75V. For DC, the bottom valve behaves as a cathode load for the top valve and the DC voltage at the top valve control grid determines the anode voltage for the bottom valve; i.e. each valve has an HT supply of 75V. Since the valves are in series, each must pass the same standing current. This current is determined by the grid-cathode voltage of the bottom valve.

14. If the two valves were connected separately across the +150V supply, they would have to be run at a large bias, giving reduced slope, in order to maintain anode dissipation within allowed limits. This would waste HT power since more valves would have to be used to obtain the same overall gain from the amplifier. The full slope, from this type of valve, can be obtained with 75V HT.

15. A similar arrangement is used for valves, V4, V5 and V6, V7. The last pair, V6, V7 operates with more bias than the others in order to preserve the signal handling capability of the top valve V7; this prevents the IF signals, already amplified by six stages, from driving V7 into grid current. It should be noted that grid current flowing in any one of the valves V3, V5, V7 will flow through the potentiometer network, providing the 75V reference for their grids, and will upset the working of all the paired stages.

16. A tertiary winding on transformer T9 is connected to a small coaxial plug TP1 which is accessible through a hole in the side of the chassis screening can. This provides a test point for noise measurement.

17. The IF transformers T2 to T9 are bifilar wound. To obtain the required overall bandwidth the various transformers are stagger tuned as follows:

T1	29 MHz
T2	30 MHz
T3, T5, T7	32·5 MHz
T4, T6, T8	27·6 MHz
T9	31 MHz

18. The normal damping resistors across the primaries of the IF transformers as well as broadening the pass band of each stage, reduce the gain. The parallel diodes D1 and 2, D3 and 4, D5 and 6 across damping resistors R4, R7 and R10 resistors R4, R7 and R10 respectively, act as additional gain limiters for each stage. The net effect on overall IF gain is to eliminate shadows following radar returns so strong as to cause IF saturation of a normally tuned circuit.

Detector and output circuit

19. The output of the final IF transformer T9 is rectified by V9 and positive-going video pulses are obtained across the load resistor R15. The IF component remaining at V9 cathode is filtered by the action of C35, L24, C41, and the filtered video pulses are applied to the grid of V10.

20. Valve V10 is the first valve of a cathode coupled video amplifier stage; the second valve of this stage is valve 4V3 in the waveform generator (*Chap.* 3). The two valves share a common cathode load consisting of 4R6, 4R7 (waveform generator).

21. Resistor R15 is returned to the junction R16, R17 where the voltage is +25V; this voltage determines the voltage at V10 grid under no signal conditions, and therefore determines the common cathode potential of V10 and 4V3 (waveform generator). The total anode current of the two valves is determined by the common cathode load and is about 10mA; of this, approximately 2mA flows through V10 and 8mA through 4V3 (waveform generator).

22. A positive-going pulse at V10 grid increases the current through V10 and reduces that through 4V3 (waveform generator) by the same amount. Large signals drive V10 hard enough to cut 4V3 (waveform generator) off altogether. The maximum video signal available at 4V3 (waveform generator) anode, is approximately 25V but the circuit is only linear for up to approximately 12V output.

23. The choke L25 provides further filtering of IF remaining at V20 cathode. It consists of a ferrite bead sinilar to those used in the heater circuits of the IF valves. Valve V10 prevents it from ringing. A test jack JK2 is provided for video signal test measurements.

Gain control

24. The receiver gain control voltage, from the waveform generator (*Chap.* 3) is applied via the suppression unit (para. 33 and 36) to pole PL2/B2. From here, the voltage is connected via filter circuits to the grids of V2 and V6. The voltage controls the gain of the top valves also, because of the DC series connection of the valves. Gain compression of 80dB is possible.

25. The swept gain waveform from the suppression unit appears at pole PL2/B2 and is applied via a filter circuit to the control grid of V4 similar to those used in the HT and heater filters.

Suppression

26. The IF amplifier valves used in the IF unit have their suppressor grids connected internally to their cathodes so that the suppressor grids are not available for the application of pulses. The suppression pulses appear superimposed on the normal gain control voltage at pole PL2/B1 and are connected to the grid circuits of V2 and V6. Merely suppressing the lower valves will not suppress the top ones since, for the short pulse period, the top valves can draw current from the decoupling capacitors C7, C22. For this reason, the suppression pulses are applied to the grid circuits of the top valves V3, V7 via L4 and C10. C10 blocks the normal gain control voltage. A terminating resistor R14 which matches the characteristic impedance of the LC network, feeding the suppression pulses to the various valves, prevents unwanted pulse reflections in the network. The chokes in the network are wire-wound components not ferrite beads.

SUPPRESSION UNIT

General

27. The suppression unit is mounted on the RF block (*Chap.* 8). It provides the suppression pulses and swept gain waveform for the IF unit. A circuit diagram is given in *fig.* 6 and two views showing the layout of components, in *fig.* 4 and 5.

28. The suppression pulse ensures that the IF strip is rendered inoperative for the period of the transmitter pulse so that it will not be paralysed by transmitter break-through. The swept gain waveform is intended to restrict the gain of the IF unit immediately after the transmitter pulse and then to allow it to increase progressively. This is an attempt to maintain the video pulse output from the unit at a constant level whatever the range of the following aircraft. The main effect of swept gain is to prevent overloading of the final IF stages by short range echoes.

Suppression pulse

29. The positive-going 7 μS prepulse, from the tertiary winding on transformer 5T1 (waveform generator) is applied to a delay line DL1 (*fig.* 6). A 7 μS positive-going pulse, delayed slightly on the prepulse, is obtained from the delay line.

30. The transmitter (*Chap.* 4) is triggered by the trailing edge of the prepulse. The time interval between this trailing edge and the transmitter pulse is influenced by various small delays in the transmitter circuit; the principal delay is caused by the ionization time of the thyratron. The delay line (*fig.* 6) is tapped to give various delay times between the limits of 0·6 and 2·4 μS to allow the suppression circuit to be adjusted to suit the particular thyratron in use in the equipment; this ensures that the trailing edge of the suppression pulse does not occur before the end of the transmitter pulse. The delay time is about 0·16 μS per section. A table showing the sections in circuit for different systems of connections is given in *fig.* 6.

31. The delayed pulse is connected via C1 to the control grid of a pentode V2 which has approximately 16V of negative bias derived from the junction R3, R4. The standing current in the valve is approximately 12mA. The delayed prepulse drives the valve into grid current and a negative-going voltage pulse, approximately 30V in amplitude, is obtained at the valve anode.

32. The coupling capacitor C1 in the control grid circuit has a large value to ensure that the grid voltage does not lag as C1 is charged by grid current. The time constant of the grid circuit is kept short by the low value of the leak resistor R3 thereby ensuring sufficient discharge of C1 in the interpulse periods.

33. The delay line DL1 and its load resistor R3 are deliberately mismatched to give a large pulse amplitude at V2 grid. Owing to the mismatch, a reflected pulse occurs in the open circuit line; this pulse is shunted by the diode D1.

34. The negative-going output pulse from V2 anode circuit is connected via C3 and pole PL6/A2 to the IF unit (para. 25). The normal gain control voltage from the waveform generator is connected to the suppression output via R5. The output line carries the normal gain control voltage as well as the suppression pulses.

35. The voltage at the grid of the suppressed valves in the IF unit tends to rise during the pulse as C3 and the IF unit capacitors charge towards the normal gain voltage via R5 and the source impedance of the gain circuit (*Chap.* 3). The extent of the tendency for voltage rise at the IF grids is determined by the time constant of the IF grid circuits and the amplitude of the suppression pulse. RV1 is included in V2 anode circuit to provide a means of adjusting the suppression pulse amplitude. The setting technique involves adjusting RV1 until the noise level immediately before the transmitter pulse is equal to the noise level immediately after it with the swept gain circuit inoperative.

Swept gain

36. The suppression pulse at V2 anode is connected via contacts A1 to a circuit consisting of C5, D2, RV3, C4. Relay A/1 is operated via a switch (SWEPT GAIN) on the indicator.

37. During the suppression pulse, C4 charges rapidly to the voltage generated at the junction RV3, RV2. After the pulse, the silicon diode D2 cuts off; C4, and the capacitors in parallel with it in the IF strip, discharge at a rate depending on the setting of RV2.

38. The waveform developed across C4 is connected to the grid circuit of V4 in the IF unit and controls the gain of V4 and V5 for a period following the transmitter pulse. When swept gain is in use, the voltage at V4 grid falls to a level determined by the setting of RV3 during the suppression pulse and then rises at a rate determined by the setting of RV2.

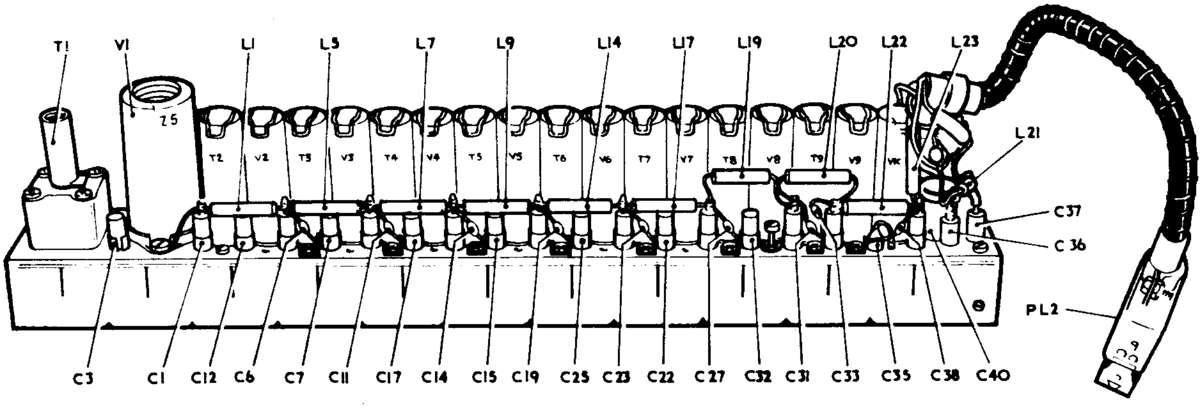


Fig. 1. IF unit 6927 : side view 1

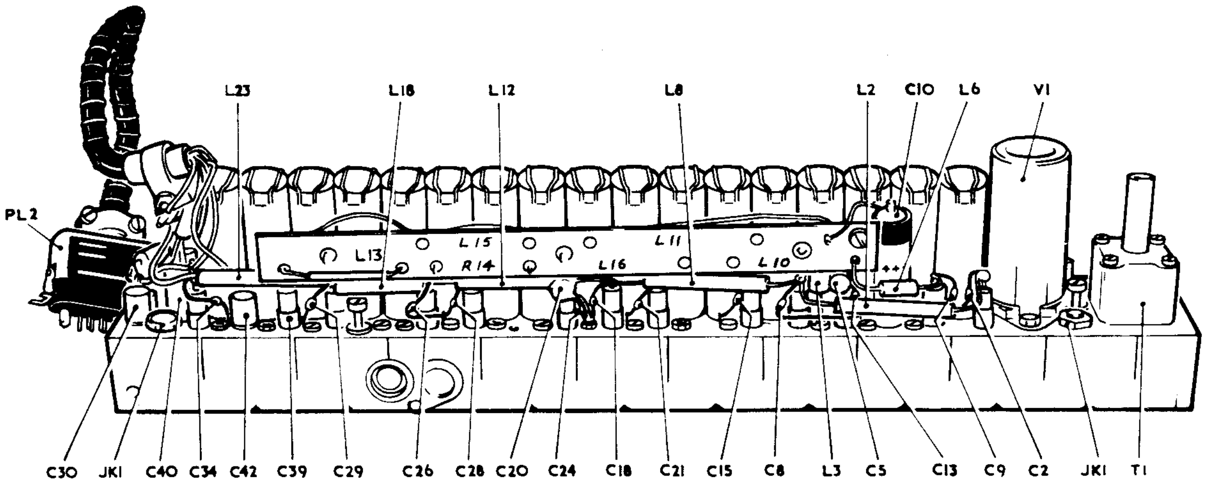
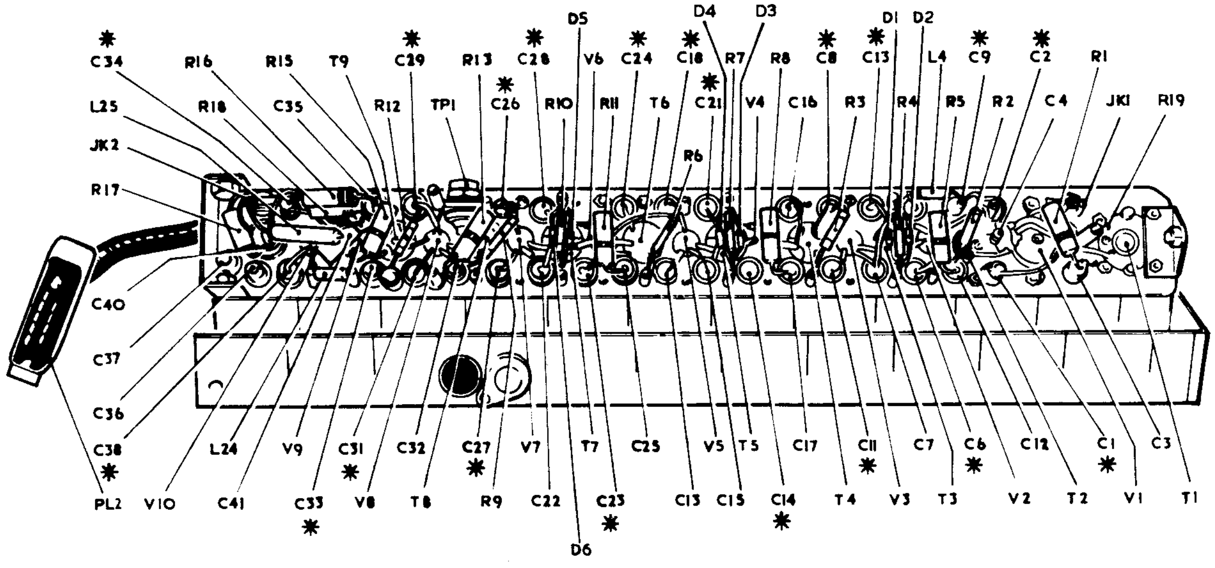


Fig. 2. IF unit 6927 : side view 2



✱ COMPONENTS ON EXTERIOR

Fig. 3. IF unit 6927 : under view

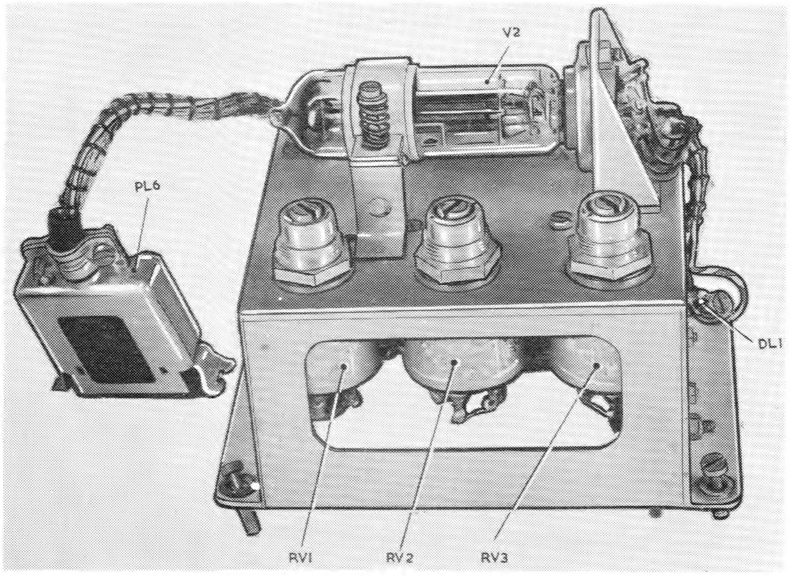


Fig. 4. Suppression unit : top view

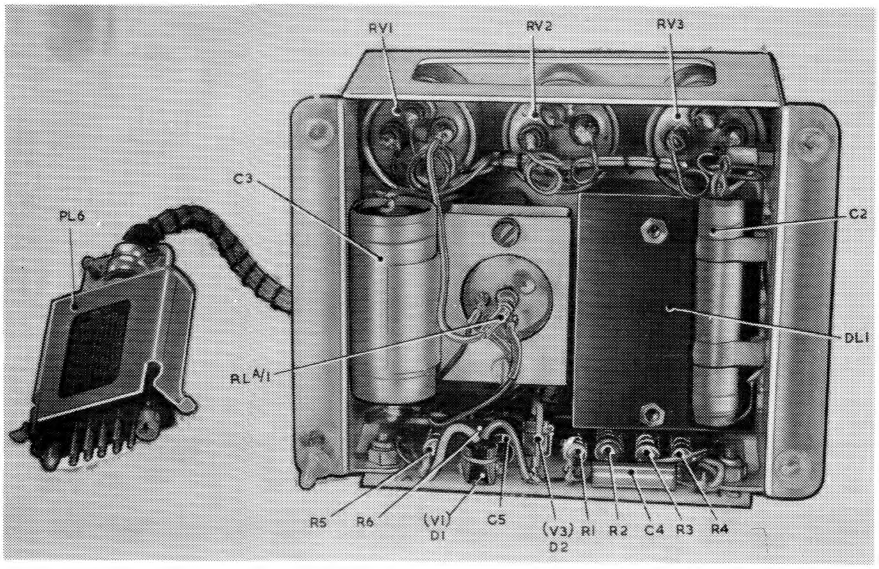
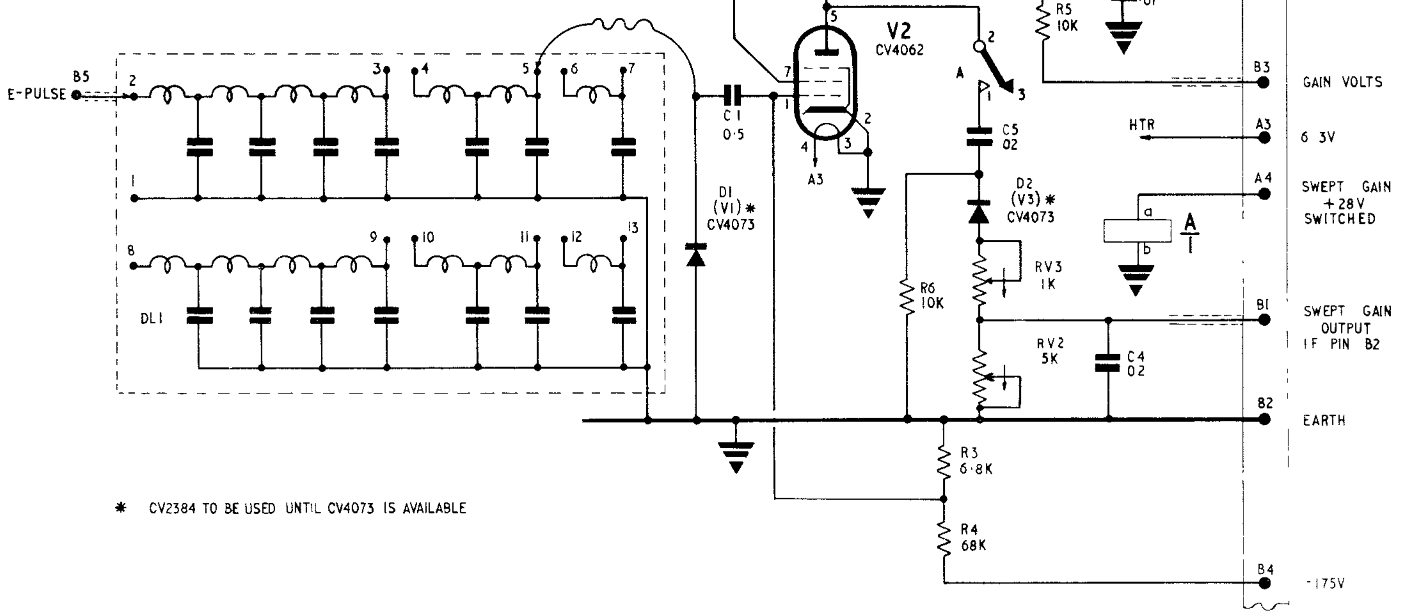


Fig. 5. Suppression unit : under view

INPUT CONNECTION	LINKS	OUTPUT CONNECTION	SECTIONS IN CIRCUIT
2	3-4, 5-6, 7-8, 9-10, 11-12	13	14
2	3-4, 5-6, 7-8, 9-10	11	13
2	3-4, 5-6, 7-8, 9-12	13	12
2	3-4, 5-6, 7-8	9	11
2	3-4, 5-6, 7-10, 11-12	13	10
2	3-4, 5-6, 7-10	11	9
2	3-4, 5-6, 7-12	13	8
2	3-4, 5-6	7	7
2	3-4	5	6
2	3-6	7	5
2	NONE	3	4
4	5-6	7	3
4	NONE	5	2
6	NONE	7	1



* CV2384 TO BE USED UNTIL CV4073 IS AVAILABLE

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ARI 5919-Suppression unit: circuit

Fig. 6

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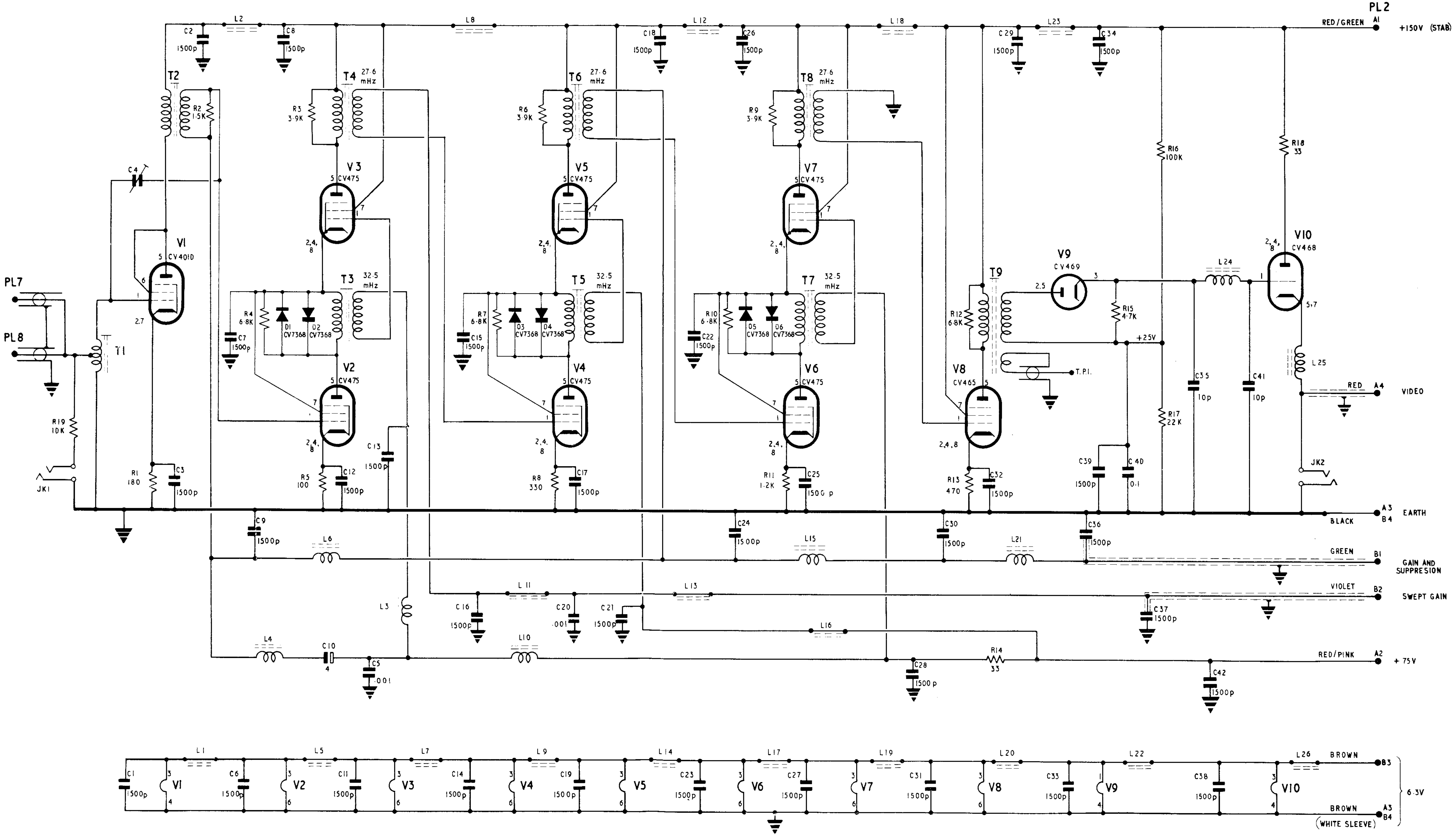

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AL37, Jan. 75

ARI 5919-1F unit 6927: circuit

Fig. 7

Chapter 10

(Completely revised)

AFC SYSTEM

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Introduction

1. The purpose of the AFC system is to control the frequency of the klystron local oscillator in such a manner that the klystron frequency is maintained at 30 MHz above the magnetron frequency.

2. The system has two functions of operation—search and lock. In the search function, the klystron frequency is made to sweep through a band of about 500 MHz; this is done by movement of a plunger in the klystron cavity. At some point during the search action, the frequency of the AFC mixer output (*Chap.* 8) becomes close to 30 MHz; the search action then ceases and the system locks on. After lock on, the klystron frequency is maintained at the value which gives a 30 MHz IF irrespective of variations in magnetron frequency. The frequency control in the lock function is achieved by control of the klystron reflector voltage.

3. The system also ensures that the klystron always operates at the centre of the chosen oscillation mode where maximum power output is obtained. When this requirement is taken into consideration, mechanical and electrical tuning are not independent since variation of one without a compensating variation of the other will move the operating point with respect to the mode boundaries. In the search function, the mode centring action is achieved by adjustment of the reflector voltage during the mechanical tuning action; after lock on, mode centring is achieved by adjustment of the cavity size in step with any change in reflector voltage.

4. The following sub-units are involved.

(1) The klystron local oscillator and tuning mechanism.

(2) The klystron control unit.

(3) Frequency control unit 12131.

(4) Relay unit (klystron) 6928.

(5) The rear tray assembly (part of the main frame assembly).

Items (2) to (4) are sub-units of the RF unit (*Chap*. 8).
Item (1) is part of the RF block assembly.

Method of operation

5. A block diagram of the AFC system is given in *fig*. 1. The output of the AFC mixer is fed through a 30 MHz amplifier to a frequency discriminator. The pulse outputs of this discriminator are applied to sum and difference rectifier circuits which provide control voltages depending on the signal level at the amplifier input ("sum" voltage), and the magnitude and sense of the difference between the frequency of this input and the correct IF ("difference" voltage). The circuit thus provides control information when the AFC mixer output frequency has been brought close to 30 MHz.

6. The klystron plunger is driven through a two-speed gearbox by a constant speed drag-cup motor. When on search, the motor rotates continuously in one direction and the plunger is driven inwards through its complete travel. When the inner limit is reached, the motor drive is automatically disengaged and the plunger is drawn out rapidly by the tension of a return spring; the plunger then starts another inward excursion. At search speed, the tuning rate is so high that the system overshoots the correct tuning point when first locking on; the consequent reversal of the motor automatically changes the gear ratio giving low gear for the final tuning adjustment.

7. A sinusoid generator is triggered by the AFC trigger pulse from the waveform generator. As described in Chapter 3, the AFC trigger pulse is the first pulse in the system and it occurs in a "dead" period (i.e. at a time after the longest range target echoes have been received and before the next transmitter pulse). The sinusoid (one complete cycle of a sinusoidal waveform) is super-imposed on the klystron reflector voltage and is more than large enough to traverse the selected mode of oscillation completely in either direction. The negative-going and positive-going half-cycles of the sinusoid are also used to generate two pulses which gate the AFC crystal current in a time discriminator circuit. If the klystron reflector voltage is the oscillation mode centre voltage, the mean crystal current during one half-cycle of the sinusoid will equal that during the other and there will be no output from the time discriminator. If this is not so, unequal amounts of crystal current will occur and there will be an output from the time discriminator of magnitude and sense depending on the error between the klystron reflector voltage and the correct mode current centre voltage for that particular plunger position.

8. In the search function, the output of the time discriminator controls the klystron reflector voltage in such a manner that mode centre conditions are maintained throughout the mechanical tuning sweep. When lock-on occurs, the klystron reflector voltage is controlled by the difference output of the frequency discriminator and the output of the time discriminator is transferred to the tuning motor control circuit. Thus, after lock-on, any change in IF is immediately countered by a change in klystron frequency brought about by automatic control of reflector voltage. This action causes a departure from mode centre which demands a change in cavity size; this change in cavity size, in turn, causes an output from the frequency discriminator which moves the reflector voltage nearer mode centre. The system finally settles down at a cavity size and reflector voltage which gives the correct frequency with the klystron operating at the centre of the mode.

9. Power is applied to the tuning motor via the contacts of a centre-stable relay whose operation is controlled by a valve known as the motor valve. The klystron reflector is fed through an integrating stage.

10. The connections from the two discriminators to the integrator and the motor valve are determined by the state of a lock-on relay. When the frequency of the AFC mixer output falls outside the bandwidth of the frequency discriminator, no sum or difference outputs are obtained and the lock-on relay is not energized. In this condition, the output of the time discriminator is connected to the integrator and the motor valve is biased so that the motor turns continuously in the correct direction for search. In this manner, the klystron frequency is swept through its whole range while operating in the centre of the oscillation made.

11. The search action causes an IF of 30 MHz to be produced at some point during the search cycle and this produces sum and difference outputs from the frequency discriminator. The sum output operates the lock-on relay which switches the output of the time discriminator to the motor control valve and connects the difference output of the frequency discriminator to the integrating stage. The system now works to hold the AFC mixer output frequency constant at 30 MHz with the klystron operating at mode centre.

12. The lock-on relay will operate when the klystron reaches a frequency 30 MHz above or below the magnetron frequency. The difference output from the frequency discriminator is incorrect for control on the low channel and if the relay operates on this channel, the IF is driven away from 30 MHz and the relay releases. The klystron reflector voltage moves back immediately to mode centre voltage which returns the IF to near 30 MHz and the lock-on relay operates again. The release of the lock-on relay operates another relay which ensures that the tuning motor continues to drive in the search direction until the high channel is encountered, when the lock-on action can take place in the normal manner.

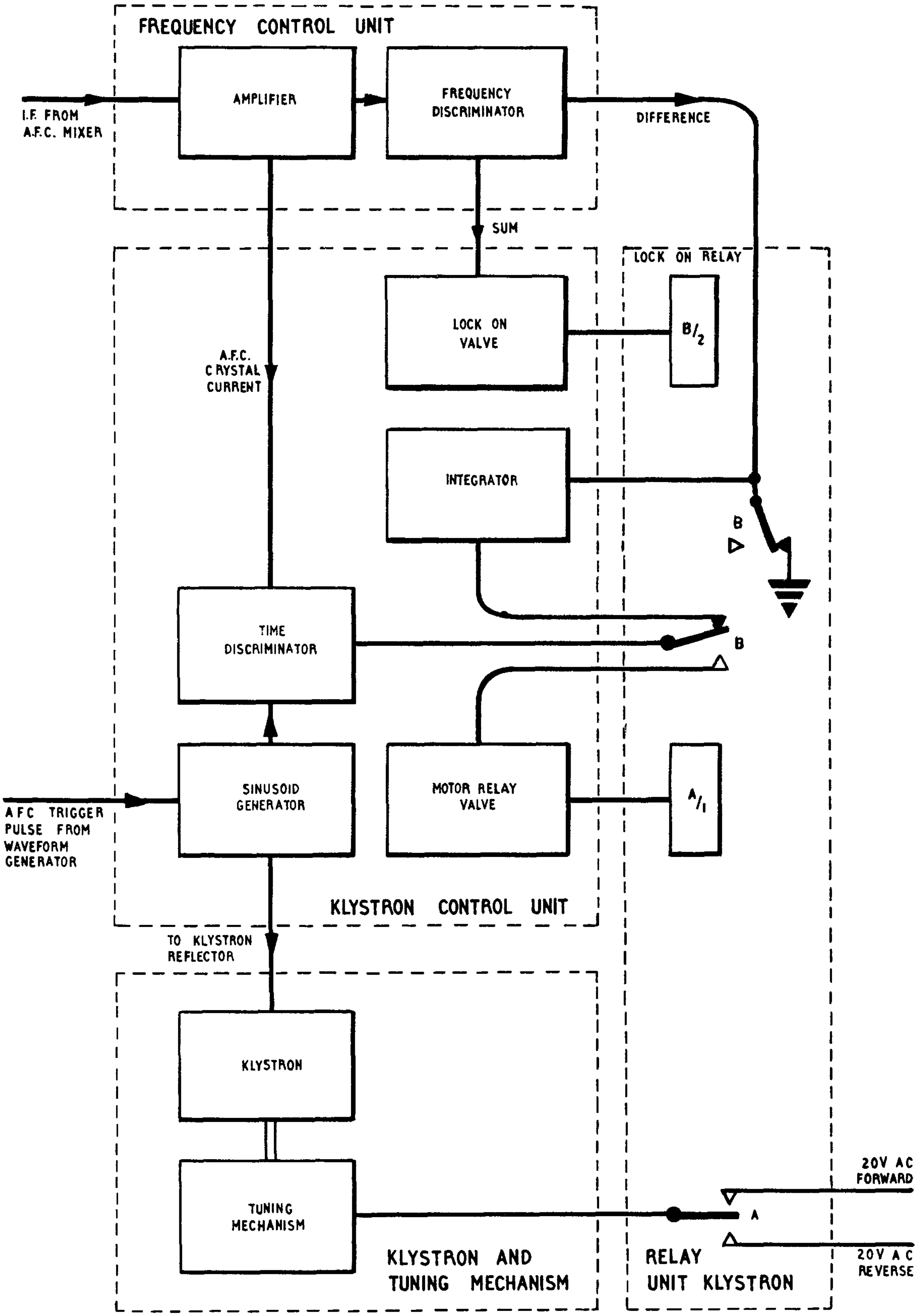


Fig. 1. AFC system block diagram

CIRCUIT DESCRIPTION

13. A complete circuit diagram of the AFC system is given in *fig.* 20. This is intended to assist in following the circuit description and for fault finding. Separate circuit diagrams of the various sub-units are given in *fig.* 15, 18 and 19. The rear tray assembly, although concerned with the AFC system is referenced as part of the main frame. A separate circuit diagram of the rear tray is given in *fig.* 17 for convenience in this chapter. It is also included in the complete interconnection diagram in *Chap.* 2.

14. Interconnections between the various sub-units are given in Chapter 8 although the connections relevant to the AFC system alone are included in *fig.* 20 (this chapter). The following component referencing conventions should be noted with regard to *fig.* 20.

(1) Components on RF unit sub-units are prefixed with the number of the plug making connection between the sub-unit and the block wiring.

(2) Components of the RF block assembly are prefixed "B" (block) e.g. the klystron is BV1 since it is V1 in the RF block series of reference.

(3) Main frame components (rear tray assembly) are prefixed "G".

(4) Plug and socket poles are referenced in a similar manner to other components but an oblique stroke is included. Thus 4C1 is capacitor C1 on the klystron control unit but 4/C1 is pole C1 on plug 4 (klystron unit).

Frequency control unit 12131

15. This unit consists of a broad-band IF amplifier followed by a frequency discriminator and sum and difference rectifier circuit. The unit provides two d.c. outputs when the IF falls within its bandwidth. One of these outputs represents the signal level at the input terminals and it indicates that a signal is present having a frequency close to the correct IF. The other output is proportional to the difference between the input signal frequency and the correct IF. The polarity of the difference output is negative when the signal frequency is high and positive when it is low.

16. The unit is constructed in a similar manner to the IF unit (*Chap.* 9); views, showing the layout of components are given in *fig.* 8, 9 and 10.

17. The output from the AFC mixer (*Chap.* 8) is connected via PL9 to the primary winding of transformer 3T1. IF signals are developed across the transformer primary and the d.c. component of the AFC crystal current is passed via a filter circuit 3C1, 3L1, 3C6 to the klystron control unit (para. 51). Chokes 3L1 to 3L3 consist of ferrite beads.

18. The transformer ratio is such that suitable power transfer is obtained together with broad bandwidth. The signals developed across the secondary windings are applied to the control grid of 3V2 and via 3C3 to the control grid of 3V1.

19. Valves 3V1 and 3V2 are connected in d.c. series across the 150V h.t. supply in a manner similar to that employed for the IF amplifier valves in the IF unit (*Chap.* 9). The +75V reference potential for the top valve is obtained from the junction 3R1, 3R2. The standing current of both valves is determined by the bias developed across 3R3, the cathode load of 3V2.

20. The anode loads of 3V1 and 3V2 are formed by the IF transformers 3T3, 3T2. The transformers have step-down ratios to give maximum power transfer to the thermionic diodes 3V3, 3V4. Capacitors 3C9, 3C10 swamp the capacitance of 3V3, 3V4. The circuits are tuned by means of ferrite cores in the transformers. 3T2 is tuned to 32 MHz and 3T3 to 28 MHz; the input transformer 3T1 is tuned to 30 MHz.

21. The IF signal pulses, (coincident with the transmitter pulses) from 3V1 and 3V2 are rectified by the diodes 3V3, 3V4 and $\frac{1}{2}\mu$ S video pulses are obtained across the diode loads 3R4, 3R5.

22. Test points are provided at the diode cathodes for use when setting up with CW applied to PL9. With an AVO connected to one of the test points, that channel can be tuned with the test point of the other channel earthed. The method eliminates trouble caused by interaction.

23. Valves 3V5 and 3V6 are straightforward video amplifiers; they operate with about 4·5V of bias derived from the junction 3R6, 3R7. Negative-going pulses, coincident with the transmitter pulses, are obtained at the anodes of the valves. When the input frequency at plug PL9 is 30 MHz, the pulses at 3V5 and 3V6 anodes have the same amplitude. When the frequency is below 30 MHz, 3V6 produces larger pulses than 3V5; when it is above, 3V5 produces the larger pulses.

24. The anodes of 3V5, 3V6 are connected via 3C14, 3C15 to a network containing 3R10 to 3R17, 3C16 to 3C19 and the silicon diodes 3D1 to 3D4.

25. For negative-going pulses at 3V5 anode, capacitors 3C14, 3C17, 3C18 form a series circuit between the valve anode and earth since the diodes 3D2, 3D4 conduct. The current flowing through the capacitor chain partly discharges 3C14 and partly charges 3C17 and 3C18.

26. During the interpulse periods, the diodes do not conduct and the charges on the capacitors change as follows.

(1) 3C14 charges via 4R22, 3R11 and 3R18.

(2) 3C17 discharges via 3R15 and 3R13.

(3) 3C18 discharges as described in para. 29.

27. A similar action involves valve 3V6. Here, the series capacitor circuit during the pulse periods is 3C15, 3V7, 3C16, 3V9, 3C19.

28. The diodes 3D1, 3D3 do not conduct during the interpulse periods and

(1) 3C15 recharges via 3R9, 3R10, 4R22.
(2) 3C19 discharges via 3R17.
(3) 3C16 discharges as described in para. 29.

Sum output

29. During the interpulse periods, the resistor 4R22 is common to the charging circuit of 3C15 and 3C14 (para. 25 and 27) and the current which flows through this resistor is the sum of the charging currents. The magnitude of the current depends on the amount by which the capacitors discharge during the pulse periods: this, in turn, depends on the amplitude of the pulses at 3V5, 3V6 control grids. The voltage developed across 4R22 by the current flow forms the sum output and its presence indicates that the frequency of the AFC mixer output is within the bandwidth of the frequency control unit. The sawtooth component of the sum output is smoothed by 4C8.

30. The sum output is used to drive the lock-on valve 4V10 in the klystron control unit (para. 61), and, in order to ensure that 4V10 is cut off in the absence of the sum output, resistor 4R22 is returned to a potential of —12V at the junction 4R24, 4R26.

31. The various waveforms encountered in the circuit are given in Fig. 2; these were taken with the AFC system locked on. The sum voltage is obtained by the addition of waveforms 2 and 7. These show that the capacitors 3C14, 3C15 recover to approximately +4V not to —12V as might be expected. This is because of the effect of 4C8 and grid current in 4V10 in the operated condition.

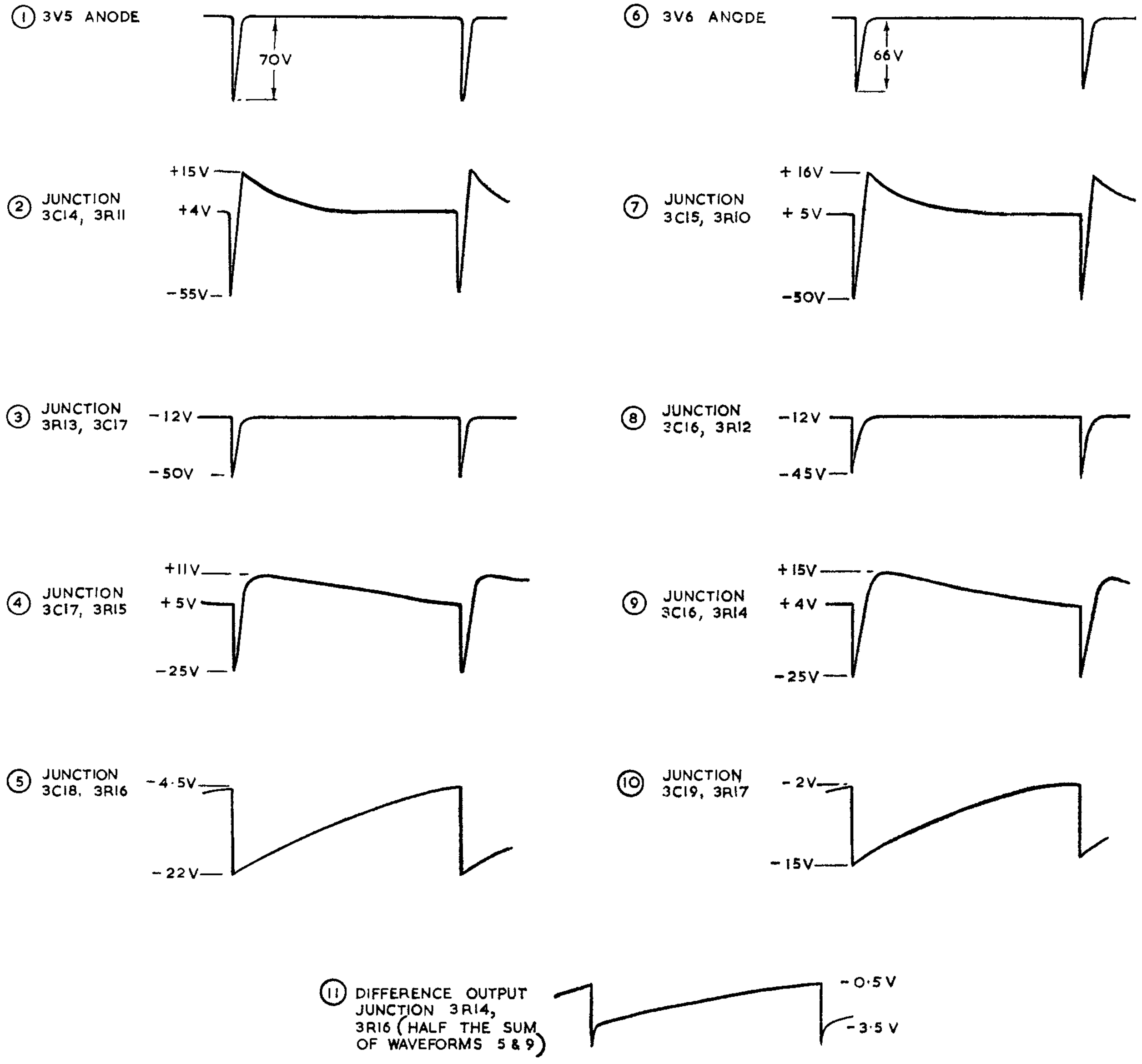


Fig. 2. Frequency control unit 12131 : typical waveforms

Difference output

32. As described in para. 25 and 26, the silicon diodes conduct during the pulse period and capacitors 3C16 and 3C19 receive charges from 3C15, 3C14. The difference output is taken from the junction 3R16, 3R14 where the voltage waveform follows a pattern equal to half the sum of the discharge waveforms of 3C18 and 3C19. The discharge path for these capacitors is 4R23, 4R24, 3R12, 3C16, 3R14, 3R16, 3C18. Note that under no signal conditions the output of the circuit is earthed by contacts 5B (para. 61) and 3C16 therefore carries a standing charge of 12V due to the lock-on valve bias. Removal of the earth will not alter this state of affairs and the charge on 3C16 will always exceed that on 3C18 by 12V; this fact does not affect the operation of the circuit. Similarly the charge on 3C17 always exceeds that on 3C18 by 12V. Note the −12V level on waveforms 3 and 8 (*fig.* 2).

33. The sawtooth component of the difference voltage is smoothed by the action of the integrator 4V12 (para. 66). When equal pulses appear at 3V5, 3V6 anodes, the voltage distribution across 3R14, 3R16 is symmetrical about earth and the junction of the resistors remains at earth potential. If the pulse amplitudes are not equal, a sawtooth voltage waveform appears. Waveform 11 (*fig.* 2) illustrates such a voltage and is for the normal on-tune condition with the IF slightly high (pulses at 3V5 grid greater than those at 3V6). When the IF is low, 3V6 grid receives the larger pulses and the output waveform is of opposite phase with its mean positive to earth.

34. Under equilibrium conditions, the IF is controlled about a value very slightly above 30 MHz since the average value of the voltage at pole 3/A2 must be slightly negative to earth if the integrator 4V12 is to work near the centre of its characteristic. The situation is taken care of during setting up when the integrator anode voltage is adjusted to +75V for equilibrium. Since the IF amplifier portion of the FCU is centred on 30 MHz an input higher than this is required for a negative output. The difference is infinitesimal (a few kHz) owing to the high loop gain of the system.

Output characteristics

35. The curves given in *fig.* 3 illustrate the relation between sum and difference outputs and input frequency. In preparing the curves, the input was derived from a pulsed signal generator. The sum output was measured across a 1 megohm load using a valve voltmeter. The difference output was similarly measured using a 2 megohm load.

Klystron and tuning mechanism

36. The tuning mechanism is mounted on an aluminium alloy casting which forms the klystron cavity. The klystron valve is mounted in this cavity and the whole assembly is fixed to the r.f. block (*Chap.* 8). The klystron valve makes electrical contact with the cavity by a ring of beryllium-copper 'fingers'. Complete annular contact between the valve and the 'fingers' must be maintained since if any one of the 'fingers' is not in good contact with the valve it can cause loading of the cavity, resulting in reduction or complete loss of a.f.c. crystal current over part of the cavity tuning range. Electrical connections to the klystron are made from socket SK12 on the rear tray assembly via a free plug (PL 12) and cable to a socket which mates with the klystron base.

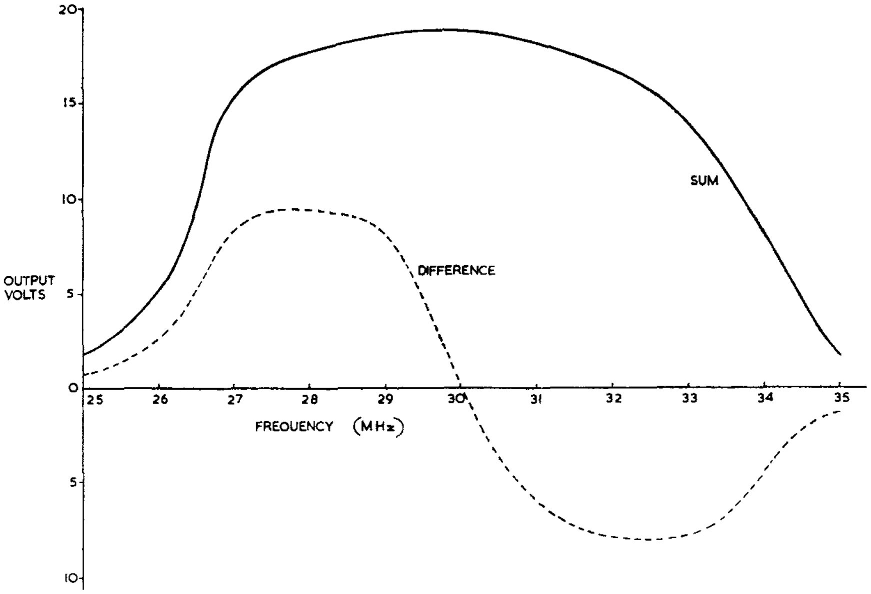


Fig. 3. Frequency control unit 12131 : output characteristics

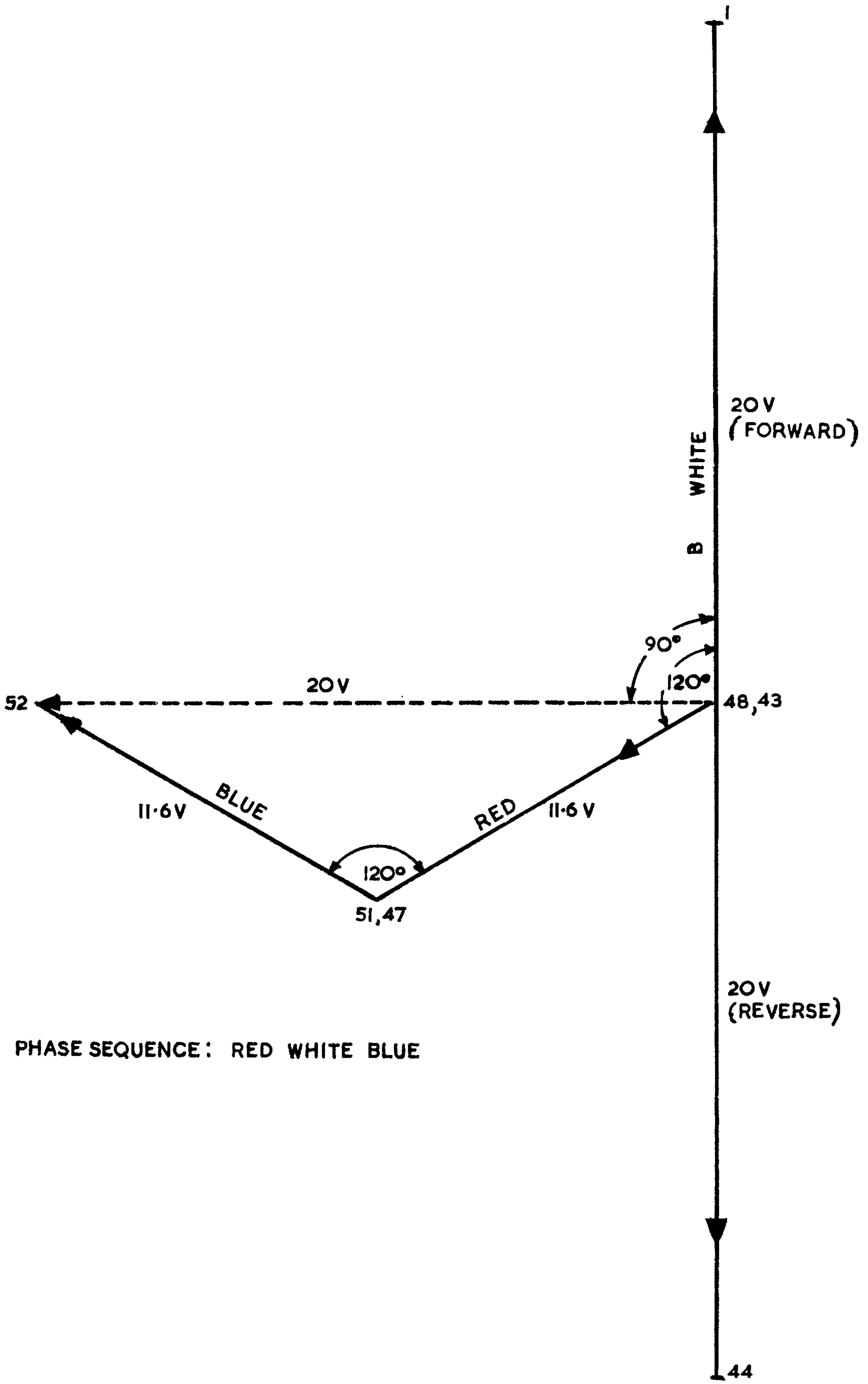


Fig. 4. Tuning motor supplies: vector diagram

Tuning motor

37. The tuning motor requires a two-phase supply and this is obtained from the main power transformer (*Chap.* 11). The motor connections are shown in Fig. 20.

38. Two supplies of 11·6V r.m.s. having a phase difference of 120° are derived from secondary windings 47,48 and 51,52 on the main power transformer GT2 (main frame). The voltage obtained between terminals 48 and 52 is 20V r.m.s.; this voltage is in quadrature with the voltage obtained from a 40V centre tapped winding 1,44 on the transformer. A vector diagram is given in Fig. 4.

39. The main winding of the tuning motor is supplied with the 20V from terminal 52 via contacts E1 of the master relay unit (*Chap.* 5) when the switch on the indicator is set to TRANSMIT. The quadrature winding of the motor is supplied via contacts A1 (klystron relay unit) from terminal 1 or 44 (GT2) depending on the state of relay 5A. Operation of the relay thus causes the motor to rotate in one direction or the other. The connection from the moving contact of the relay to the motor winding is made via the 25-pole test plug.

40. The motor relay (relay 5A/1 in the klystron relay unit) is a centre stable polarized relay having two operating coils. One of the coils is per-

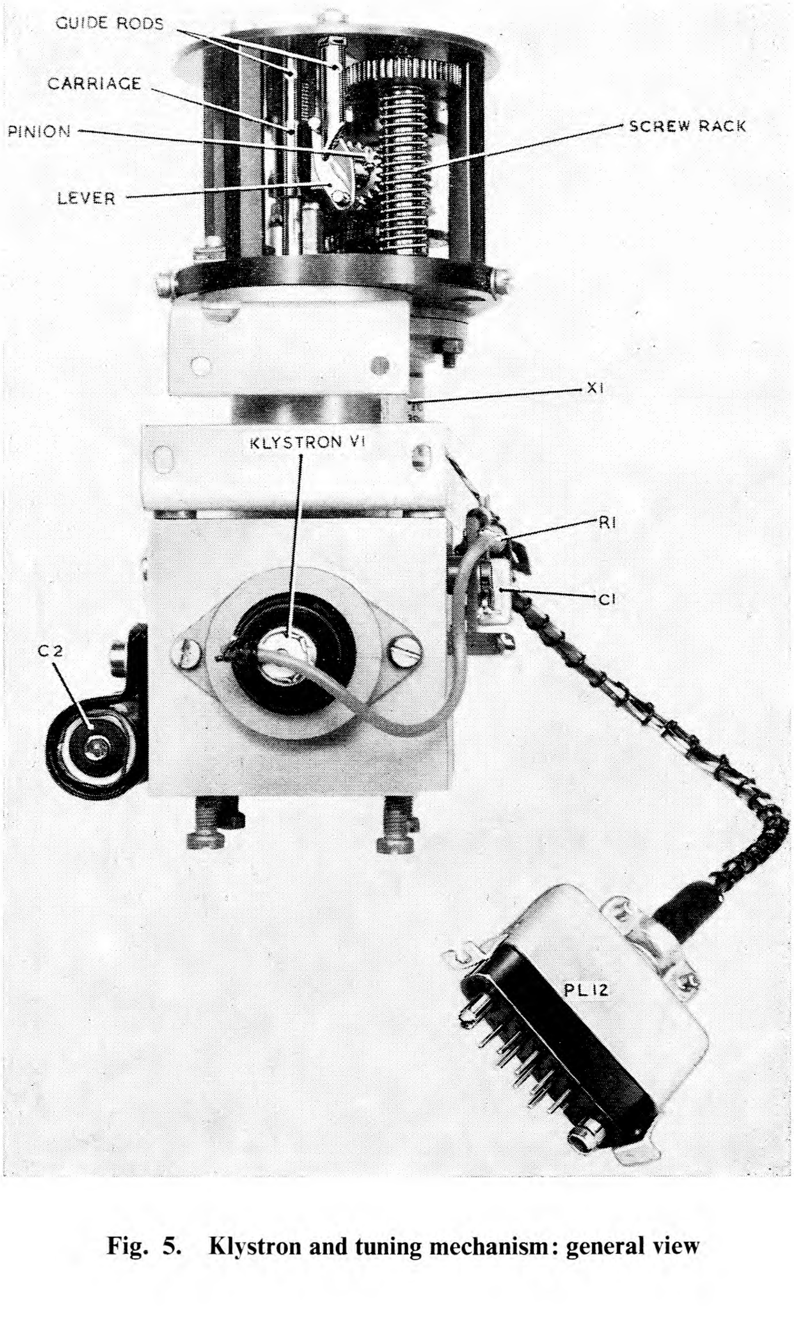


Fig. 5. Klystron and tuning mechanism: general view

manently energized from the +150V supply; the other forms the anode load of the motor relay valve 4V11. Under search conditions, the motor valve is biased so that relay contact 10 makes to 9 and the motor runs continuously in one direction. After lock on, the motor valve is fed with the output of the time discriminator and provides an on-off control of the motor for rotation in either direction.

Tuning mechanism

41. A view of the klystron and tuning mechanism is given in Fig. 5. The klystron tuning plunger is connected to a carriage which slides on guide rods. The carriage carries a pinion which is prevented from turning by a lever which bears on another guide rod. The pinion engages a screw rack which is driven by the motor through gearing.

42. On search, the motor drives continuously in one direction. Since the pinion cannot rotate, rotation of the screw rack drives the plunger into the cavity giving a progressive increase in klystron frequency. When the plunger reaches the inner limit, the lever preventing the pinion rotation slips off the end of its guide rod and the worm wheel becomes free to rotate. The carriage and plunger are drawn back rapidly under the action of a tension spring until the other end of the lever strikes the guide rail, setting a limit to the outward movement of the plunger. The cycle continues until lock-on occurs.

43. The rate of plunger movement during the search action is too great for satisfactory control after lock on. To prevent the system from being unstable, the gear train between the motor shaft and the screw rack includes an automatic gear change device. This operates when the motor reverses giving a greater gear reduction over a range corresponding to about one turn of the screw rack. When the rack has made this turn, high gear is automatically engaged until the next reversal of the motor.

Klystron control unit

44. The klystron control unit contains:

(1) The sinusoid generator.
(2) The time discriminator circuit.
(3) The motor relay valve.
(4) The lock-on valve.
(5) The integrating stage which controls the klystron reflector voltage.

Views of the unit, showing the layout of components are given in Fig. 11 and 12.

Sinusoid generator

45. The AFC trigger pulse from the waveform generator (*Chap.* 3) is applied to the KCU at pole 4/C1 and is connected via a diode 4D1 to the control grid of 4V2. Diode 4D1 normally conducts via 4R1 and the winding of the pulse transformer supplying the AFC trigger pulse in the waveform generator. The grid of 4V2 is therefore at earth potential during the interpulse periods. Under these conditions, the current through 4V2 is approximately 12mA. This current is unaffected by valve changes owing to the heavy d.c. feedback across 4R2 in the cathode circuit. Valve 4V3 is normally cut off by the voltage at the junction 4R5, 4R6.

46. The negative-going 1 μS trigger pulse (waveform 1, Fig. 6) reduces the current through 4V2 and through the primary of transformer 4T1. The resulting positive-going pulse at one end of 4T1 secondary winding is applied to 4V3 grid and that valve starts to conduct. 4V3 anode potential falls taking with it the grid of 4V2 by coupling via 4C3. The action is cumulative and ceases when 4V3 is fully conducting and 4V2 cut off. Capacitor 4C2 holds the junction of 4T1 primary and 4R2 at earth potential so allowing 4V2 to be cut off. Diode 4D2 clamps the junction of 4C2, 4R2 to a maximum negative potential at 4C2 anode of approximately ½ volt during the warm up time of 4V1 when due to the absence of current flow in 4R2 this point would otherwise be at −175V approximately. The primary winding of 4T1 now rings with the capacitor 4C1 connected across it: the period of the ring is approximately 30 μS and the first half-cycle is negative-going. The grid circuit of 4V3 includes a series resistor 4R3 which limits grid current and prevents the ring from being damped.

47. The second half-cycle of the ring is positive-going at 4V2 cathode and negative-going at 4V3 grid. 4V3 cuts off and its anode potential rises taking with it the grid of 4V2. The diode 4D1 prevents 4V2 grid from rising above earth potential but 4V2 cannot conduct since the ring holds its cathode potential up. At the end of the second half-cycle 4V2 conducts and the cathode current, passing through 4T1 primary, damps the ring and stops it.

48. The resulting waveform across the primary and secondary of 4T1 is thus a single cycle of a sine waveform: this is known as a sinusoid (waveform 3, *fig*. 6).

49. An output is taken from the primary tap on 4T1 and is connected to the klystron reflector via pole 4 A4 and a capacitor 4C3 on the RF block. Two outputs are taken from 4T1 secondary winding; one (first half-cycle positive-going) is applied via 4R7 to 4V4 grid (waveform 7, Fig. 6) and the other (second half-cycle positive-going) is applied via 4R9 to 4V5 grid (waveform 6, Fig. 6).

Time discriminator

50. Valves 4V4 and 4V5 are gate valves which share a common cathode load 4V6. The gate valve control grids are biased by the voltage at the junction 4R5, 4R6 which is fed via the secondary winding of 4T1. Ideally, this bias voltage should be sufficient to cut off the valves in the quiescent

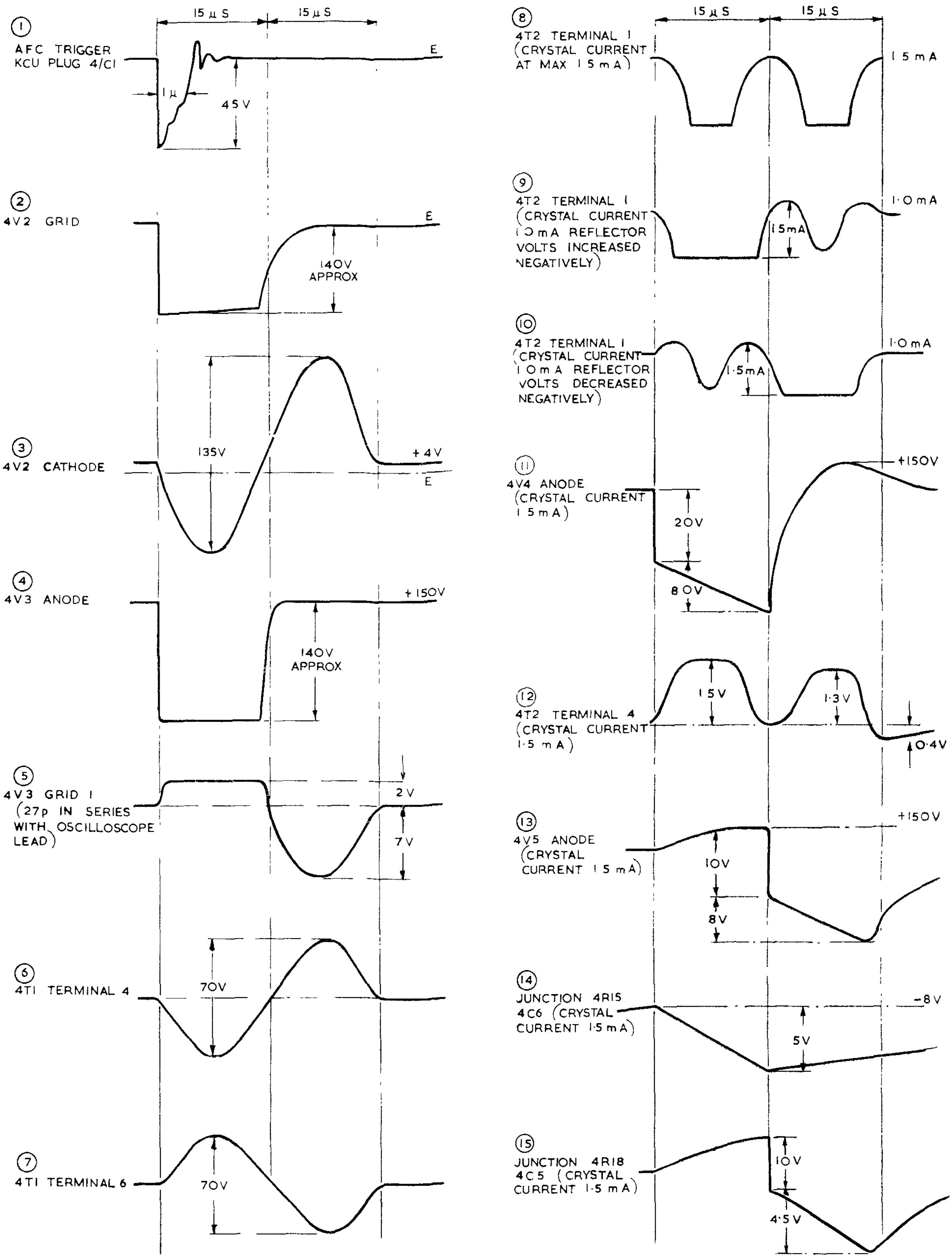


Fig. 6. Klystron control unit: waveforms

state but, owing to the spread of tolerances in components and valves, small anode currents (up to about 0·5mA) may flow in some equipments. The effect of these standing anode currents is unimportant as far as the efficient working of the circuit is concerned but confusing waveforms may be encountered during servicing.

51. The a.f.c. crystal current return line from the frequency control unit (para. 17) passes to earth via pole 4/C3 and the primary of transformer 4T2. A lead, from the junction of 4T2 primary and 4R16 is connected via poles 4/C5 and G6/B2 to pole Q of the 25-pole test plug D; this provides a point for crystal current monitoring. When monitoring the crystal current, the meter is connected between poles Q and Z (earth) of the test plug and the meter is then shunted by 4R16 in the KCU; in normal operation, poles Q and Z of the test plug are shorted by a link which also shorts 4R16.

52. The impression of the sinusoid on the klystron reflector voltage (para. 49) causes the crystal current to vary in the manner shown in Fig. 7. The curve marked "klystron mode" shows the variation in crystal current (or output power) for variations in reflector voltage. If the klystron is in fact operating at mode centre voltage when the sinusoid arrives (as shown in the upper drawing), a symmetrical crystal current waveform is generated. The lower drawing shows a condition where the mean crystal current is 1·0mA corresponding to a mean reflector potential below the mode centre value. It can be seen that the crystal current waveform obtained is not now symmetrical since the mean value during the first (negative-going) half-cycle of the sinusoid is less than that during the second half-cycle. If the klystron operates at a reflector voltage more positive than the mode centre value, it will be found that the first half-cycle of the sinusoid generates the greater average crystal current.

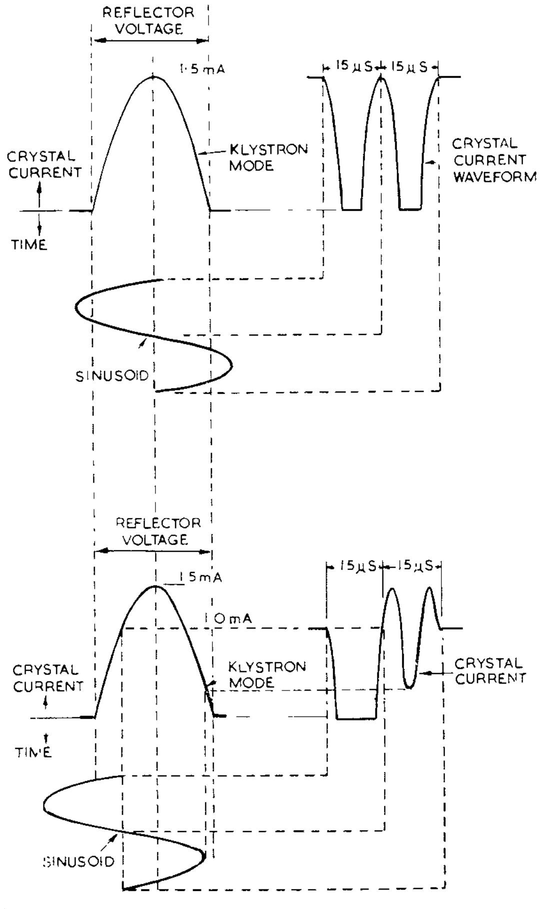


Fig. 7. Generation of the crystal current waveform

53. The output from the secondary winding of transformer 4T2 is applied to the grid of 4V6. The voltage waveform obtained during the sinusoid is roughly the inverse of the current waveform so that a falling crystal current causes a rising current through 4V6. It should be noted that 4V6 grid voltage only changes while the crystal current is changing; when the crystal current is steady, 4V6 grid rests at the potential of the —175V line. The voltage waveform for a typical mode centre operating condition is shown in waveform 12 (Fig. 6).

54. In the quiescent state, the current passed by 4V6 flows to earth via the silicon diode 4D3 since valves 4V4, 4V5 are cut off by the bias at the junction 4R5, 4R6. The first half-cycle of the sinusoid is positive-going at 4V4 grid (waveform 7, Fig. 6) so that 4V6 current is diverted through 4V4 for this period. The second half-cycle of the sinusoid is positive-going at 4V5 grid so that 4V6 current is then diverted through 4V4.

55. The anode circuit of 4V4 includes the network 4C4, 4D4 and 4C6. In the equilibrium condition, there will be a negative charge on capacitor 4C6. At the onset of current through 4V4 the anode voltage of the valve drops sharply until the amplitude of the negative voltage edge passed through 4C4 is equal to the charge of 4C6. The silicon diode 4D4 then conducts and 4V4 anode voltage now follows an exponential decay as capacitors 4C4, 4C6 discharge through 4V3 and 4V5. The result of this action is that the voltage across 4C4 decreases and that across 4C6 increases.

56. When current is cut off in 4V4, the diode 4D4 cuts off also. 4V4 anode voltage rises steeply at first and then exponentially as determined by 4R13, 4C4, 4R8. The exponential rise is towards h.t. but there may be a fall after the end of the complete sinusoid as 4V4 goes back into a small standing current (para. 50). The waveform at the junction 4C4, 4R13 is similar but at a lower d.c. level—this is not illustrated.

57. The waveform at the junction 4C6, 4R15 is shown in Fig. 6 (waveform 14). This consists of a negative-going exponential during the current pulse through 4V4 followed by an exponential discharge as 4C6 discharges through the network

4R15, 4C5, 4R11. The time constant of the circuit is too long for this discharge to be complete during the interpulse period so that a negative charge remains at the start of the next sinusoid (para. 55).

58. A similar argument covers the action of valve 4V5. The anode waveform is shown in Fig. 6 (waveform 13). The positive-going portion at the start of the waveform is due to the cut-off of the standing current in the valve by the first part of the sinusoid. The second half of the sinusoid drives the valve into current giving a negative-going edge sufficient to drive the voltage at the junction 4C5, 4R13 down to that at the junction 4R17, 4C7 resulting from the charge left on 4C7 from the preceding pulse. The silicone diode 4D5 then conducts discharging 4C7, 4C5 through the diode and 4V4. At the end of the current pulse through 4V5, the diode cuts off and the voltage at 4V5 anode rises exponentially as 4C5, 4C6 recharge via 4R15, 4R11.

59. The waveform across 4C7 is similar to that across 4C6 but is some 15 μS later; i.e. the negative-going slope is coincident with the second half of the sinusoid.

60. The output of the circuit is taken from the junction 4C5, 4R15. The waveform here is similar to that at 4V5 anode but at a lower d.c. level. The d.c. level, depends on two factors—firstly the mean charge of 4C5 and secondly the mean charge on 4C6. The charge lost by 4C5 during the current pulse through 4V5 is determined by the magnitude of the current pulse and this in turn depends on the mean current driven through 4V5 by the crystal current waveform during the second half of the sinusoid. Similarly, the negative charge gained by 4C6 during the current pulse through 4V4 depends on the mean crystal current during the first half of the sinusoid. Briefly, if the mean current passed by 4V6 during the first portion of the sinusoid exceeds that during the second the d.c. level of the output waveform at the junction 4R15, 4C6 becomes negative to the equilibrium level. Conversely, if 4V6 passes the greater current during the second half of the sinusoid, the level of the output waveform is positive to the equilibrium level.

Lock-on valve

61. When the frequency of the a.f.c. mixer output is outside the bandwidth of the frequency control unit, the lock-on valve 4V10 is cut off by the voltage at the junction 4R24, 4R26. When the i.f. becomes close to 30 MHz, an output is obtained from the sum circuit of the FCU and as described in para. 29 this output appears across 4R22. Valve 4V10 then conducts and the lock-on relay (relay 5B/2 in the klystron relay unit) in the anode circuit of the valve, operates. The lock-on relay has two contact sets. One set makes a connection from the time discriminator output to the grid of the integrator 4V12 on search and to the grid of the motor relay valve 4V11 at lock on. The other contact set releases an earth at the input end of 5R2 effectively connecting the difference output of the FCU to the grid of the integrator valve 4V12 at lock on; it also initiates the action of the relay system in the klystron relay unit which ensures that a stable lock-on condition can only be obtained when the klystron frequency is 30 MHz above the magnetron frequency.

Motor relay valve

62. The motor relay valve 4V11 has one of the coils of the polarized 5A/1 in its anode circuit; the other coil is connected in series with a resistor 5R1 across the 150V h.t. supply.

63. In search function, the connection from the junction 4R18, 4R19 to 4V11 control grid is broken by the lock-on relay contacts; the current through the valve is determined by the bias derived from the junction 4R23, 4R24. This current, being less than the current through the second coil of the motor relay causes the relay contacts to assume a position giving the correct motor rotation for search.

64. When the lock-on relay operates, the junction 4R18, 4R19 is connected to 4V7 grid and the stage comes under the control of the time discriminator. When the klystron operates at mode centre, the current passed by 4V7 is such that equal currents pass through the two coils of the motor relay; the relay contacts assume a centre-stable condition and the motor stays at rest.

65. If the klystron reflector voltage should become more negative than the mode centre voltage, as a result of the controlling action of the FCU, a negative output is obtained from the time discriminator; this decreases the current through 4V7 and operates the motor relay to give motor rotation in the normal (search) direction. Conversely, if the klystron reflector voltage is insufficiently negative reverse rotation of the motor is obtained.

Integrating stage

66. Valve 4V12 is connected as a Miller integrator having GR31 (fixed deck) as its anode load. A "virtual earth" may be considered to exist at the control grid of the valve and the anode voltage (hence the klystron reflector voltage) depends on the voltage existing across the feedback capacitor 4C9.

67. On search, the time discriminator output is connected to 4V12 grid via contacts 2, 3 of the lock-on relay 5B and the current in 4R18 determines the charge (or discharge) rate of 4C9. When the klystron operates at mode centre, no current flows in 4R18 and 4V12 anode voltage remains static. If the klystron reflector is too negative, the current in 4R18 charges 4C9, and 4V12 anode voltage (hence the klystron reflector voltage) rises until mode centre operation is obtained and the time discriminator output assumes the equilibrium level. Conversely, a klystron reflector voltage less negative than mode centre voltage gives a reverse current in 4R18 which discharges 4C9 causing the reflector voltage to become more negative.

68. The action of the integrator on lock is similar to that on search but the lock-on relay connects the difference output of the FCU to the stage instead of the time discriminator output. The difference output of the FCU is a measure of the error between the existing IF and the correct IF of 30 MHz; this output determines the current which flows via 5R2 to 4V12 grid so providing automatic control of the klystron reflector voltage.

Rear tray assembly

69. This unit carries certain components associated with the supply of the various electrode voltages required for the klystron. The unit also carries the timing unit (*Chap.* 5). A circuit diagram of the assembly is given in *fig.* 17 and a view, showing the layout of components, in *fig.* 16.

70. The circuit, consisting of the neon valves GV25 to GV32, GRV1 and GR32, is connected between the anode of the integrator valve 4V12 and the —1kV smooth voltage from the main power supply (*Chap.* 11). The connection from GV25 to 4V12 anode is made via a shorting link between poles O and N of the 25-pole test plug D.

71. The oscillation mode chosen from the klystron is the one which occurs when the reflector is some 180V negative to the klystron cathode. The klystron resonator is earthed and the cathode is supplied with —300V from the stabilizer chassis (*Chap.* 11). Owing to the action of GV25 to GV32, the voltage of the junction of GV32 and GRV1 is always approximately 480V negative to the anode voltage of 4V12; that is, approximately 400V negative to earth and 100V negative to the klystron cathode. The additional negative voltage required at the reflector is obtained by adjustment of GRV1 during setting up. The use of the chain of neons enables a change in 4V12 anode voltage to appear at a different mean d.c. level at the klystron reflector with less attenuation than would be the consequence with a purely resistive potentiometer network.

72. The heater voltage for the klystron is obtained from terminals 49, 50 of the main h.t./l.t. transformer GT2. Terminal 49 of the transformer is connected to the unsmoothed −350V line (*Chap.* 11).

73. The various klystron supply voltages are connected to socket G/12 (rear tray): from here, connections are made to the klystron base socket (RF unit) via a free plug and cable. Connections to the timing unit (*Chap.* 5) are made via soldering tags.

Relay unit (klystron) 6928

74. The unit contains the lock-on relay 5B/2 (para. 61), the motor relay 5A/1 (para. 62) and the system of relays (para. 61) which ensures that stable lock-on conditions can only be maintained on the high channel (i.e. klystron frequency 30 MHz above magnetron frequency): this system includes relays 5C/2, 5D/1 and 5E/1. Relays 5D/1 and 5E/1 form what is known as a binary scaler; they relate the operation of relays 5C/2 to relay 5B/2 by a scale of two. If relay 5B/2 makes a number of successive operations, relay 5C/2 makes half that number. A circuit diagram is given in *fig.* 15 and views of the unit, showing the layout of components are given in *fig.* 13 and 14.

75. The difference output of the FCU is connected to the relay unit at pole 5/C4. When on search, this pole is earthed via contacts 5B5, 6 alone or by both 5B5, 6 and 5C2, 3 depending on the condition of relay 5C/2 which in turn depends on the action of the binary scaling relays 5D/1 and 5E/1.

76. As already described, when the IF becomes close to 30 MHz an output is obtained from the FCU sum channel and this causes 4V10 to conduct and operate the lock-on relay 5B/2. Assuming that the klystron frequency is 30 MHz above the magnetron frequency, the polarity of the FCU difference output is correct for control and, assuming also that relay 5C/2 is operated,operation of the lock-on relay releases the earth at pole 5/C4 and allows the difference output to control the klystron reflector voltage (hence the klystron frequency) via the integrator stage. At the same time, the mode centring voltage is connected via contacts 5B1, 2 and 5C4, 5 to the motor valve grid ensuring that the motor controls the mode centring operation.

77. If relay 5C/2 is released, when the lock on relay operates, the earth at pole 5/C4 is maintained by contacts 5C2, 3. The integrator operates without bias and its anode voltage (hence the klystron reflector voltage) runs down rapidly. This drives the IF outside the band of the FCU and the lock-on relay promptly releases. The release of the relay has two effects. Firstly, it operates the binary scaler (para. 80) causing relay 5C/2 to operate; secondly it reconnects the mode centring voltage to the integrator grid which retunes the IF close to 30 MHz causing the lock-on relay to operate again. At the second operation, relay 5C/2 is operated and lock is maintained.

78. The circuit action, when a 30 MHz IF is obtained with the klystron frequency below the magnetron frequency, is as follows.

79. Immediately the IF is obtained, the lock-on relay operates. If relay 5C/2 is released, the integrator runs down and causes the lock-on relay to release as described in para. 77. This causes relay 5C/2 to operate and the lock-on relay operates again. This time, the sense of the difference output is incorrect and the IF is driven away from 30 MHz instead of towards it. The lock-on relay therefore releases again, and the action of the binary scaler releases relay 5C/2 so that the action is continuous. Relay contacts 5C4, 5 play a part in the action since they are connected in series with the motor valve grid. Thus, during the periods when relay 5C/2 is released, there is no control voltage applied to the motor valve grid and the motor drives in the search direction as determined by the bias applied to 4V11 from the junction 4R23, 4R24. The resultant effect of this is that the lock-on relay chatters for a period sufficient for the tuning motor to drive the IF through the FCU bandwidth at half speed. The lock-on relay then remains released until the high channel is encountered when the action described in para. 76 and 77 takes place.

Binary scaler

80. The binary scaler consists of relays 5D/1 and 5E/1. Its function is to control the action of relay 5C/2 in such a manner that it is released for one operation of the lock-on relay and operated for the next and so on.

81. Relays 5D/1 and 5E/1 have two operating coils each. For either relay to operate, only one of its coils must be energized; either relay will release if both its coils are energized or both de-energized.

82. In the configuration shown in *fig.* 15 and 20 all the relays are released. When the lock-on relay 5B/2 operates, contact 5B5 makes to 5B4. The *a,b* winding of relay 5D/1 is energized via 5V1 and the *c,d* winding via 5R5 and contact 5D1; since both windings are energized contacts 5D/1 remain released. Relay 5C/2 remains released since it can only operate if contacts 5D2, 3 are made. The *a,b* coil of relay 5E/1 is energized via 5V1 and 5R6; contact 5E2 makes to 5E3 and provides a holding circuit.

83. The next release of the lock-on has no effect on relay 5E/1 since the *a,b* coil of the relay (energized in para. 82) is held by contacts 5E2, 3. The *c,d* coil of relay 5D/1 de-energizes but the *a,b* coil is held via contacts 5E2, 3. Relay contacts 5D2, 3 make energizing relay 5C/2.

84. When the lock-on relay operates again, the *a,b* coil of relay 5E/1 is energized via 5V1, 5R6 and the *c,d* coil via 5R7 and contacts 5D2, 3: contacts 5E1, 2 make. Coil *a,b* of relay 5D/1 is energized via 5V1, 5R4 but the circuit of coil *c,d* is broken since contact 5D1 remains made to 5D2. Relay 5C/2 remains energized.

85. Since, in para. 84 contacts 5E2, 3 are broken, a further release of the lock-on relay 5E/1 removes the earth connection from all the relays 5D/1, 5E/1 and 5C/2. The circuit relaxes to the condition shown in *fig.* 20 and the conditions of para. 82 are obtained.

86. The relay operating sequence is summarized in the following list.

Operation	Relay 5B/2	Relay 5D/1		Relay 5E/1		Relay 5C/2
		Winding	Contacts	Winding	Contacts	
1	Off	a, b, Off c, d, Off	Released	a, b Off c, d, Off	Released	Off
2	On	a, b, On c, d, On	Released	a, b, On c, d, Off	Operated	Off
3	Off	a, b, On c, d, Off	Operated	a, b, On c, d, Off	Operated	On
4	On	a, b, On c, d, Off	Operated	a, b, Off c, d, Off	Released	On
1	Off	a, b, Off c, d, Off	Released	a, b, Off c, d, Off	Released	Off

87. Test points are provided on plug PL5 to enable the relay circuit to be checked on the bench.

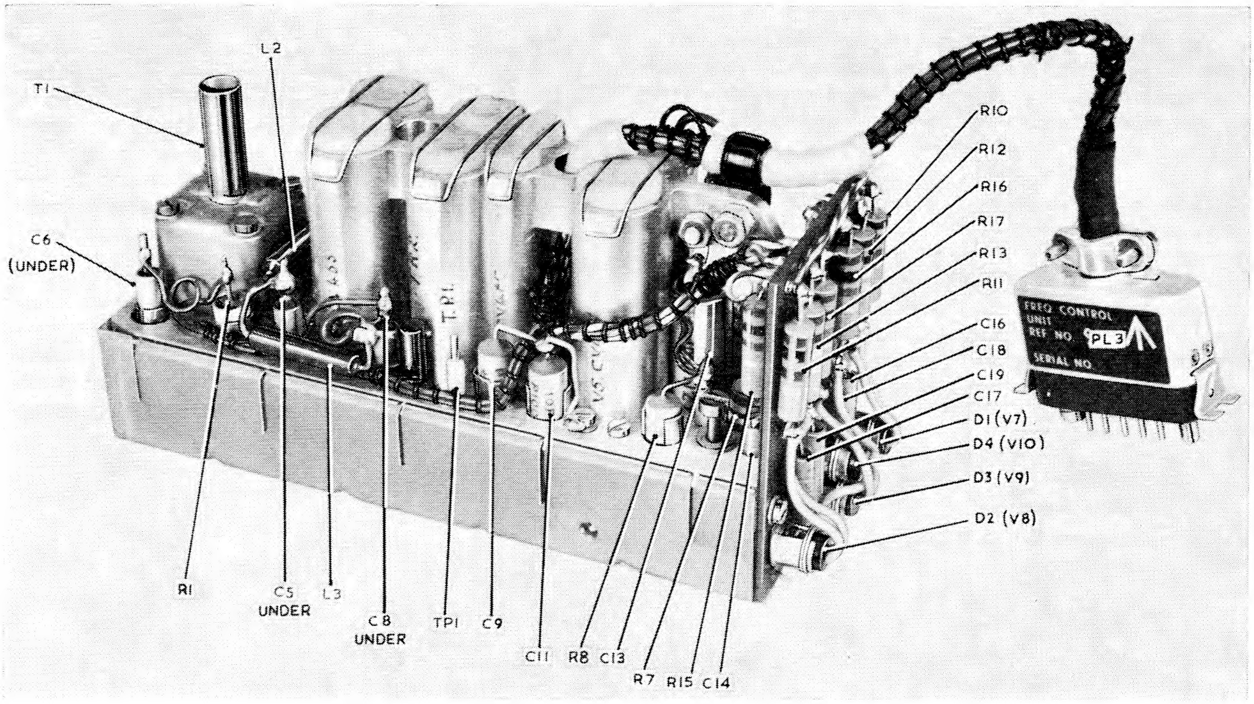


Fig. 8. Frequency control unit 12131: side view (1)

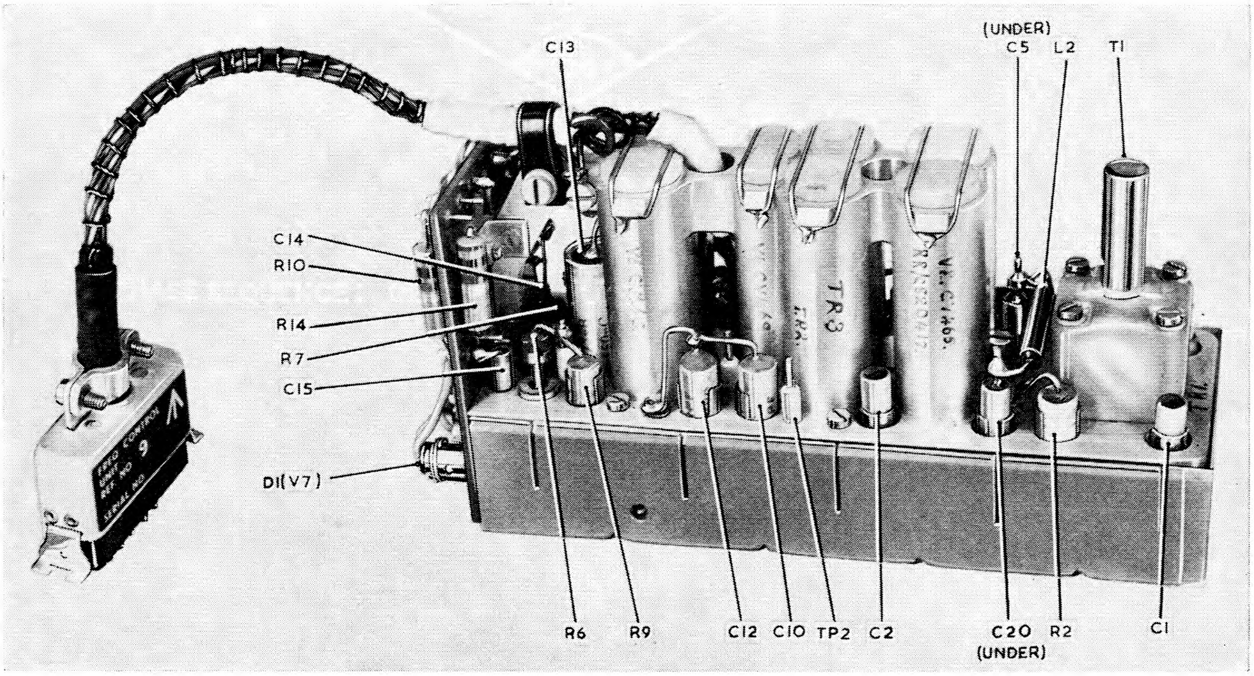


Fig. 9. Frequency control unit 12131: side view (2)

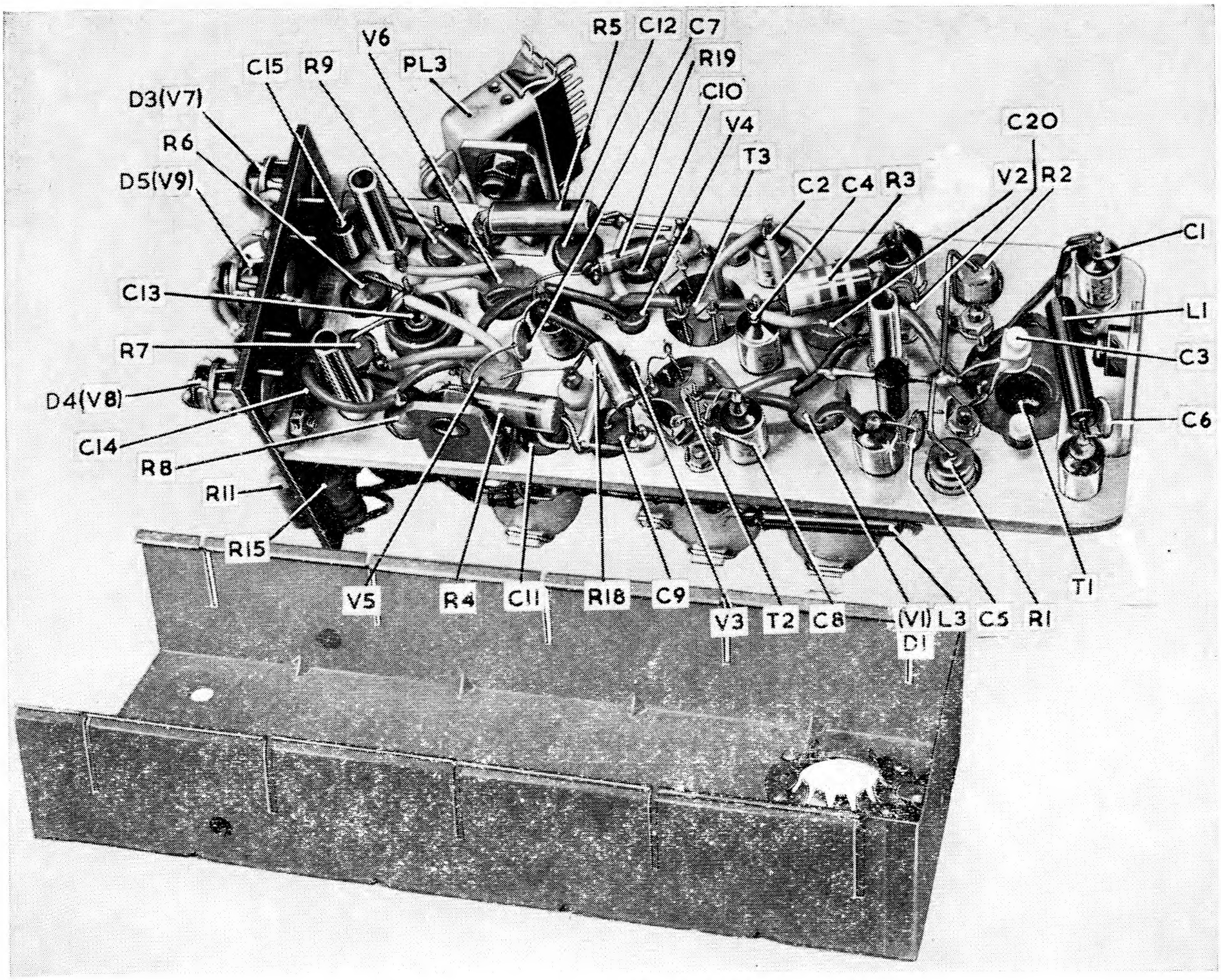


Fig. 10. Frequency control unit 12131: under view

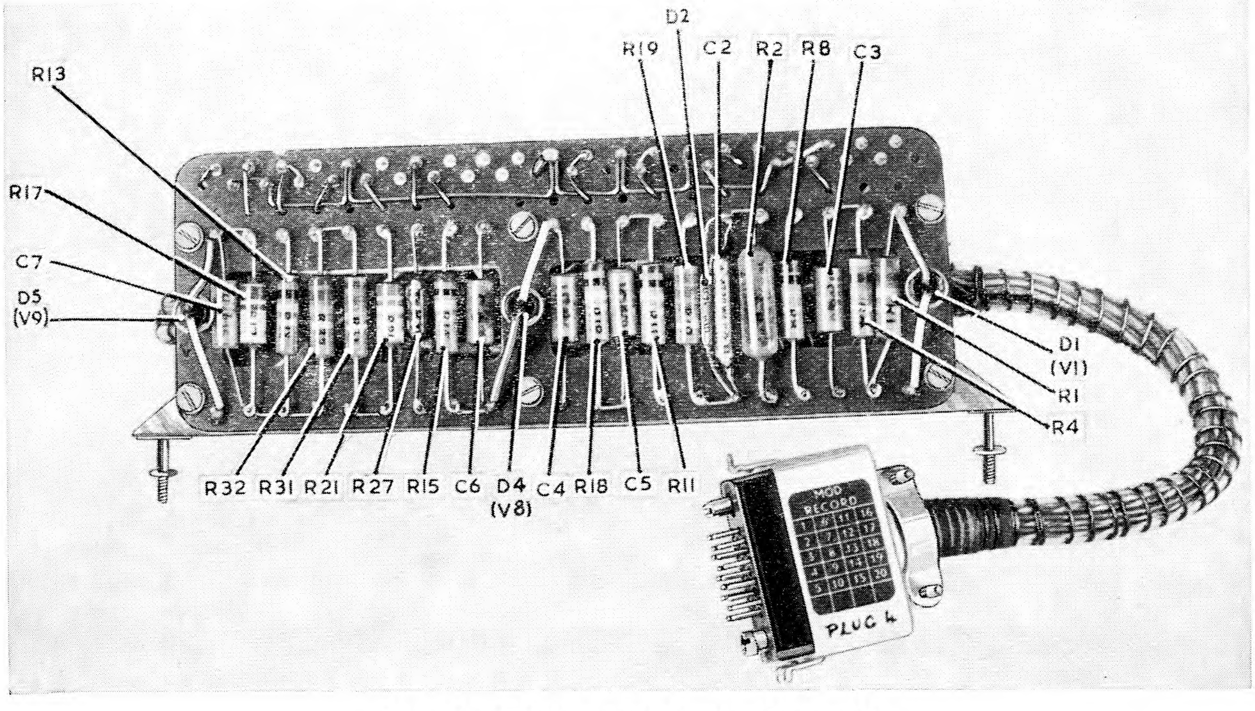


Fig. 11. Klystron control unit: side view (1)

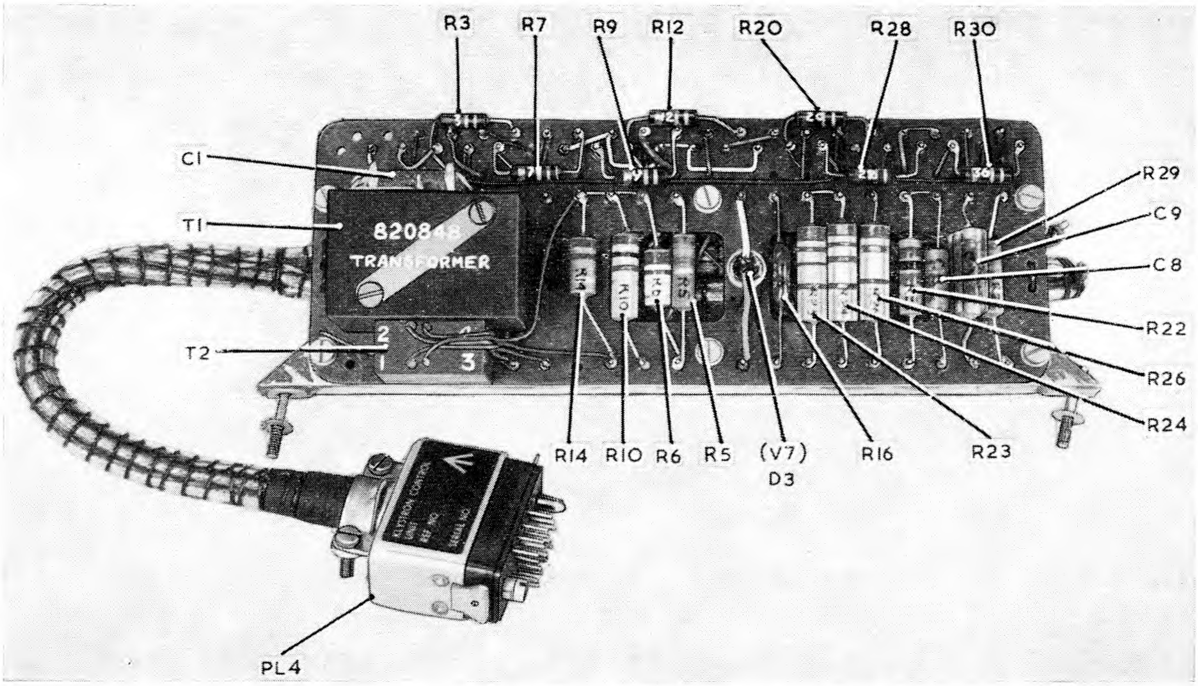


Fig. 12. Klystron control unit: side view (2)

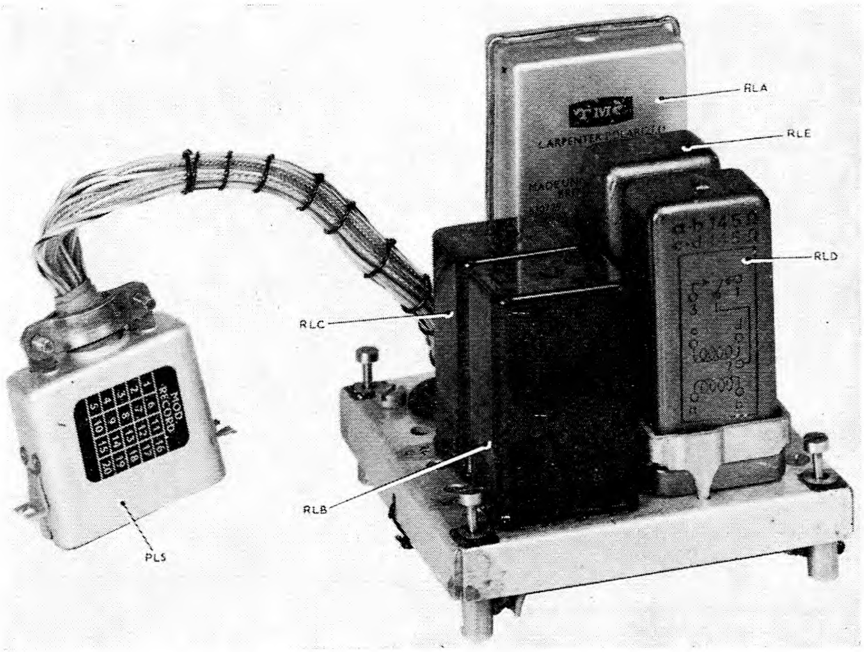


Fig. 13. Relay unit klystron 6928: top view

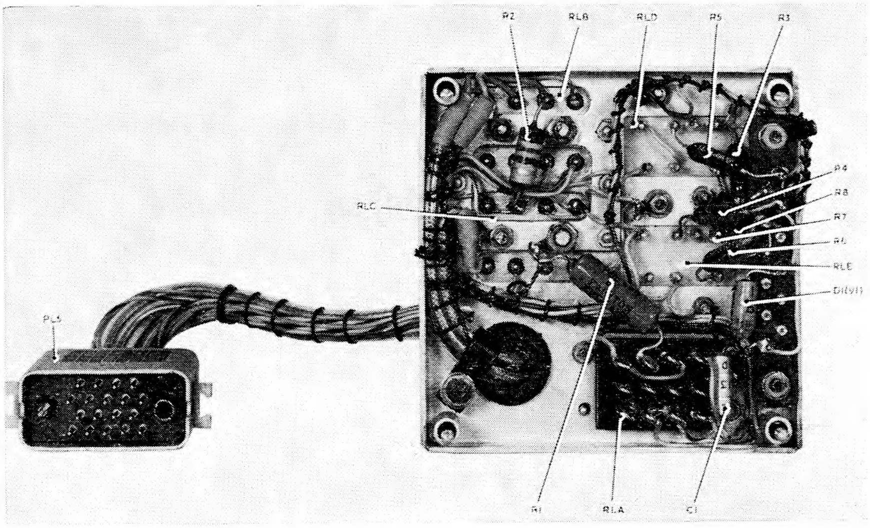
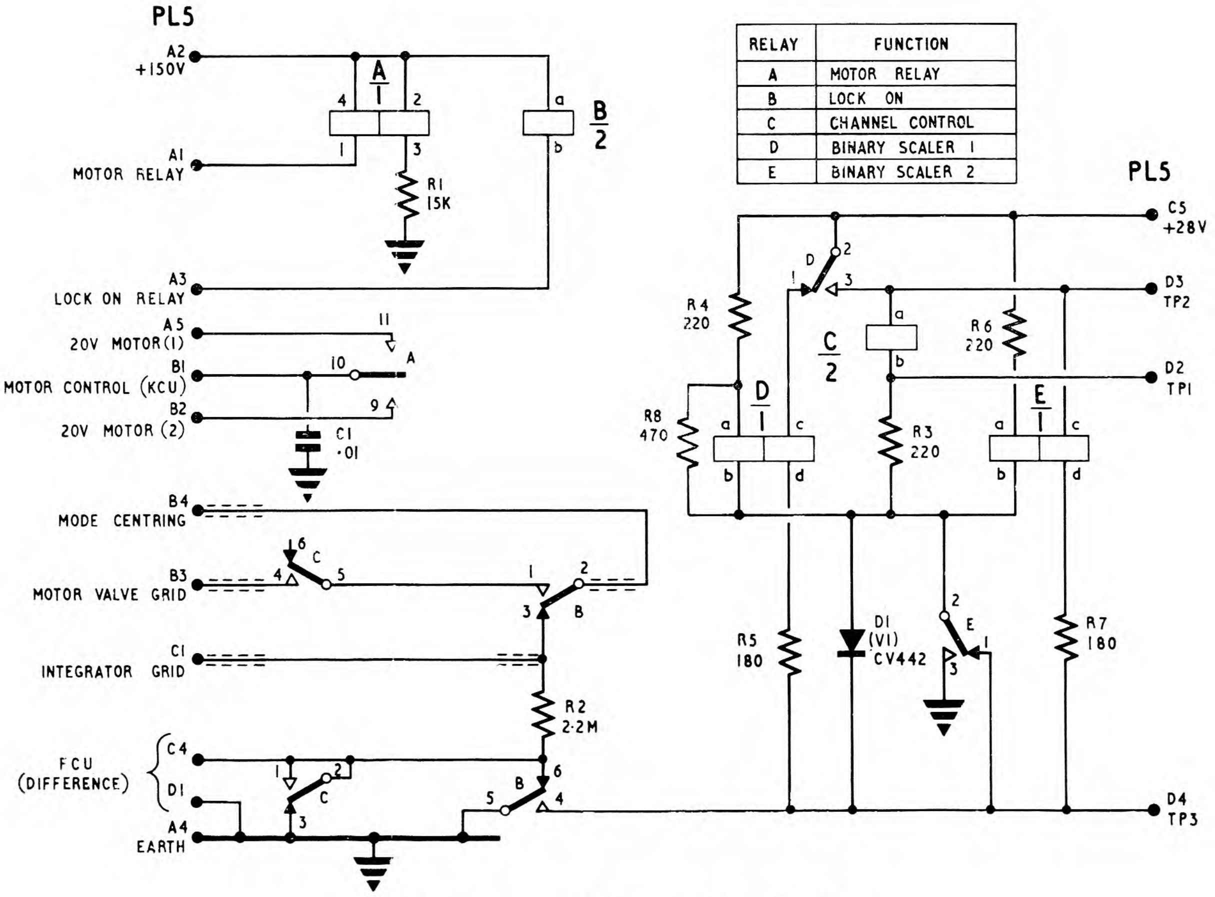


Fig. 14. Relay unit klystron 6928: under view



RELAY	FUNCTION
A	MOTOR RELAY
B	LOCK ON
C	CHANNEL CONTROL
D	BINARY SCALER 1
E	BINARY SCALER 2

Fig. 15. Relay unit klystron 6928: circuit

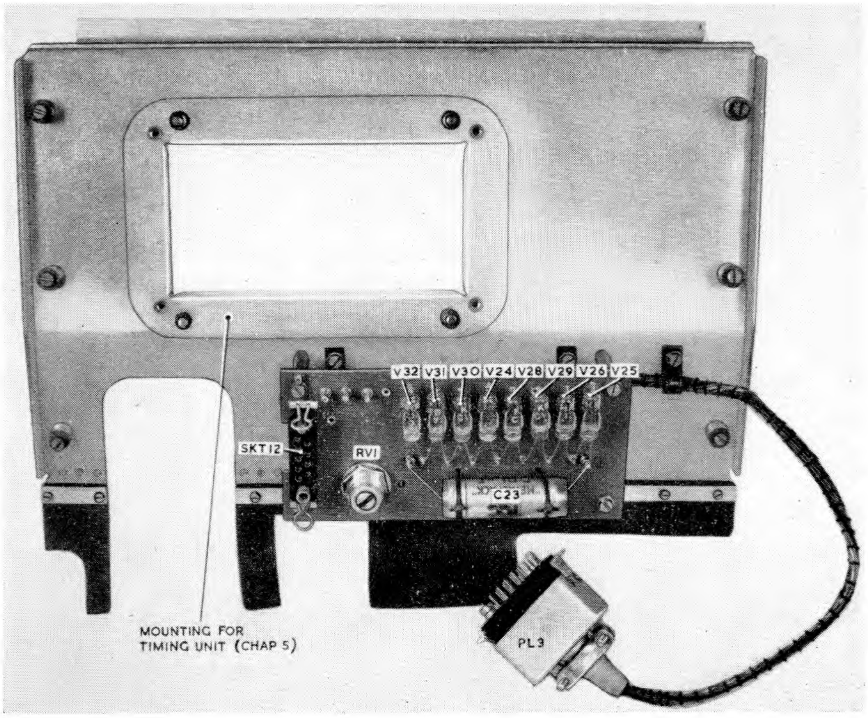


Fig. 16 Rear tray assembly: top view

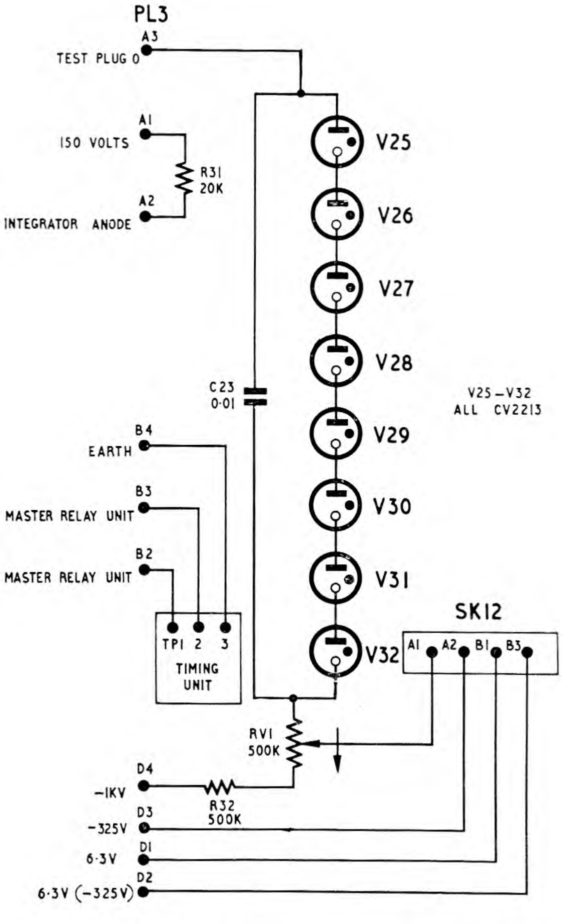
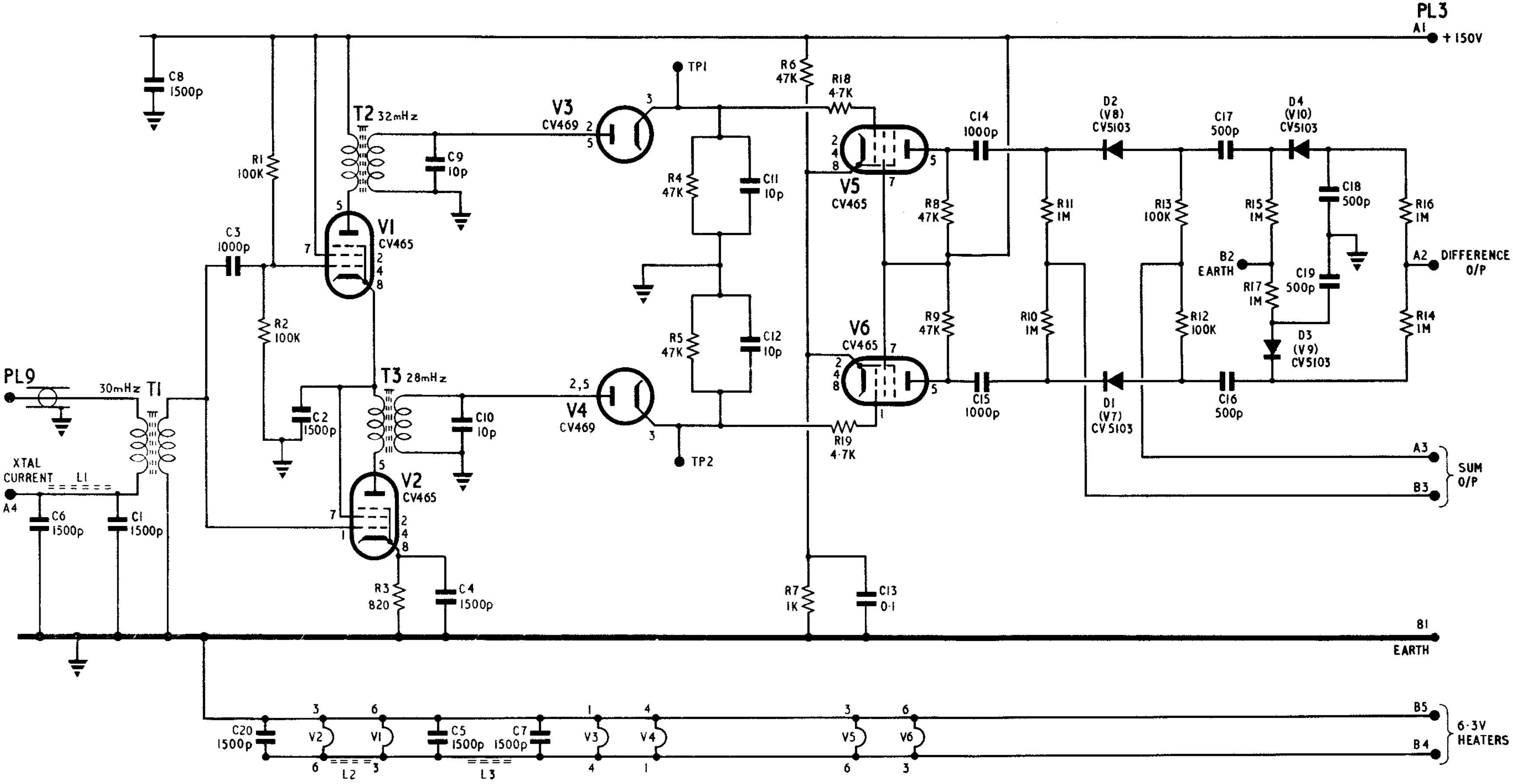


Fig. 17 Rear tray assembly: circuit



ARI 5919—Frequency control unit 12131 : circuit

Fig.18

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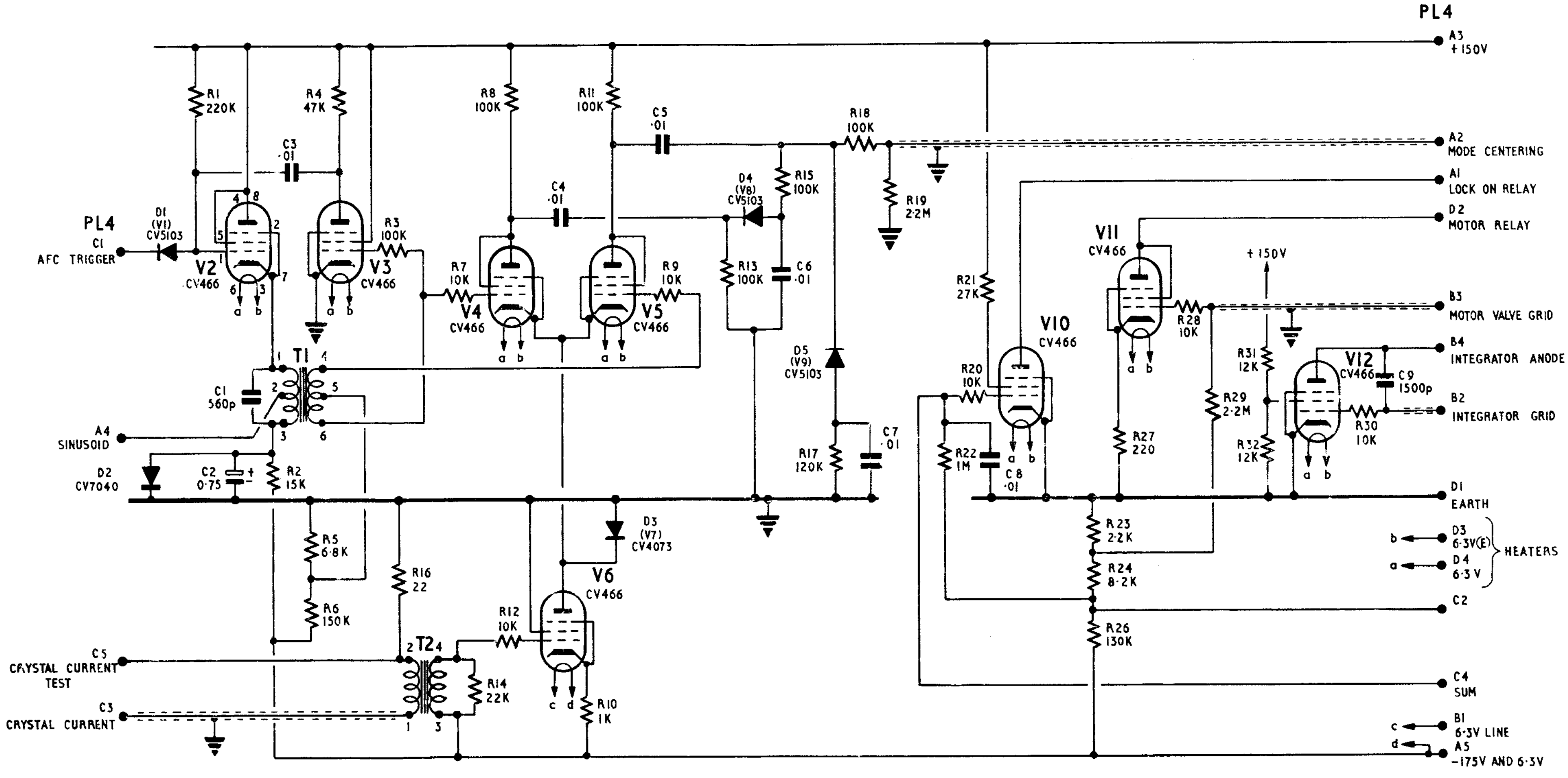

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ARI 5919-Klystron control unit : circuit

Fig.19

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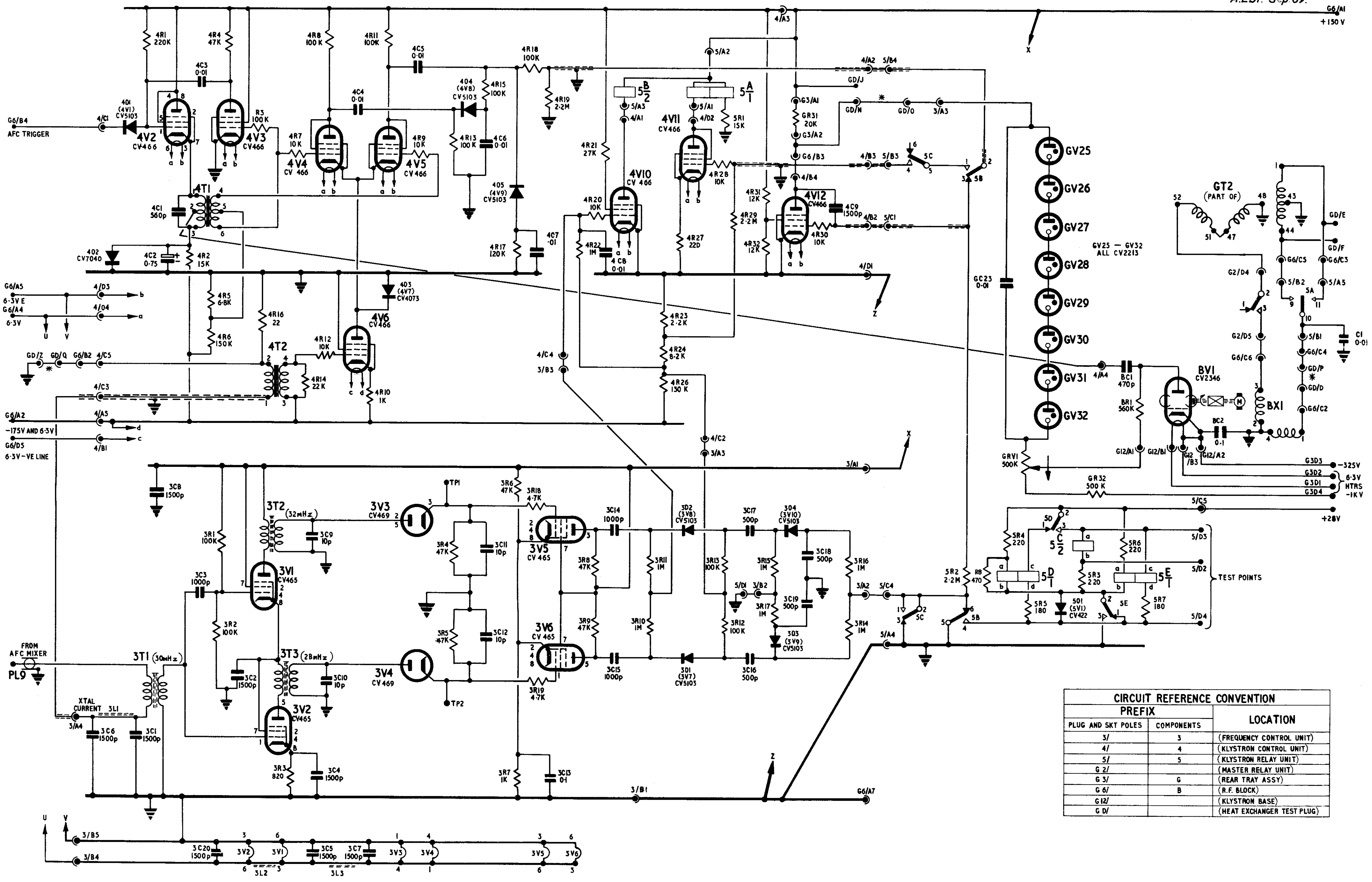

CIRCUIT REFERENCE CONVENTION		
PREFIX		LOCATION
PLUG AND SKT POLES	COMPONENTS	
3/	3	(FREQUENCY CONTROL UNIT)
4/	4	(KLYSTRON CONTROL UNIT)
5/	5	(KLYSTRON RELAY UNIT)
G 2/		(MASTER RELAY UNIT)
G 3/	G	(REAR TRAY ASSY)
G 6/	B	(R.F. BLOCK)
G 12/		(KLYSTRON BASE)
G D/		(HEAT EXCHANGER TEST PLUG)

ARI 5919 - AFC System : complete circuit

Fig. 20

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Chapter 11

(*Completely revised*)

POWER SUPPLIES

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(*Chassis Mod. state* 18)
(*Stabilizer Mod. state* 2)

200V, 400Hz three-phase supply

1. The three-phase supply from the aircraft generator is connected to the radar head at the 12-pole plug A on the heat exchange panel. From here, the supply is connected to the master relay unit and to the 25-pole test plug D. The 28V d.c. supply is also connected via plug A to plug D and via socket C to the function switch on the indicator. Details of the wiring are given in Chap. 2.

Master relay unit

2. A description of the master relay unit and the method by which the three-phase supply is connected to various points in the system is given in Chap. 5.

Modulator e.h.t. supply

3. This circuit is described in Chap. 4.

Indicator e.h.t. supply

4. The 14kV EHT supply for the indicator CRT is derived from an RF EHT unit built into the indicator (*Chap.* 12).

L.T. supplies

5. The l.t. provisions for the valves in the transmitter section of the equipment are discussed in Chapter 4. Heater supplies for the valves in the indicator are provided by a heater transformer in that unit (*Chap.* 12). All remaining heater supplies, and the klystron tuning motor supply (para. 23) are provided by the main power transformer T2 on the main frame.

H.T. and bias supplies

6. The circuit for these supplies is distributed between the main frame and a sub-unit—the voltage stabilizer. A complete circuit diagram, is given in Fig. 5. In this, components mounted on the main frame are printed in black and those on the voltage stabilizer chassis in red. Note that the stabilizer has its own series of component references. Views of the stabilizer unit are given in Fig. 2, 3 and 4.

7. The main frame components are all mounted adjacent to the waveform generator at the mounting ring end of the radar head. A scrap view of this part of the frame is given in Fig. 1. The silicon diodes D1 to D18 are mounted together with the fuses on a heavy gauge metal panel which forms a heat sink.

8. In general all the rectifier valves and stabilizing circuits are mounted on the voltage stabilizer chassis and all the main smoothing chokes and capacitors on the main frame. The power transformer T2 provides the a.c. voltages for driving the rectifiers.

150V positive supply

9. The 150V positive supply is obtained from a six-phase rectifier circuit employing the centre-tapped secondary windings 38–39–40, 33–34–35, and 28–20–30 on T2 and the silicon diodes D1 to D4, D9 to D14 and D17, D18. The diodes are used in series pairs in order to limit the voltage across each one to a value which gives satisfactory reliability. The negative end of each rectifier branch is connected to earth and a positive output is obtained from the centre taps of the transformer secondaries which are connected together. The output is smoothed by a choke input filter consisting of L2, C11 to provide d.c. at 150V. This is connected via poles PL4/A3 and PL4/B5 on the voltage stabilizer unit to the various units in the radar head (*Chap.* 2). The capacitors C5–C10 associated with the transformer windings protect the diodes from the effects of hole storage.

285V positive supply

10. This is obtained by adding the output of a three-phase rectifier circuit to the output of the 150V circuit just described. The circuit employs half of each of the transformer secondary windings used for the 150V circuit together with the silicon diodes D5 to D8 and D15, D16. The rectifiers are used in series pairs so that the voltage across each is limited to a safe value. The positive ends of the rectifier branches are connected together and the voltage obtained at the common connection is some 135V positive to the common centre tap of the transformer secondaries and therefore is 285V positive to earth. This voltage is smoothed by a choke input filter consisting of L1, C12, C13 giving a supply which is connected via poles PL4/A1 and PL4/D6 to other units as shown in the main frame circuit (*Chap.* 2). The 285V supply is also used in the stabilizer unit to provide the basis for the +175V stabilized supply and to provide the anode voltage for V10 (stabilizer unit).

175V negative stabilized supply

11. The ends of the secondary winding 9–10–11 on the main power transformer T2 are connected via poles PL4/D3 and PL3/D4 to the anodes of diodes D1, D2 (stabilizer unit). The d.c. output at the common cathode connection of these diodes is connected via pole PL4/B6 to the choke input filter L3, C17, C16 (main frame), and a smooth d.c. voltage is obtained between the junction L3, C17 and the centre-tap of the transformer winding (terminal 10). The voltage at the transformer winding centre-tap is stabilized at −175V by the action of valves V8 to V11 (stabilizer unit). Resistor R22 is included to ensure that all the heater current flows in the connection to pin C4 of SKT4 and not in the −175V line which is connected to pin A4 which in turn is commoned to pin C4 at the socket.

12. Valves V8, V9 are connected in series with the positive line. The voltage drop across them for a given current drain depends on the voltage at their control grids which, in turn, is determined by the anode voltage of the shunt valve V10; V10 anode is supplied from the +285V line (para. 10). Stopping resistors are used in the grid circuits of V8, V9 to prevent parasitic oscillation. V10 cathode voltage is stabilized at about 85V above the negative output line by the action of the neon valve V11.

13. The action of the circuit is as follows:— Suppose that the level of the −175V line changes (owing to a variation in loading, in the supply voltage to the power transformer, in the level of the +285V line or to aging of rectifiers). The whole of the change appears at V10 cathode and half of it at V10 grid (owing to the potential dividing effect of R18 to R20); the net result is that half of the change appears between grid and cathode. The voltage movement at V10 anode resulting from this is applied to V8, V9 grids causing a variation in the effective resistance in series with the supply such that the level of the negative line is maintained very close to the required value. The degree of stability depends on the gain of the system and this is made large by the use of a pentode for V10 and a large anode load R14. The capacitor C5 is included between V10 grid and earth to improve the response of the circuit to ripple; this it does by removing the potential dividing effect of R18 to R20 (necessary to provide the correct d.c. level at the grid) at ripple frequencies. The whole of any ripple voltage thus appears between grid and cathode of the valve.

13A. During warm-up period for the thermionic stabilizing circuits, a small negative voltage (−40V) is applied to the −175V line by D19 and R37. This ensures that the circuits within the radar unit always have some degree of bias to prevent excess current flow. When the −175V is available, D19 becomes non-conducting and full bias is applied to controlled stages.

14. The connections of the −175V stabilized supply to the various points in the system are given in Chap. 2. The action of relay RLA is explained in Chap. 5 para. 19.

300V negative supply

15. The ends of the secondary winding 2–3–4 on the main power transformer are connected via poles PL4/D1 and PL4/D2 to the anodes of diodes D3, 4 (stabilizer unit). The cathodes are connected to the −175V stabilized line and a voltage negative to this is obtained at the transformer winding centre-tap (terminal 3). This voltage is smoothed by the action of L4, C14, C15 and an unstabilized −350V supply is obtained at the junction L4, C14. This is connected to the voltage stabilizer unit at pole PL4/C1.

16. The −300V supply is derived from the −350V supply by means of R1 and the circuit associated with V7 (stabilizer unit). The action of this circuit is to reduce the amplitude of ripple voltages.

17. The circuit C1, R5 ensures that V7 grid remains at earth potential for the a.c. frequencies involved. Any change which takes place at the output terminal PL4/A6 must alter V7 cathode potential and be the result of a change in the grid/cathode potential of the valve. Suppose that the output changes by 1V and that the valve has a mutual conductance of 7mA per volt. The 1V causes a change of 7mA in the current through V7 and this must be the result of a change of 7V across the series resistor R1 or a total change of 8 volts in the input voltage at pin PL4/C1. The action of the valve, under these supposed conditions, is to reduce the amplitude of a.c. voltages present at PL4/A6 to one eighth of that at PL4/C1. The −300V at pin PL4/A6 forms the cathode voltage for the klystron local oscillator (*Chap.* 10).

175V positive stabilized supply

18. This is derived from the +285V unstabilized supply by the action of valves V4 and V6 on the voltage stabilizer unit. The action of the stabilizer circuit is similar to that described for the −175V supply.

19. The +285V supply enters the stabilizer unit at pole PL4/A1. Valve V4 is the series valve and V6 the shunt valve. The cathode of V6 is connected to earth and variations in the stabilized output are applied to V6 grid from the junction R12, R13; R13 is returned to the −175V line to provide the correct DC voltage at V6 grid. C2 is included to improve the gain of the circuit at ripple frequencies.

20. The +175V stabilized output is obtained at pole PL4/A2 and is connected to various points in the system (*Chap.* 2).

1kV negative supply

21. Terminal 8 of the secondary winding 7–8 on the main power transformer is connected to the anode of a half-wave rectifier valve V5 (stabilizer unit). The cathode of this valve is connected to earth and a negative 1kV DC voltage is obtained at terminal 7 of the transformer. This voltage, in its unsmooth state, is connected to the "keep-alive" electrodes of the TR cell via R4, R5 (fixed deck), poles PL6/5 and PL6/6 (RF block) and R1, R2 (RF block).

22. The −1kV unsmooth voltage is filtered by C18, R23, C19 and the smooth voltage so otbained is connected to the rear tray assembly at pole PL3/D4 (*Chap.* 10).

Klystron tuning motor supply

23. The voltages for driving the klystron tuning motor are obtained from the three secondary windings 44.1; 47–48 and 51–52 on T2. The voltages obtained from these windings differ in phase, one from another, by 120 deg.

24. Terminals 47 and 51 are connected together so that a voltage across the separate windings (i.e. 20V RMS) is obtained between terminals 52 and 48; this voltage is in quadrature with the voltage across the third winding 44–1. The voltage obtained at terminal 52 therefore lags the voltage at one end of the winding 44–43–1 by 90 deg. and leads the voltage at the other end by 90 deg. The connections between T2 and the motor are detailed in Chap. 10.

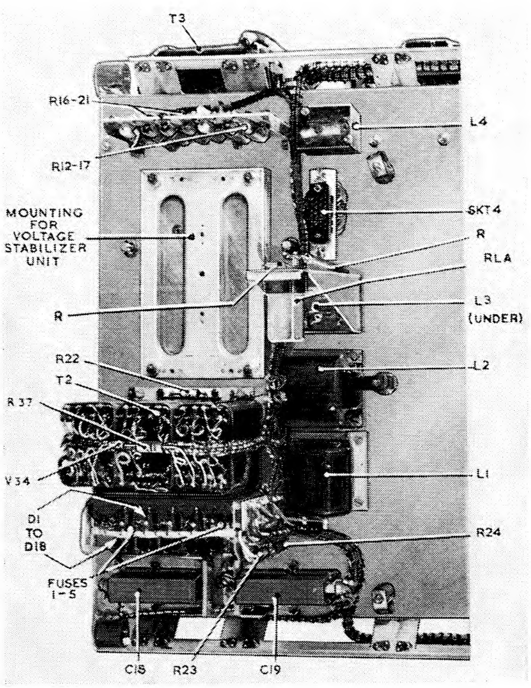


Fig. 1. Power supplies components
(Chassis mod. state 18)

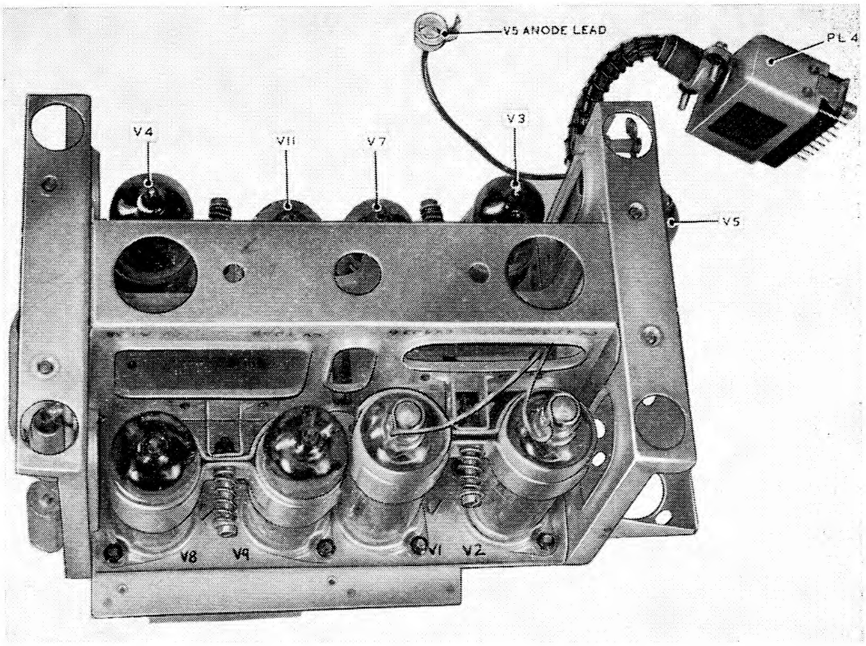


Fig. 2. Stabilizer unit (voltage): top view (Mod state 0)

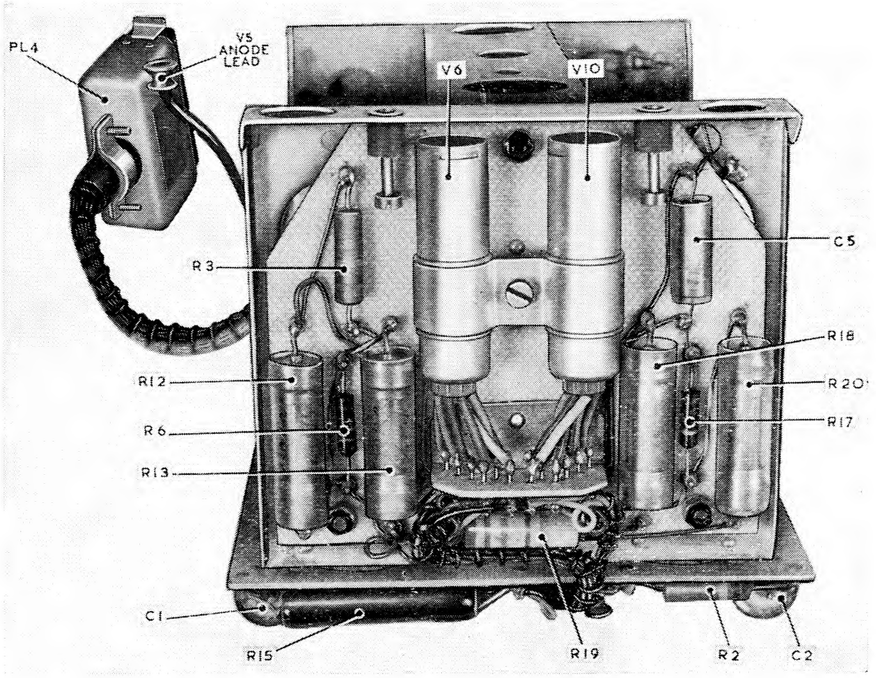


Fig. 3. Stabilizer unit (voltage): end view

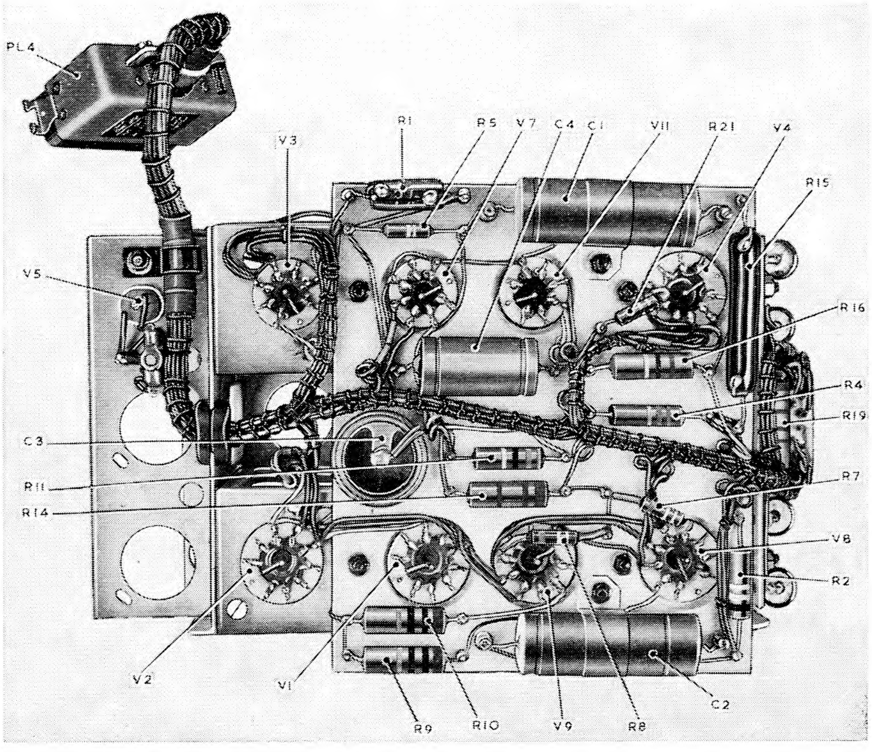


Fig. 4. Stabilizer unit (voltage): under view (Mod. state 0)

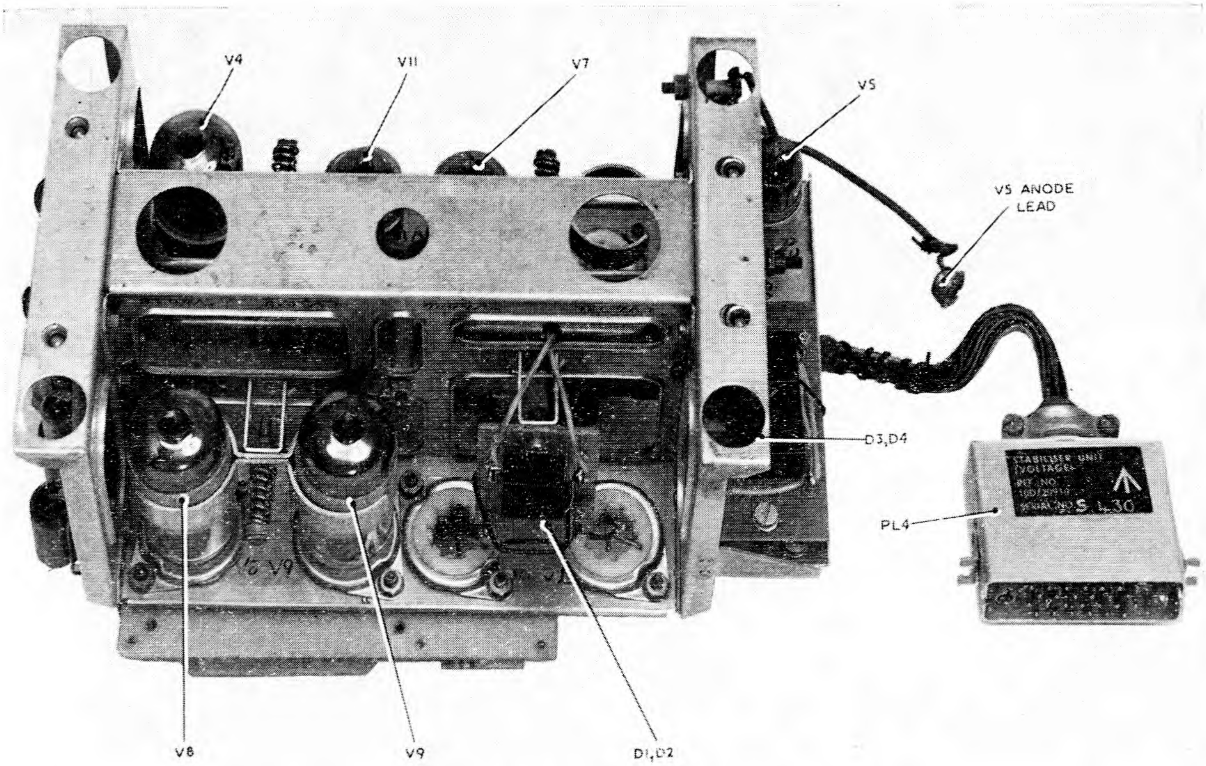


Fig. 2A. Stabilizer unit (voltage): top view (Mod. state 2)

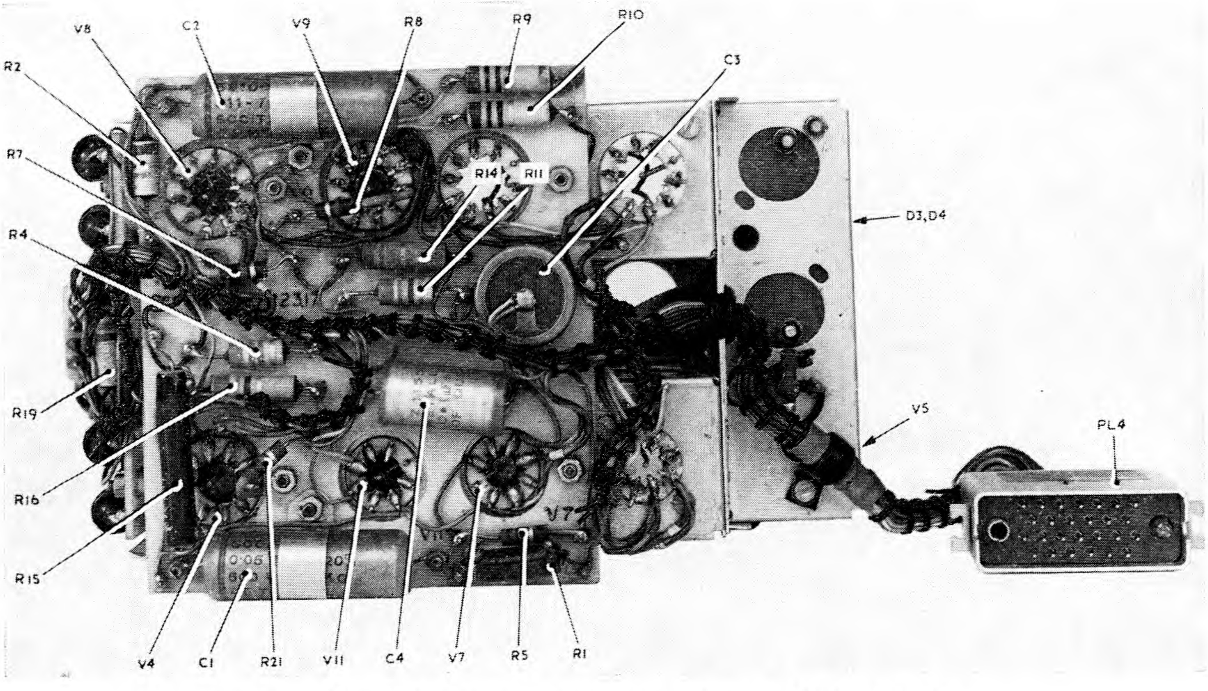
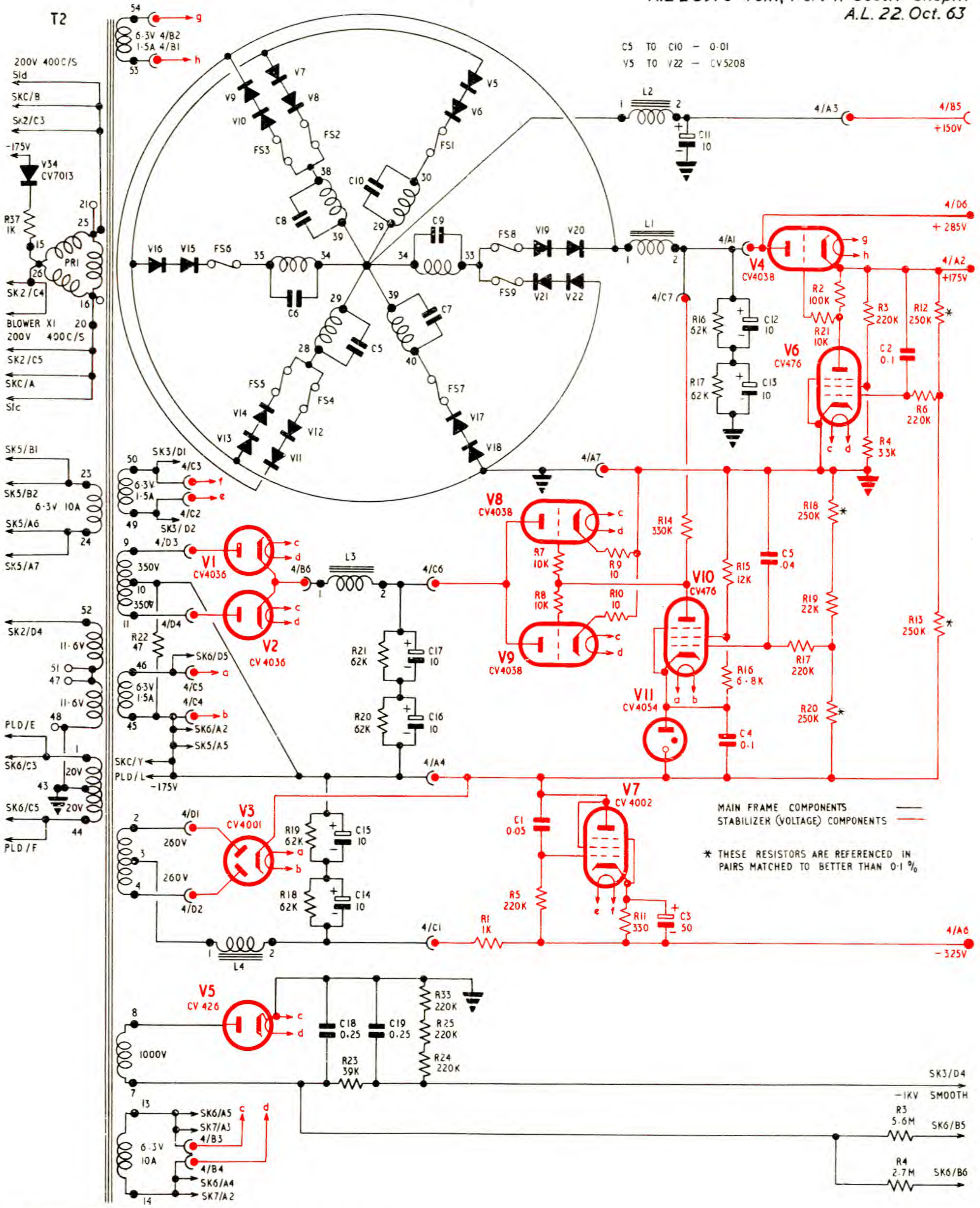


Fig. 4A. Stabilizer unit (voltage): under view (Mod. state 2)



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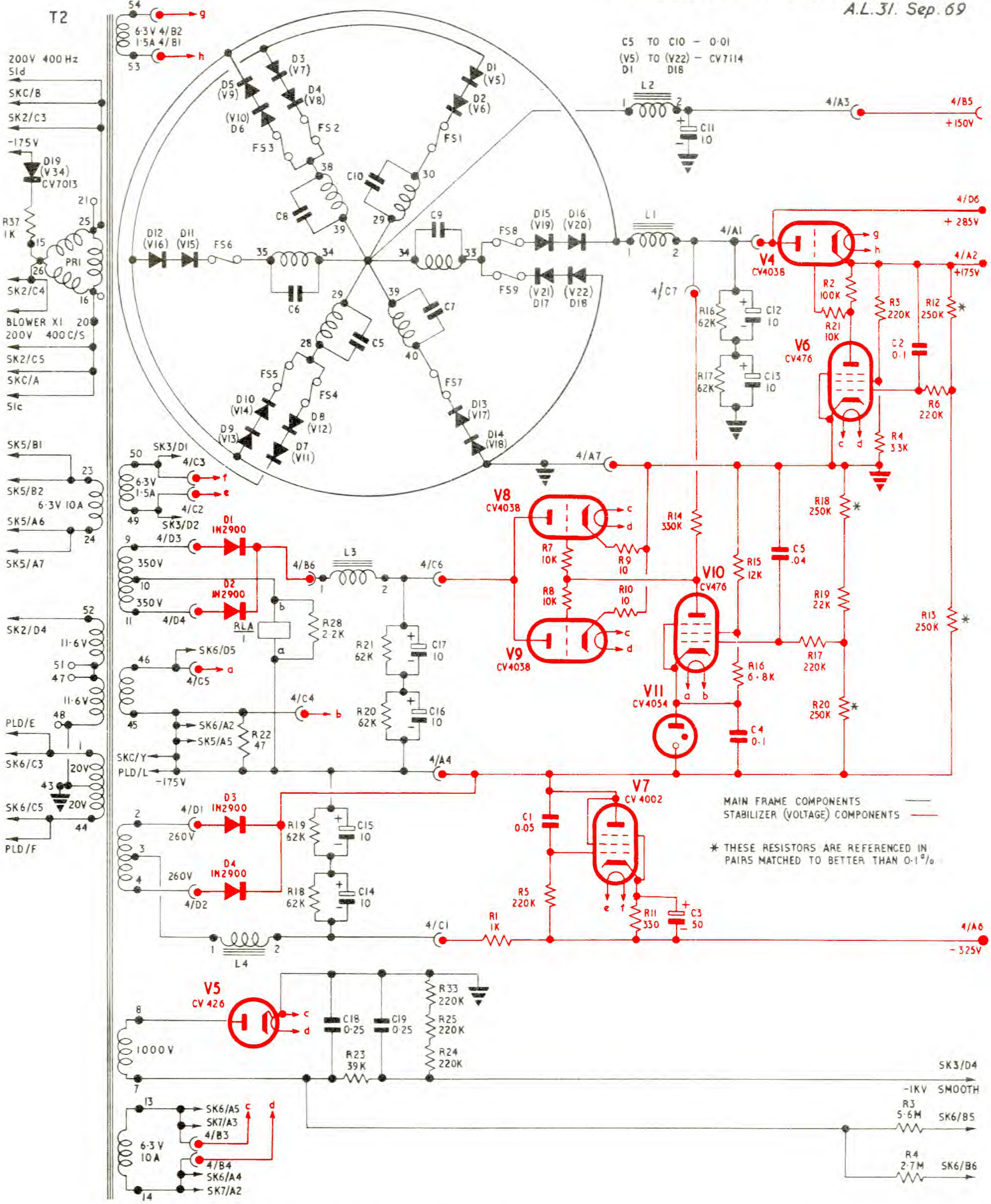
ARI 5919 HT/LT Power supplies: circuit

Fig. 5

3913/371340/14/1/64 J. T. & S.



C5 TO C10 – 0·01
(V5) TO (V22) – CV7114
D1 D18

MAIN FRAME COMPONENTS ——
STABILIZER (VOLTAGE) COMPONENTS ——

* THESE RESISTORS ARE REFERENCED IN PAIRS MATCHED TO BETTER THAN 0·1%

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ARI 5919 HT/LT Power supplies circuit Fig.5A

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Chapter 12

INDICATOR C.R.T. 6935

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7 C.R.T. supply unit : view with end cover removed ... ... (17/18)

8 ARI 5919 - Indicator C.R.T. 6935 : circuit 19/20

INTRODUCTION

1. Indicator C.R.T. 6935 provides the display for the Air Electronics officer and gives him facilities for switching and controlling the radar.

2. The unit consists of :

(1) Chassis assembly (indicator) 12301.
(2) Amplifying unit (video) 12300.
(3) C.R.T. supply unit.

3. The chassis assembly is a rectangular structure designed for rack mounting. It carries the c.r.t. together with its scanning coils and focus magnet. The front panel carries the various controls required for controlling the equipment and adjusting the c.r.t. display. These controls are grouped round a perspex graticule through which the c.r.t. display is viewed.

4. The front panel itself is made of perspex and is edge lit by red lamps. The front face of the perspex is painted with a translucent white paint and then with an opaque black paint. The panel engravings appropriate to the various controls thus appear white on a black ground. In the dark, when the panel illumination is used, the engravings appear red.

5. An external view of the indicator is given in Fig.1. Interior views are given in Fig.2 and 3.

6. Connections between the indicator and the radar head are made via a 24-pole plug at the rear of the chassis. This plug is connected to sockets SKB and SKC on the radar head via a fixed socket in the aircraft racking. Details of the inter-connections are given in Chapter 2.

7. The video amplifier provides amplification of the mixed video and marker signals from the waveform generator before they are applied to the c.r.t. cathode.

8. The c.r.t. supply unit consists of a r.f. oscillator which feeds a voltage double rectifier system delivering an e.h.t. supply of 13.5kV. A protection circuit (incorporated in the indicator chassis assembly) prevents the oscillator from working if the timebase circuit should fail for any reason.

CIRCUIT DESCRIPTION

GENERAL

9. A complete circuit diagram of the indicator is given in Fig. 8. For convenience in the circuit diagram, the chassis assembly, video amplifier and c.r.t. supply unit are considered as sub-units 1, 2 and 3 respectively of the

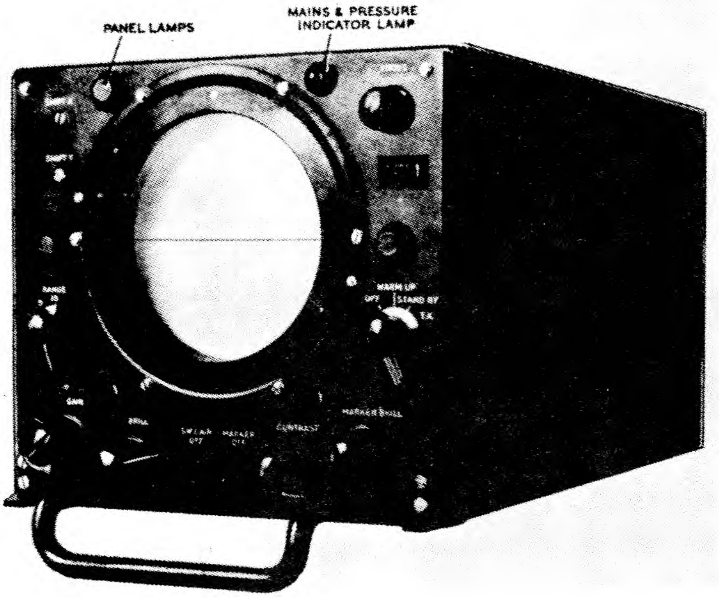


Fig. 1. Indicator C.R.T.6935 : general view

indicator. Component references in the text are prefixed with the number of the sub-unit in which they occur.

CHASSIS ASSEMBLY (INDICATOR) 12301

Panel controls (Fig.1)

10. Master switch. The master switch S1 has four positions viz. OFF - WARM UP - STD. BY - T.X. Switch wafer 1S1a controls the application of power to the various circuits in the radar head by routing the + 28V line as described in Chapter 5. In addition to this, some circuit switching takes place in the indicator itself. Note that the 28 volt supply at pole PL1/7 is not present unless the radar unit air pressure is adequate (Chap.5).

11. In the STD. BY position of the switch, the +28V line is connected to the timebase range switch 1S2, to the shift network, to the cathode of 1V2 (para. 26) and to the SW. GAIN and MARKER switches.

12. When the master switch is set to T.X., switch wafer 1S1b connects the +175V line to the anode circuit of valve 1V2 (para.27).

13. RANGE switch. The range switch 1S2 has two positions viz. 5 and 18. These refer to the two timebase ranges 0 - 5 n.m. and 0 - 18 n.m. The +28V d.c. line is connected to switch wafers 1S2a and 1S2b when the master switch

is in positions STD. BY and T.X. The switch wafers connect the +28V d.c. line to relays "O" in the waveform generator when the switch is turned to "18". The circuit action consequent on the operation of these relays is discussed in Chap. 3.

14. SWEPT GAIN switch. Operation of this switch (1S3) connects the 28V d.c. line to relay A/1 in the suppression unit. The relay operates enabling the swept gain circuit to operate as described in Chapter 9.

15. MARKER switch. Operation of this switch breaks the 28V d.c. supply to the operating coil of relay "Q" in the waveform generator. This allows range markers to be applied to the video and marker mixing stage in the waveform generator (Chap. 3).

16. MARKER BRILL control. The stator of potentiometer 1RV5 is connected in series with ◀1R15 across the +175V h.t. supply.▶ The voltage picked off by the slider forms the screen voltage of valve 7V8 in the waveform generator. The slider is moved by means of the MARKER BRILL knob which hence controls the current turned on by the markers in 7V8 (waveform generator) and controls the brilliance of the markers on the display (Chap. 3).

17. BRILL control. This controls the slider of potentiometer 1RV2 whose stator is connected in series with 1R1 and 1R2 across the +285V supply. Operation of the control determines the d.c. level of the c.r.t. grid and hence the brightness of the display.

18. When the various switches and relays in the equipment or in the aircraft are operated, transient voltage pulses appear on the +28V line. These may be picked up in the video amplifier circuit and appear on the c.r.t. cathode. In order to prevent a bright flash from appearing on the tube, the pulses are rectified by the crystal diode 1V3 and negative pulses are developed across 1R16. These are applied via 1C8 to the c.r.t. grid so cutting off the beam current.

19. CONTRAST control. This determines the amplitude of the video signals applied to the video amplifier and therefore controls the contrast of the picture on the c.r.t.

20. FOCUS control. This determines the sharpness of the c.r.t. display by mechanical control of the air gap in the focus magnet.

21. GAIN control. The gain control provides a means of varying the effective resistance of 1RV6. This potentiometer is connected in series with the maximum gain preset WRV8 (waveform generator tray) and 4R9, 4R10 (waveform generator) between earth and the -175V line. The voltage at the junction of WRV8 and 4R9 (waveform generator) is connected via the suppression unit and determines the gain of the i.f strip (Chap. 9).

22. SHIFT controls. The SHIFT X and SHIFT Y controls are preset potentiometers 1RV4 and 1RV3. The operation of the shift network is given in para.31.

23. Mains and pressure indicator lamp. This lamp 1LP6 is powered by the thyratron heater supply as described in Chapter 5. The lamp is coloured blue and is fitted with a dimmer control in the form of a mechanical iris. This is operated by means of the milled ring which surrounds the lamp holder.

Panel illumination

24. The edge lighting for the perspex front panel is provided by five 28V lamps 1LP1 to 1LP5. The current for these is obtained from the aircraft cockpit lighting circuits. One cockpit circuit supplies 1LP1, 1LP2; ◀ the other supplies 1LP3, 1LP4 and 1LP5.▶

C.R.T. protection circuit

25. This circuit involves valves 1V1 and 1V2. Its purpose is to prevent the e.h.t. voltage from being applied to the c.r.t. if the timebase scan waveform should fail for any reason.

26. The +28V d.c. line is connected to the cathode of 1V2 in the STD. BY and T.X. positions of the master switch. In the absence of any voltage at 1V2 grid, the valve is cut off by cathode bias and relay 1RLA/2 in its anode circuit is released.

27. When the timebase circuits are operating normally, the sine component of the resolved timebase waveform from the scanner synchro appears at pole PL1/22 and is applied to the anode of 1V1. Owing to the rectifying action of the valve, a positive d.c. voltage is obtained at its cathode; smoothing is provided by 1C6. This voltage is sufficient to lift the bias on 1V2 and that valve conducts if the master switch is set to T.X. (para.12). Relay 1RLA/2 operates with the following results:

(1) Contacts A1 complete the +285V d.c. supply to the anode of the r.f. oscillator valve 3V1.

(2) Contacts A2 complete the +175V d.c. supply to the screen grid circuit of 3V1.

28. If the sine component of the timebase waveform disappears from pole PL1/22, 1V1 cathode falls to earth potential and 1V2 becomes cut off by cathode bias. Relay A/2 then releases breaking the h.t. supplies to 3V1 and the oscillator stops working.

Scanning coils

29. The scan coils are fed with the current sawtooth timebase components from the timebase synchro on the scanner. The synchro rotor is fed from the timebase amplifier in the waveform generator. The circuits for the current waveforms are completed in the indicator via the electrolytic capacitors 1C3, 1C4 and 1C5.

30. Damping resistors 1R3, 1R4 are included to damp ringing which occurs between the capacitance of the interconnecting cables and the synchro leakage inductance; they also damp resonances caused by cross-coupling at high frequencies in the scanning coils.

Shift networks

31. Picture shift is obtained by passing d.c. through the scan coils from the +28V d.c. supply; the return path of this current is through the scanner synchro windings. The shift potentiometers 1RV3, 1RV4 are connected in series with resistors 1R7, 1R10 across the 28V d.c. supply so that about half the supply voltage appears across each potentiometer. The common return line from the scanner synchro stators is connected to a potential of approximately +6V at the junction 1R8, 1R9. This enables shift current to be passed through the coils in either direction as required for centring the picture on the cathode-ray tube.

Valve heater supplies

32. Heater current for the c.r.t. and the valves in the indicator is obtained from the secondary winding of transformer 1T1. This transformer is energized by the red and blue phases of the 200V, 400Hz three-phase supply via contacts of relay B/3 in the master relay unit in the standby and transmit functions of the equipment.

AMPLIFYING UNIT (VIDEO) 12300

33. The video amplifier is mounted on a sub-chassis and makes plug and socket connections with the indicator chassis assembly. Connections to the c.r.t. are made from the video amplifier chassis by means of a free cable and socket.

34. The mixed video signals and range markers (Chap. 3) are connected via a capacitor (WC1) on the waveform generator tray to pole PL1/12 on the indicator where they are developed across the stator of the CONTRAST control 1RV1. The signals obtained at the slider of this control are connected via pole 2B4 and resistor 2R3 to the cathode of valve 2V1. Also applied to 2V1 cathode via 2R20 is the negative-going bright-up waveform from the cathode of valve 7V1 (waveform generator). The effects of this bright-up waveform is ultimately to depress the cathode potential of the c.r.t. during the timebase sweep to the point where beam current just starts to flow; this enables the output valve 2V4 to be run at low current during inter-trace periods.

35. As described in Chap. 3, the negative-going video signals fall from a negative-going bright-up pedestal. The amplitude of this pedestal at 2V1 cathode is subject to the setting of the CONTRAST control. The arrangement ensures that the apparent black level remains constant when the CONTRAST control is varied to offset a change in incident illumination on the tube face; this minimizes the need for adjustments to the BRILL control during operation.

36. The control grid of 2V1 is biased by approximately -2V derived from the junction 2R1, 2R2. Negative voltage feedback, from the anode of 2V4, is applied via 2R9, 2C1. The feedback determines the amplifier gain and ensures that it remains constant despite variations in h.t. voltage and valve characteristics.

37. The negative-going video waveform obtained at 2V1 anode is applied via 2C3 to 2V2 grid where the positive limit is clamped at earth potential by the action of the crystal diode 2V5. The positive-going waveform at 2V2 anode is connected via 2C4 to 2V4 grid where the level during the inter-trace periods is clamped at -18V, derived from the junction 2R12, 2R13 by the action of 2V3.

38. Valve 2V4 rests with an anode current of approximately 3mA. The arrival of the negative going bright-up pulse at pole PL1/23 increases this current to about 20mA so depressing the c.r.t. cathode to the black level. The video signals, superimposed on a bright-up pedestal, cause a further increase in 2V4 anode current so driving the c.r.t. cathode below the black level and turning on beam current in the tube.

Construction

39. The chassis consists of two pressed metal plates spaced by tubes which form screening cans for the valves. Each plate has a central hole which allows the assembly to be mounted round the neck of the c.r.t. and bolted to the rear of the focus magnet assembly. The valve cans are packed with silicone grease to assist in heat conduction; the grease is retained by a silicone rubber bung in each can. Views of the units are given in Fig. 4 and 5.

C.R.T. SUPPLY UNIT

40. The c.r.t. supply unit consists of a r.f. oscillator incorporating valve 3V1 and a voltage doubler rectifier circuit using 3V2 and 3V3.

41. Valve 3V1 is connected as a conventional r.f. oscillator having its anode and grid coils coupled to a load coil. The three coils are wound on a closed loop ferroxcube core. The load coil is tapped to provide heater current for the rectifier valve 3V3; the other rectifier valve (3V2) is supplied from a separate heater winding on the core. The circuit operates in class C at a frequency of approximately 20kHz.

42. The h.t. voltages for the anode and screen of the valve are connected by contacts of relay 1RLA/2 on the indicator chassis assembly as described in para.27. The anode circuit is de-coupled by a 100mH choke and a capacitor 3C1; this prevents the oscillatory voltage from being fed into the h.t. supply.

43. The oscillatory voltage obtained from the load coil has a peak amplitude of approximately 7kV. This is applied to the voltage doubler circuit.

44. During negative half-cycles of the voltage at 3V3 heater, the valve conducts and the 1000pF capacitor charges to +7kV. During positive-going half-cycles 3V2 conducts and the reservoir capacitor, formed by the c.r.t. coating, charges to the peak amplitude of the positive-going half cycle plus the value of the charge on the 1000 pF capacitor, i.e. approximately 14kV.

Construction

45. The c.r.t. supply unit is mounted on a flat plate which is bolted to the base of the indicator chassis assembly at the rear. The oscillator anode transformer, the high-voltage 1000 pF capacitor and the decoupling choke are cast into a silica-loaded Araldite block having the connections for the rectifiers brought out to anti-corona rings situated in a groove at the end of the block. A silica-loaded Araldite end cover is bolted to the end of the block; the cover is also grooved so that a cylindrical space is formed which houses the rectifiers. The space is packed with silicone grease retained by a silicone rubber bung. The outer surfaces of the block and cover are coated with a conducting material which is earthed. A general view of the unit is given in Fig.6 and a view showing the end cover removed in Fig.7.

46 The coaxial e.h.t. cable, passes out of the block through a conical insulator formed in the Araldite and its inner conductor is soldered to the appropriate corona ring. The braiding of the cable is clamped at the top of the cone in a conventional manner and is retained by a screwed brass ferrule which makes contact with the conductive coating of the block.

47. The outer end of the cable has a moulded polythene cone carrying a spring This cone fits into the anode cone of the c.r.t. and the spring makes contact with the anode connection. The cable is retained by a split polythene ring which is grooved internally and externally. The internal groove engages the lip on the c.r.t. cone; the external groove provides a seating for a synthetic rubber securin ring. The assembly is sealed with silicone grease.

DISMANTLING AND REASSEMBLING NOTES

VIDEO AMPLIFIER

48. Removal

(1) Remove the dust cover from the indicator.

(2) ▶◀

(3) Remove the c.r.t. base connector.

(4) Withdraw the video amplifier plug ◀(red).▶

(5) Remove the four 6B.A. screws securing the video amplifier chassis to the focus magnet assembly.

(6) Withdraw the video amplifier.

49. Fitting. Before fitting the video amplifier, the c.r.t. and the c.r.t. supply unit must be in place.

(1) Offer the video amplifier chassis to the rear of the focus magnet assembly and secure it with four 6B.A. screws.

(2) Fit the ◀red▶ plug and the c.r.t. base connector.

(3) ▶◀

CATHODE-RAY TUBE

50. Removal

(1) Remove the video chassis (para. 48).

(2) Remove the rubber ring and the split polythene ring securing the c.r.t. anode connector and withdraw the connector.

(3) Slacken the locking ring at the rear of the focus magnet assembly using the larger of the tube spanners supplied with test kit 6516.

(4) Slacken the tube clamping ring using the smaller of the two tube spanners supplied in the test kit.

(5) Remove the lower screw and the two upper screws from the tube mask assembly at the front of the indicator.

(6) Remove the mask.

(7) Withdraw the c.r.t. from the front.

51. To fit a new c.r.t.

(1) Slacken the four screws securing the focus magnet assembly and draw the assembly to the rear to the limit allowed by the slotted holes.

(2) Enter the tube base through the front of the indicator and push it through the scanning coils and focus magnet as far as it will go.

(3) Fit the tube mask assembly and secure it with three 6B.A. cheese head screws.

(4) Draw the tube forward into the mask as far as possible.

(5) Push the focus magnet assembly forwards until the scanning coils are arrested by the c.r.t. flare.

(6) Tighten the four screws securing the focus magnet assembly in position.

(7) Fill the c.r.t. anode cone with silicone grease (M.S.4) and insert the e.h.t. connector. Fit the split polythene retaining ring and rubber securing ring.

(8) Tighten the c.r.t. clamping ring using the special spanner provided until all radial freedom is cancelled; do not over-tighten it.

(9) Tighten the locking ring using the special spanner provided.

FOCUS MAGNET

52. This assembly will not normally require attention.

SCANNING COILS

53. Removal

(1) Remove the c.r.t. (para.50).

(2) Disconnect the leads at the forward end of the scanning coils, noting the colour coding of the wires.

(3) Remove the four nuts securing the clamp plate.

(4) Withdraw the coils.

54. To fit new scanning coils

(1) Offer the new scanning coils to the focus magnet assembly making sure that the spigot enters correctly.

(2) Turn the coils until the connecting tags are uppermost with the left hand tag immediately over the centre.

(3) Fit the clamp plate and start the four nuts. Do not fully tighten the nuts.

(4) Connect the four leads disconnected in para.53 (2), noting the colour coding.

(5) Align the registration marks on the coil assembly and chassis and tighten the four securing nuts.

(6) Fit the c.r.t. (para.51) and the video amplifier (para.49).

55. If it should happen that the scanning coils and chassis are not marked, the coils should be fitted as follows :

(1) Perform the operations of para.54 (1) to (4).

(2) Fit the c.r.t. (para.51) and the video amplifier (para.49) but do not replace the dust cover on the indicator.

(3) Disconnect the lead from tag 2 (numbering from the left) on the scanning coils.

(4) Turn the BRILL control fully counter-clockwise.

(5) Switch on the complete equipment to transmit.

(6) When the five minutes timing period has elapsed, advance the BRILL control carefully until a single line trace can be seen on the c.r.t.

(7) Taking care not to touch any connections, turn the scan coils until the trace on the c.r.t. is horizontal (assuming the scanner synchro to be already correctly set (Chap. 7)).

(8) Switch off the equipment.

(9) Tighten the four nuts securing the scanning coils clamping plate.

(10) Reconnect the lead to tag 2.

(11) Fit the indicator unit dust cover.

C.R.T. SUPPLY UNIT

56. It is possible to remove the cover from the e.h.t. block without removing the complete unit from the chassis. This will enable the diode rectifiers to be changed or a new e.h.t. cable to be fitted.

57. Diodes

(1) Remove the end cover of the Araldite block by removing four 6B.A. screws. Note the silicone rubber bung.

(2) Clean out surplus grease.

(3) Valves can be unsoldered and replaced as necessary.

Note...

> When resoldering, take great care not to leave sharp ends or corners which may cause corona discharge when the unit is operated.

(4) Pack the groove in the end cover with silicone grease (M. S. 4) and refit it using four 6B.A. screws. Remove surplus grease and fit the silicone rubber bung.

58. E.H.T. cable

(1) First remove the end cover from the Araldite block (para.57(1) and and (2).

(2) Release the braid clamp by unscrewing the brass ferrule at the top of the insulating stub.

(3) Unsolder the end of the inner conductor from the corona ring nearest to the insulating stub.

(4) Take a replacement cable and prepare it as follows :

- (a) Remove $3\frac{3}{4}$in. of the PVC sleeving.
- (b) Remove 3in.of the braiding and flare the end.
- (c) Bare 2in. of the inner conductor.

(5) Thread the screwed brass ferrule over the cable. Thread on the two conical ferrules one outside the braid and the other inside.

(6) Thread the end of the cable through the hole in the insulating stub and observe that it appears at the groove in the block.

(7) Screw the ferrule into position to clamp the braiding.

(8) Solder the inner conductor to the end corona ring taking care not to leave sharp ends or corners.

(9) Fit the end cover to the block (para.57 (4)).

59. To remove the complete unit

(1) Remove the indicator dust cover and withdraw the c.r.t. supply unit plug (orange).

(2) Disconnect the e.h.t. cable at the c.r.t. (para.50 (2)).

(3) Invert the indicator chassis.

(4) Support the c.r.t. supply unit by hand and remove the six 6B.A. screws securing it to the indicator chassis.

(5) Withdraw the c.r.t. supply unit through the side of the indicator chassis frame. It will be an advantage to remove the video amplifier (para.48).

60. To replace the complete unit

(1) Invert the indicator

(2) Invert the c.r.t. supply unit and pass it through the indicator frame into its correct position.

(3) Fit the six 6B.A. securing screws.

(4) Turn the indicator into its normal position.

(5) Fit the e.h.t. cable to the c.r.t. (para.51 (7)).

(6) Fit the orange plug of the c.r.t. supply unit.

(7) Fit the indicator dust cover.

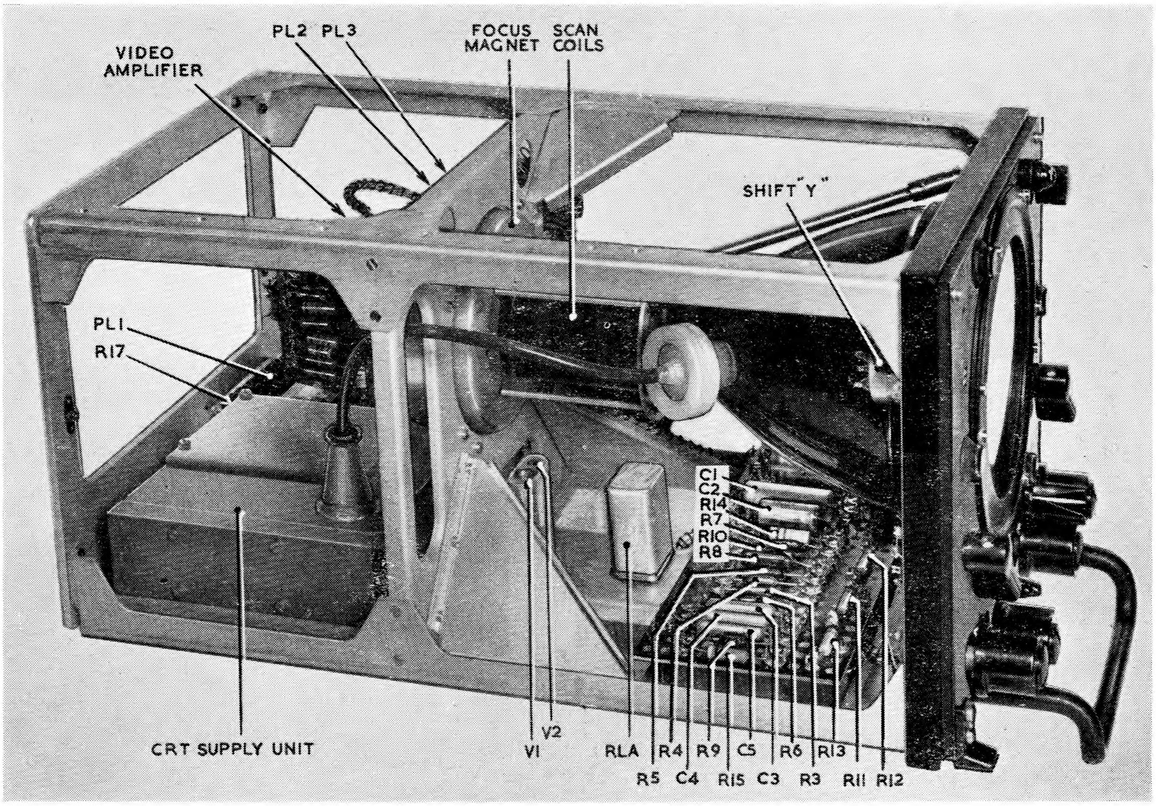


Fig. 2. Indicator C.R.T. 6935 : side view (1)

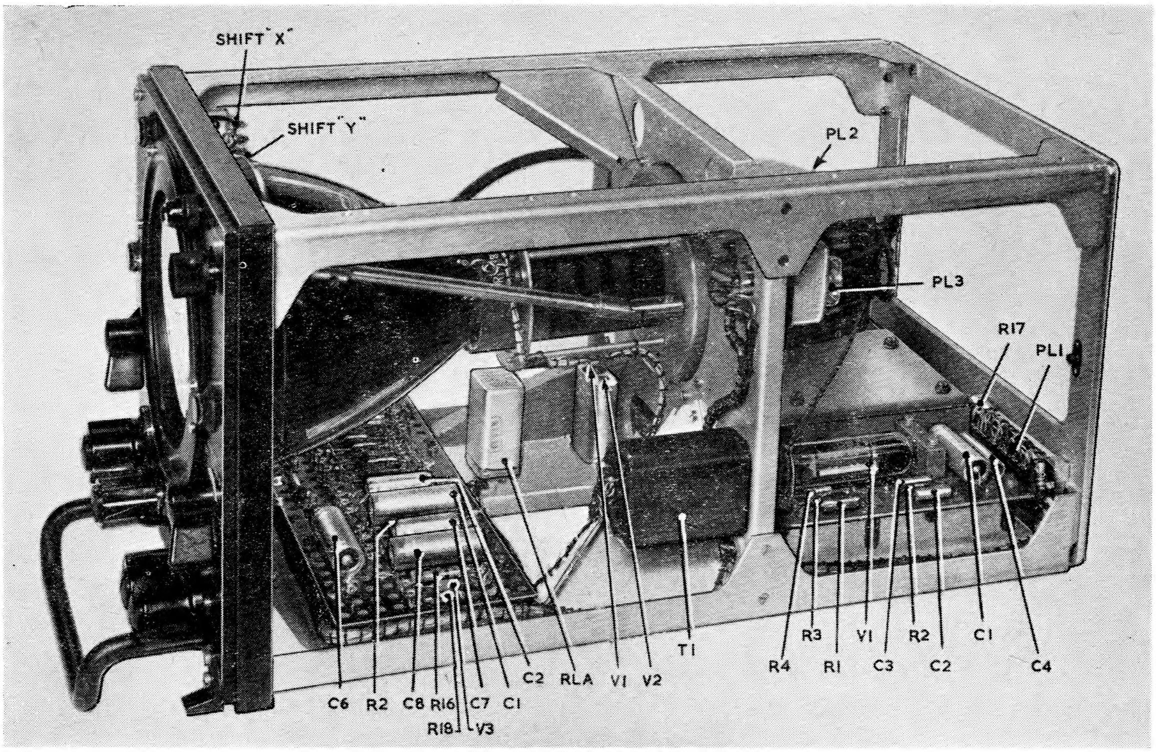


Fig. 3. Indicator C.R.T. 6935 : side view (2)

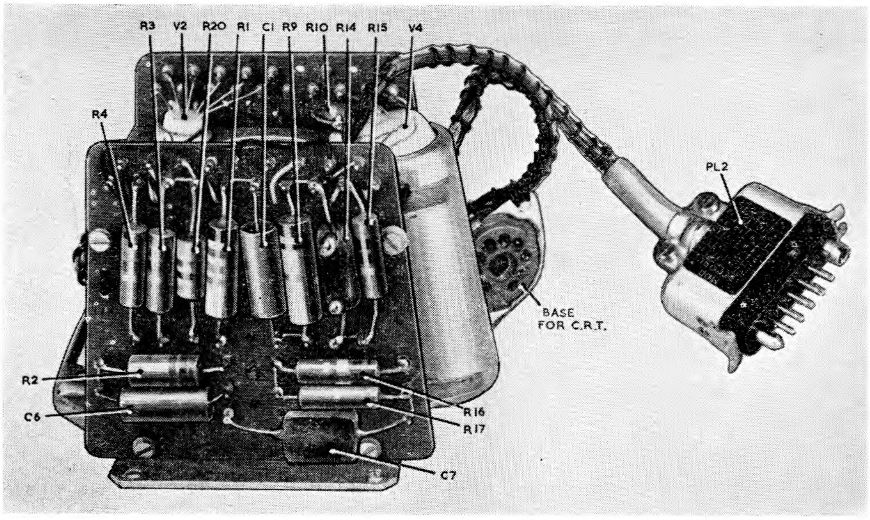


Fig. 4. Amplifying unit (video) 12300: side view (1)

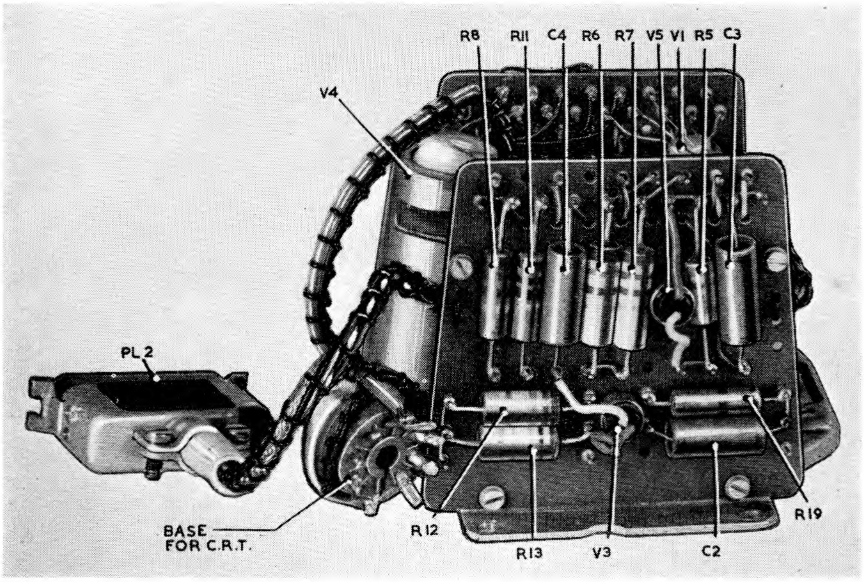


Fig. 5. Amplifying unit (video) 12300: side view (2)

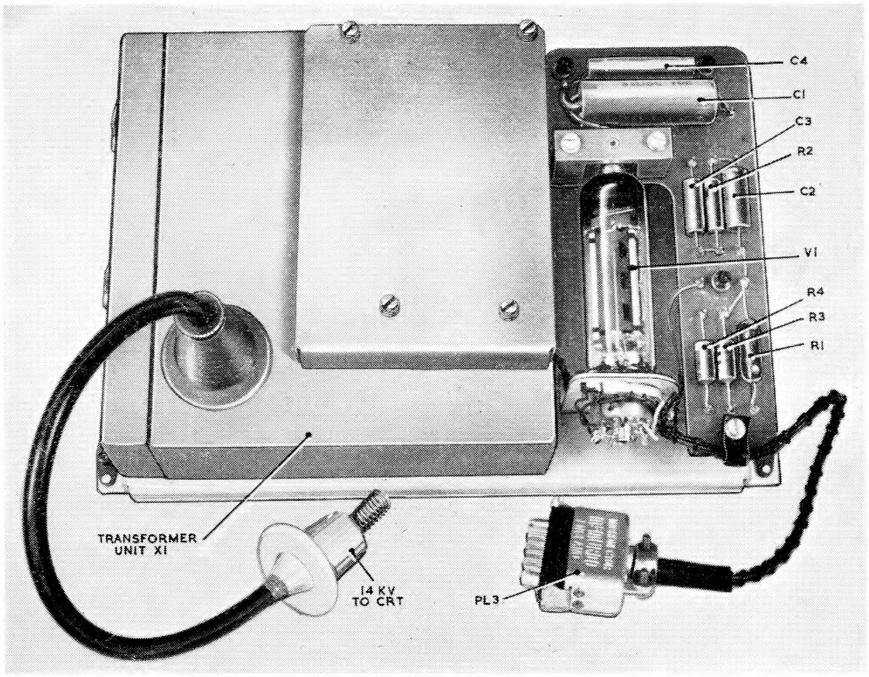


Fig. 6. C.R.T. supply unit : general view

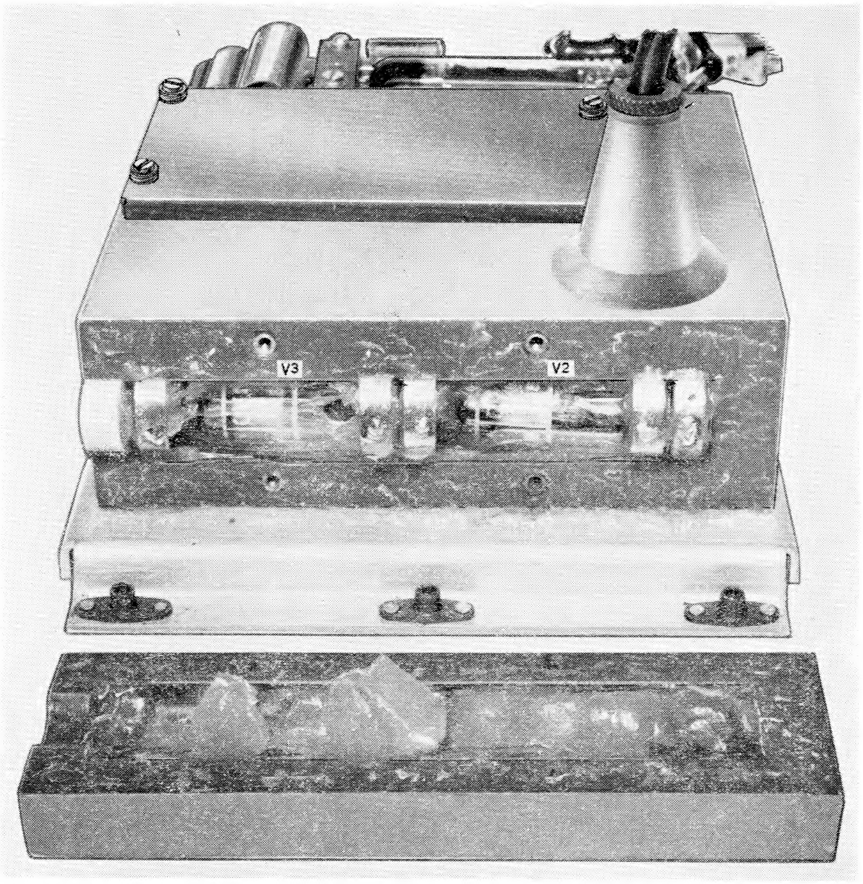
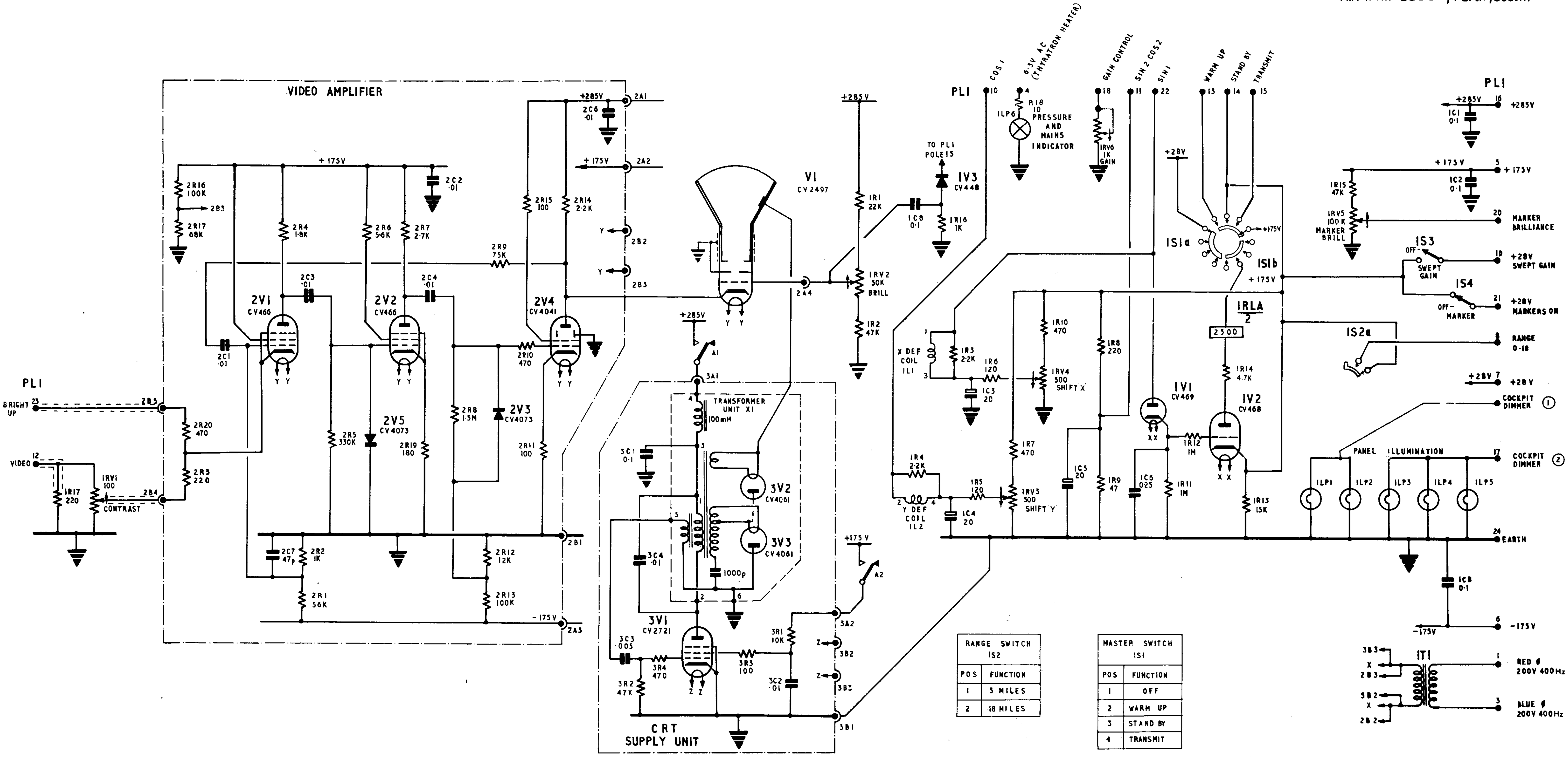


Fig. 7. C.R.T. supply unit : view wtih end cover removed



RANGE SWITCH 1S2	
POS	FUNCTION
1	5 MILES
2	18 MILES

MASTER SWITCH 1S1	
POS	FUNCTION
1	OFF
2	WARM UP
3	STAND BY
4	TRANSMIT

ARI. 5919 Indicator C.R.T. 6935: circuit.

Chapter 13

RESONATOR PERFORMANCE TESTING, 12549

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Introduction

1. The resonator performance testing, 12549 is mounted in the radar unit, 5934 (Fig. 1) and is used in conjunction with the gating unit, 10D/23451 (Part 2, Chap.6) to provide facilities for measuring the overall performance of ARI.5919 during ground servicing routines.

2. The resonator performance testing consists of a high-Q cavity tuned by means of a piston driven by a motor and gearbox. Transmitter energy is fed to the cavity through a ferrite switch and an attenuator from the main sampling coupler in the r.f. block (Chap. 8).

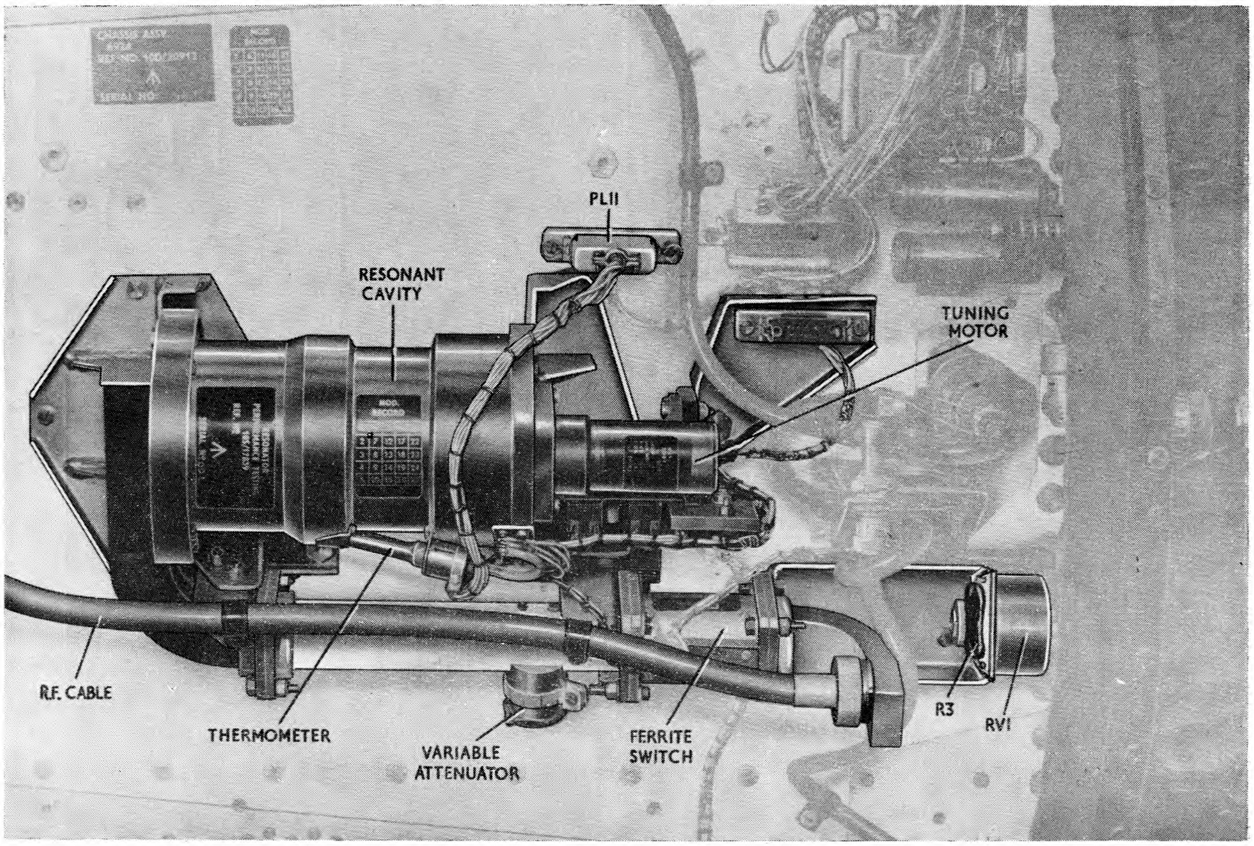


Fig. 1. Resonator performance testing—general view

Principle of overall performance measurement

3. The overall performance factor is expressed as the signal at the input to the receiver which gives a video signal to noise voltage ratio of 2 : 1 expressed in the terms of dB down on the transmitter power.

4. A block diagram of the resonator performance testing is given in Fig.2. The transmitter power fed to the resonator performance testing (r.p.t.) is attenuated by 26 dB in the main sampling coupler of the r.f. block (Chap.8), 18 to 32 dB (25 dB nominal) in the r.p.t. attenuator (i.e., a nominal 51 dB total attenuation) and is applied to the tuned cavity (echo box). On receipt of the transmitter pulse the echo box rings and this ring is returned via the r.p.t. attenuator and 26 dB coupler, suffering a further 51 dB (nominal) attentuation, to the receiver as the receiver input signal.

5. On alternate transmitter pulses a ferrite switch, connected in the transmitter pulse path to the r.p.t., is energized giving a further 25 dB attenuation in each direction (i.e., 50 dB total). The transmitter power so attenuated (by at least 152 dB) is considered negligible and so the receiver input is noise only.

6. The echo box ring decays exponentionally (at a rate of 5·4 dB/μs from a maximum that is directly related to the transmitter power. Therefore the time interval between the transmitter pulse and the instant that the echo box ring has decayed to a level that is twice the receiver noise voltage is directly re-

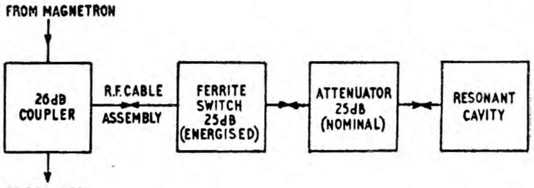


Fig. 2. Resonator performance testing—block diagram

lated to the difference beween the transmitter power and the receiver noise power.

7. The gating unit (Part 2, Chap.6) is used in conjunction with the r.p.t. as follows:

(1) To deliver gating pulses for the ferrite switch (para.5).

(2) To sample the echo box signal plus noise and noise alone outputs of the receiver.

(3) To measure the difference between receiver echo box signal plus noise and twice noise voltage alone.

(4) To adjust the time interval between the transmitter pulse and the echo box signal sampling pulse to be such that the quantities measured in (3) are equal.

8. The control that adjusts the interval in para.7 (4) is calibrated in dB and the figure obtained is related to the production specification limits of the transmitter power and receiver overall noise factor.

General description

9. The r.p.t. comprises the following principal sub-assemblies:

(1) Tuned cavity
(2) Attenuator
(3) Ferrite switch
(4) R.F. cable

Note . . .

The sub-assemblies of the r.p.t. are not replaced unless full facilities are available for

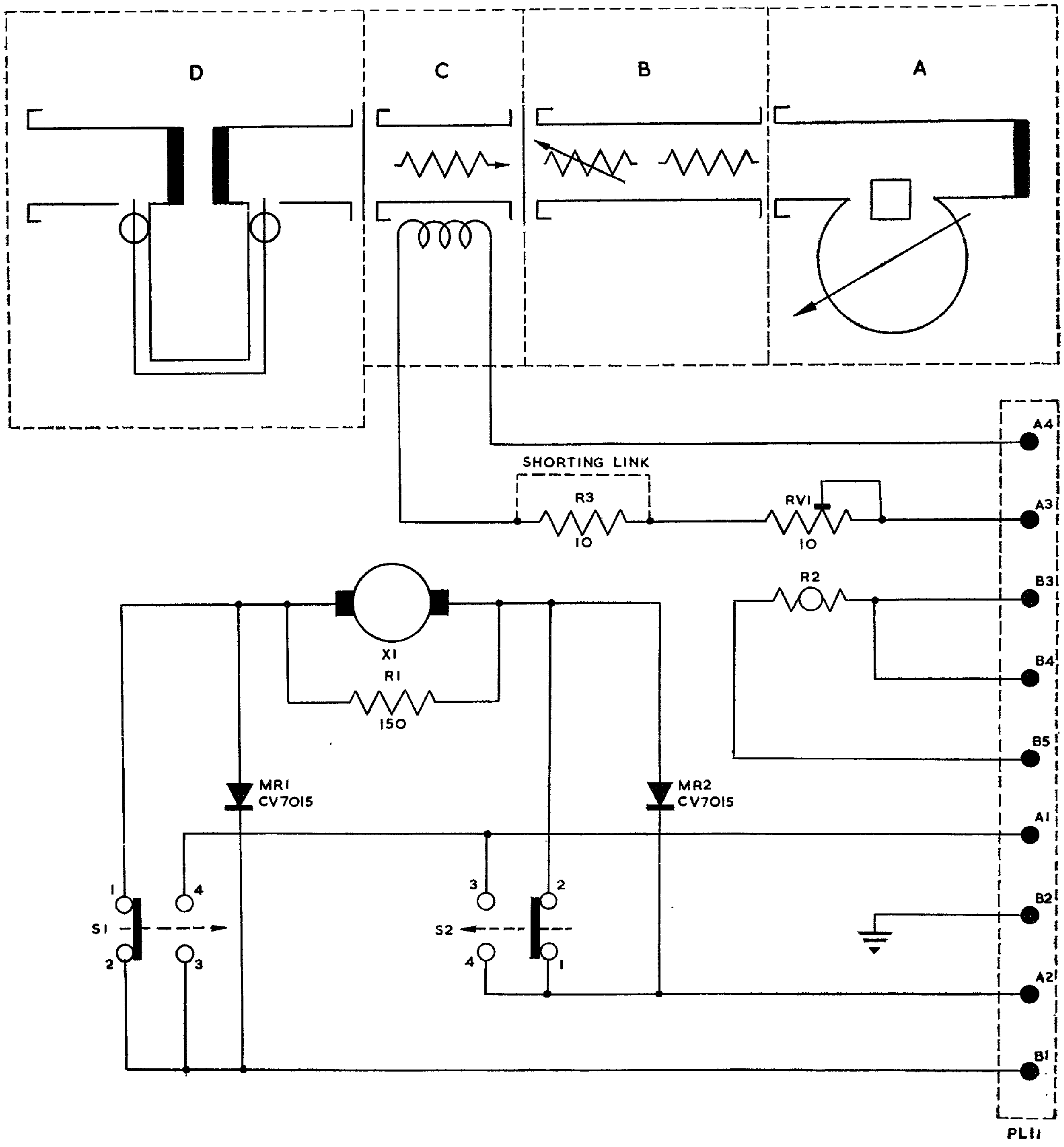


Fig. 3. Resonator performance testing—circuit diagram

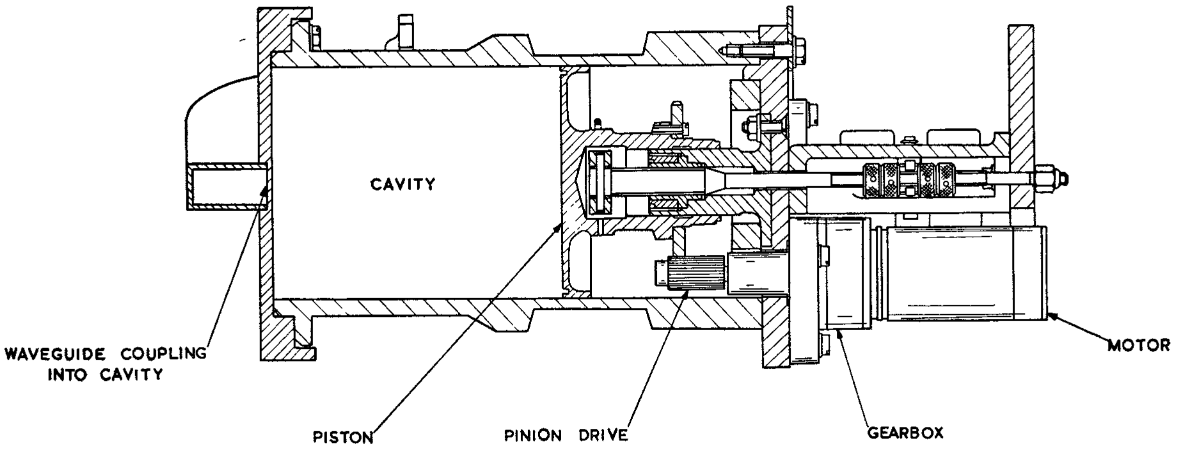
testing and setting-up the complete r.p.t. assembly for a standard ring time (i.e. at the manufacturers).

10. During overall performance testing of ARI.5919, PL11 on the r.p.t. is connected via a test plug (PLD) in the heat exchanger panel (Chap. 2) to PL1 on the gating unit (Part 2, Chap 6). The interconnections between the r.p.t. and the gating unit are shown in Chap.2, Fig.13.

11. A circuit diagram of the r.p.t. is given in Fig3. A 26 dB sample of the magnetron energy (i.e. the transmitter pulse) from an r.f. outlet of the r.f. block (Chap.8) is fed via the r.p.t. r.f. cable assembly (D), ferrite switch (C)-provided that it is not being fed with a current pulse from the gating unit (para.19)-and attenuator (B) to the tuned cavity (A). The tuned cavity is a resonator which is capable of being tuned to the frequency of the magnetron. Upon receipt of a transmitter pulse the tuned cavity is shock excited into oscillation and, if correctly tuned, its oscillations are fed back (via the attenuator, the ferrite switch and the r.f. cable assembly) into the receiver as an echo signal to enable the overall radar performance of ARI.5919 to be measured by the gating unit (Part 2, Chap.6).

Tuned cavity

12. Two sectional views of the tuned cavity are shown in Fig. 4. The resonant tuned cavity consists of a copper plated, aluminium alloy cylinder which is fed with r.f. power via two coupling holes in the base cover assembly. One side of this



SECTION THROUGH X-X

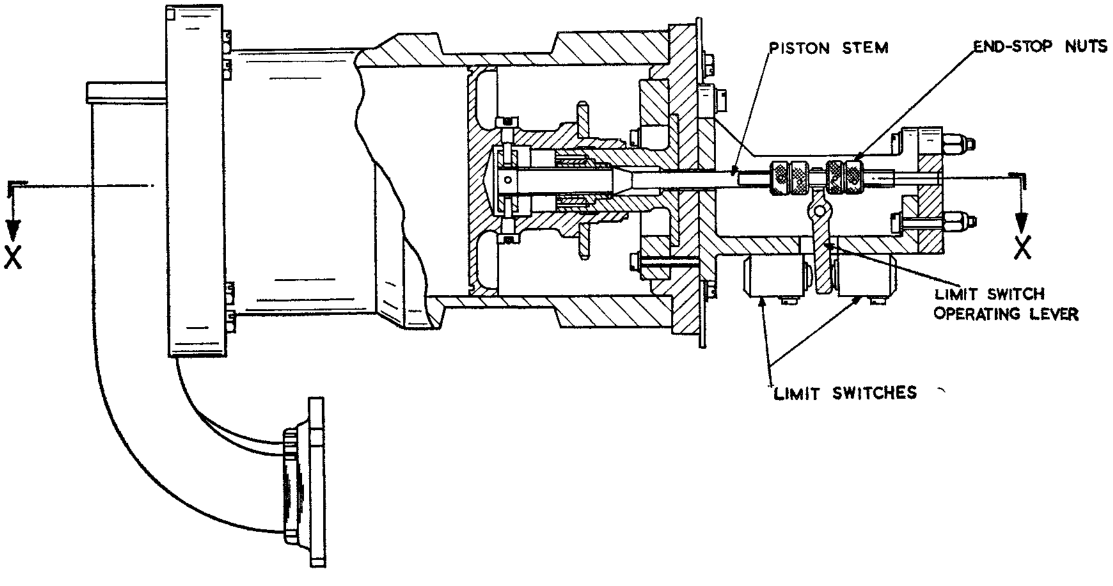


Fig. 4. Tuned cavity—sectional view

assembly forms the base of the cavity; the other contains one narrow wall of an 'H' bend waveguide. The coupling holes are in this narrow wall section. The other end of the 'H' bend is connected to the variable attenuator. The coupling holes favour magnetic coupling and, (because they are spaced by a half wave) ensure that the magnetic fields excited in the cavity will be 180° out of phase; this is a condition favouring the launching of the H_{01} mode. In this manner the H_{01} mode is strongly excited with large discrimination against unwanted modes. Within the cavity H_{014} is the dominant mode throughout the frequency band covered by the resonator. With this particular mode the current flow in the walls is entirely circumferential and a non-contacting piston can be used to tune the cavity without affecting the loaded Q.

13. Resonance in the cavity behind the tuning piston is completely eliminated by means of a lossy material incorporated in that section. The lossy material consists of a shaped block of loaded epoxy resin and the effect of this is to lower the Q of the back cavity. This arrangement prevents any serious loss of power from the main cavity which would lower its effective Q.

14. A 28V d.c. reversible motor driving a gearbox with a reduction ratio of 298 : 1 (which is increased to 1490 : 1 by the drive pinion gear ratio) is used to move the piston and thereby increase or decrease the electrical length of the cavity. The end-to-end travel of the piston is approximately 0·2 in for a frequency range of 8895 Mc/s to 9025 Mc/s ; the time taken for the piston to transverse this band is 60s ± 15s. The 28V d.c. supply to drive the tuning motor is obtained from the gating unit.

15. Adjustable end-stop nuts are fitted to the piston stem outside the cavity and are used to operate micro-switches at the limits of piston travel. The lower limit is adjusted to be between 8875 Mc/s and 8895 Mc/s, and the upper limit is adjusted to be between 9025 Mc/s and 9045 Mc/s. The micro-switches are connected in the 28V d.c. supply lines to the tuning motor so that the tuning motor is stopped when either micro-switch is operated. In addition to stopping the tuning motor, the switching arrangement lights the tuning limit lamp on the gating unit to inform the operator that the tuning piston has reached one extremity of its travel. In this condition a continued demand to move the tuning motor in the same direction has no effect, but reversing the polarity of the 28V d.c. supply (by reversing the TUNE switch on the gating unit) causes the motor to run in the opposite direction. A slipping clutch is incorporated in the gearbox assembly to prevent physical damage in the event of failure of the limit-switching arrangement.

16. Temperature variations of the r.p.t. alter the resistivity of the copper plating in the resonant cavity, affecting the Q of the cavity and therefore affecting the ring time (para. 6). A platinum resistance thermometer (R2, Fig. 3) inserted in the outside wall of the r.p.t., monitors the temperature of the r.p.t. so that temperature variations can be taken into account by the gating unit (Part 2, Chap. 6).

Attenuator

17. The attenuator provides a range of attenuation of the transmitter pulse fed to the resonant cavity to compensate for variations in the Q factor of individual resonant cavities. It is preset at the manufacturers so that it gives a standard ring time. A calibrated dial, fitted to the control of the attenuator, enables the preset level of attenuation (normally 25 dB) to be increased or decreased by approximately 3 dB. This adjustment is provided to compensate for variations in individual r.f. cable assemblies and r.f. block attenuation when the r.p.t. is installed in a radar unit.

18. The attenuator is a high-stability metallized glass vane attenuator inserted in a straight length of No.16 waveguide between the ferrite switch (para. 19) and the resonant cavity (para. 12). The waveguide also contains a fixed attenuator vane so that the combined attenuation is variable from 18 dB to 32 dB. A sectional view of the waveguide is shown in Fig. 5.

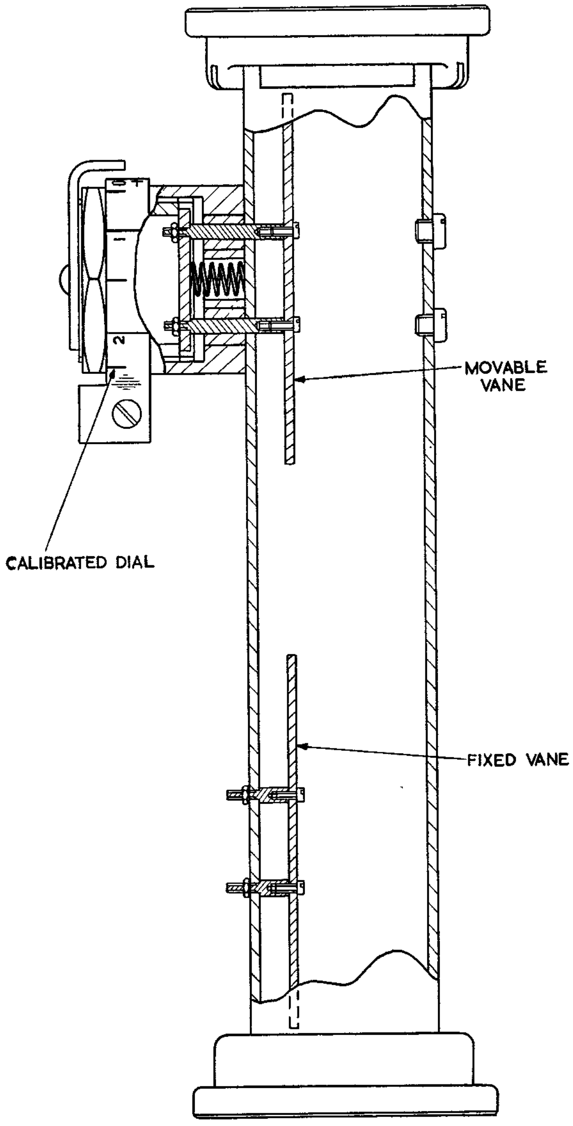


Fig. 5. Attenuator—sectional view

19. The ferrite switch functions as a pulsed attenuator whose purpose is to suppress alternate transmitter pulses to the tuned cavity. The ferrite switch is operated by current pulses from the gating unit.

20. With no current applied to the operating coil of the ferrite switch, its attenuation is not greater than 0·3 dB.

21. The ferrite switch has an optimum operating current and temperature which gives a peak attenuation of not less than 25 dB. This current is adjusted during setting up of the r.p.t. by adjustment of a variable resistor RV1 connected in the current supply line from the gating unit. The value of RV1 is such that variations in operating current down to approximately 0·8A are accommodated.

22. To extend the range of operation below this level resistor (R3) can be brought into circuit, in series with RV1 and the operating coil of the ferrite switch, by removing a link wire which normally short-circuits the resistor.

23. The ferrite switch is connected between the attenuator (para. 18) and the r.f. cable assembly (para. 24). PTFE insulating bushes in the ferrite switch and waveguide flange fixing holes, together with mica shims between the flange faces, electrically isolate the body of the ferrite switch from the waveguide. The isolation prevents the body of the ferrite switch from forming a shorted turn on the operating coil since this would slow the response of the ferrite switch to fast switching.

R.F. cable assembly

24. The function of the r.f. cable assembly is to provide connection between the r.p.t. and the radar unit r.f. block without recourse to a complicated arrangement of waveguide bends. It consists of a length of UR60 cable terminated at each end by coaxial-to-waveguide transformers. The coaxial-to-waveguide transformer connection to the r.p.t. includes an E-plane waveguide bend.

25. Attenuation of the coaxial cable to waveguide transitions is not greater than 2 dB at 8960 Mc/s ; the VSWR is not worse than 0·5 at the same frequency.

CIRCUIT DESRIPTION

Resonant cavity tuning

26. The resonant cavity is shock excited into oscillation by the transmitter pulse but the frequency to which it is resonant is dependant upon its physical size and therefore on the position of the tuning piston. When the piston is fully in or out, the cavity frequency is incorrect and no response is received by the ARI. 5919 radar receiver. With the cavity tuned to the transmitter frequency however, the cavity oscillations are fed back through the connecting waveguide, the ferrite switch and r.f. cable assembly to the receiver. Correct tuning of the cavity is obtained by driving the piston from one extremity until a maximum receiver signal is observed by the gating unit.

Tuning motor

27. As shown in Fig. 3, switches S1 and S2, the lower limit switch and the upper limit switch respectively, are both unoperated, i.e. the piston in the cavity is positioned such that the limit switch operating lever (Fig. 5) is somewhere between the two limits of travel.

28. With the TUNE switch on the gating unit set to LOW, +28V d.c. is applied to PL11 pole B1 and earth to A2; the tuning motor X1 drives the piston so that the cavity size is increased. The tuning motor draws its current through swiches S1 and S2 and therefore contiues to rotate (provided that the TUNE switch is maintained in the LOW position) until switch S1 operates. This action breaks the supply to the motor and applies +28V d.c. to PL11 pole A1 to light the TUNING LIMIT lamp in the gating unit.

29. If the TUNE switch is now set to the HIGH position, +28V d.c. is applied to PL11 pole A2 and earth to B1; the motor draws current via switch S2 and MR1, and drives the piston so that the cavity size decreases. After a short travel of the piston switch S1 returns to the unoperated position bypassing MR1 current for the motor now flows through switches S1 and S2. The motor continues to rotate until switch S2 operates breaking the supply to the motor and applying +28V d.c. to PL11 pole A1 to light the TUNING LIMIT lamp.

30. If the TUNE switch is again set to the LOW position the low tuning cycle is re-established and motor current is drawn via switch S1 and MR2 until switch S2 returns to the unoperated state bypassing MR2. Current then flows through switches S1 and S2 (para. 28).

31. Under normal operating conditions with the shorting socket connected to the test plug PLD (Chap. 2) +28V d.c. is applied to PL11 pole A2 and earth to PL11 pole B2. The cavity is therefore driven off tune to the high limit and no cavity response is received by the ARI. 5919 receiver.

32. Resistor R1, Fig. 3 is a damping resistor connected across the armature of the motor to provide magnetic braking.

Part 2

TEST EQUIPMENT

Chapter 1

INTRODUCTION

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Introduction

1. This chapter gives a list of the test equipment required for servicing ARI.5919 and, where applicable, makes reference to other Air Publications and to chapters that describe the test equipment in Part 2 of this A.P.

List of test equipment

2. The following equipment is required for servicing ARI.5919.

Item	Reference No.	Remarks
Trolley, radar servicing	4F/1924	Platform trolley for trolley radar servicing, 12016.
Trolley, radar servicing, 12016	10S/17400	Servicing stand.
Ring assembly, radar head.	10S/17398	Used with trolley, radar servicing, 12016 (Victor, Vulcan and Varsity aircraft installations).
Leak indicator, CT106	10S/16589	Described in A.P.2563BX.
Tester insulation, A	5G/1621	Described in A.P.4343S.
Voltmeter, electrostatic 0-10 kV	5Q/202	For checking modulator h.t. line.
Test meter, 100	10S/16190	For checking e.h.t.
Spark gap voltmeter (radar kilovolter)		Only required if test meter, 100 is not available.
Meter unit (monitoring), 6415	10T/13204	Described in Part 2, Chap. 2.
Cable assembly, power electrical, B14/20B/T.2472. RR/B.824.759	10HB/3319	For use with meter unit (monitoring), 6415 at Victor stations only.
Signal generator (i.f. pulse), CT406	10S/9433040	Described in A.P.2563CL. For aligning i.f. and a.f.c. units and for range calibration with the calibrator range (delayed), 4912.
Calibrator range (delayed), 4912	10S/17355	Described in A.P.2563CM.
Oscilloscope, CT316	10S/16605	Described in A.P.2563A.
Pulse generator and i.f. gating unit, 4579	10S/16566	Described in A.P.2563E. Contains filter and voltmeter necessary for i.f. strip alignment.
Dummy load (transmitter), 4735	10S/16665	

Item	Reference No.	Remarks
Bench connector set comprising:		
Connector B/12/20/A/T1399	10HS/1203	Drawing No. RR/B/RES. 692505.
,, B/14/20/B/T1400	10HS/1204	
,, B/37/20/B/T1401	10HS/1205	
,, B/14/20/A/T1402	10HS/1206	
,, B/16/20/A/T1403	10HS/1207	
Trolley, air cooling Mk. 2 or Trolley, air cooling Mk. 2A	4F/1912 4F/2002	Described in A.P.3450A. Required only whe ARI.5919 is not being used in V. aircraft.
Monitor, 100	10T/6151	Described in A.P.2563EE. For obscure cabl faults rectification team may need to borro from C.S.B. but independent provisioning i unnecessary.
Voltmeter electrostatic, 0–750 volts	5Q/185	For setting klystron reflector voltage.
Control unit, 12152	10L/16725	Described in Part 2, Chap. 3. Used to adap the monitor, 100 for use with ARI.5919.
Stand scanner servicing	10S/NIV/759	To be locally manufactured.
Motor generator set 200V, 400 c/s, 3 phase 5 kVA	5P/3354	Described in A.P.4343S
Sling assembly, 12166	10S/17399	Attachment for lifting the radar head.
Tester performance, CT104A	10S/17241	Described in A.P.2563CB. Used for checkin overall noise factor and i.f. signal/noise ratio.
Test kit, 6516	10S/17276	Described in Part 2, Chap. 5.
Dummy load (modulator), 6413	10S/17394	Described in Part 2, Chap. 4.
Space load, radar signal Mk. 1	10AL/2199	Used to absorb r.f. energy when operatin the gating unit 10D/23451.
Calorimeter, power measuring, CT423	6625-99-9439347	Described in A.P.2563EN.
Adaptor crystal testing, X6988	10AD/3330	For checking crystals CV 7108 and CV 7109
Spectrum analyser, CT152 (8500–10000 Mc/s)	10S/A.P.60832	For checking frequency coverage of resonato and drive unit.
Test set, 200V, 400 c/s 3 phase a.c.	10QP/3198	Used for the measurement of voltage (r.m.s. and frequency. Described in A.P.4343S.
Frequency meter, 300 c/s–500 c/s	5Q/1003731	Only required if test set 200V 400 c/s, 3 phas a.c. is not available.
Power supply, mobile, E/E 200V, 400 c/s (Vernon, 30 kVA converter trolley).	4F/3752	Driven from modified 50/50 kW d.c. PE/ set
Valve voltmeter, CT54	10S/9432418	Described in A.P.2536C.
Multimeter, 9980 or Multimeter, 1	10S/17001 10S/16411	Listed in A.P.2276F. Described in A.P.2887C, A.P.2536C.
Tester Noise (X-Band)	10S/16559	Described in A.P.2896AW.
Test kit, 32	10S/16560	Described in A.P.4400, A.P.4401.

Item	Reference No.	Remarks
Gating unit	10D/23451	Described in Part 2, Chapter 6. For overall performance checks. Used in conjunction with space load radar signal Mk. 1.
Leak locator, CT105	10S/16588	Described in A.P.2563BX.
Blower, air, portable,	5A/4124	
Type D with Nozzle	5A/4305	
Microammeter 25–0–25	5Q/168	For setting discriminator currents in f.c.v. 12131, 10D/20918.
Hoist, aircraft heavy component, 5 cwt. with	4GC/5703	
Handle winch 9″ and	4GC/5743	
Tube extension 36″ and	4GC/5443	
Hook cable end	4GC/5429	
Platform, aircraft servicing mobile, adjustable, Mk. 2.	4G/5628	
Ladder, aircraft servicing, elevating/extending, Giraffe type, Model AA. Mk. 2. with	4G/5641	
Jib	4G/5708	
Trolley, nitrogen charging	4G/4272	
Calibrating scale (for setting up T/B calibration marker circuits)		To be locally manufactured (from a sheet of Perspex) to drawing in A.P.2891J, Vol. 4.
Hook, top sheath, 5 cwt.	4GC/5736	Used when installing radar head into aircraft.
Unit, pressure regulating with	6D/2351	
Assembly hose	4G/3745	
Unit, pressure regulating	6D/2184	Only required if unit pressure regulating 6D/2351 is not available.
Pump, pressurising	4G/5435	
Radome, rear assembly	26DE/14764	For use with trolley, radar servicing, 12016 for stations servicing Victor aircraft. The 3rd line servicing unit may use either this item or the ring and radome assembly, 26DC/7869.
Ring and radome assembly	26DC/7869	For stations servicing Vulcan aircraft.
Capacitor, 10026	10C/24037	Capacity voltage divider,
Trolley, H.P. air charging Mk. 2.	4G/4221	For replenishing air bottles fitted in aircraft.

Item	Reference No.	Remarks
The following items are required by third line servicing unit only.		
Dynamic balancing equipment	1251/A	Used for testing scanning unit, 6923.
Vibration pick-off	1251/3	Used for testing scanning unit, 6923.
Frequency meter and distribution panel	10S/17875	Used for testing scanning unit, 6923.
Monitor and distribution panel, M16	10D/23587	Used for testing the klystron control unit 10AD/3081.
Pulse generator and power supply unit	10S/17873	Provides pulses for testing the klystron control unit 10AD/3081.
Monitor and distribution panel, M70	10D/23588	Used for testing the i.f. unit 6927 and the frequency control unit, 12131.
Test panel, M4	10D/23592	Used for testing the stabilizer unit (voltage), 10D/20910.
Load and monitor panel	10D/23589	Used for testing the chassis assembly, 6924.
Monitor and distribution panel, M18	10D/23590	Used for testing the thyratron drive unit, the suppression unit, and the waveform generator sub-units,
Pulse generator and video oscillator	10S/17872	
Power supply unit, M97	10K/24490	
Power supply unit M99	10K/24492	
Power supply unit, M100	10K/24493	
Power supply unit, M101	10K/24494	
Suppression unit, Type Jig	10AG/1903	Used in conjunction with the monitor and distribution panel, M18 for testing the suppression unit, 10AF/888.
Power supply unit, M98	10K/24491	Used for testing the indicator chassis assembly, 12301.
Power supply unit, M102	10K/24496	
Video oscillator and scan generator	10S/17876	Used for testing the indicator c.r.t. 6935.
Monitor and distribution panel, M19	10D/23591	
Connector cables		Used with items supplied for third line servicing unit.
Valve voltmeter, CT429	10S/9438384	Used in dynamic balancing of scanner.
Oscilloscope, CT386A	10S/9437177	
Stroboflash	6C/610	
Motor d.c. 24V or	5UD/4798	
Motor electric, PMID	5UD/7240	Supersedes motor, 5UD/4798.
Tubing rubber	32C/56	

Chapter 2

METER UNIT (MONITORING) 6415

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Introduction

1. Meter unit (monitoring) 6415 provides a means of indicating the presence and correctness of a.c. and d.c. voltages appearing at the 25-pole test plug D on the radar unit 6934. It also indicates correctness of phase rotation of the three-phase a.c. supply, measures a.f.c. crystal current and integrator anode voltage, and provides manual control facilities for the klystron reflector voltage and klystron tuning motor. The accuracy of the meter indication is within 3% on voltage ranges and within 14% on the crystal current range.

2.◀The unit is illustrated in Fig. 1 and 2. It consists of a front panel, carrying the meter and various switches, with a tag panel mounted behind it on brackets. The tag panel can be hinged open to provide access to components. The unit is fixed in a dust-proof case by means of captive screws through the front panel. When in use, the instrument is connected to the radar unit by means of a 10 ft. long connector. (For Victor aircraft a cable adaptor is included). A special carrying bag (Fig. 1) is provided. The test set must be transported in this bag; it may be operated in the bag if used at the aircraft.▶

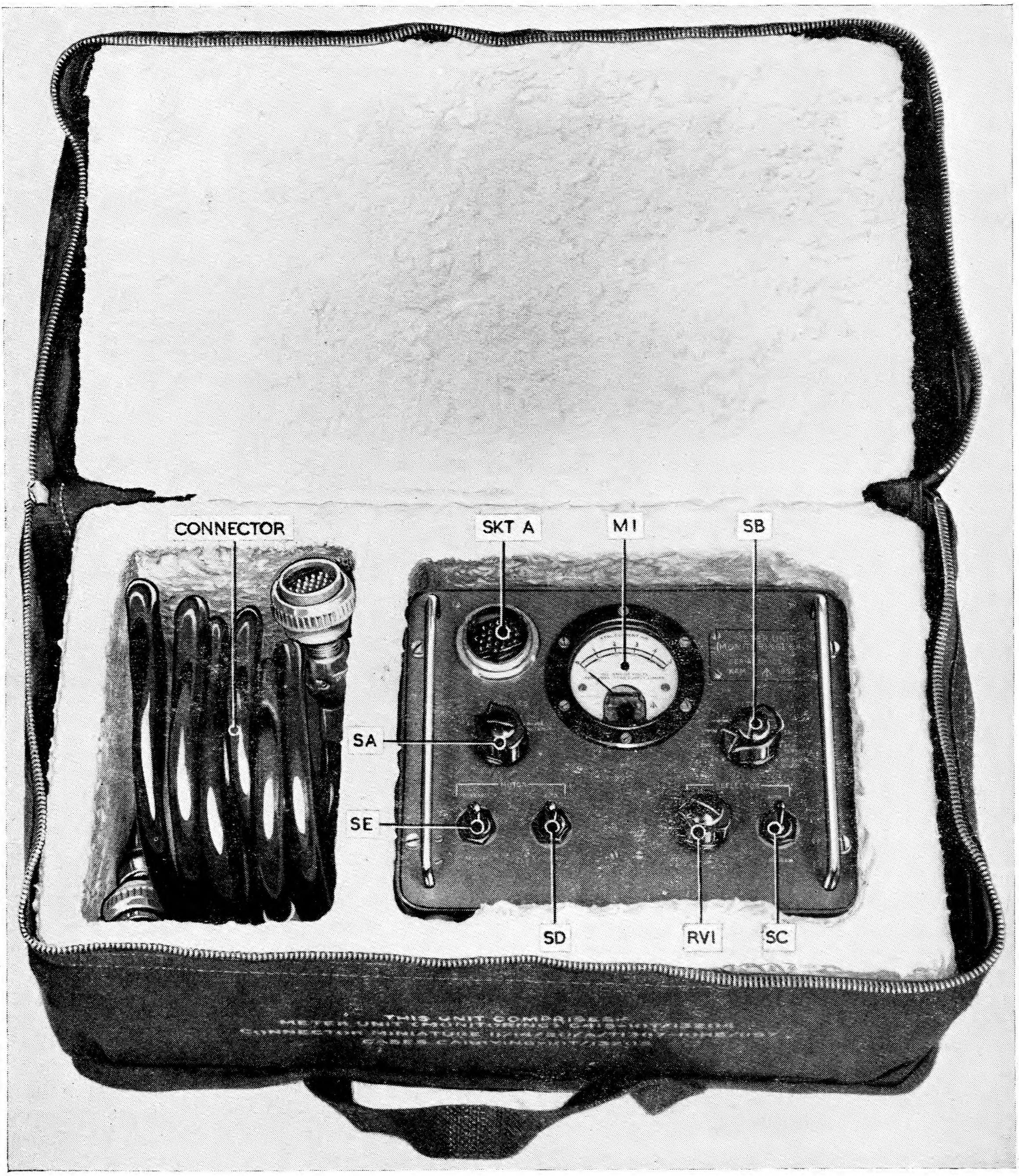


Fig. 1. General view

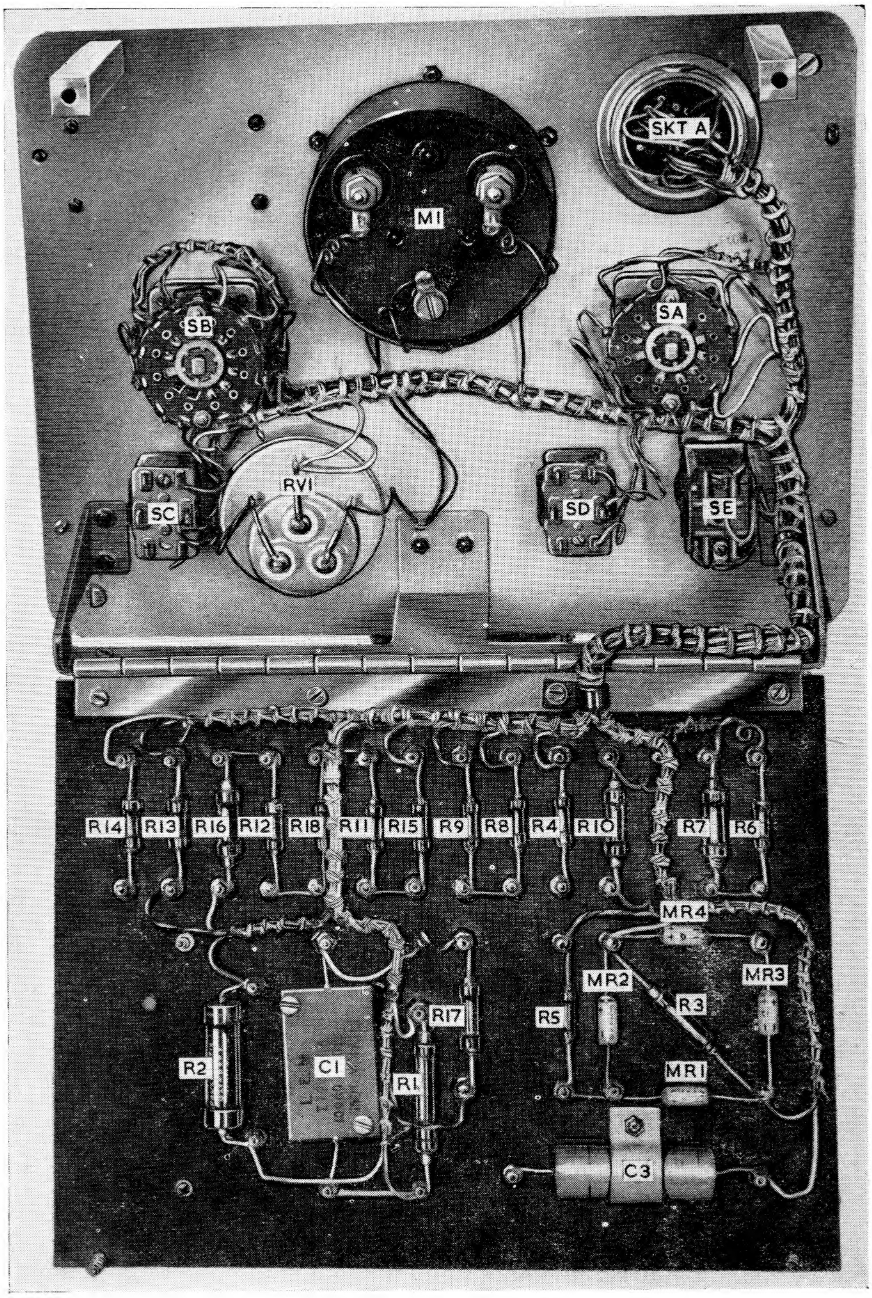


Fig. 2. Interior view

Circuit description

3. The meter unit is connected to the 25-pole servicing plug D on the heat exchanger panel of the radar unit (Part 1, Sect. 1, Chap. 2, Fig. 11) in place of the dummy socket normally fitted when airborne.

Meter

4. The meter (Fig. 1) is a 1mA moving-coil instrument having a resistance of 40 ohms.

Meter switch

5. The METER switch SB has nine positions. The first of these (a.c.) connects the a.c. measuring circuit (para. 8) to the meter. The next six positions connect the meter to the various h.t. and bias supply lines in turn. Each line has resistance in series with it such that the current drawn when the supply is correct is 0·5mA (half-scale meter reading). Positive supplies are connected to the positive meter terminal via SB2F, and SB1F earths the negative terminal. For the measurement of negative voltages, the line is connected to the negative meter terminal via SB1F and the positive terminal is earthed via SB2F and the appropriate series resistance.

6. *Crystal current.* Pole Q of the 25-pole test plug is normally shorted to pole Z (earth) by the dummy socket in order to complete the path for the a.f.c. crystal current through the primary of transformer T2 in the klystron control unit (Part 1, Sect. 1, Chap. 10). When the meter unit is connected, the short between poles Q and Z is broken and the crystal current return is through the parallel combination of R14 (18 ohms) in the meter unit and R16 (22 ohms) in the klystron control unit. When the METER switch is set to XTAL CURRENT, the meter is connected in parallel with these two resistors. The meter full scale deflection is 5mA under these conditions.

7. *Integrator anode volts.* In the final switch position (INT ANODE VOLTS) the meter negative terminal is earthed via SB1F and the positive terminal is connected via R17 to pole O of the 25-pole socket; the meter full scale deflection is then 150V. Pole O is normally connected to pole N by the dummy socket to complete the circuit from the klystron reflector to the anode of the integrator valve V12 in the klystron control unit. When the meter unit is used, the klystron reflector can be connected by means of the REFLECTOR AUTO-MAN switch (para. 14) either to the integrator anode or to the slider of the REFLECTOR control RV1 (meter unit). It should be noted that the meter reading is a measure of reflector volts rather than integrator anode volts; the quantities are the same only when switch SD is set to AUTO.

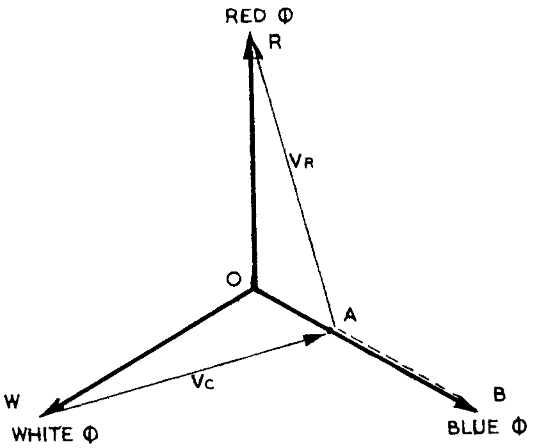
A.C. SUPPLIES switch

8. This switch, SA, is brought into circuit by setting the METER switch to A.C. Switch wafers SB2F and SB1F connect the meter between the output terminals of a bridge rectifier circuit formed by the crystal diodes MR1 to MR4.

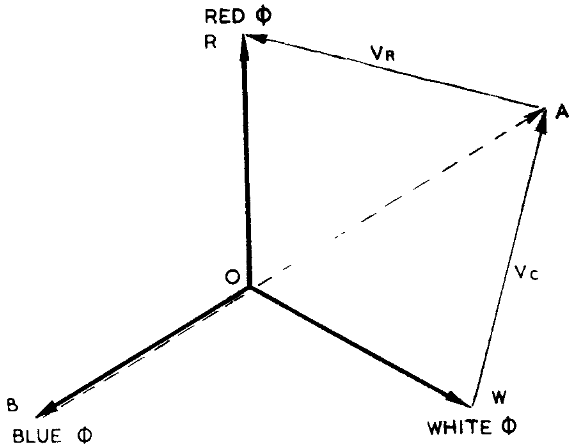
9. The three-phase 200V, 400c/s supply is present at poles A, B, W of the 25-pole socket. In each of the first three positions of the A.C. SUPPLIES switch, one of the three phase-to-phase voltages is applied to the circuits consisting of the bridge rectifier and the series resistors R4, R5. In each case, the current through the meter will be 90% of the r.m.s. current through the a.c. circuit (i.e. 0·5mA, giving half-scale deflection) if the voltage is correct. The resistor R3 is included across the d.c. terminals of the bridge to prevent the peak-inverse voltage rating (100V) of the crystal diodes being exceeded when the meter is not connected.

10. *Phase rotation.* This switch position provides a means of checking that connections are correct in the three-phase supply. The action of the circuit is as follows.

11. A resistor (R1) and a capacitor (C1) are connected in series between the red and white phase lines of the supply. The voltage at the junction C1, R1 is connected via SA1F (poles 3, 4) and R5 to one a.c. terminal of the bridge rectifier. The rectifier a.c. circuit is returned via R4, SA1F (poles 10, 9) and R2 to the blue phase line.



(a) Rotation incorrect



(b) Rotation correct

Fig. 3. Vector diagrams

12. The a.c. voltages in the circuit are represented in the vector diagrams of fig. 3. Note that the reactance of C1 is numerically equal to the resistance of R1 at 400c/s so that the voltages across the components are equal in magnitude.

13. If the phase rotation is correct, the voltage from the blue phase to the junction C1, R1 is the long vector BA in fig. 3b. The total resistance in series with the a.c. circuit of the bridge rectifier is such that a half-scale reading is obtained on the meter. If the rotation is incorrect, the voltage applied to the rectifier is the short vector AB in fig. 3a; this causes a much smaller meter deflection (about one eighth of full scale).

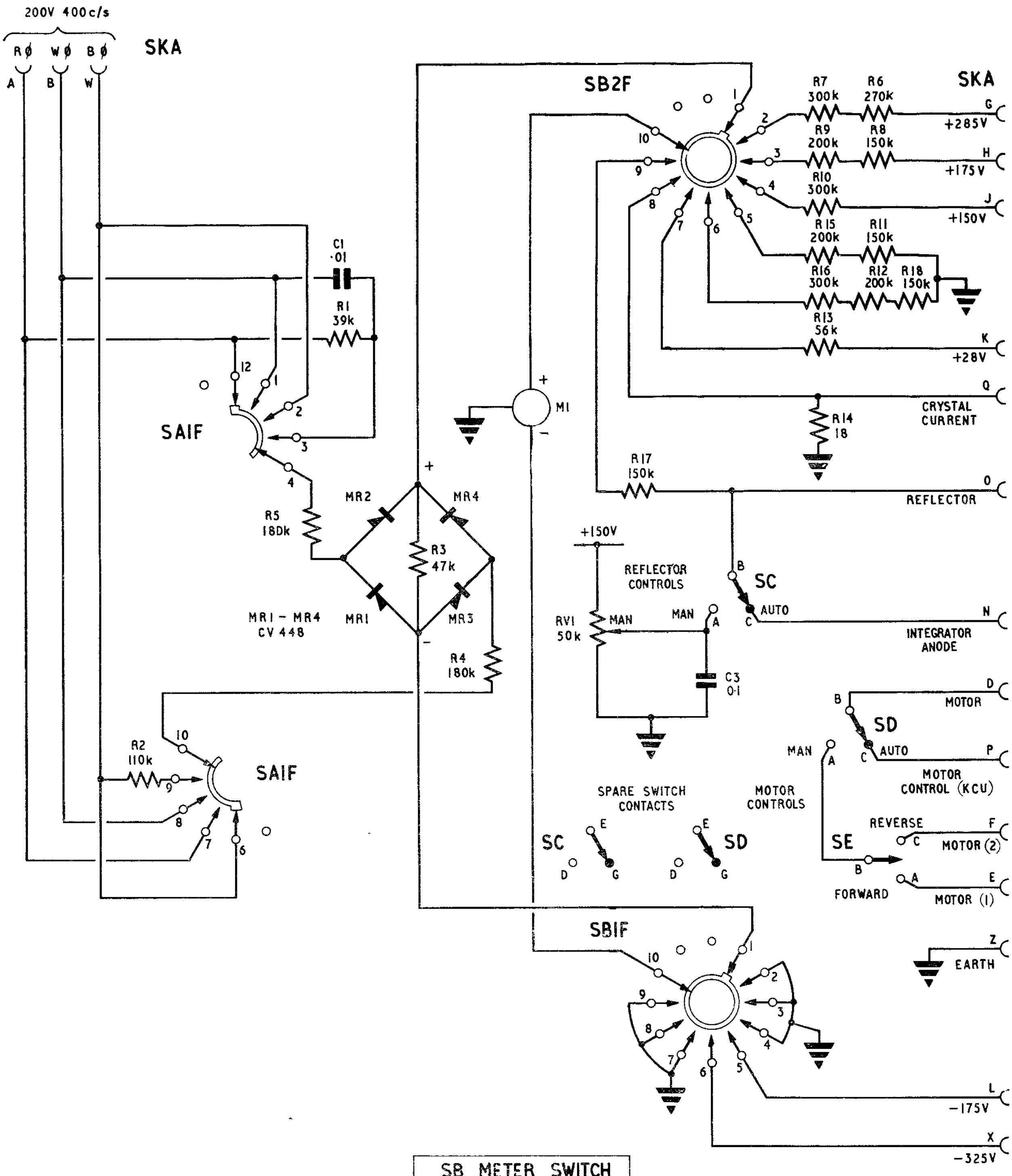
REFLECTOR controls

14. When the REFLECTOR AUTO-MAN switch is set to AUTO, the a.f.c. circuit in the radar head operates normally. In the MAN position, the a.f.c.

servo loop is broken and the voltage from the slider of RV1, the REFLECTOR voltage control, is connected via SC to the klystron reflector.

MOTOR controls

15. When the MOTOR AUTO-MAN switch is set to AUTO, it makes a circuit (normally made by the dummy socket) between poles D and P of the 25-pole socket. This connects the klystron tuning motor control winding to the moving contact of the motor relay (relay unit klystron) and automatic operation of the klystron mechanical tuning mechanism is obtained. When the switch is set to MAN, the motor control winding is connected to the FORWARD—STOP—REVERSE switch SE which is biased to the centre (STOP) position. Operation of the switch SE selects one or other of the 20V r.m.s. supplies for the motor; the motor drives in the direction appropriate to the switch position.



CONTROL	FUNCTION
SA	AC SUPPLIES
SB	METER
SC	REFLECTOR AUTO MAN
SD	AFC MOTOR AUTO MAN
SE	MOTOR FORWARD REV
RV1	MAN REFLECTOR

SB METER SWITCH	
POSN	FUNCTION
1	AC SUPPLIES
2	+285V
3	+175V
4	+150V
5	−175V
6	−325V
7	+28V
8	CRYSTAL CURRENT
9	INTEGRATOR ANODE

SA AC SUPPLIES	
POSN	FUNCTION
1	RED BLUE
2	RED WHITE
3	BLUE WHITE
4	PHASE ROTATION

Chapter 3

CONTROL UNIT 12152

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Introduction

1. Control unit 12152 is intended to adapt monitor 100 (*Ref. No.* 10*T*/6151) for particular use in the servicing of ARI.5919. A front view of the control unit is given in fig. 1. Monitor 100 is described in A.P.2563EE.

2. When in use, the control unit is mounted in the rectangular compartment at the front of the monitor. Connections to the 6-pole test plug PLE and the 25-pole test plug D on radar unit 6934 are made from sockets SK2 and SK4 on the control unit. The 115V a.c. power supply for the monitor is derived from plug PLD on the radar unit and appears on the free socket SK5 of the control unit; this is connected to the power supply plug at the front of the monitor. Connections to the monitor meter and the monitor Y amplifier are made via the 12-pole free socket SK1 on the control unit; this is connected to the internal fixed plug PL2 in the monitor before the control unit is installed.

3. In general, the control unit fulfils the purpose of a combined junction box and switch unit. It provides for connecting various voltages and waveforms to the monitor and enables the monitor meter to give an indication of the radar a.f.c. crystal current and the phase-to-phase voltages of the three phase 200V, 400 c/s supply for the radar. If an accurate measure of crystal current is required, meter unit (monitoring) 6415 (*Chap.* 2) must be used. An accurate check of the three phase a.c. supply can be obtained by means of test set 200V, 400 c/s, three phase, a.c. (*Ref. No.* 5*G*/3198) (*A.P.*4343*S*).

4. In addition, the control unit provides:

(1) A means of indicating the correctness of rotation of the three phase a.c. supply.

(2) Tuning facilities for resonator performance testing X12549 (when fitted in the radar unit).

(3) Manual control facilities for the klystron reflector voltage and klystron tuning motor.

Circuit description

5. A circuit diagram of control unit 12152 is given in fig. 5. Interior views of the unit, showing the layout of components, are given in fig. 2 and 3.

Monitor meter

6. The meter fitted to monitor 100 is a 1mA moving coil instrument having scales calibrated from 0 to 3 and 0 to 10. When relay A in the monitor is operated (*para.* 7) the meter terminals are connected via PL2 (monitor) to poles SK1/2 and SK1/10 in the control unit. When relay A is not operated, the meter is connected to the monitor circuitry.

Meter switch

7. The METER switch S3 has three wafers. The first of these, S3A, completes the 28V d.c. circuit to the operating coil of relay A in the monitor in all positions except the OFF position. When the monitor relay is operated, the monitor meter is connected to the wipers of wafers S3B and S3C.

8. *D.C. voltage.* In the positive voltage positions, the meter negative terminal is earthed by S3B and the voltage is connected via a resistor to the meter positive terminal via S3C. In negative voltage positions, the meter positive terminal is earthed via 3SC and the voltage is connected through a resistor to the negative meter terminal via S3B. The full scale deflection of the meter appropriate to the various switch positions is as follows:

METER switch position	*Meter f.s.d.* (*volts*)
+285V	300
+175V	300
+150V	300
—175V	300
—325V	1000
INT ANODE (A.F.C.)	300
+28V	30

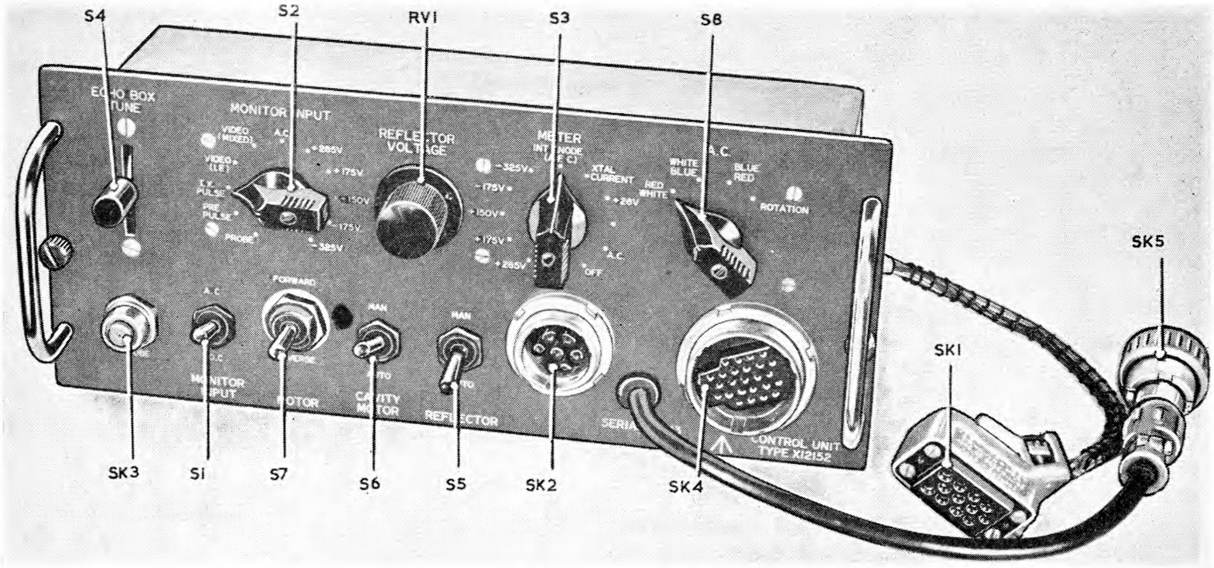


Fig. 1. Front view

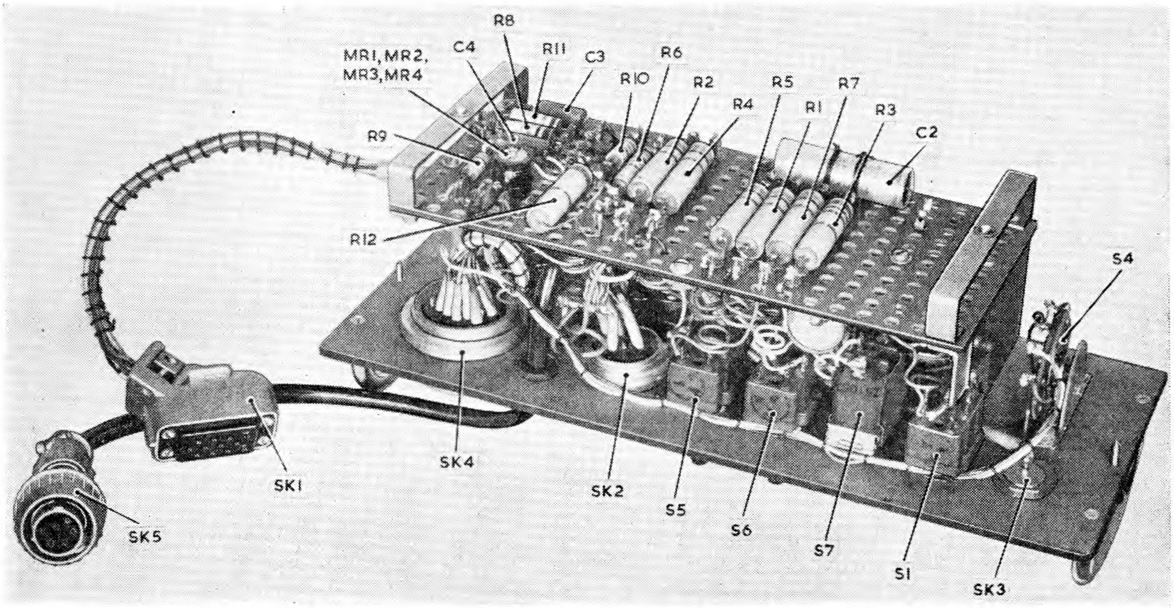


Fig. 2. Interior view (1)

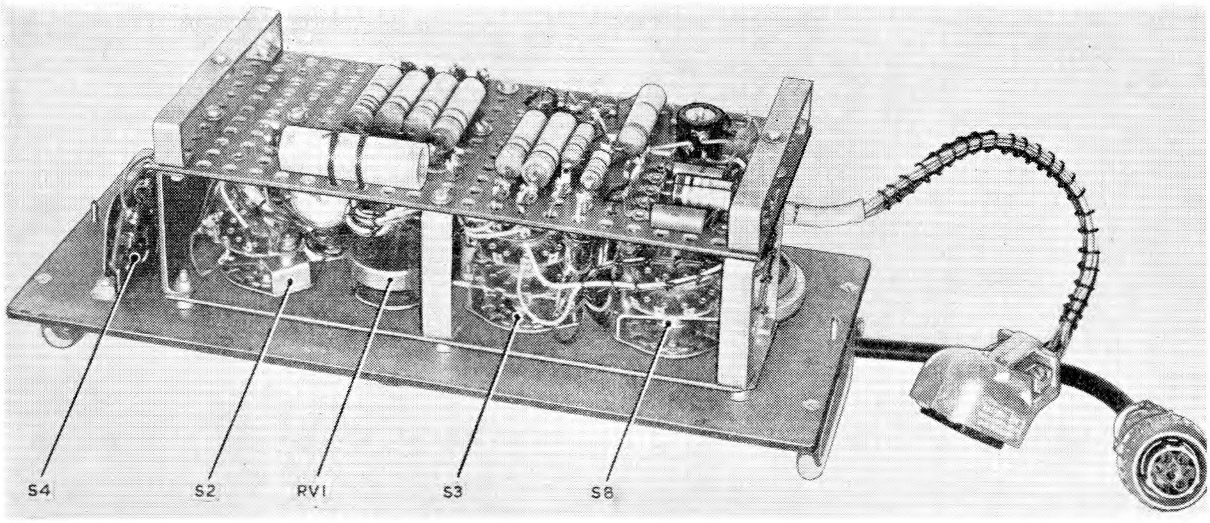


Fig. 3. Interior view (2)

9. *Crystal current*. Pole Q of the 25-pole test plug D on the radar unit is normally shorted to pole Z (earth) by a dummy socket in order to complete the path for the a.f.c. crystal current through the primary of transformer T2 in the klystron control unit (*Part* 1, *Sect*. 1, *Chap*. 10). When control unit 12152 is connected instead of the dummy socket, the short between poles Q and Z is removed and the crystal current return is through R16 (22 ohms) in the klystron control unit. When the METER switch on control unit 12152 is set to XTAL CURRENT, the monitor meter is connected in parallel with this 22 ohms resistor. The meter reading should only be taken as an indication of the presence of crystal current since, owing to the variation in meter resistance from monitor to monitor, meter full scale deflection varies from approximately 6mA to 18mA.

10. *Integrator anode voltage*. When the MET
switch is set to INT ANODE (A.F.C.), the met
negative terminal is earthed by S3B and t
positive terminal is connected via S3C, R7
pole 0 of the 25-pole socket. Pole 0 is normal
connected to pole N by the dummy socket
complete the circuit from the klystron reflector
the anode of the integrator valve V12 in t
klystron control unit. When the control u
12152 is used, the klystron reflector can be co
nected by means of the REFLECTOR MAN-AU
switch (*para*. 19) either to the integrator anode
to the slider of the REFLECTOR VOLTAGE contr
RV1 (control unit 12152). It should be noted th
the meter reading is a measure of the reflector vol
rather than integrator anode volts; the quantiti
are the same only when switch S5 is set to AUT

11. *A.C.* In this switch position, the monitor meter is connected to the a.c. measuring circuit incorporating the bridge rectifier MR1 to MR4.

A.C. switch

12. This switch can be used to connect any line of the three phase supply to the monitor Y amplifier via the MONITOR INPUT switch (set to A.C.). Also, when the METER switch is set to A.C., any of the three phase-to-phase voltages can be measured on the monitor meter (full scale deflection=300V).

13. Switch wafers S8A and S8B connect the a.c. voltage (via R10, R12) to the a.c. terminals of the bridge rectifier consisting of MR1 to MR4; switch wafers S3B and S3C connect the d.c. output of the bridge to the meter terminals. The resistor R9 is included across the d.c. terminals of the bridge to prevent the peak-inverse voltage rating of the rectifier from being exceeded when the METER switch is in a position other than A.C.

14. *Phase rotation.* When the A.C. switch is set to ROTATION, the monitor meter can be used to check that connections are correct in the three-phase supply. The action of the circuit is as follows:

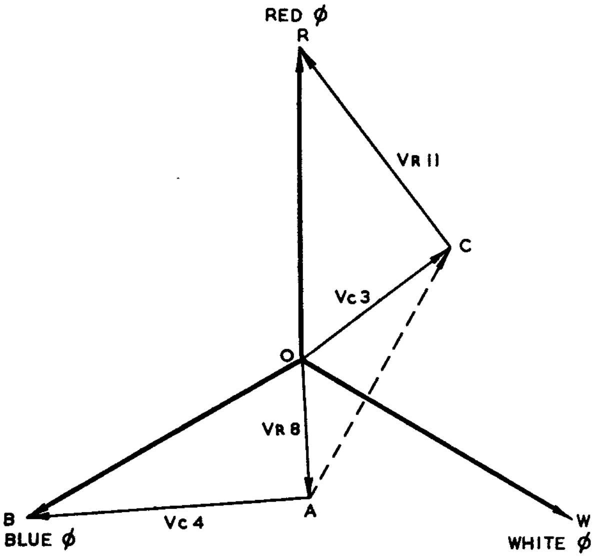
15. A resistor (R11) and a capacitor (C3) are connected in series between the red phase line and earth, and a similar circuit consisting of a resistor (R8) and a capacitor (C4) is connected between the blue phase line and earth. The a.c. voltage between the junction C3, R11 and the junction C4, R8 is applied across the a.c. terminals of the bridge rectifier via switch wafers S8A and S8B, and resistors R10, R12.

16. The a.c. voltages in the circuit are represented in the vector diagram of fig. 4. If the phase rotation is correct, the voltage applied to the rectifier is the vector AC in Fig. 4a and a reading of approximately 100V will be obtained on the monitor meter. If the rotation is incorrect, the output voltage of the circuit will be the vector AC in Fig. 4b giving only a very small meter reading.

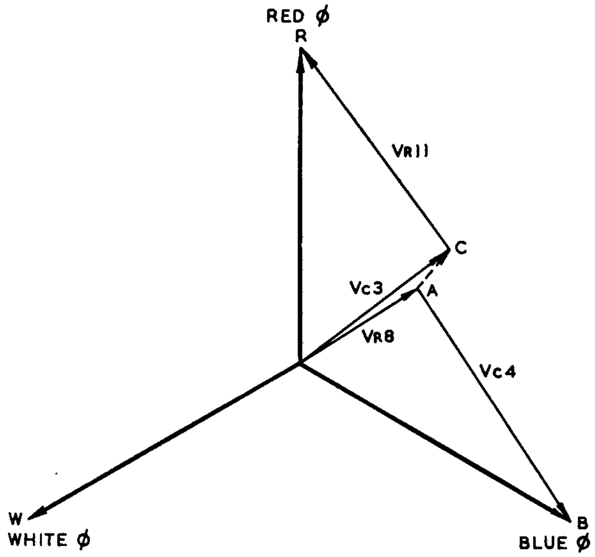
MONITOR INPUT switch

17. The MONITOR INPUT switch S2 selects the quantity to be applied to the monitor Y amplifier.

18. In the first position (PROBE) the switch connects to the monitor any signal applied to the PROBE coaxial socket on the control unit. The next four positions select in turn the various waveforms available at the 6-pole test plug PLE on the radar unit. In the A.C. position of the switch, the waveform applied to the monitor depends on the setting of the A.C. switch (para. 12). For example, if the MONITOR INPUT switch is at A.C. and the A.C. switch is at RED WHITE, the red phase line of the 400 c/s supply is connected to the monitor. If the A.C. switch is set to ROTATION, the waveform connected to the monitor is that at the junction C3, R11. The remaining positions of the MONITOR INPUT switch enable the various h.t. and bias supply lines to be applied to the monitor for the examination of ripple; for this purpose, the MONITOR INPUT coupling switch S1 must be set to A.C.



a ROTATION CORRECT



b ROTATION INCORRECT

Fig. 4. Vector diagrams

Reflector controls

19. When the REFLECTOR MAN—AUTO switch S5 is set to AUTO, the a.f.c. circuit in the radar unit operates normally. In the MAN position of the switch, the a.f.c. servo loop is broken and the klystron frequency is determined by the setting of RV1, the REFLECTOR VOLTAGE control.

Motor controls

20. When the CAVITY MOTOR MAN-AUTO switch is set to AUTO, it makes a circuit (normally made by the dummy socket on the radar unit) between poles D and P of the 25-pole socket. This connects the klystron tuning motor control winding to the moving contact of the motor relay (relay unit klystron) and automatic operation of the klystron mechanical tuning mechanism is obtained. When the switch is set to MAN, the motor control winding is connected to the MOTOR FORWARD-REVERSE switch S7 which is biased to the centre (stop) position. Operation of the switch S7 selects one or other of the 20V r.m.s. supplies for the motor present at poles SK4/F and SK4/E; the motor drives in the direction appropriate to the switch position.

ECHO BOX TUNE switch

21.◀This switch S4 provides a means of tuning the resonator performance testing X12549 built into the radar unit. The switch is biased to the centre (off) position. Operation of the switch connects the 28V d.c. supply to poles S and R of the 25-pole socket, the polarity, and hence the direction of rotation of the resonator tuning motor, depending on the direction of operation of the switch.▶

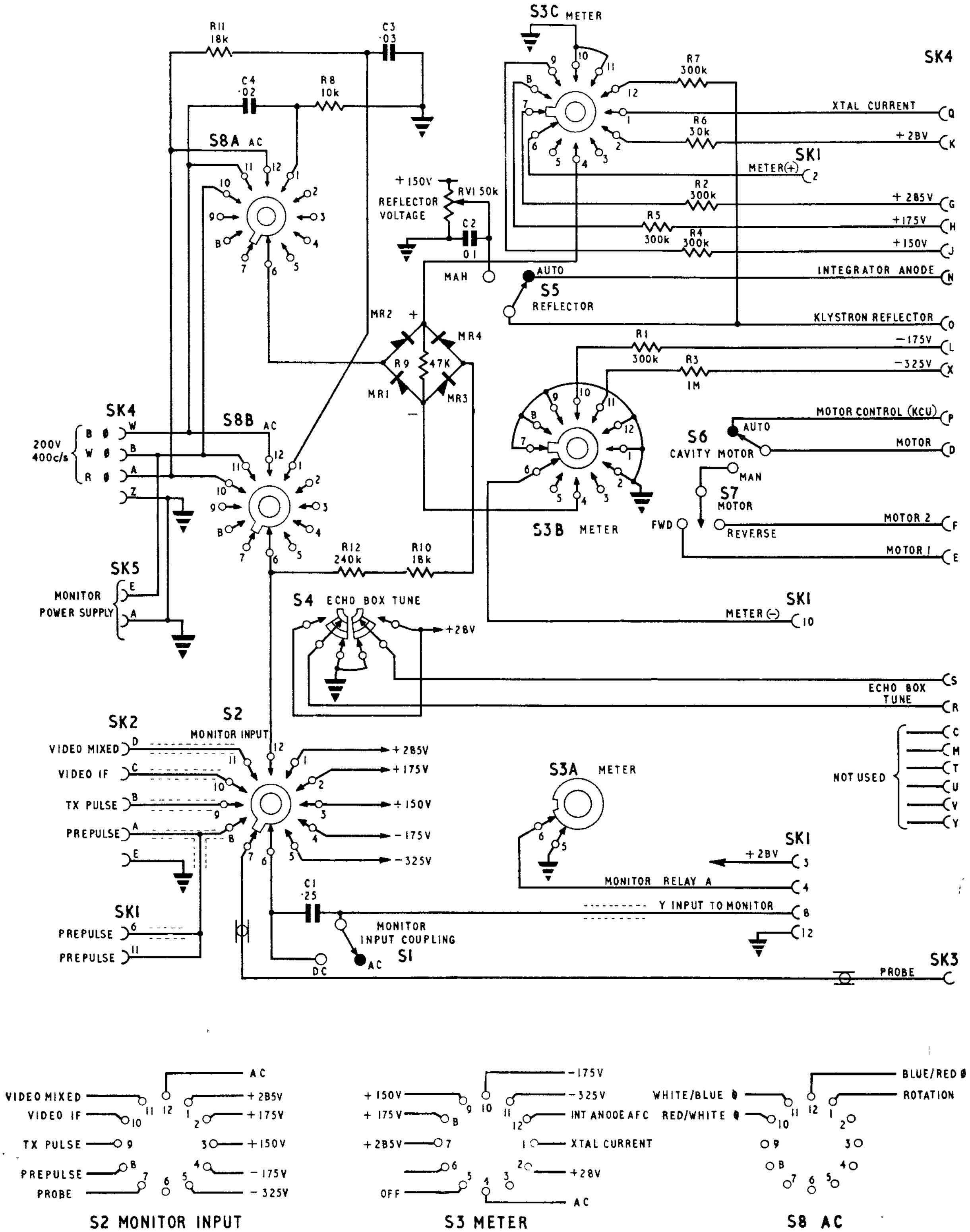


Fig. 5. Circuit

Chapter 4

DUMMY LOAD (MODULATOR) 6413

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Introduction

1. During servicing of ARI.5919 it may be necessary to operate the equipment without the magnetron in the transmitter unit (Part 1, Chap. 4) generating r.f. pulses. To achieve this, the magnetron must be removed and, in order that certain circuits associated with the magnetron remain correctly loaded, the dummy load (modulator) 6413 (Ref. No. 10S/17394) is provided for insertion in the transmitter unit in place of the magnetron.

Mechanical description

2. A general view of the dummy load (modulator) is given in Fig. 1. The dummy load (modulator) consists of a 1000 ohm ± 5%, (250W at 20°C or 160W at 70°C) non-inductive resistor mounted in a glass fibre tube and metal can assembly. To prevent overheating of the resistor, when the dummy load (modulator) is inserted in the transmitter unit, an air scoop near the base of the dummy load (modulator) permits cooling air from a blower motor in the transmitter unit to be blown around and inside the resistor. In addition, the metal can assembly is perforated to allow circulation of the cooling air.

3. Inside the metal can assembly, the resistor is surrounded by a glass fibre tube: the resistor is clamped at the top of this tube by a clip assembly. Soldered to the clip assembly are two lengths of wire that make connection to contacts on a mounting flange near the base of the dummy load (modulator). These contacts are connected to earth when the dummy load (modulator) is mounted in the transmitter unit.

Functional description

4. When the dummy load (modulator) is mounted in the transmitter unit, its end connection (Fig. 1) fits a protrusion provided for the magnetron cathode on the transformer assembly, hence the secondary winding of the pulse transformer T4 **in** the transmitter unit is loaded by the 1000 **ohm** resistor of the dummy load (modulator).

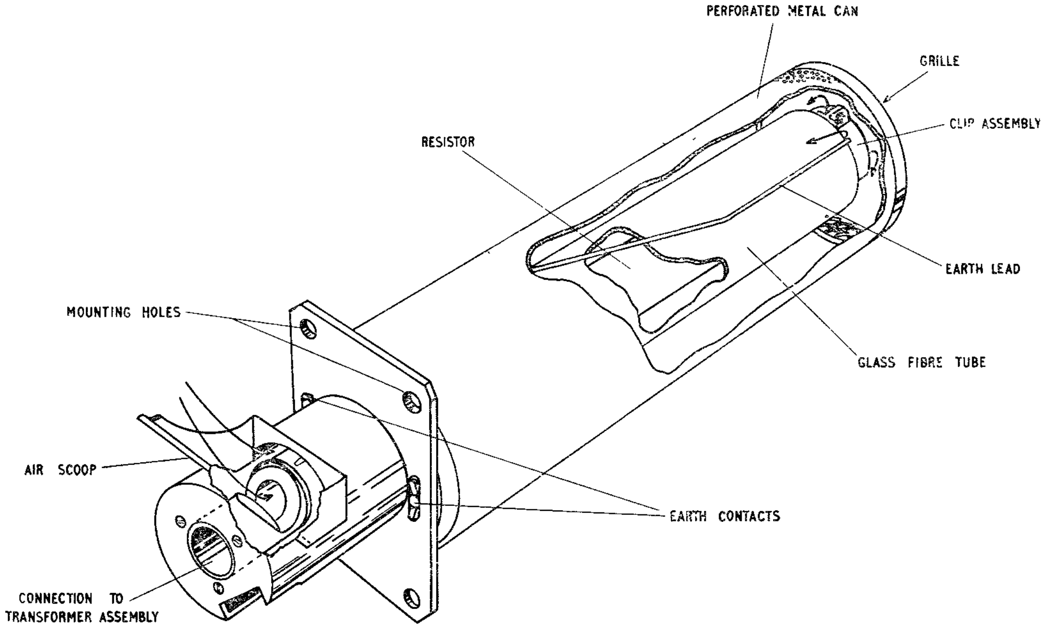

Fig. 1. Dummy load (modulator—6413) general view

Chapter 5

TEST KIT 6516

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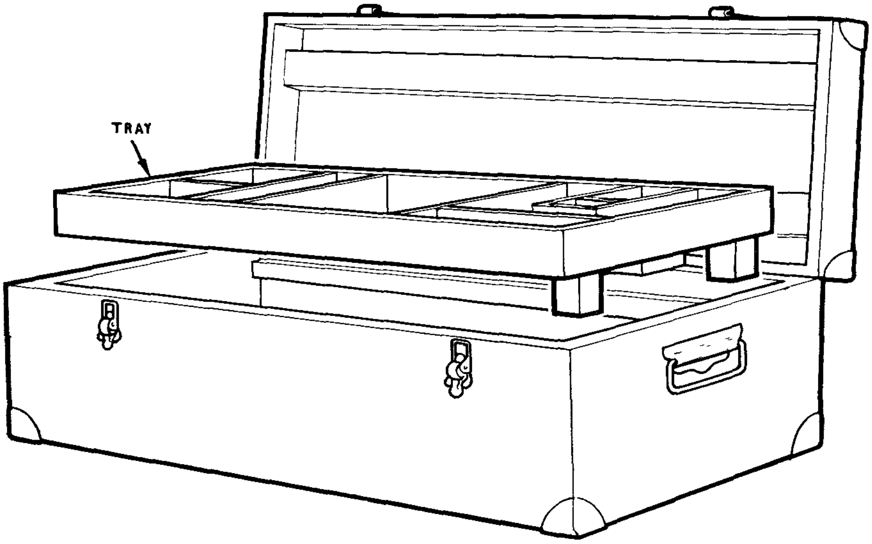


Fig. 1. Test equipment carrying case—general view

Introduction

1. The test kit 6516 (Ref. No. 10S/17276) consists of a number of items of test equipment used during servicing of ARI.5919. This chapter gives a list of the test equipment contained in the test kit and describes the function of each item. Fig. 1 shows the carrying case in which the test equipment is stored and Fig. 2 shows the location of each item in the case.

Contents of test kit 6516

2. The items of test equipment contained in the test kit are given in Table 1. The item numbers given in column 1 refer to Fig. 2.

Functional description

3. The items of test equipment contained in the test kit 6516 are used during servicing of ARI.5919. The following paragraphs describe the function of each item of test equipment; operating instructions are given in the relevant chapters of C.S.D.E. Schedule, Provisional Pt. 6, ARI.5919.

Connector, moulded, C/270/10/B/T2134

4. The connector, moulded, C/270/10/B/T2134 is used to connect the output at jack socket JK1 or JK2 on the i.f. unit, 6927 to an oscilloscope for monitoring purposes.

Connector, moulded, C/270/20/D/T2135

5. The connector, moulded, C/270/20/D/T2135 is used to connect the tester performance, 104A to the i.f. unit, 6927 when the overall noise factor of the radar unit is checked.

Clips, retaining, 381

6. The clip, retaining, 381 is used to restrain the scanner springs when the scanning unit, 6923 is serviced.

Tool, trimming

7. The tool, trimming is used to tune the transformers and chokes of the frequency control unit, 10D/20918 and the i.f. unit, 6927 when these units are aligned.

TABLE 1

Contents of test kit 6516

Item No.	Test equipment	Qty.	Ref. No.
1	Connector, moulded, C/270/10/B/T2134	1	10HS/1151
2	Connector, moulded, C/270/20/D/T2135	1	10HS/1196
3	Clips, retaining, 381	1	10H/22203
4	Tool, trimming	1	10AG/723
5	Spanner (locking ring), 156	1	10AG/724
6	Spanner, 158	1	10AG/726
7	Pin (scanner synchro)	1	10AG/3001
8	Pillars, servicing	4	10AS/3239
9	Plug, lead assembly	4	RR/B/823565
10	Impedance matching unit, 12315	1	10B/18754
11	Impedance matching unit, 12337	1	10B/18761
12	Impedance matching unit, 12314	1	10B/18753
13	Adaptor (crystal current), 345	1	10AD/3331
14	Adaptor (waveguide), 346	1	10AD/3332
15	Plug, servicing	1	10H/22202
16	Chart, calibration	1	10AF/635
17	Spanner, 157	1	10AG/725
18	Pillars, servicing	4	10AS/3238
19	Spanner, 159	1	10AG/727
20	Box, connecting, 105	2	10AD/3336
21	Box, connecting, 106	2	10AD/3337
22	Box, connecting, 103	2	10AD/3334
23	Box, connecting, 104	2	10AD/3335
24	Box, connecting, 102	1	10AD/3333
25	Test unit (synchro alignment)	1	10S/17313
	Carrying case	1	10S/17277

Spanner (locking ring), 156

8. The spanner (locking ring), 156 is used to lock the c.r.t. clamps of the indicator unit, 6935.

Spanner, 158

9. The spanner, 158 is used to adjust the c.r.t. clamps of the indicator unit, 6935.

Pin (scanner synchro)

10. The pin (scanner synchro) is used to lock the scanner in the dead ahead position when the time-base synchro on the scanning unit, 6923 is aligned.

Pillars, servicing, 10*AS*/3239

11. The pillars, servicing, 10AS/3239 are used with the pillars, servicing 10AS/3238 (para. 21) to form a mounting assembly for the r.f. block when it is serviced out of the radar unit.

Plug, lead assembly

12. The plug, lead assembly is used in conjunction with the boxes, connecting (items 20 to 24, Fig. 2) to monitor waveforms, voltages and currents.

Impedance matching unit, 12315

13. The impedance matching unit, 12315 matches the signal generator, CT406 to the i.f. unit, 6927 when the i.f. unit is aligned.

Impedance matching unit, 12337

14. The impedance matching unit, 12337 matches the signal generator, CT406 to the frequency control unit, 10D/20918 when the frequency control unit is aligned.

Impedance matching unit, 12314

15. The impedance matching unit, 12314 matches the tester performance, 104A to the i.f. unit, 6927 when the signal to noise ratio of the i.f. unit is checked.

Adaptor (crystal current), 345

16. The adaptor (crystal current), 345 replaces the i.f. unit, 6927 to enable the receiver crystal current to be measured.

Adaptor (waveguide), 346

17. The adaptor (waveguide), 346 is a taper waveguide section (from 16 to 15 waveguide) which enables the dummy load (transmitter), 10S/1335 to be fitted to the r.f. block.

Plug, servicing

18. The plug, servicing, is fitted between PL5 and SK5 of sub-unit 5 on the waveform generator. Its function is to convert a 2·4 Kc/s amplifier, located in sub-unit 5, to a 2·0 Kc/s oscillator in order that pre-pulses can be generated when the indicator switch is set to the STD. BY position. Incorporation of Modification 5599/1 on sub-unit 5 (removal of induction generator from scanning unit 6923) renders the plug, servicing obsolete.

Chart, calibration

19. The chart, calibration is used in conjunction with the tester performance, 104A when the receiver signal to noise ratio and the transmitter/receiver overall noise factor is checked.

Spanner, 157

20. The spanner, 157 is a C spanner for the lock nuts of scanning unit 6923, (item 45 on Fig. 1 of Part 1, Chap. 7).

Pillars, servicing 10*AS*/3238

21. These are used in conjunction with the pillars, servicing, 10AS/3239.

Spanner, 159

22. The spanner, 159 is made of a non-ferrous material and is used on the nuts that secure the magnetron to the casting of the transmitter unit.

Boxes, connecting, 103, 104, 105 *and* 106

23. The boxes, connecting, 103, 104, 105 and 106 are made up of strip connectors and associated shorting plug assemblies connected between miniature plugs and sockets. In conjunction with the plug lead assemblies (para. 12), the boxes connecting enable voltages, waveforms and currents from miniature plugs and sockets to be monitored.

(1) The box, connecting, 103 connects to 26-pole miniature plug and socket connectors.

(2) The box, connecting, 104 connects to 34-pole miniature plug and socket connectors.

(3) The box, connecting, 105 connects to 9-pole miniature plug and socket connectors.

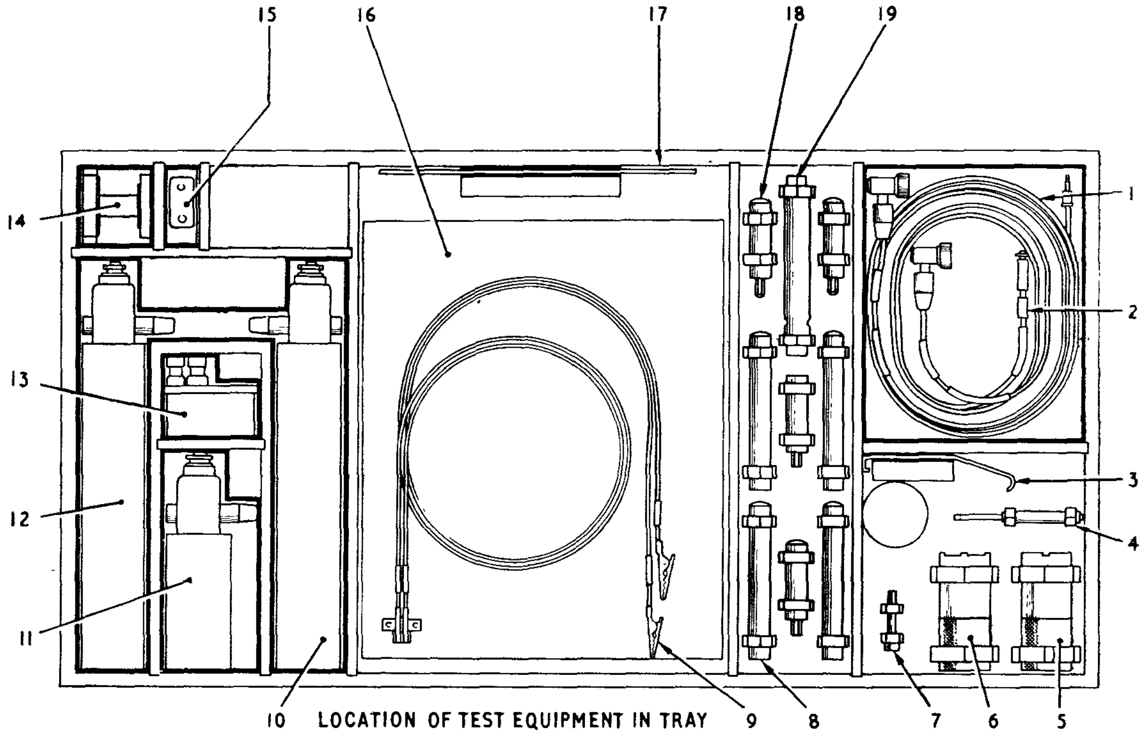
(4) The box, connecting, 106 connects to 18-pole miniature plug and socket connectors.

Box, connecting, 102

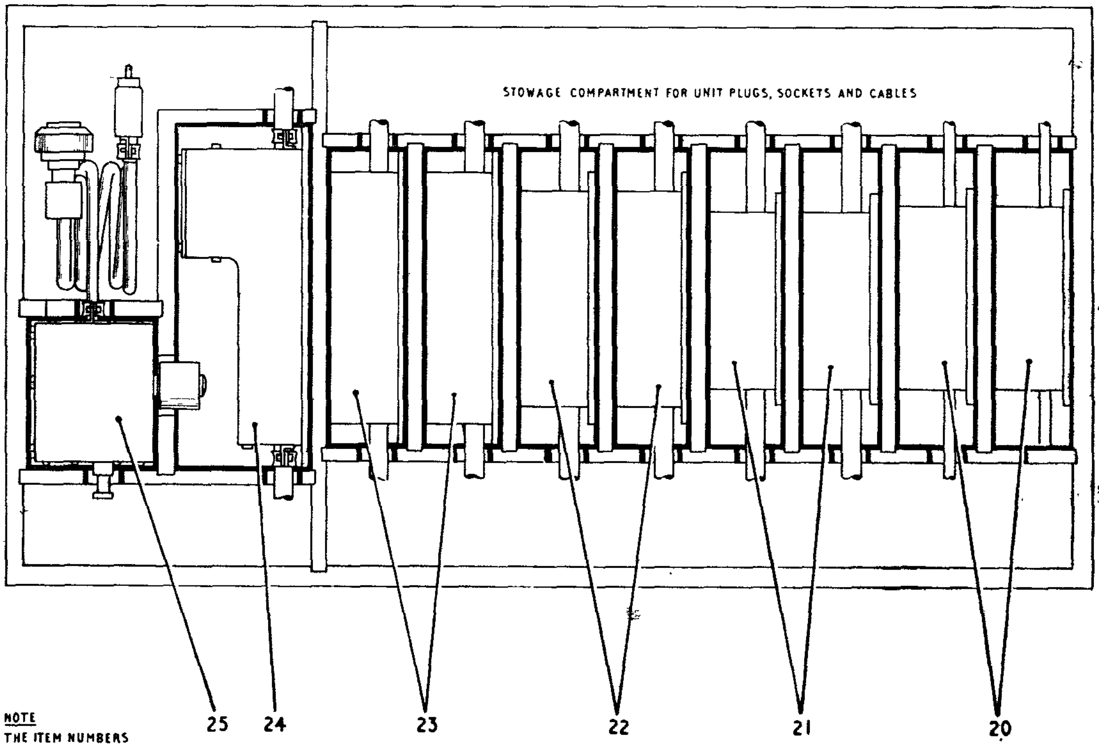
24. The function of the box, connecting, 102 is the same as that of the boxes, connecting, 103, 104, 105 and 106 except that it is only used with the stabilizer unit voltage, 10D/20910 and it incorporates a three position switch to control certain connections within the box. The three positions of the switch are OFF, NEG. ONLY and ON and these provide the switching facilities shown in Fig. 3.

Test unit (synchro alignment)

25. The test unit (synchro alignment) and the pin (scanner alignment) para. 10, are used to align the scanner; the test unit (synchro alignment), Fig. 4 provides reference voltages used for setting up the scanner synchro.



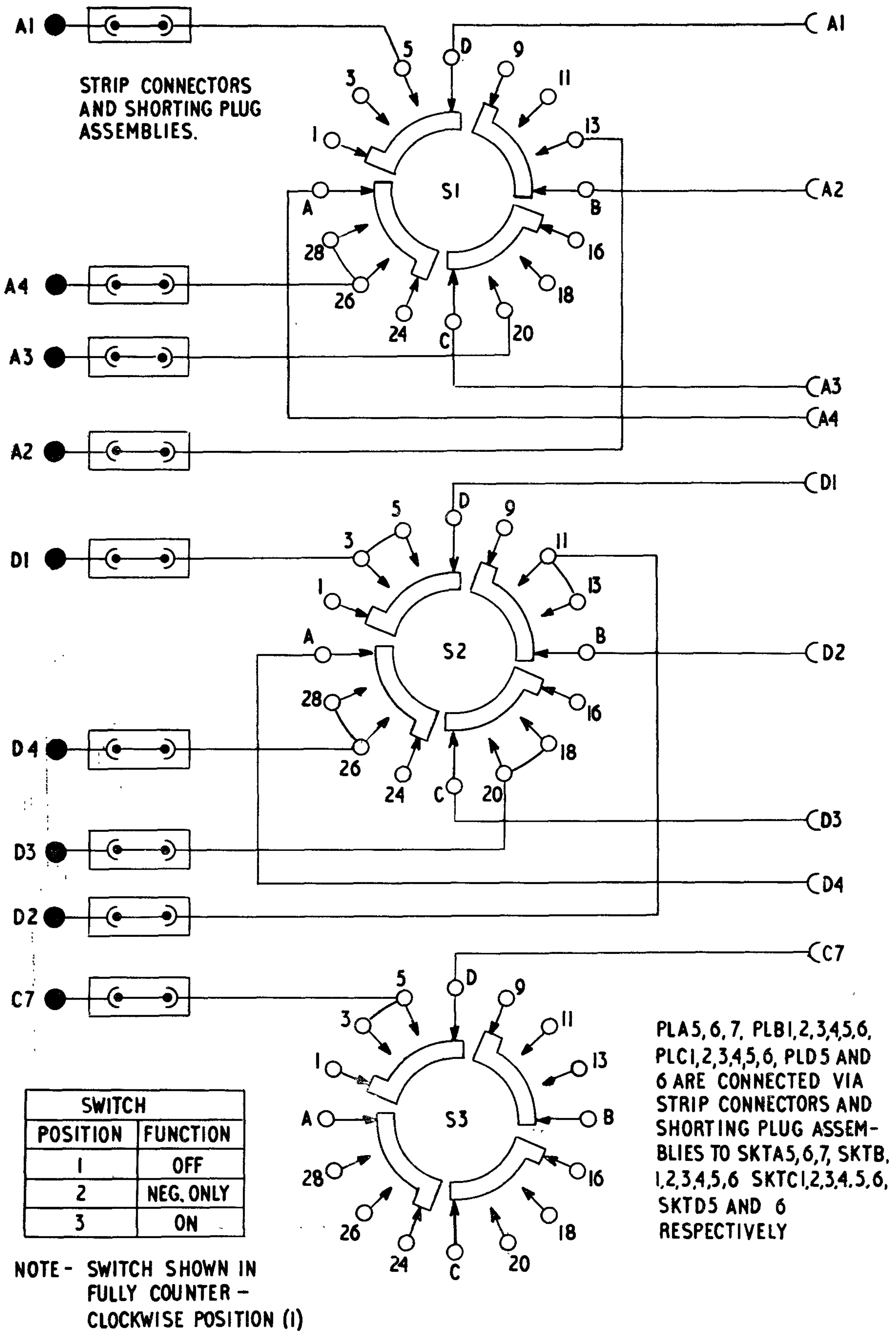
LOCATION OF TEST EQUIPMENT IN TRAY



NOTE
THE ITEM NUMBERS
OF TEST EQUIPMENT
REFER TO TABLE 1 COLUMN 1

LOCATION OF TEST EQUIPMENT IN CASE

Fig. 2. Location of test equipment in test kit 6516



SWITCH	
POSITION	FUNCTION
1	OFF
2	NEG. ONLY
3	ON

NOTE- SWITCH SHOWN IN FULLY COUNTER-CLOCKWISE POSITION (1)

PLA5, 6, 7, PLB1, 2, 3, 4, 5, 6, PLC1, 2, 3, 4, 5, 6, PLD5 AND 6 ARE CONNECTED VIA STRIP CONNECTORS AND SHORTING PLUG ASSEMBLIES TO SKTA5, 6, 7, SKTB, 1, 2, 3, 4, 5, 6 SKTC1, 2, 3, 4, 5, 6, SKTD5 AND 6 RESPECTIVELY

Fig. 3. Box, connecting, 102—circuit diagram

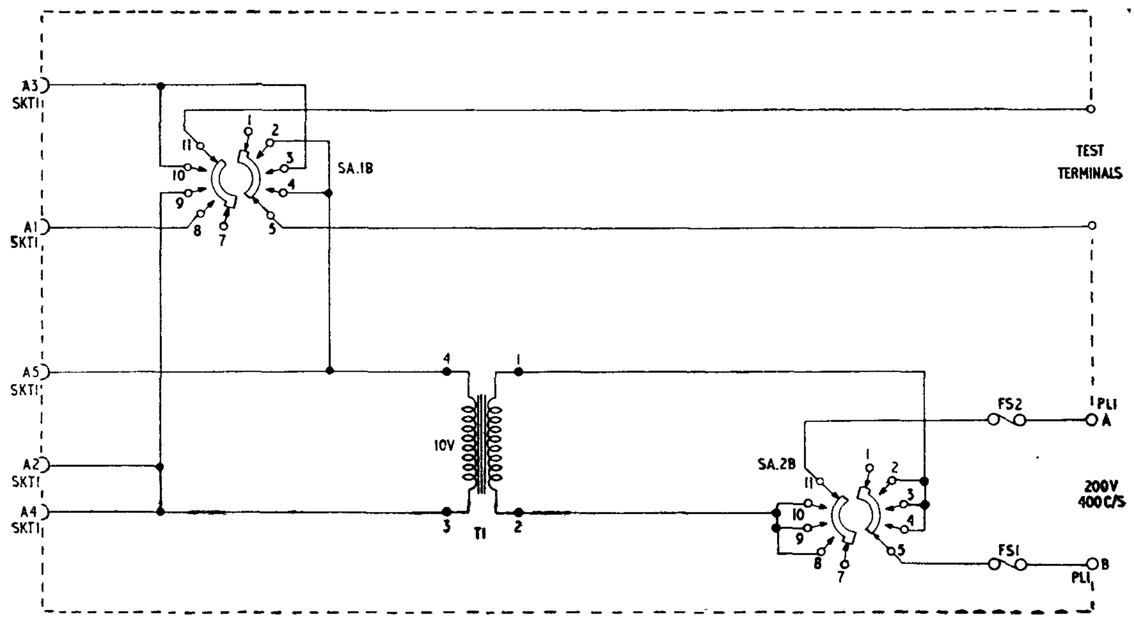


Fig. 4. Test unit synchro alignment—circuit diagram

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Chapter 6

GATING UNIT 10D/23451

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Introduction

1. The gating unit 10D/23451 is a portable, first line test unit which, in conjunction with the resonator performance testing, 12549 (Part 1, Sect. 1, Chap. 13) provides facilities for measuring the overall radar performance of ARI.5919.

2. Fig. 1 shows a general view of the gating unit in its carrying case and the cables that are provided for connecting the unit to ARI.5919.

3. The gating unit is normally operated in its canvas carrying case and is constructed to be shower proof. All controls for remotely operating the resonator performance testing (r.p.t.) and for measurement of the overall radar performance are mounted on the front panel of the unit. The gating unit receives all its power supplies from ARI.5919 and operates within the ambient temperature range of −10°C to + 55°C; a thermometer is provided on the front panel of the unit to monitor the internal ambient temperature of the unit.

General

4. In order to measure the overall performance of a radar system it is necessary to determine the ratio of transmitter output power to received signal input power that produces a specified received signal-to-noise ratio. Basically, this may be achieved by inserting an attenuator between the transmitter output and the receiver input and measuring the received signal-to-noise ratio. However, because the receiver of the ARI.5919 is inoperative during the transmitter pulse period, it is necessary to delay as well as attenuate the transmitter pulse energy before feeding it to the receiver.

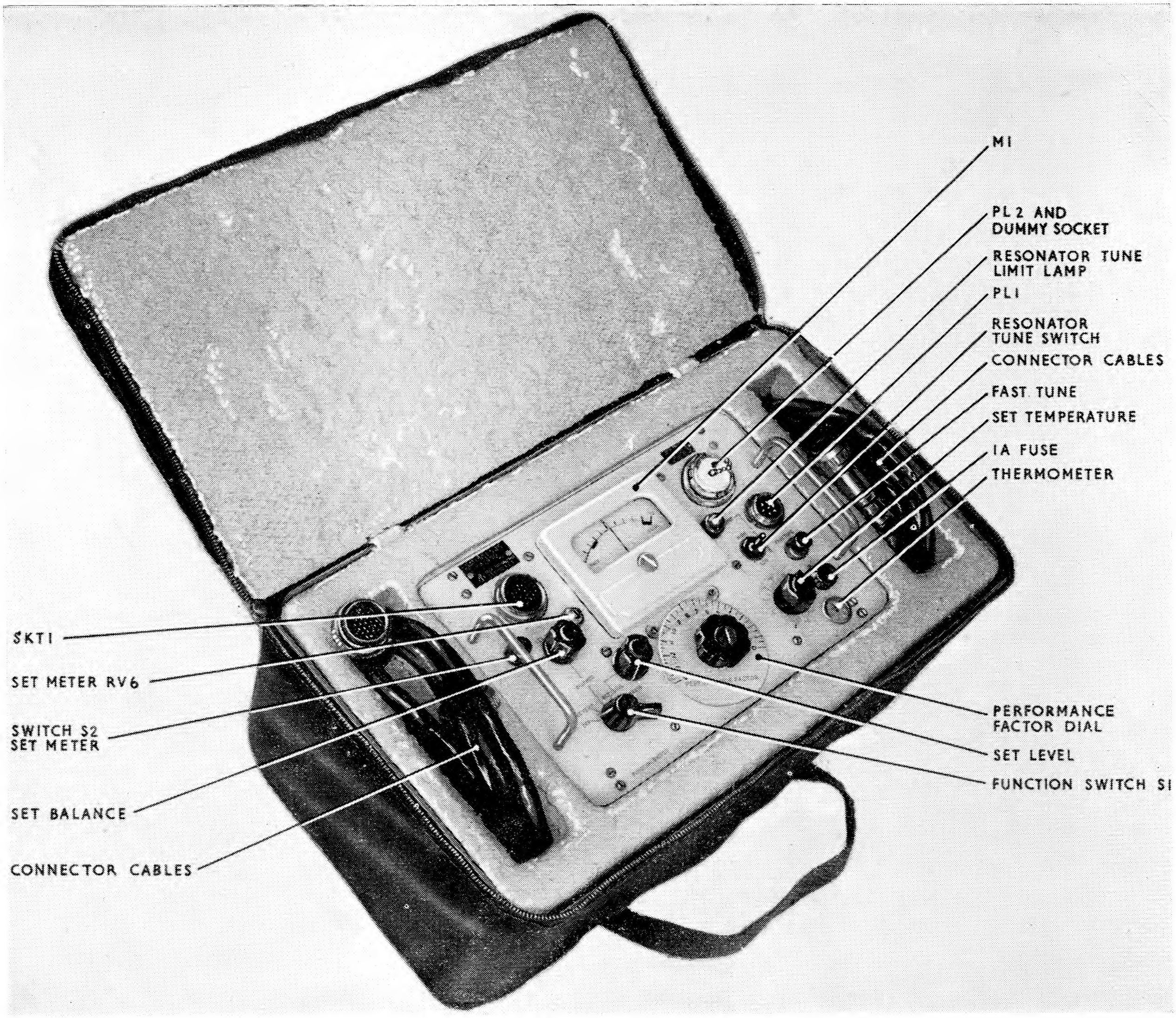

Fig. 1 — Gating unit : general view

The delaying and attenuating of the transmitter pulse energy for ARI.5919 is done by the r.p.t. mounted on the main frame of the radar unit, 6934. Part 1, Sect. 1, Chap. 13 describes the r.p.t.

5. When the r.p.t. is fed with an attenuated sample of the transmitter pulse during overall performance testing (provided that no current is flowing in a ferrite switch, para. 6) a resonant cavity (echo box) rings at the same frequency as the transmitter. This echo box ring is fed into the receiver as the receiver input signal. The amplitude of the echo box ring decays exponentionally with time and since the initial amplitude is proportional to the power output of the transmitter, the time taken for the signal to decay to a level that is twice noise depends on the overall performance of ARI.5919.

Outline of operation

6. The gating unit generates 1 μs pulses which are used to gate the video output of the radar receiver of ARI.5919. In addition, circuits in the gating unit provide a current output that drives the ferrite switch in the r.p.t. during alternate periods between gating pulses. When current is not driven through the ferrite switch, the echo box (para. 5) rings at the transmitter frequency and this ring is fed into the radar receiver. Hence, the gating unit 1 μs pulses alternately sample receiver video *noise plus echo box signal* and receiver video *noise alone*.

7. In the gating unit the gated video *noise alone* signal and the gated video *noise plus echo box signal* are amplified and then compared by feeding them to a centre zero meter. The voltage gain ratio of the video *noise alone* signal channel to the video *noise plus echo box signal* channel is maintained at 2 : 1, therefore a gated video *noise plus echo box signal* compared with twice gated video *noise alone* produces a zero reading on the centre zero meter.

8. By varying the time of the gating pulses a greater or weaker echo box signal (plus video noise) is sampled because the echo box signal decays exponentially with time. Since the position in time of the gating pulses determines how much of the echo box signal is sampled in order to obtain the 2 : 1 ratio of the gated video signals, it follows that when this ratio is attained, the position in time of the gating pulses is related to the performance of the radar receiver under test.

9. The movement in time of the gating pulses is controlled by a PERFORMANCE FACTOR dial mounted on the front panel of the gating unit. This dial is calibrated from 0 dB to 14 dB and it is arranged that a serviceable ARI.5919 radar with a minimum transmitter power output (100 kW) and maximum noise (13 dB) corresponds to a PERFORMANCE FACTOR dial setting of 6 dB when the centre zero meter reads zero. ARI.5919 radars that give a dial setting below 3 dB when the meter reads zero, are to be considered unserviceable (i.e. 3 dB down on the lower production limit).

Schematic description

10. A simplified block schematic diagram of the gating unit is given in Fig.2.

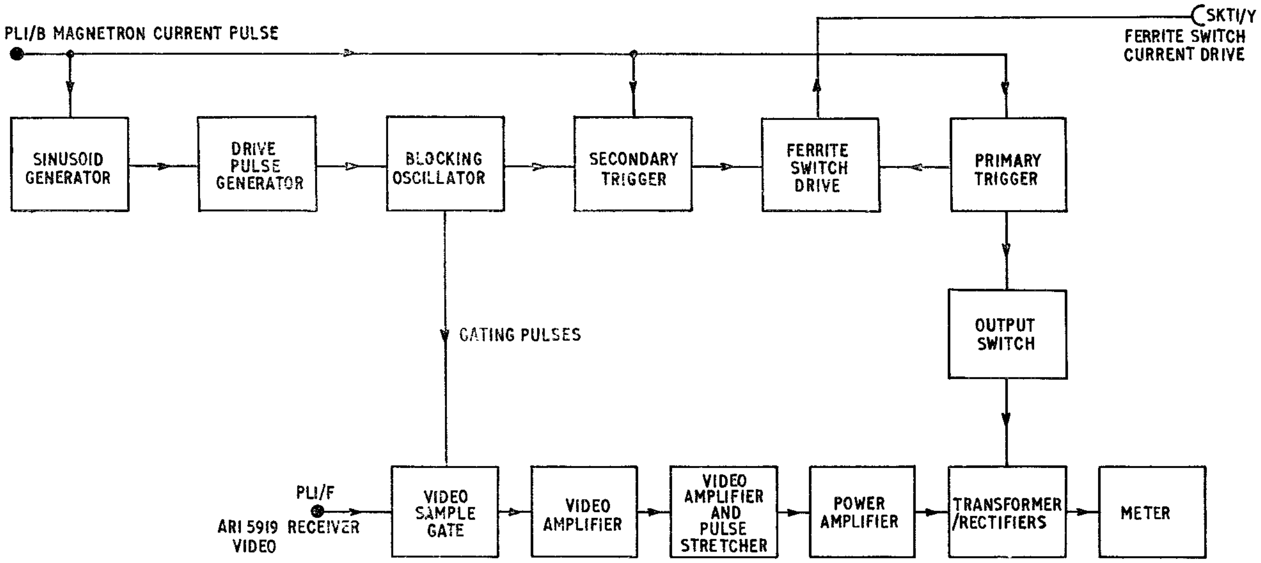

Fig. 2 — Gating unit : simplified block schematic diagram

Sinusoid generator

11. The sinusoid generator is triggered by the magnetron pulse from the radar unit and generates one complete cycle of a sinusoidal oscillation. The duration of the sinusoid depends on the natural frequency of the tuned circuit producing it and the frequency of this tuned circuit, in turn, depends upon the setting of a variable capacitor driven from the PERFORMANCE FACTOR dial. The first half-cycle of the sinusoid forms the variable length pulse required by a drive pulse generator to drive a blocking oscillator.

Drive pulse generator and blocking oscillator

12. At the crossover between the first and second half-cycle of the sinusoid, the drive pulse generator delivers a current pulse to fire the blocking oscillator. The blocking oscillator generates 1 μs pulses that have very fast leading and trailing edges. These pulses are used primarily to gate the radar receiver video signal at a time coincident with the end of the first half-cycle of the sinusoid. The interval between the magnetron pulse and the blocking oscillator pulse (the gating pulse) therefore depends upon the setting of the PERFORMANCE FACTOR dial. The gating pulses are also used to switch a trigger circuit (para. 14).

Trigger circuits

13. Because the ferrite switch in the r.p.t. is highly inductive it takes an appreciable time to switch from one state to the other. The drive current is, therefore, switched on or off immediately after the gating pulses so that the ferrite switch has the whole repetition cycle to change its state.

14. The magnetron pulse and the trailing edge of the gating pulse control the outputs from a primary trigger circuit and a secondary trigger circuit. The outputs from these trigger circuits are, in turn, fed to the ferrite switch drive circuit to switch the drive current on or off at the cessation of each gating pulse.

15. The primary trigger circuit also operates an output switch. This switch controls the outputs of two opposite polarity rectifier networks so that they alternately feed the gated video signals (para. 16) to a centre zero meter. The rectifier networks have a 2:1 output ratio to maintain the voltage of the video signals in the correct relation (para. 7).

Video sample gate and video amplifiers

16. The alternate switching on and off of the drive current to the ferrite switch (para. 14) causes the radar unit video signals fed to the video sample gate to be alternately video *noise alone* and video *noise plus echo box signal.* These video signals are gated in the video sample gate and the output from this stage is fed via amplifiers, a pulse stretching circuit, a power amplifier and transformer/

rectifier networks (para. 15) to the centre zero meter. Since the outputs from the two rectifier networks are of opposite polarity, and as they alternately feed the video signals to the centre zero meter, this meter indicates the difference between the gated video *noise plus echo box signal* and twice the video *noise alone signal.*

CIRCUIT DESCRIPTION

17. A circuit diagram of the gating unit is given in Fig. 6 and interior views of the unit showing the location of components are given in Fig. 4. During overall performance testing, the gating unit 25-pole socket SKT1 and 6-pole plug PL1 are connected to the test plug PLD and test socket SKTE respectively on the radar unit heat exchanger panel (Part 1, Sect. 1, Chap. 2, Fig. 11). The interconnections between the gating unit and ARI.5919 are shown in Part 1, Sect. 1, Chap. 2, Fig. 14. Plug PL2 on the front panel of the gating unit is provided so that the meter unit monitoring (Chap. 2) can be operated when the gating unit is connected to PLD on the radar unit. The connections to PL2 are shown in Fig. 6.

Delay pulse generator

Sinusoid generator

18. The sinusoid generator incorporates transistors VT1 to VT4. Transistor VT3 supplies a constant current of approximately 1·2 mA to either VT1 or VT4 depending upon which transistor is switched on. The current passed by VT3 is determined by its base potential, approximately 4V, from the junction of R3 and R4, and its emitter resistor R7.

19. In the quiescent state, the emitter-follower VT2 is conducting and its emitter current energizes the primary winding of transformer T2. VT2 base is held at -9V by the diode MR3 so that its emitter current is 9 mA as determined by R6. Because the mean base potential of VT4 (derived from the junction of R8 and R9) is more negative than that of VT1 (earth), VT4 passes all VT3 current and VT1 is held cut off by the potential on its emitter

20. The positive going magnetron current pulse, derived from the radar unit, is fed via PL1 pole B and diode MR1 (included to block any negative-going over-swing of the magnetron pulse) to the primary winding of transformer T1. A positive going pulse, obtained from the secondary winding of T1 and fed via MR2 to the base of VT2, cuts off VT2. Cutting off VT2 cuts off the current in the primary winding of T2 and causes the tuned circuit T2, C11, C2 and C3 to ring at a frequency determined by the setting of C11. The first positive-going half-cycle of the ring cuts off VT4 on its base so that the potential at its emitter and hence VT1 emitter rises until VT1 cuts on and passes the current determined by VT3. This current passes through R2 and maintains VT2 cut off (when the magnetron pulse ends) by driving its base to the potential at the junction of R8 and R9 (approximately earth) where it is clamped by MR4. The diode MR4 prevents VT1 from bottoming, so reducing any tendency to hole storage, and the diode MR2 is included to permit the base of VT2 to be driven positive with respect to the -9V line and to isolate the potential at the junction of R8, R9 from other circuits in the gating unit (i.e., diodes MR22, MR23, para. 29).

21. At the end of the first positive-going half-cycle of the ring, VT4 base commences to move negative as the second half-cycle of the ring goes negative. This permits the transistor to conduct again and the current of VT3 is transferred from VT1 to VT4. VT1 cuts off but VT2 remains cut off because its emitter is driven negative by the negative-going second half-cycle of the ring. At the end of the second half-cycle of the ring VT2 emitter commences to go positive with respect to base and the transistor is driven hard on. This places a low impedance path to earth across the tuned circuit T2, C11, C2, C3 and immediately damps out the ring. The sinusoid generator circuit then remains quiescent until the arrival of the next magnetron pulse.

22. The waveform obtained across the tuned circuit is shown in Fig. 5 (waveform 2). Transistor VT4 is cut off for the first half-cycle of the sinusoid but at all other times conducts the 1·2 mA current of VT3. The waveform at VT4 collector is a negative-going square wave coincident with the first half-cycle of the sinusoid and is due to current in VT5 base being cut off (para. 23).

Drive pulse generator

23. The drive pulse generator incorporates transistors VT5 and VT6. During the quiescent periods, VT5 base is driven by VT4 collector current and the transistor is bottomed. VT4 collector potential rests at approximately -8V; transistor VT6 is cut off. When VT4 is cut off by the first half-cycle of the sinusoid, VT5 is cut off also as its supply of base current is removed. The capacitor C7 discharges via MR6 until VT5 collector potential reaches earth where it is clamped by MR5. At the end of the first half-cycle of the ring VT4 cuts on again restoring the drive to VT5 base and causing C7 to charge rapidly via VT6 and VT5. The charging current is drawn from the base of VT6 hence VT6 collector circuit draws a high intensity short duration current pulse through the primary winding of the blocking oscillator transformer T3.

Blocking oscillator

24. The blocking oscillator includes transistors VT7, VT8 and VT9 and their associated components. In the quiescent state these three transistors pass leakage current only.

25. The drive current pulse, flowing via VT6 and the transformer T3 primary winding, is coupled by the transformer secondary winding 3, 4 to the base of VT8. By blocking-oscillator action VT8 is driven hard on and the base current flowing via R14, gives a positive-going voltage edge (Fig. 5, waveform 4) at the emitter of VT7 and cuts off the leakage current in this transistor. At the same time, the drive pulse is tranferred by transformer T3 secondary winding 7,8 to the base of VT9 and this transistor is driven hard on. The emitter of

VT9 is connected via a delay line DL1 to VT7 base and, after an interval of 1 µs, base current arrives at VT7 driving it hard on. The emitter current turned on in VT7 is greater than the base current of VT8 (turned on by the drive pulse) so that VT8 is cut off on its base. When VT8 cuts off, VT9 is cut off on its base also and 1 µs later, base current is cut off in VT7 so that all three transistors revert to their quiescent state.

26. Outputs from the blocking oscillator (1 µs positive-going pulses) are taken from the collector of VT8 and from the secondary winding 5,6 of transformer T3. The output from the collector of VT8 is fed to the base/emitter circuit of VT10 which acts as a clamping diode preventing VT8 collector from going negative to −9V ; the clamping current forms the drive to VT10 (para. 32). The output from the secondary winding 5,6 of transformer T3 is fed to the video gate circuit (para. 41).

Trigger circuits

27. There are two bi-stable trigger circuits in the gating unit, the primary trigger circuit, involving VT27 and VT29 and the secondary trigger circuit involving VT11 and VT12.

Primary trigger circuit

28. The positive-going magnetron pulse from the secondary winding 5,6 of transformer T1 is applied to the junction MR22, MR23. If, before the receipt of the magnetron pulse VT27 is cut off, its collector potential is clamped at −9V by MR22, and the base potential of VT29, derived from the junction R64, R63, is held near earth by VT29 base current flowing through R63. Transistor VT29 bottoms so that its collector potential rests at approximately earth and VT27 is held cut off by the positive potential fed to its base from the junction R62, R61.

29. The positive-going magnetron pulse is applied via MR22 and MR23 to the bases of VT29 and VT27 but affects only VT29. The voltage at VT29 collector falls and this fall is coupled via C20 to VT27 base causing VT27 to conduct with a consequent rise of collector potential. This rise in VT27 collector potential is coupled via C21 to VT29 base and causes a further fall of VT29 collector voltage. The action is regenerative until VT27 bottoms and VT29 is cut off by the positive bias at the junction of R63 and R64 ; VT29 collector potential is clamped, at this stage, at −9V by MR23. The circuit rests in this condition until the receipt of the next magnetron pulse when a similar action takes place but with the roles of the two transistors reversed.

30. The waveform obtained from VT29 collector is given in Fig. 5 (waveform 8). It consists of a voltage square wave of 9V amplitude and frequency half that of the magnetron pulse repetition frequency. Two outputs are taken from the primary trigger circuit. One output, from the junction of R66 and R67 in VT29 collector circuit, is associated with driving the ferrite switch in the echo box (para. 34). A second output, in anti-phase with the first, is taken from VT27 collector and is used to switch the meter circuit (para. 50).

Secondary trigger circuit

31. The secondary trigger circuit, involving VT11 and VT12, is identical in operation with the primary trigger circuit (para. 28) but the method of triggering is different. The secondary trigger circuit is switched on by the magnetron pulse and off by the blocking oscillator overswing current. Because these two pulses are of opposite polarity, both are applied to the base of VT12.

32. Before receipt of the magnetron pulse the secondary trigger circuit rests in the condition where VT12 is bottomed and VT11 is cut off with its collector caught at −9V by MR8. When the magnetron pulse arrives VT12 is cut off on its base and VT11 is driven on by regenerative action. After a period dependent upon the setting of the PERFORMANCE FACTOR dial (which determines the duration of the sinusoid) the overswing current of transformer T3 drives transistor VT10 on (para. 26) and current is drawn through R20 and R25 ; MR7 prevents this current from being shunted via transformer T1. The consequent fall in potential at VT12 base drives VT12 on and by regenerative action VT12 bottoms and VT11 is cut off. The resultant waveform at VT12 collector is given in Fig. 5 (waveform 6). It consists of a rectangular waveform at the same frequency as the magnetron repetition frequency, with the negative-going portions occupying the periods between the magnetron pulses and subsequent blocking oscillator pulses.

33. Two outputs are taken from the secondary trigger circuit, one from the junction of R26 and R27, and the other from the junction of R27, R28. These outputs are associated with the driving of the ferrite switch in the echo box (para. 34).

Ferrite switch drive

34. The drive to the ferrite switching circuit from the primary trigger circuit is taken from the junction of R66 and R67 in the collector circuit of VT29. In the condition where VT29 is bottomed (para. 28), its collector is at earth potential and the potential at the junction of R66 and R67 is approximately −7V ; this is connected via R65 to VT28 emitter so that VT28 is cut off. On receipt of the next magnetron pulse, VT29 cuts off and its collector potential falls to −9V (clamped by MR23). The potential at the junction of R66 and R67 also falls and allows current to flow via the base/emitter circuit of VT28. However, current does not yet flow in the collector circuit of VT28 because the transistor is connected in the emitter circuit of VT13. This transistor is cut off on its base by the potential at the junction of R27 and R28 because VT12 is cut off by the same magnetron pulse that cuts off VT29.

35. At the end of the blocking oscillator pulse the secondary trigger circuit switches over, i.e. VT12 bottoms (para. 32) the base potential of VT13 rises, and current is drawn via VT13 and VT28 from the base/emitter circuits of VT15 (a driver transistor) and the ferrite switch transistor VT16. Transistors VT15 and VT16 have a large current gain and a current of approximately 800 mA is drawn from the 14V supply via switch S1B (set to OPERATE), the ferrite switch in the radar unit and switch S1G.

36. When the next magnetron pulse is received the primary trigger circuit switches over (VT29 bottoms and the potential at the junction of R66 and R67 rises) and cuts off VT28. At the same time the secondary trigger circuit switches over (VT12 is cut off and the potential at the junction of R27 and R28 falls) and cuts off VT13. This action breaks the path via VT13 and VT28 for the ferrite switch drive current but an alternative path is available via VT14.

37. When VT13 and VT28 cut off (para. 36) transistor VT15 collector current continues to flow because of the effects of hole storage and the charge built up on the base capacitor C9. Hence, the potential at the junction R30, R31, and consequently VT14 base potential, is held positive. In addition, when VT12 cuts off (para. 36) the potential at the junction R26, R27 (VT14 emitter) falls so that base current of VT15 and VT16 flows via VT14, instead of VT13 and VT28, and maintains the drive for the ferrite switch. This current continues to flow via VT14 until the blocking oscillator pulse is generated. When this occurs, VT12 bottoms and VT14 is cut off by the positive potential on its emitter; VT15 and VT16 therefore cut off after the decay of hole storage and the charge on C9. MR12 and R36, connected across the ferrite switch coil, provide overshoot damping to protect VT16 from excessive collector voltage.

38. Resistors R82 and R34 connected across the +9V line provide a small positive bias to VT16 base to reduce VT16 leakage collector current at high ambient temperatures.

39. The waveforms associated with the ferrite switching circuit and the primary and secondary trigger circuits are given in Fig. 5 (waveforms 6 to 10). These show that current is drawn through the ferrite switch (waveform 10) during alternate periods between blocking oscillator pulses (waveform 5). Also, it can be seen that the ferrite switch changes state after each gating pulse since current is turned on when VT12 and VT29 are in opposite states and off when they are in the same state (waveforms 6,8 and 10).

Video gate and video amplifier circuits

40. The video gate circuit is VT17; the video amplifier circuits involve VT18, VT19 and MR12, VT20, VT21 and MR13, VT22, VT23 and T5, C13.

41. The input stage of the video amplifier VT18 is a gated grounded base amplifier, the video signals from the radar unit (Fig. 5, waveform 11) being fed via switch S1A (set to OPERATE) to its emitter. In the quiescent state VT18 collector current flows via MR12 through VT17, and VT19 is held cut off on its emitter by the negative potential derived via VT17 from the junction R15, R16. Application of the positive-going 8V gating pulse (Fig. 5, waveform 5) to the base of VT17 raises its emitter potential and hence MR12 cuts off. Transistor VT19 cuts on and passes the collector current of VT18 (which is proportional to the video signals) to one half of the centre-tapped primary winding of transformer T4. At the cessation of the gating pulse VT17 emitter potential falls so that MR12 conducts again and VT19 is cut off.

42. Coupled to the second half of the primary winding of the transformer T4 is a neutralizing circuit VT20, VT21 and MR13. The operation of this circuit is identical with VT18, VT19 and MR12 (para. 41) and it is included to neutralize the standing current of VT18 and the switching transients of VT18, VT19 and MR12. Transistor VT18 emitter load (R40) is larger than that of VT20 (R41) since VT18 passes the d.c. component of the radar unit video amplifier output cathode follower in addition to the current via R40. A neutralizing control RV1, SET BALANCE, connected in the emitter circuits of VT18 and VT20 enables the emitter currents of VT18 and VT20 to be exactly balanced (para. 59).

43. During the gating pulse period (1 μs) the output from the secondary winding of the transformer T4 is a voltage pulse of amplitude proportional to the video signals from the radar unit (Fig. 5, waveform 12). A preset gain control RV7, connected across the secondary winding of T4, is adjusted at the manufacturers to set the overall gain of the video amplifier stage and hence the output from T4. Switch S1, SET METER (a press-button on the front panel of the gating unit) when pressed earths the video output signal of T4 to enable the meter M1 to be zeroed (para. 62).

44. The 1 μs voltage pulse from the secondary winding of T4 is fed to a cascode amplifier stage VT22, VT23 where it is further amplified. Resistors R42, R43, R45 in the emitter circuit of VT22 are such that the current gain of VT22 is constant over the range of video signal input. In addition the resistor R76 included in the base circuit of VT23, enables the cascode pair to amplify the video signals without distortion since when VT23 is driven its base potential rises towards earth thus leaving a larger effective collector voltage available before limiting occurs.

45. The output from the cascode pair is taken from VT23 collector and is fed into a pulse stretching circuit which consists of a high Q tuned circuit, transformer T5 and C13. On receipt of the gated video signal this circuit rings at 40 kc/s and produces at the secondary winding of transformer T5 a voltage output proportional to the amplitude of the gated video signal but extending over a longer time interval (Fig. 5, waveform 13).

46. Transformer T5 secondary winding output is fed into a power amplifier transistor, VT24 which drives an output transformer T6. Transistor VT24 employs negative voltage feedback via C17, R47 to linearize its gain characteristics.

Output switch

47. The 40 kc/s input to the primary winding of transformer T6 is proportional in amplitude to the gated video signals (para. 45) and these are, in turn, alternately video *noise alone* and video *noise plus echo box signal* (para. 16). Transformer T6 has two secondary windings but by means of a switching transistor, VT25, only one of these is in circuit at a time; changeover of the secondary windings is related to the change in state of the ferrite switch.

48. When transistor VT27 cuts off on receipt of alternate magnetron pulses (para. 29), the potential at its collector, and hence transistor VT26 emitter, falls until VT26 conducts and draws current through R54. Resistor R54 is connected in the base of transistor VT25 and this transistor also cuts on as its base potential falls. When VT25 cuts on, the potential at the junction MR14, R51 rises until MR14 conducts and clamps the centre tap 4 of transformer T6 secondary winding 3, 5 to earth.

49. With VT27 cut off, VT29 bottoms (para. 29) and since VT12 is cut off (para. 32) current is being driven through the ferrite switch (para. 39 and Fig. 5) when the gating pulse is generated. Consequently, video *noise alone* is sampled in the video gate and this signal is fed to transformer T6 where the secondary winding 3,5 is in circuit (its centre tap is clamped at earth potential (para. 48)). The output of the secondary winding 3,5 is fed to a full-wave rectifier circuit, MR21, MR16 and reservoir capacitor C18; these feed, via switch S1D (set to OPERATE), a positive d.c. voltage proportional to video *noise alone* to the centre zero meter M1.

50. On receipt of the magnetron pulse that cuts on VT27, transistor VT26 cuts off since its emitter potential rises with the collector potential of VT27 to earth. Transistor VT25 also cuts off and the potential at the junction of MR15, R53 falls until MR15 conducts, clamping the centre tap 7 of the secondary winding 6,8 to earth. The secondary winding 3,5 is no longer in circuit since MR14 is cut off and the centre tap 4 is at a negative potential.

51. With VT27 cut on, VT29 is cut off (para. 29) and because VT12 is also cut off (para. 32) current is not being driven through the ferrite switch when the gating pulse is generated. Hence, video *noise plus echo box signal* is sampled in the video gate and this signal is fed to transformer T6 where the secondary winding 6,8 is in circuit. The output of this secondary winding is fed to a full-wave rectifier MR17, MR20 and C18 (also MR18, MR19 para. 54) and these feed via switch S1D (set to OPERATE) a negative d.c. voltage proportional to the video *noise plus echo box signal* to the meter M1.

52. The centre tapped secondary windings of transformer T6 have turns in the ratio of 2:1; the secondary winding 3, 5 which is in circuit when video *noise alone* is sampled (para. 49) is the larger secondary. It is shown in para. 49 and 51 that the meter M1 is alternately fed with a positive d.c. voltage proportional to gated video *noise alone* and a negative d.c. voltage proportional to gated video *noise plus echo box signal* (waveform 16, Fig. 5). Therefore, because of the ratio of the secondary windings, the meter M1 indicates zero when gated video *noise plus echo box signal* is equal to twice gated video *noise alone*.

53. The preset resistor RV4, SET METER, connected in the collector circuit of VT25 sets the standing d.c. current through the meter circuit when VT25 is bottomed; the standing d.c. current when VT25 is cut off is determined by the chain RV4, R51, R52, R53. RV4 is adjusted to make these two currents equal and opposite so that with no video input signals (para. 43 and Fig. 5, waveform 15) the meter reads zero (para. 62).

54. In order to maintain a constant load on the primary winding of transformer T6, the smaller secondary winding 6,8 has an additional rectifier circuit, MR18, MR19, C19 and R59 connected across it.

Function switch S1

55. The function switch S1 has five positions. The first of these (OFF) disconnects the ARI.5919, 200V 400 c/s supply from the gating unit transformer T7 (para. 69); in all other positions of the function switch 200V 400 c/s is connected to the primary winding of transformer T7.

SET TEMP. position

56. The Q of the echo box in the r.p.t. is inversely related to temperature and, since the Q affects the amplitude of the echo box signal, a setting up procedure is necessary to adjust the time of generation of the gating pulses according to the temperature of the r.p.t.

57. A platinum resistance thermometer, incorporated in the echo box body, is connected (via PL11/B3, B5, in the r.p.t., PLD on the ARI.5919 radar unit and SKT1/T,U, on the gating unit) as one arm of a Wheatstone bridge in the gating unit. Resistors R55, R56, R77 and RV5, SET TEMP. are the other arms of the bridge. The variable resistor RV5 is coupled through gears to a SET TEMP. control on the front panel of the gating unit (Fig. 1) and also to the stator of the variable capacitor C11 which controls the position in time of the gating pulse (the rotor of C11 is connected to the PERFORMANCE FACTOR dial, para. 11).

58. When the function switch S1 is in the SET TEMP. position, the Wheatstone bridge is connected via switch contacts S1G/2 to -14V and via switch contacts S1C/2 to earth. The meter M1 is connected across the bridge by switch contacts S1D/2 and S1E/2. Adjustment of RV5, SET TEMP. for a zero reading on the meter M1 alters the value of capacitor C11 and so varies the duration of the sinusoid (para. 11).

BALANCE position

59. Because of the extreme linearity requirements of the gating unit, the nature of the noise signal and variations in the d.c. level at the ARI. 5919 receiver output cathode follower, it is necessary to set up the video amplifier stage (para. 40) within close limits.

60. With the function switch set to the BALANCE position, two d.c. voltages of 3:1 ratio are alternately switched to the input of the video amplifier stage by relay contacts RLA1. At the same time, the meter M1 is shunted in the ratio of 1:3 by contacts RLA2 and, by adjustment of the balancing currents in the gated video stage (by the SET BALANCE control) the meter needle is made to remain stationary in the red band on the meter scale. This procedure sets the video amplifier stage to operate at points on its input/output characteristic separated by an amount comparable with the signal amplitude. Added to the d.c. voltage switched to the gated video amplifier input is the d.c. level of the ARI.5919 receiver output cathode-followers, so that the balancing procedure takes this into account. The balancing procedure also neutralizes the d.c. standing currents and switching transients of the gated video amplifier stage and eliminates non-linearity in the input/output characteristic of the video amplifier stage (caused by the diodes in the rectifier circuits para. 49 and 51).

61. When the function switch S1 is set to the BALANCE position, contacts S1F/3 and S1G/3 connect a 14V floating supply across a resistance network RV3, R32, R35 and R33, and contact S1A/3 connects PL1/F to R33 so that the d.c. voltage at the cathode of the ARI.5919 receiver output is superimposed on the 14V supply. The potential at the junction R32, R35 is three times that at the junction of R32, R33 and the preset resistor RV3 is set at the manufacturers so that video signals, when added to the mean d.c. of the cathode follower, do not overdrive the video stage. Contact S1H/3 of the function switch connects h.t. (+28V d.c.) to a multivibrator circuit (para. 63) which alternately energizes and de-energizes relay RLA, hence contacts RLA 1 cause the effective input to the video amplifier stage to be switched in the ratio of 3:1. At the same time, the action of contacts RLA2, connected via contact S1E/3 of the function switch, causes the meter to be shunted in the ratio of 1:3. The meter is also connected via contact S1D/3 to the output of the transformer/rectifier networks (para. 49 and 51). Under these conditions the currents in the gated video stage VT18, VT20 are adjusted (by means of the SET BALANCE control) until the meter needle remains stationary in the red band marked on the meter scale.

62. The preset resistor, RV6 in the meter M1 circuit, is set at the manufacturers to trim the shunt resistors of the meter to a 3:1 ratio. The pre-set resistor RV4, SET METER (para. 53) is adjusted, with the function switch set to BALANCE, so that with no input video signals (para. 43 and Fig. 5, waveform 15) the mean output of C18 (para. 49 and 51) gives a zero meter reading.

63. *Multivibrator circuit.* The function of the multivibrator circuit VT30, VT31 and VT32 is alternately to energize and de-energize relay RLA2 (para. 60) at approximately one second intervals. Transistors VT30 and VT31 are connected as a conventional free-running multivibrator which is operative when the function switch is set to the BALANCE position and +28V d.c. is connected via R74 and contacts S1H/3 to the emitters of the transistors. The +28V d.c. supply is decoupled by R74, C33; C33 is shunted by a 39V Zener diode which protects the multivibrator transistors against the effects of voltage surges on the +28V line. Transistor VT32, an emitter-follower, shunts the inductance of the relay coil when VT30 cuts off ensuring a fast multivibrator switching action. When VT31 is cut off during the multivibrator action VT32 is cut off also and the necessary discharge path for C29 is completed via MR35.

SET LEVEL position

64. In the SET LEVEL position of the function switch S1, a variable resistor RV2, SET LEVEL is connected, via the interconnections shown in Fig. 3 in parallel with the GAIN control in the indicator unit, Part1, Chap. 12. Provided that the indicator GAIN control is set for a maximum resistance adjustment of the gating unit SET LEVEL control enables the gain level of the i.f. strip to be set and hence the noise level of the video signal fed to the gating unit.

65. Under the SET LEVEL conditions, the video signal (at PL1/F) is connected via contacts S1A/4, R79 and contacts S1E/4 to one terminal of the meter M1. The other terminal of the meter is connected via contacts S1D/4 to the potential (approximately 5V) at the junction R80, R81 ; this sets the meter to approximately mid-scale (with no noise). The required video noise level (i.e. approximately 0·6V) is obtained by adjusting the SET LEVEL control from its fully counter-clockwise position (minimum i.f. gain) until the meter reading increases by ten small divisions on the meter scale.

OPERATE position

66. In the OPERATE position of the function switch S1, the ARI.5919 overall radar performance is measured. Contacts S1A/5 connect the radar receiver video signal at PL1/F to the input of the gated video stage, contacts S1E/5 connect one terminal of the meter M1 to the output of the rectifier circuits and the other terminal of the meter is connected to earth via contacts S1D/5. Contact S1C/5 connects the SET LEVEL resistor RV2 into the i.f. gain line (para. 64). Contacts S1B/5 in the collector circuit of VT16 (para. 34) connect the current drive pulses to the ferrite switch coil in the resonator performance testing via socket SKT1/Y ; contacts S1G/5 and S1F/5 complete the circuit for the ferrite switch by connecting -14V h.t.

R.P.T. cavity tuning

67. The switch S4, TUNING, is a centre-biased two-way switch which is provided to operate the tuning motor of the resonator performance testing (r.p.t.) (Part 1, Chap. 13). When TUNING switch S4 is set to the HIGH position, +28V d.c. is connected via R75 to SKT1/R, and earth is connected to SKT1/S. Under these conditions the tuning motor in the r.p.t. is driven such that the tuning piston increases the resonant frequency of the cavity. With the

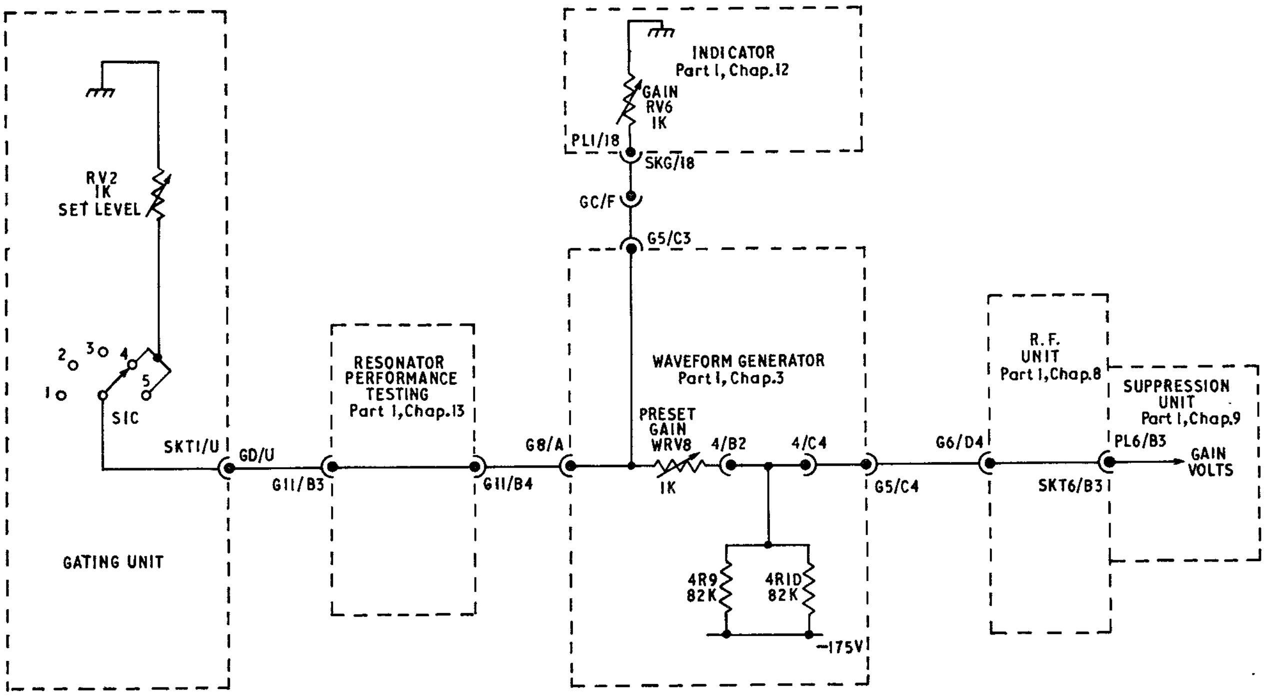

Fig. 3— Set level control : simplified circuit

TUNING switch S4 set to the low position, the +28V d.c. and earth connections are reversed and the tuning motor causes the cavity resonant frequency to decrease. When the tuning limits of the resonant cavity in the r.p.t. are reached, +28V d.c. from the r.p.t. is connected to SKT1/C and lights the red LIMIT lamp on the front panel of the gating unit. Correct tuning of the r.p.t. cavity is indicated by a maximum meter needle deflection to the left (with the function switch set to OPERATE, para. 80).

68. A press button switch S3, FAST TUNE, when pressed, shunts the resistor R75 to provide a fast tune facility for the cavity in the r.p.t.

Power supplies

69. From the ARI.5919, a 200V 400 c/s single phase supply is connected to SKT1/W and SKT1/B and a +28V d.c. supply is connected to SKT1/K. The 200V 400 c/s supply is fed via a 1A fuse FS1 and the contacts S1J and S1K of the function switch S1 (provided it is set to a position other than OFF) to the primary winding of transformer T7. Connected in the secondary windings of T7 are three full-wave rectifier circuits using silicon diodes and Zener diodes which develop stabilized outputs of +9V d.c., -18V d.c. and an unstabilized floating output of 14V d.c. A -9V d.c. supply is derived from the -18V d.c. supply current.

OPERATING INSTRUCTIONS

70. Remove the dummy socket from the 25-pole test plug PLD and the blanking plug from the 6-pole test socket SKTF on the radar unit heat exchanger panel. Connect the gating unit socket SKT1 and plug PL1 to PLD and SKTF respectively using the cables provided with the gating unit. If the meter unit monitoring 6415 is not to be connected to PL2 on the gating unit, the dummy socket removed from the radar unit must be fitted instead.

71. Fit a space load, radar signal Mk. 1 to the aircraft radome or, connect the r.f. block output waveguide to a dummy load (transmitter) 4735.

72. On the radar indicator c.r.t., 6935 :—

(1) Set the GAIN control fully counter-clockwise.
(2) Set the SWEPT GAIN control to OFF.
(3) Set the master switch to TX and allow the ARI.5919 to run for a warming up period of at least 20 minutes.

73. With the gating unit function switch set to OFF, check the mechanical zero of the meter and reset it if necessary.

74. Set the function switch to the SET TEMP. position and adjust the SET TEMP. control to zero the meter. This is to adjust the gating unit to compensate for the temperature of the echo box in the r.p.t. It has nothing to do with the thermometer dial fitted to the gating unit. The purpose of the thermometer dial is to indicate the temperature of the gating unit to the operator since the accuracy of the performance factor measurement is suspect below -10°C or above +55°C.

75. Set the TUNING switch to LOW and press the FAST TUNE button until the LIMIT lamp lights. This ensures that the echo box is well off tune.

76. Set the function switch to BALANCE. Press the SET METER button and adjust the preset SET METER to zero the meter if necessary. Release the SET METER button.

Note . . .

On the BALANCE *position of the function switch, a mechanical tick is heard at approximately* 1*s intervals. If the meter needle is off zero, the needle deflection varies with the tick. As the zero position is reached (by adjustment of the* SET METER *preset) the meter needle becomes steady.*

77. Adjust the BALANCE control until a meter needle deflection to the left is obtained with the needle stationary in the red band marked on the meter scale. Slight kicks of the needle may be observed ; these are due to the switching transients of the relay RLA and are acceptable.

78. Set the function switch to SET LEVEL and turn the SET LEVEL control fully counter-clockwise Note the meter reading. Turn the SET LEVEL control slowly clockwise until the meter reading is increased by 10 small divisions of the meter scale. By this means the radar noise is set to a determined level (approximately 0·6V).

79. Set the function switch to OPERATE and the PERFORMANCE FACTOR dial to 0 dB.

80. Set the TUNING switch to HIGH and depress the FAST TUNE button. Watch the meter needle and release the TUNING switch and FAST tune button when a meter needle kick to the left is observed. Operate the TUNING switch again in the appropriate direction to obtain maximum meter deflection to the left. Under normal conditions this action drives the needle hard against the stop ; therefore it is necessary to adjust the PERFORMANCE FACTOR dial until the maximum meter reading is reached with the needle free of the stop. The echo box is now on-tune.

81. Adjust the PERFORMANCE FACTOR dial until the meter reads centre zero. Read off the performance factor from the dial.

Note . . .

The SET METER *button can be used in the* OPERATE *position of the function switch. If the* SET METER *preset requires adjustment, re-check the* BALANCE *procedure (para.* 76).

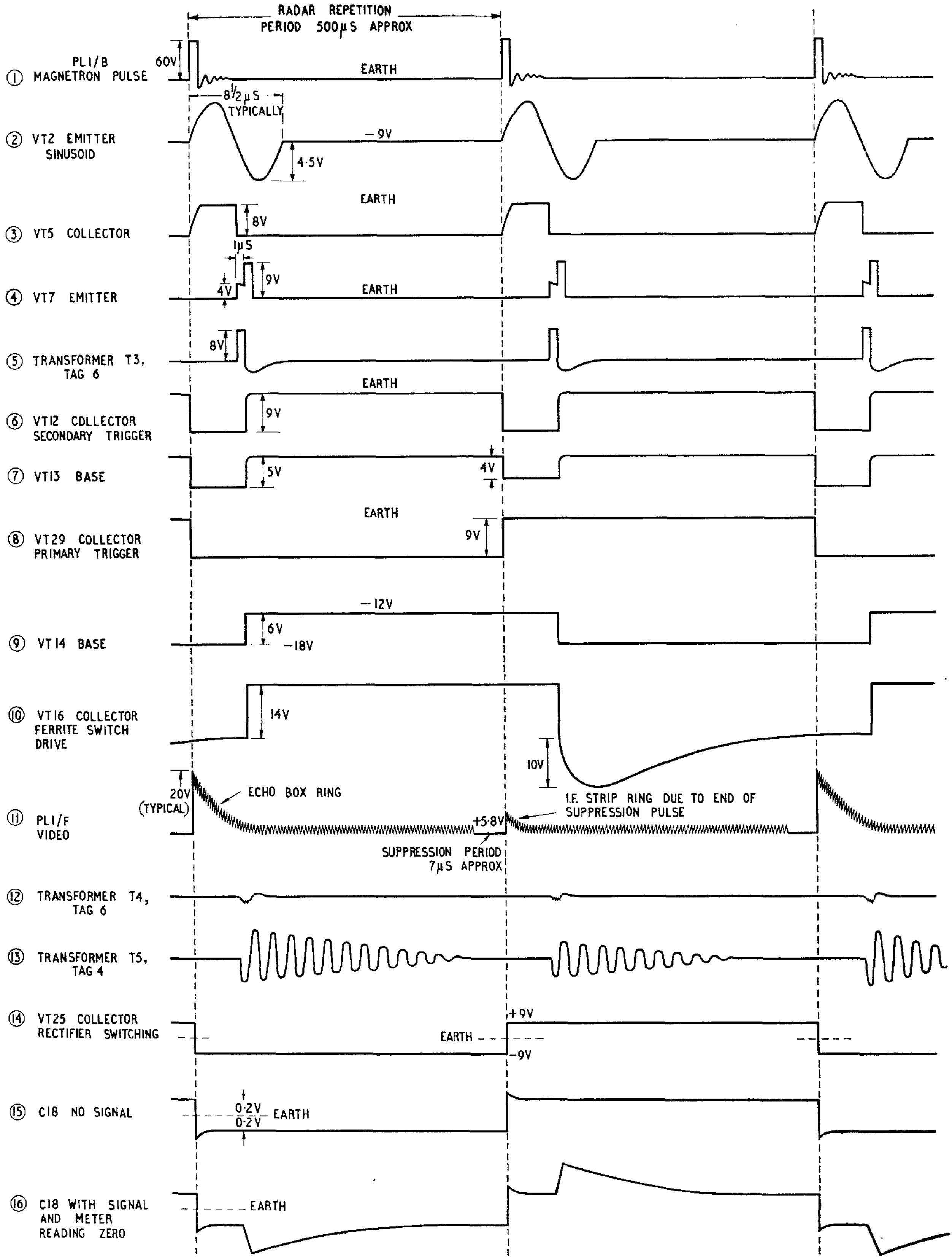

Fig. 5 — Gating unit : typical waveforms

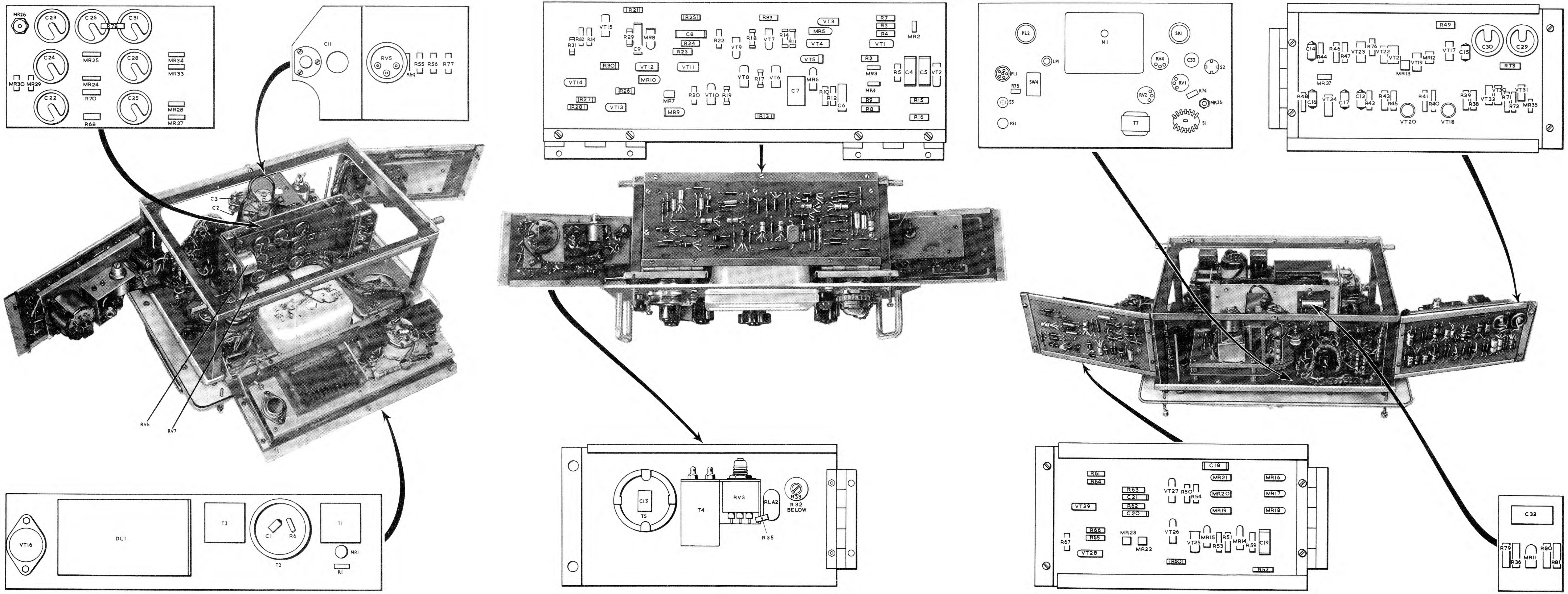

Fig. 4 Gating unit–component location Fig.4

712506/429261/12/69 J. T. & S.

Fig.6 Gating unit 10D/23451 : circuit Fig.6

PART 5

FUNCTIONAL DIAGRAMS PREPARED BY TECHNICAL TRAINING COMMAND, R.A.F.

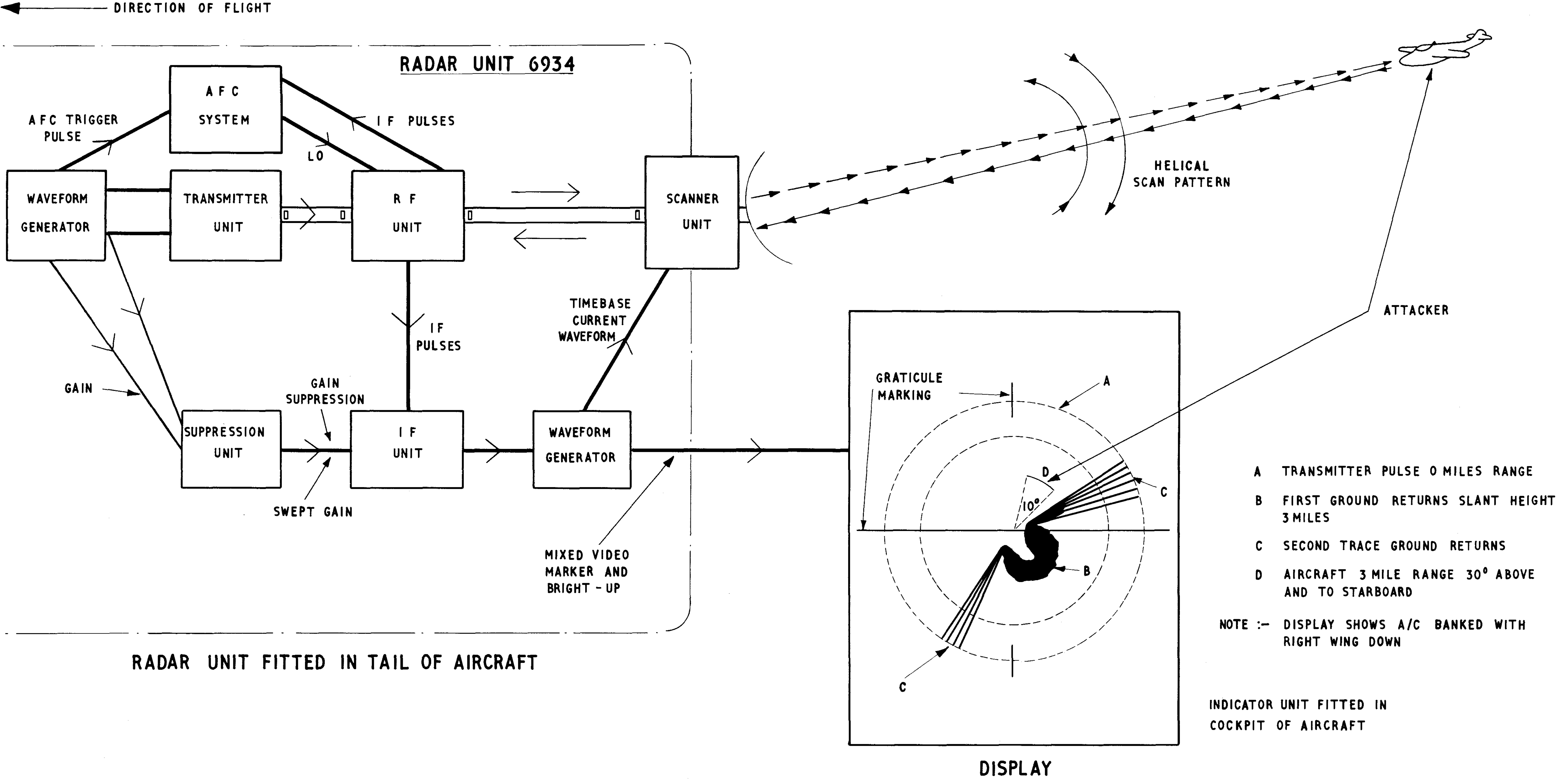

DIAGRAM-MIN
0200-MD501
THE DEFENCE COUNCIL FOR USE IN THE
ROYAL AIR FORCE
D BY TECHNICAL TRAINING COMMAND

RED STEER ARI 5919 - SYSTEM DIAGRAM - SHEET 1

AIR DIAGRAM-MIN
114M-0200-MD502
BY COMMAND OF THE DEFENCE COUNCIL FOR USE IN THE ROYAL AIR FORCE
ISSUE 1 PREPARED BY TECHNICAL TRAINING COMMAND

RED STEER ARI 5919 TRANSMITTER CHAIN SHEET 2

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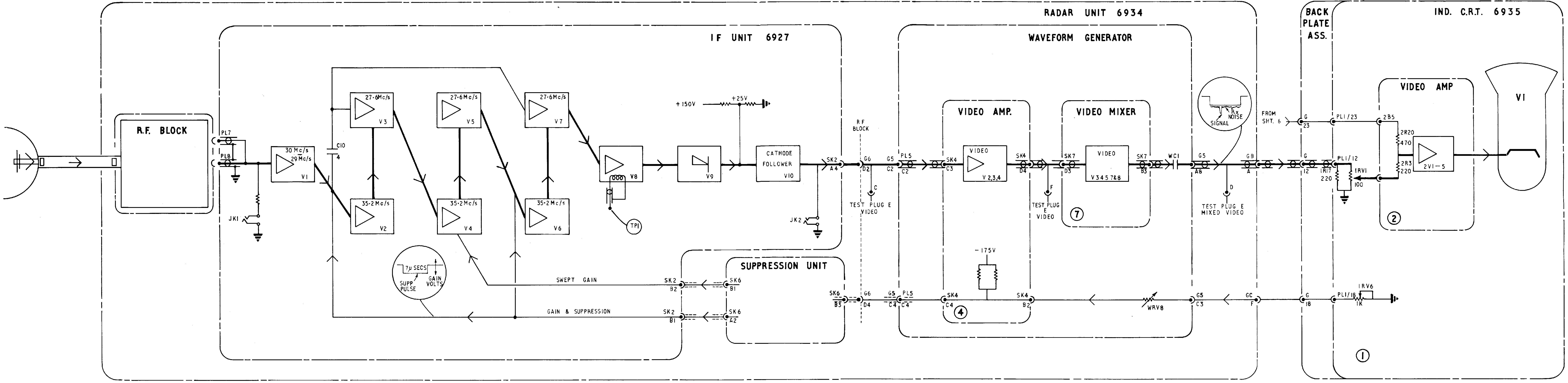

CONTROLS

TEST POINTS

JK1 SIGNAL GENERATOR I/P

(TP1) NOISE MEASUREMENT CHECK

JK2 RECEIVER ALIGNMENT TEST

1RV1 CONTRAST CONTROL
1RV6 RECEIVER GAIN CONTROL

AIR DIAGRAM-MIN
114M-0200-MD503
BY COMMAND OF THE DEFENCE COUNCIL FOR USE IN THE ROYAL AIR FORCE
ISSUE 1 PREPARED BY TECHNICAL TRAINING COMMAND

RED STEER ARI 5919 RECEIVER CHAIN SHEET 3

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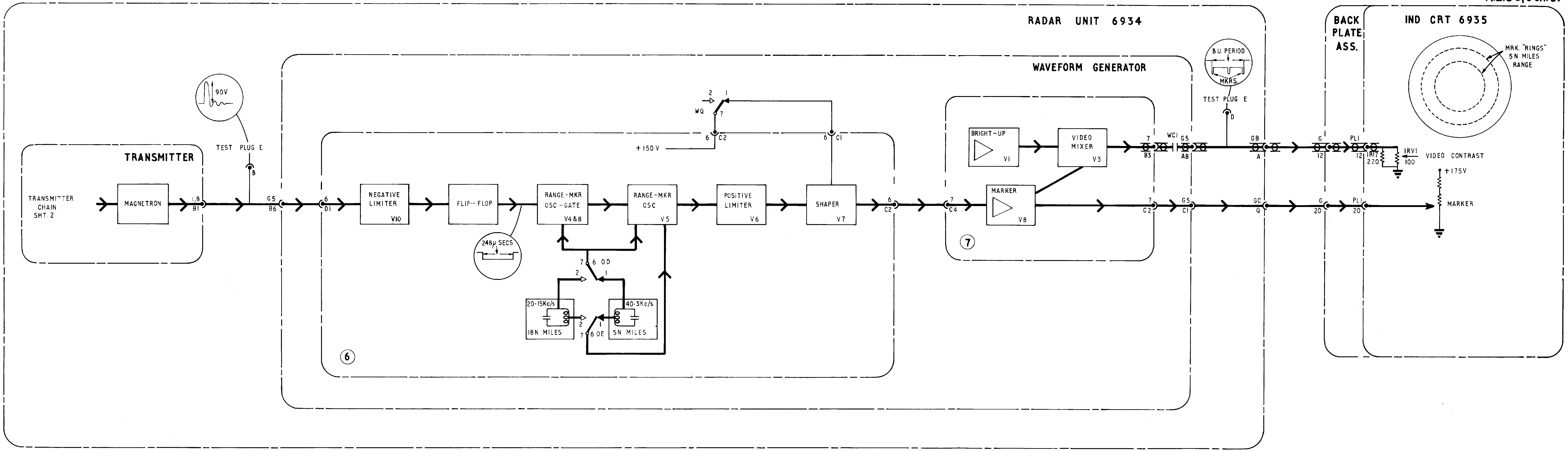

AIR DIAGRAM-MIN
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BY COMMAND OF THE DEFENCE COUNCIL FOR USE IN THE ROYAL AIR FORCE
ISSUE 1 PREPARED BY TECHNICAL TRAINING COMMAND

RED STEER ARI 5919 MARKER CHAIN SHEET 4

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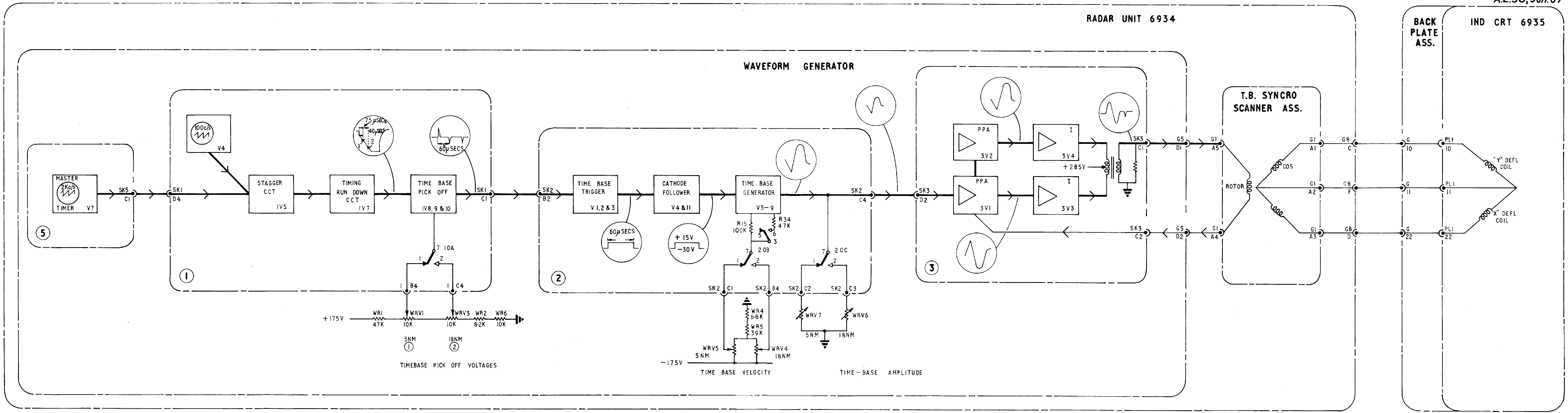

AIR DIAGRAM-MIN
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RED STEER ARI 5919 TIMEBASE CHAIN SHEET 5

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COS 2604

IRV1 CONTRAST CONTROL

AIR DIAGRAM-MIN
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RED STEER ARI 5919 BRIGHT UP CHAIN SHEET 6

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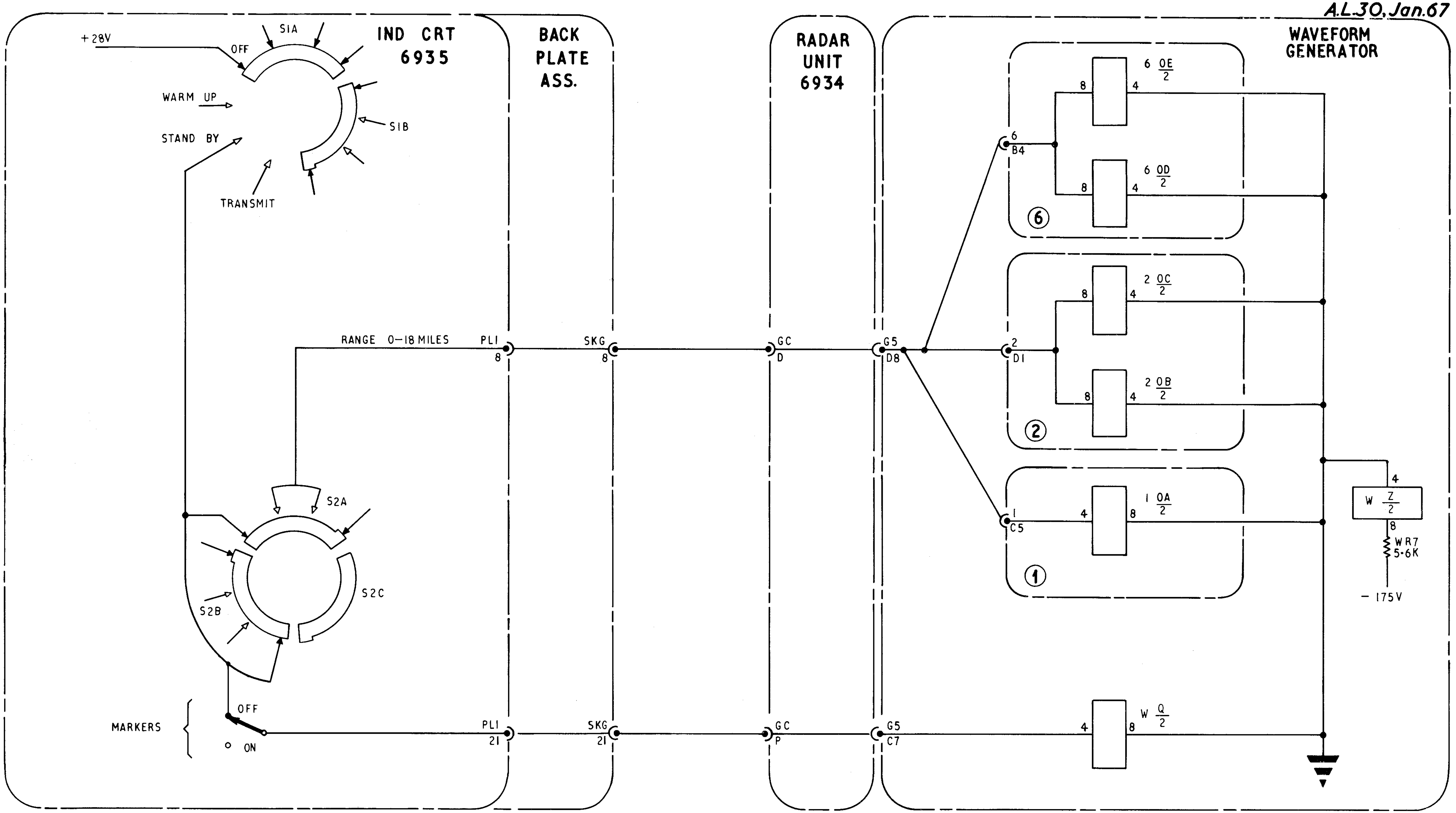
COS 25SB



AIR DIAGRAM-MIN
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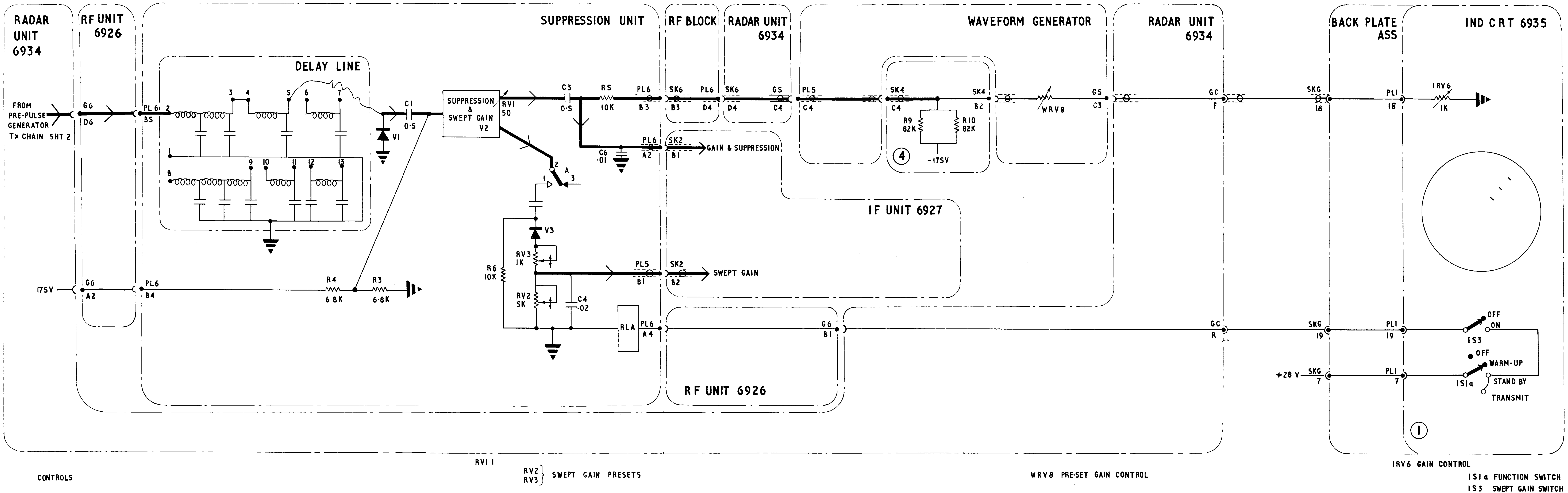
BY COMMAND OF THE DEFENCE COUNCIL FOR USE IN THE ROYAL AIR FORCE
ISSUE 1 PREPARED BY TECHNICAL TRAINING COMMAND

RED STEER ARI 5919 MARKER & TIMEBASE RANGE SELECTION CHAIN SHT. 7



NOTE:-
EFFECT OF SWEPT GAIN IS TO PREVENT OVERLOADING BY SHORT RANGE ECHOES WHILST MAINTAINING MAX GAIN TO DISTANT ECHOES

AIR DIAGRAM-MIN
114M-0200-MD508
BY COMMAND OF THE DEFENCE COUNCIL FOR USE IN THE ROYAL AIR FORCE
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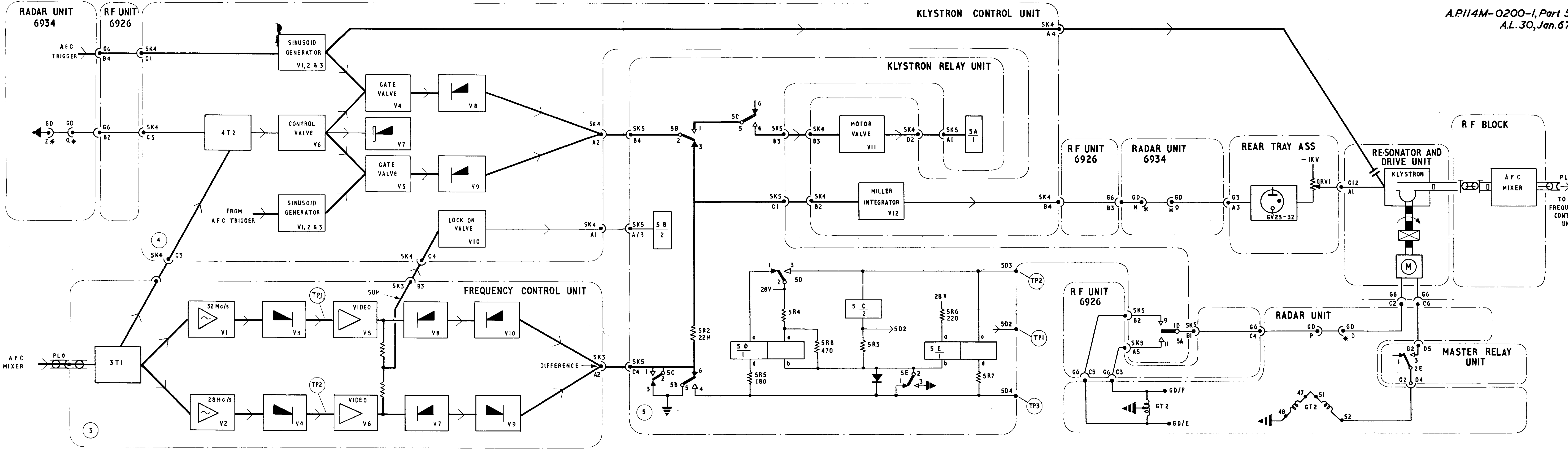
RED STEER ARI 5919 SWEPT GAIN & SUPPRESSION CHAIN SHEET 8

256 M—— D.460469 804 3/67 A.(W) Ltd Gp.956/3

COS 2566



CONTROLS
TEST POINTS

AIR DIAGRAM-MIN
114M-0200-MD509
BY COMMAND OF THE DEFENCE COUNCIL FOR USE IN THE ROYAL AIR FORCE
ISSUE 1 PREPARED BY TECHNICAL TRAINING COMMAND

TP1
TP2 } VIDEO TEST POINTS

* TEST PLUG GD REMOVABLE FOR BENCH TESTING & 1st LINE SERVICING

TP1
TP2
TP3 } RELAY TEST POINTS

GRV1 KLYSTRON REFLECTOR VOLTS ADJUST

COS 2605 47

RED STEER ARI 5919 AFC CHAIN SHEET 9

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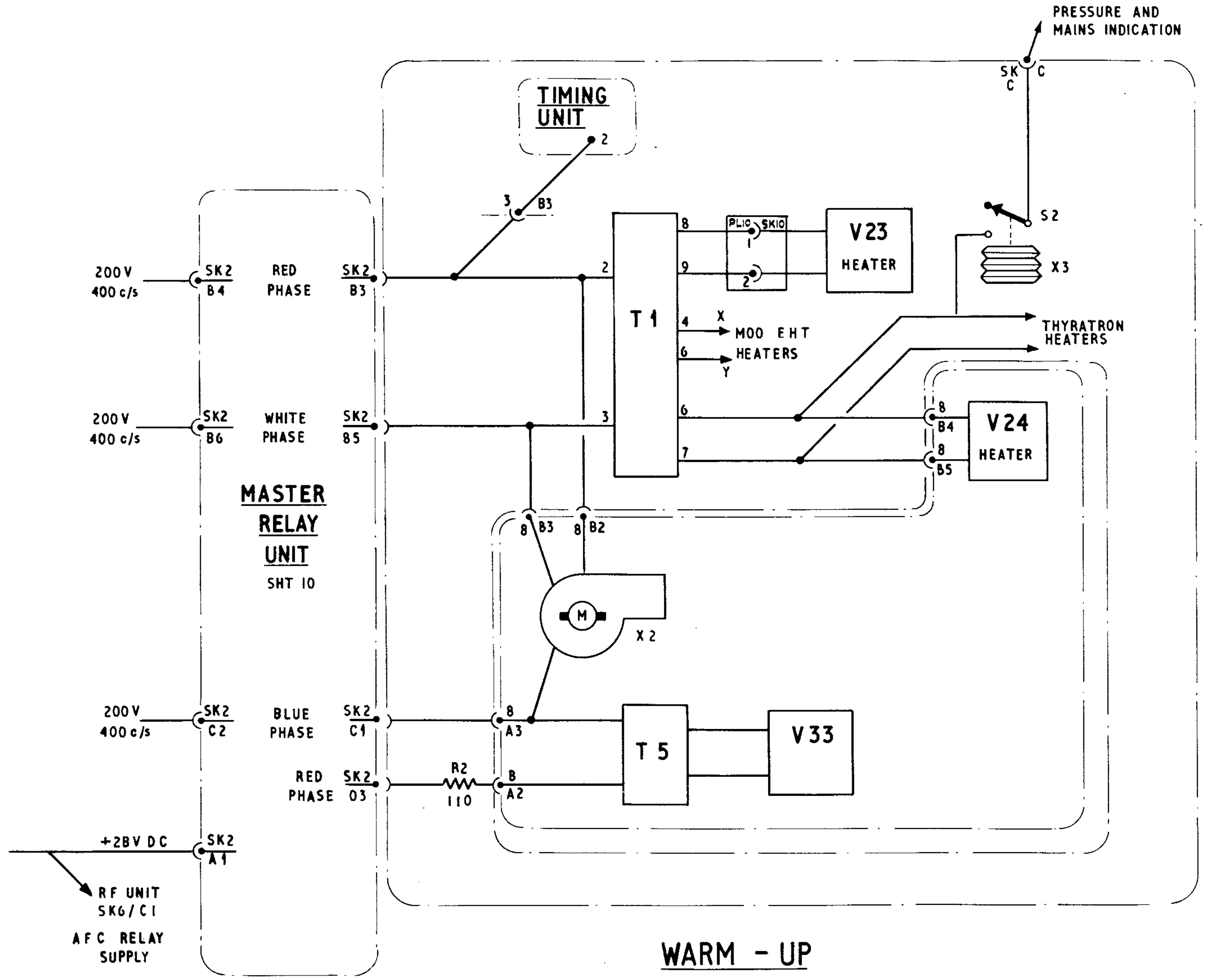
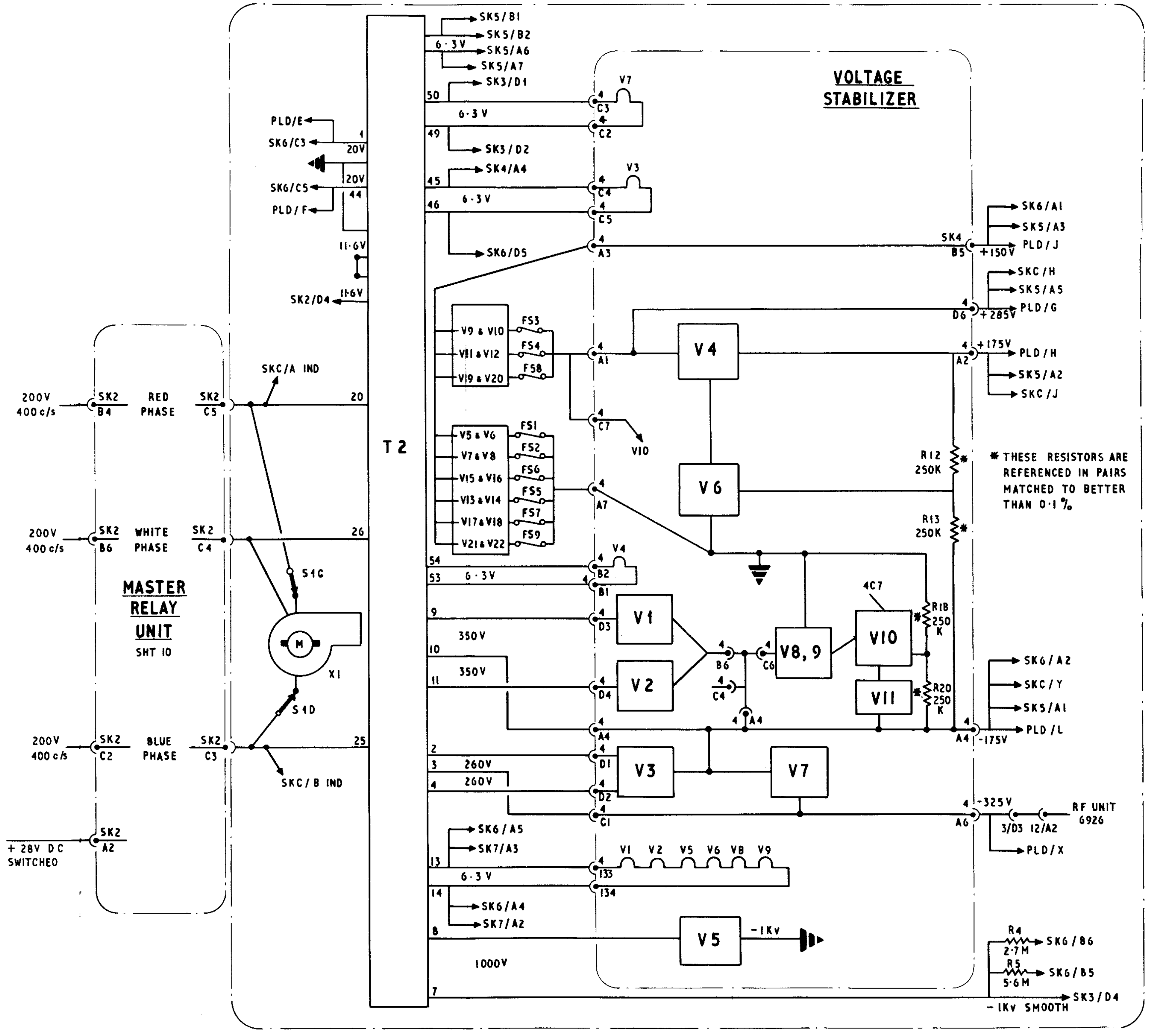
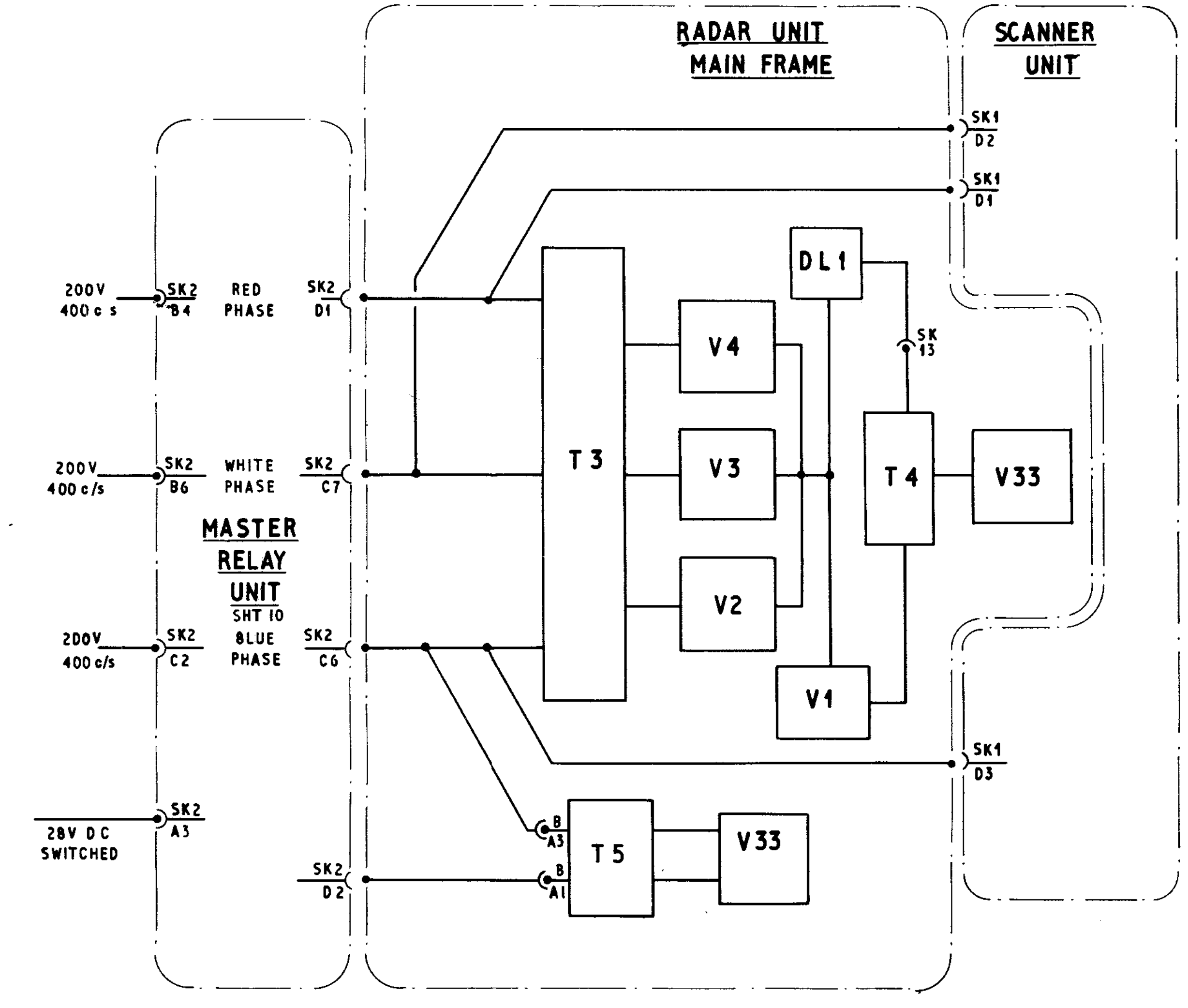


WARM - UP



STAND - BY



TRANSMIT

AIR DIAGRAM-MIN
114M-0200-MD511
BY COMMAND OF THE DEFENCE COUNCIL FOR USE IN THE ROYAL AIR FORCE
ISSUE 1 PREPARED BY TECHNICAL TRAINING COMMAND

RED STEER ARI 5919 POWER DISTRIBUTION ON WARM-UP STAND-BY & TRANSMIT - SHEET XI

256 M— D.460469 804 3/67 A.(W) Ltd Gp.956/3

COS 2603 47.