Trainee Note

RADAR TYPE 84

PART I

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

This note is not intended as a substitute for the relevant Air Publication and must not be regarded as authority for modifications, servicing procedures, etc.

RADAR T84

LIST OF SECTIONS

SECTION 1

INTRODUCTION AND CONCISE DETAILS

LIST OF CONTENTS

SECTION 1

RADAR TYPE 84

INTRODUCTION AND CONCISE DETAILS

Definition of the Radar Type 84

1. This is a long range early warning radar for the detection and plotting of a manned bomber threat. The radar has a number of special features to enable detection and plotting of targets in strong fixed and moving clutter, together with facilities to detect and plot in a jamming environment.

The Radar Equation

2. The various factors which tend to reduce the efficiency of any early warning radar may be considered by examining the Radar Equation.

$$r = 4\sqrt{\frac{\lambda^2 G^2 A}{4\pi^3} \cdot \frac{\hat{P}TX}{PRX\ (Min)}}$$

3. The maximum range PRX represents the minimum detectable received power and therefore needs to be as small as it is possible to detect. The other factors in the equation need to be as large as possible.

a. λ - Wavelength. This cannot be increased indefinitely since in order to obtain a narrow HPD the aerial dimensions have to be large compared with the wavelength. (T84 24 cms).

b. G Aerial Gain. If this is made too great the aerial becomes prohibitively large and eventually the number of pulses per beamwidth becomes too small for satisfactory integration on the surface of the p.p.i. tube.

c. A Target Echoing Area. This is not under the control of the designer (for a Canberra 15 metres^2).

d. $\hat{P}$TX Transmitter Peak Power. This is made as large as possible and limitation is the mechanical design of the magnetron (T84 5 megawatts).

The other factor which determines the range of the radar is the minimum detectable power.

4. PRX (Min) = NKTBπ.

a. N = Noise factor, smallest at present 7dB.

b. KT, these terms are constant.

c. B = Receiver bandwidth; this cannot be made too small since this would imply a long duration radar pulse with a consequent loss in range discrimination. (T84 B = 200 kc/s).

d. π = Perception factor. Depends on three things:

(1) PPI Operator.

(2) PRF; it has been shown experimentally that the higher the p.r.f. the smaller is the π, which is what we are aiming for. This is due to the integration of the received pulses on the face of the tube. However if the p.r.f. is made too great the maximum range of the 84 is limited (T84 PRF 250 p.p.s.).

(3) The final thing π is dependant on is the amount of unwante clutter on the p.p.i. It is these observations that the T84 is designed to combat.

Concise Details

5. a. PRF - each radar type 84 is different but lies in the band 246.7 - 255.8 p.p.s.

b. Pulse Length - 10µs.

c. Peak Power - 5 Megawatts.

d. Mean Power - 12.5kW.

e. Horizontal Polar Diagram - 0.9 degrees at 3dB points.

f. Vertical Polar Diagram - $Cosec^2$ radiation pattern (achieved by variation of power to feed horns).

g. Aerial System - Eight stacked horns feeding an eliptical paraboloid, 60ft long, 21ft 8 inches high.

h. Rotation Speed - Maximum 6 r.p.m., also incorporates sector scan.

j. Range - exceeds 200 N miles.

k. Power Input - 415V 50 c/s 3 phase, maximum load approximately 160 KVA for radar 110 KVA for turning gear.

l. Receiver - Linear and AJ IF 13.5 Mc/s overall bandwidth 200 kc/s.

m. Local Oscillator - High stability quartz crystal modulated push pull oscillator.

6. Special Features: To improve π in obscuration are as follows:

a. Circular polarisation.

b. Special AJ receiver.

c. Log receiver with pulse length discrimination (PLD).

d. Moving target indication, MTI cancels fixed and moving clutter (can be doppler compensated).

e. Swept gain.

f. PRF discrimination.

7. Equipment. The radar aerial and transmitter are mounted in a modified T80 gantry. Most of the special features are contained in the seven equipment racks of signal processing. Three Consoles T64 are used for monitoring and controlling the signal processing.

8. Introduction to the Control System. The Radar Type 84 contains eighteen stabilised power supply units, sixteen 3 phase motors driving fans, compressors and pumps, a 50kW modulator, a low noise receiver and built in monitoring facilities. In addition there is an air conditioner providing the transmitter with cooling sir, and a compressor and dehumidifier supplying the waveguide and magnetron with clean dry air.

9. <u>Purpose of Control System</u>. To switch on these devices at the right time interval and to interrupt the sequence in the absence of any service to prevent damage to the equipment.

10. Due to the expectation of a radiation hazard and a requirement for the transmitter to be housed in an unmanned building, remote control of the switching on and off is incorporated. The normal switching on controls have been reduced to a Tx ON button which is repeated on the remote control panel. The other aspect of the control system is to reduce off the air time due to temporary overloads in the magnetron, modulator or HT supply. The HT is switched off then restored automatically until the fault condition is considered so serious as to need attention.

11. Finally there is a circuit which corrects the magnetron cathode current against changes in mains voltage.

<u>Air and Water Systems</u>

12. The T84 Tx has an input requirement of 50 KVA and an output of 12.5kW (Mean), there is 37.5kW, which is mainly in the form of heat. It is therefore necessary to incorporate a forced air and water cooling system.

13. Surplus heat is removed by the following means.

a. Air at atmospheric pressure blown through the equipment from bottom to top.

b. Water is circulated around components having a large temperature rise, ie. Magnetron, Electromagnet, overswing diodes and RF isolator.

c. Low pressure air 15lbs/□", is circulated through the internal high power waveguide, this cools the magnetron dome and also pressurises the guide.

14. In addition the Radar Type 84 uses high pressure air (75lbs/sq in) for the operation of various pneumatic control and safety devices.

15. The source of high and low pressure air is the Air Compressor SH121. This supplies clean dry air at 75lbs/sq in and 15lb/sq in.

16. The heat acquired by the water and circulated low pressure air is removed by using air and water heat exchangers cooled by the circulating atmospheric air.

17. The air recirculation is a servo temperature controlled blower, when the ambient temperature is high air is not recirculated and the system becomes 'Open'; when the ambient temperature is low the system becomes recirculary, a 'closed' system. At intermediate temperatures the system will take up an intermediate position.

SECTION 2

THE TRANSMITTER

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

SECTION 2

THE TRANSMITTER

D.C. Supply Control System

1. General Description. A source of d.c. is needed for the modulator, this is obtained from the three phase 415V mains supply. The final e.h.t. to the modulator being about 10.5 kV. In order to obtain a variable output the mains are applied to a motor driven three phase variac, capable of varying the supply from 208V to 415V a.c., the upper limit being controlled automatically to maintain a specific mean magnetron cathode current. Both variac and motor are housed together in an oil filled tank. The variac output is stepped up by a DELTA/STAR transformer the output of the latter being taken to six heavy current diodes connected to give three phase full wave bridge rectification. The variac therefore controls the e.h.t. from 6 kV minimum to an absolute maximum of 11.5 kV and is capable of compensating for a mains variation of ±10%.

2. Purpose. To give controlled high tension d.c. supply to the modulator.

3. Action. When the switch on the auxillary switch board is closed three phase mains are connected to the live side of isolator contactor 'A', the red phase being also connected to internal lights and servicing sockets. At this stage all live terminals are covered and servicing may be carried out in safety. The 'Mains Available' lamp lights, this is the first of a number of lamps along the front of the transmitter cabinets which light in sequence as the transmitter runs up.

4. When the "Mains On" button is pressed contactor 'A' is made and held, other parts of the transmitter may now be considered live as far as h.t. 'Contactor B'. The Red, Yellow and Blue phase indication lamps come on; nothing further happens until the Compressor SH121 switch is on, and its Local/Remote switch is set to Remote and the 'Transmitter ON' button is pressed thus completing the mains circuit to the 50V power supply from the circuit breaker assembly M3.

5. The 50V power supply immediately produces an output which energises RLA in Panel Control M15, RL'A1' contact shorts out the 'Tx on' button and holds the supply on.

6. The automatic control circuits in the Panel Control M15 and circuit breaker assembly 3M now take over, switching on the dehumidifier in the SH121, 'Dehumidifier Lamp', all the gate unit heater supplies, 'Gate Heaters' lamp, and the thyratron heaters, 'Thyratron Heaters' lamp. This last supply is also the start of the e.h.t. interlock line. When all gate supplies have warmed up, the ten minute run up sequence will commence, also the h.t. regulator is driven up to pre-set h.t. up level before the magnetron heaters supply is made at the latters minimum voltage level. The mag heaters voltage is steadily increased to normal level as the h.t. regulator is run down. This prevents a large current surge through the cold heaters. This sequence takes about 40 seconds.

7. When the ten minute run up sequence is complete and the e.h.t. interlock circuit final stages all operated, h.t. contactor B will make ('HT ON' lamp) applying the regulator output to a three phase delta/star transformer where it is stepped up and appears after rectification and smoothing (L3 C1) as 10.5 kV d.c. when the regulator has run up to normal level ('HT UP' lamp).

8. It is to be noted that the control system has at this stage, only been dealt with in bare outline and has been introduced merely to help illustrate the control and sequence of the three phase supply system to the modulator.

The Modulator Figure 2.1

9. General. Of the conventional resonant choke charging type with tetrode thyratron switching to discharge the PFN. Charge and discharge of the PFN is controlled by four tetrode thyratrons in parallel. These are primed and triggered by the Pulse Generator M12 which produces both priming pulse and trigger pulses for the thyratrons from either its own internal oscillator or, as under normal running conditions, a trigger from the p.r.f. cabinet of signal processing.

10. The use of four thyratrons in parallel is to share the high current.

11. Timing of the triggers A, B, C and D on grid two of the thyratrons is automatically adjusted for equal thyratron loading. (By monitoring the cathode currents and applying to an error detection system). This is to prolong the life of the thyratrons and therefore serviceability of the equipment.

12. Purpose. To provide a high power 10 μ sec pulse to drive the magnetron.

13. Action. D.C. supply from the three phase full wave rectifier is smoothed by L3 and C1 and is applied as nominally 10.5 kV d.c. to the resonant choke L4 which, after initial switching, will attempt to resonant about 10.5kV. Thus the PFN is charged to approximately 21 kV through the charging diodes until the next trigger pulse cuts on the thyratrons, V1, V2, V3 and V4 to discharge the PFN developing the voltage across the primary of the pulse transformer and the impedance of the PFN. As each half of the PFN is 5 μ secs long they each form a 10 μ sec delay and result in a pulse 10 μ secs wide and approximately minus 10 kV in amplitude being formed across the primary of the pulse transformer and stepped up by it to 45 kV 10 μ secs still retaining the negative polarity.

14. An overswing diode circuit is included to conduct away the negative swing due to a slight built in mismatch between PFN and pulse transformer. If an excessive mismatch occurs the current through the overswing diodes which is developed across a resistor network, increases the charge in C12 via C11 and MR1. If the mismatch exists for longer than 2 to 3 seconds, set by RV2, RLW will energise routing 50V d.c. to the control panel M15. to initiate a trip and reset sequence.

15. The heater transformers of all the e.h.t. rectifiers, charging diode and overswing diodes are fed from the circuit breaker assembly, contactor B.

The Magnetron Circuits Figure 2.3

16. General. The magnetron has an electromagnet and both are water cooled, in addition low pressure air cools the magnetron launching dome. The magnetron has a peak power output of 5 Megawatts and operates at a fixed frequency within the station colour band.

17. The pulse transformer T6 is housed in the right hand cabinet in an oil filled tank together with the mag filament transformer.

18. The magnetron M565, is of the long block Boot type, using vaned cavity resonators instead of the conventional drilled type. The weight is approximately 1 cwt and a pneumatic hoist is built into the cabinet to facilitate magnetron installation and removal.

19. Action. The magnetron is cathode modulated by 10 μ sec negative going pulses stepped up by the pulse transformer from nominally 10 kV to 45 kV. To obtain the required rate of rise on the leading edge of the modulator pulse, a dispiking network is connected across the pulse transformer primary which is double wound because of the large peak current flow.

20. The 0-120V a.c. single phase supply to the magnetron heater transformer is derived from the fixed yellow phase and the variable yellow phase, the latter being taken from the regulator output and both are brought via circuit breaker assembly 3M, contactor C. As e.h.t. is increased the filament supply is reduced and finally switched out completely at a preset level of e.h.t., the cathode temperature being maintained by electron bombardment. The 8 μF capacitor C9 connected across the heater of the magnetron presents a short circuit path to any modulator pulses that may appear across the heater. The capacitor is made up of a number of parallel connected capacitors housed together in a cylindrical copper container which is screwed onto the top of the magnetron and makes contact via a plug retained in the screw. Capacitor C11 which is connected directly across the heater transformer secondary winding prevents any r.f. pick up being fed to the magnetron heater or back into the supply.

21. Pulses of r.f. oscillation are coupled from the output dome of the magnetron into the waveguide system at the launching section. The mean cathode current of the magnetron being maintained at 600 mA by the automatic current control circuits housed in the control panel M15.

Pulse Generator M12 Figure 2.5 2.6

22. Purpose. To produce a priming pulse for the control grids of the four thyratrons in the modulator, and in addition four trigger pulses one for each of the thyratron screen grids.

23. General. The tetrode construction of the four thyratrons to be used in parallel. Ionization of the gas is initiated by the priming pulse and anode to cathode breakdown occurs when separate trigger pulses are applied approximately 2 μ secs later to the screen grids. These G2 pulses are each automatically variable in time and are controlled by the cathode currents of the thyratrons in such a manner as to maintain a balanced current flow.

24. Both primary and trigger pulses are derived from a single trigger pulse generated either in the radar office or an internal oscillator.

Pulse Shaping and Priming Pulse Circuits

25. Action. V1 is a phase shift oscillator of frequency variable between 230 and 270 c/s used only for test purposes in the absence of external trigger from the Signal Processing racks.

26. The external trigger is a 2 to 4 μ sec positive pulse fed via a long c.r. to the cascade amplifier V2A V2B. The output is coupled to V3 via C9 which with R18, R19, forms a s.c.r. if the trigger is derived from the internal oscillator. V3 is cut on by the positive pulse on its grid, the negative going output being used to cut off V5 and V4A (again the coupling circuits forming s.c.r. when on 'Local' trigger). The pre-pulse shaper V5 amplifies and inverts this input and the resultant output pulse is taken via cathode followers V6 and V7 as 10 volt 3 to 15 μ sec positive pips (with 68 ohm termination) to trigger external test equipment and the internal w/f monitor and noise monitor. The positive squarewave from V4B cathode is

delayed by DL1 by 2.5 μ secs so that the main trigger is delayed by at least that amount on the pre-pulse enabling display of main trigger waveforms on the waveform monitor trace. The delayed 3 to 15 μ sec pulse from DL1 is differentiated by C18 R43. The positive peak drives V8 into conduction producing a negative 120V pulse at its anode which triggers the high speed monostable multivibrator V9 and V10.

27. Normally V9 is conducting heavily due to the positive bias applied via R48 and R49, and V10 is cut off with its control grid at minus 100V. The standing anode potential of V9 is in the order of 100V but rises when the negative trigger pulse cuts the valve off. This rise relieves the bias on V10 which starts conducting. Cumulative action causes V10 to conduct heavily for a period determined by the rate of discharge of C23 through R49 and R48. A steep sided 5 μ sec current pulse is produced in T1 primary, R5 damps ringing in the transformer.

28. The output valves V11 and V12 are normally biased off by minus 10'V on T1 secondary winding, this is overcome by the 70V negative pulse at V10 anode stepped up and inverted by T1 to 120 positive. The common anode load of the heavy current tetrodes V11 and V12 is the primary of T2, C29 provides an h.t. reservoir during the pulse period. The output from T2 is 800V 5 μ sec positive squarewave used to prime the four thyratrons in the switch electronic M6 circuit.

29. This pulse is also tapped off to V13A which is strapped as a diode, via potential divider R63 and R64. When the trigger is present the diode will conduct having about 75V (mean) on its anode. This voltage will appear on the cathode, which being strapped to V13B grid will cause the latter to conduct holding RLA energised thus making the interlock contact RLA 1.

30. Should the trigger fail momentarily then the c.r. time of C30 R65 is such that V13B will be kept conducting for 1/10th of a second. RLA when energised, also lights a trigger presence light.

G2 Trigger Pulse Circuits

31. Purpose. To provide G2 triggers to the modulator thyratrons with timing control on each to maintain balance of current through the thyratrons.

32. Action. From the delay DL1 in the pulse shaping circuits the 60V 15 μ sec pulse is fed to V24 a cathode follower. Its output is split to drive four cathode followers each of which having a delay circuit of the order of 2.5 μ secs in its cathode. These delay lines are automatically varied according to the thyratron associated with a particular trigger channel with reference to the other three channels.

33. D.C. sample voltages produced by the diode rectifiers in the thyratron cathode circuits are fed to three separate error-detector circuits. Each is a resistance network balanced by means of a preset potentiometer to produce a zero error voltage when the associated thyratrons are taking equal current. In the event of thyratron B taking more current than thyratron A, positive error voltage is produced at V17A grid. This causes the standing anode potential of V17A and thus the anode current of V18, to fall. As the bias winding of DL3 is in the anode circuit of V18 the delay time is increased and the firing pulse applied to thyratron B is retarded to restore the balance. By comparing the combined currents of A and B with C and D a balance of current drawn by these thyratron pairs is maintained by variation of DL4 in the triggering to thyratron C.

34. The bias current for DL2, which controls the timing of the firing pulse to thyratron A, is supplied by a constant current pentode V27. The current is nominally set to 8 mA by the preset cathode bias resistor RV5. The resultant delay between priming pulse and firing pulse is used as a reference delay for the system. Switches B and C are incorporated to enable the thyratrons to be balanced prior to being put into use.

Trigger Amplifier M25 Figure 2.8

35. General. This unit contains four identical circuits each concerned with the G2 trigger to one of the thyratrons on the Switch Electronic M6.

36. Purpose. To give final shaping and amplification of the G2 trigger pulses.

37. Action. The trigger waveforms arrive from the variable delays in the M12 units as positive 20V 5 μ sec squarewaves. These are first differentiated, the positive pips are amplified and inverted by V1 and the negative waveform at V1 anode is used to trigger a multivibrator circuit V2 and V3. V2 is normally conducting in the stable state and the resultant 70V 5 μ sec squarewave at V3 anode is stepped up to 120V and inverted by T1 before application to the grids of the tetrode power amplifiers V4 and V5 connected in parallel. The primary of T2 is their common anode load producing at its secondary winding the final G2 trigger, a positive 800V 5 μ sec squarewave.

Switch Electronic M6

38. General. This unit is essentially part of the modulator and, in addition to the four main thyratrons, carries components concerned with the timing control of the individual G2 trigger pulses.

39. Purpose. To control the discharge of the PFN.

40. Action. The four thyratrons are primed by a common priming pulse fed to their respective control grids, but there is a slight difference in the timing of individual screen grid (G2) triggers. In each thyratron cathode is a transformer taking a current sample, which after rectification is compared with a similar sample of opposite polarity from an adjacent thyratron. These are compared in a resistor network and providing the samples are equal and opposite the centre tap of the network will be zero volts. Any change in balance will produce a voltage at this centre which is amplified and used to vary the inductance in the associated pulse delay line.

41. The thyratrons are independantly heated, mains being applied, as soon as the Tx On button is pressed, by contactor 'A' ensuring that the thyratrons have a full 10 minute warm up period before e.h.t. is applied to the modulator.

The Electromagnet

42. Purpose. To provide an axial field of uniform flux density of approximately 800 gauss for the magnetron.

43. General Description. The magnet is a water cooled solenoid 16 inches long with a bore of $7\frac{1}{4}$ inches to accommodate the magnetron block. It comprises twelve equally spaced slots formed by copper disc separators into which are wound coils of copper tape. Attached to the periphary of each separator is a $\frac{1}{4}$" copper tube through which water is pumped. The solenoid is enclosed in a cast iron container which short circuits any external field and protects the solenoid mechanically.

44. To provide necessary flux density a current of 30 amps is passed through the series wound coils.

45. Units and Major Components in the Magnetron Field System

a. Three phase Saturable Reactor.

b. Transformer.

c. Rectifier and Protection unit M1.

d. Filter Choke.

e. Electromagnet.

f. D.C. Amplifier M31.

46. Purpose. To supply a regulated 30 amps current through the electromagnetic field winding.

47. Overall Action. The low voltage high current supply is derived from a 3 phase 415/40V star/delta transformer and a full wave 3 phase rectifier unit. The input to the transformer is controlled by a variable series impedance in each line of the transformer. Control current for the reactor is supplied from the Amplifier DC M31 and is of the order of 100 mA. The main rectified current through the magnet coil is sampled by means of a low series resistance (0.03 ohms) made from 'Ferry' strip and having practically zero temp coefficient of resistance. The voltage developed across the resistance is applied to the input of the high gain d.c. amplifier which in turn controls the input to the transformer. The loop gain of the system is such that the variation of current with the magnet coil resistance is negligible, the stability being dependant only on the internal reference.

48. The 300 c.p.s. ripple component of the rectified current is reduced to a low valve by:

a. The Filter Choke.

b. The self inductance of the magnet coil.

49. An accurate meter shunt is included in the current path to enable an external meter, calibrated 0-50 A and fitted to the Panel Test Electrical No. 5, to monitor the magnetron field current continuously. A low valve resistance is connected between the main filter choke and the smoothing capacitors, which in the event of overload develops sufficient voltage to operate a carpenter relay (RLA) causing the Mag field supply contactor E to drop out. The contactor is reset by a push button on the rectifier and protection unit M1.

Power Supply and Saturable Reactor

50. Purpose. To give control on the 3 phase supply using a relatively small d.c. control current.

51. General. This unit is fitted in the top left hand corner of the left hand cabinet. The reactor is contained in an oil filled tank. The power supply (50V) is also mounted on the same chassis.

52. A non linear resistance is connected across the control coil to prevent excessive rise in voltage across the coil should the control current supply be interrupted, safeguarding components.

53. Action. In this particular application the reactor acts as a variable impedance in series with each of the three phase supply lines.

54. When the control current falls, permeability of the cores increases and because of the resultant high impedance of the power windings the output current is reduced. As the d.c. control current tends to drive the core towards saturation and resultant decrease in impedance results in output current increase to the transformer.

55. The Transformer. This is a 1.75 k.v.a. Star/Delta transformer with primary taps at 415, 395, 375 and 355 volts. It is oil filled and mounted below the filter choke at the rear of the left hand cabinet. The inputs from the saturable reactor are normally connected to the 375V tappings. The output is 3 phase a.c. at 40 volts to the rectifier M1.

Rectifier Protection Unit (Mag Field) M1 Figure 2.10

56. General. The rectifier consists of 18 germanium diodes used in 6 sets of 3 in parallel connected to give 3 phase full wave rectification. The system is rated at 90 amps at 35° C but de-rates to 35 amps at 60° C. Should the cooling system fail, a thermostat is fitted and set to make at 60°C. This energises RLB and the supply contactor E will drop out.

57. Purpose. To provide heavy current (30 amps) to the electromagnet coil.

58. Action. As described in Overall action.

Amplifier (D.C) M31 Figure 2.13

59. General. The amplifier consists basically of a high gain d.c. voltage amplifier and a voltage to current converter. The high gain is achieved by a "chopper" amplifier consisting of a pair of syncroverter relays and two high gain pentode a.c. amplifiers in cascade.

60. Purpose. To amplify and convert fractional changes in input voltage into a control current of practical dimensions for the control winding of the saturable reactor.

61. Action. Under ideal conditions the input sample is 0.9 volts and when compared with the reference voltage (0.9 volts), by the syncroverter Relay A, it produces no difference output to V2 grid. Any rise or fall of the sample input will result in a square wave at V2 grid as RLA "chops" between the sample and reference levels at a frequency of 50 c/s. This is achieved by supplying the syncroverter relays A and B from a 6.3V a.c. 50 c/s source.

62. V2 and V3 amplify the square wave which is limited by MR1 and MR2 to $\pm$7.5V. The cathode follower (V4A) output is connected to RLB moving contact. At RLB the amplified square wave is clamped to earth, and depending on whether the sample input was higher or lower than the reference voltage, a positive or negative d.c. is amplified by V4B and converted to a rise or fall in current through V6 and V7. The latter two valves are beam tetrodes connected in parallel and having for a common anode load the reactor control coil.

63. RLC operates causing the h.t. contactor to be tripped in circuit of a variation in the magnet coil of more than $\pm$3 amps.

64. Waveguide System Within the Transmitter Cabinet. The waveguide system within the Tx cabinet is pressurised to 15 lb/sq inch. This air is circulated, cooled and returned to the waveguide to direct the cooled air onto the magnetron launching dome. The waveguide external to the cabinet is pressurised at a constant 15 lbs/sq inch. R.F. is launched from the magnetron in the E01 configuration, into the rectangular waveguide (6½" by 3¼") where it is transformed into the H01 mode. Inserted into the

'A' dimension of the rectangular launching section are two thermo couples spaced ¼ of a wavelength apart and connected to a meter on the L.H. Light and Meter assembly, which is calibrated 0-20 KW, to read mean power. The waveguide 'A' dimension is then stepped down to conform with the requirements of the 'R.F. isolator'.

65. Isolator R.F. Reflection. The isolator is a matched waveguide component which gives low attenuation to r.f. in the forward direction, less than 0.4 dB, and high attenuation in the reverse direction, more than 10 dB. It is used to reduce the effects of mismatch in the waveguide system which might otherwise upset the satisfactory operation of the magnetron. Resonant absorbtion of reflected r.f. by ferrite strips occurs in the isolator, the resultant heat is dispersed by water cooling.

66. Important. The field strength of the permanent magnets which form part of the isolator is critical mishandling of the unit will reduce its effectiveness resulting in probable damage to the magnetron.

Duplexer System

67. Purpose

a. To ensure transmitter pulses are routed with minimum loss of power to the aerial from the magnetron.

b. To divert Tx pulses from the receivers.

c. To ensure that reflected signals are routed from the aerial to the receiver with minimum losses.

68. Action. The transmitter R.F. pulse enters the duplexer from the launching section and is divided equally in the forward direction by the first 3 dB coupler, the wave passing through the slot undergoes a phase change of -90°. The first of the T/R tubes to energise will be the rear ones which reflect a high voltage $\lambda g/4$ back across the 'Main' T/R tubes. A high percentage of the power is now reflected, the power in the first section is divided equally, to join the reflected power going to the aerial in phase, by the 3 dB coupler. Any power which breaks through the T/R tubes is absorbed by a dummy load and a small but harmless portion is passed to the Rx.

69. On reception the received signals are passed through the T/R tubes and routed to the receiver via the two 3 dB couplers.

70. Four forty dB directional loop couplers are fitted to the power input arm of the duplexer and are colour coded accordingly to the magnetron frequency band in use. One for spectrum analyser, one a.f.c. mixer, one r.f. wavemeter the fourth is not used.

External Waveguide Within Tx Hall

71. Phase Shifter. The phase shifter in its electrical effect is an adjustable length of waveguide, its purpose being to match the waveguide run to the magnetron in use. The position of the dielectric slab in the unit is adjustable to a mid point of a range over which frequency pulling of the magnetron does not occur. This range of stability must be common to both circular and horizontally polarized transmission.

Low Pass Filter

72. Purpose. To pass the π mode unaffected but to eliminate the π' and π'' modes.

73. Action. The filter consists of a 3 dB coupler followed by a double waveguide assembly, each channel consisting of a cosine taper followed by a second cosine taper containing an absorbant load.

74. Considering the π mode the r.f. pulse is fed into the filter and is divided by the 3 dB coupler. The two power branches continue their forward direction till they reach the first cosine taper. They are then reflected so as to be in phase and additive at the aerial branch. The π' and π'' modes will not be reflected but will continue down the reduced section waveguide to be absorbed in the dummy loads. Any resultant heat in the dummy loads is dispersed by a constant loss exhaust of the pressurized air.

SECTION 3

RECEIVER

LIST OF CONTENTS

RECEIVER

LIST OF ILLUSTRATIONS

SECTION 3

RECEIVER

Type 84 Anti Swept Frequency Jamming Features

1. Jammers. There are several different ways of Jamming a radar equipment but the one considered most vicious is the Swept Frequency Jammer - (Carcinotron) - with noise modulation.

2. The carcinotron is a device whose frequency is proportional to the applied voltage and fairly small carcinotrons can be constructed giving outputs of about a Kilowatt, at L Band frequencies the maximum sweep is about 150 Mc/s.

3. A.J. Features. In order to limit the response of the radar to this type of jamming the following measures are taken:

   a. The radars at different sites are as far apart as possible in transmitter frequency within the L band.

   b. The aerial is horn fed, this stops 'squint angle' and therefore avoids beam swinging which will broaden the angle of jamming.

   c. The transmitter power is high and will 'blast' its way through interference, i.e. greater power larger received signals therefore easier to detect through jamming.

   d. The pulse width is made fairly long, (10 microsecs), overall i.f. bandwidth can then be made small (200 Kc/s).

   e. A special A.J. receiver is used.

4. Self Screening Range, is defined as that range at which the power received by the radar from the jammer and from reflection by the target are equal. With the type 84 Anti-Jam system, the radar is expected to improve its performance by about 17dB.

The Waveguide Filter Assembly

5. Purpose. To give second channel image rejection and preserve the shape of the interference for anti-jamming purposes.

6. Construction. Two filter sections are used both being three feet long and of normal waveguide cross section. In each section there are pairs of thin rods across the narrow dimension of the waveguide, each a tuned series accepter circuit to wanted frequencies at a bandwidth of 20 Mc/s and developing all other unwanted frequencies across it.

7. Each tuned circuit has a three position plunger into it. The total of eight matching plungers are mechanically linked to a handle which is set to position A, B or C, according to a chart in reference to the STALO frequency crystal in use. There are also four screws set into each section, one per tuned circuit. These are preset at the factory and must not be moved.

Waveguide/Loose Transition

8. Purpose. To enable the insertion of the noise tube and travelling wave tube at ideal stages of the receiver chain and to give final transition to the signal mixer.

Noise Tube Mount

9. Purpose. To provide a source of constant noise for comparison with inherent noise and permit monitoring of the receiver noise factor without taking the equipment off the air.

10. General. The noise tube mount retains the 50 ohms impedance of the coaxial cable, the helix forming the inner conductor. With the noise tube not struck the mount has a small loss, of less than ½dB at 1300 Mc/s. With the noise tube ionized, noise at 15.5dB above KTB is generated and goes into the TWT All received signals and noise are effectively shorted out as the noise tube 'looks' like a short circuit when struck.

11. Every twentieth pulse cycle of the PRF the tube is struck for the 500 microsecs immediately preceding the transmitter pulse, this represents a range above 350 N Miles and will not interfere with the display. (See monitoring system).

Travelling Wave Tube and Mount (TWT) Fig 3.2

12. Purpose. Used in the Type 84 as a low noise r.f. amplifier.

13. Theory of Action. In the travelling wave tube provision is made to produce modulation of the velocity of an electron beam by an alternating field travelling along a structure in close proximity to the beam and with approximately the same velocity as the electrons. Amplification results from an exchange of energy between the electric field of the structure and the electrons in the beam. The velocity of propagation of an EM wave in a conductor approaches that of light, but since the velocity of convenient electron beams is about one tenth of this, the wave is launched on a 'slow wave structure' which reduces the linear velocity by causing the wave to take a tortuous path. TWTs invariably use a helix for this purpose, a fraction of an inch in diameter with a pitch to circumference ratio suited to the required reduction in forward velocity. The diameter of the beam of electrons projected along the axis of the helix by an electron gun is adjusted by the surrounding magnetic field to produce a very small "interaction gap" between the inside of the helix and the electron beam, the forward velocity of the electrons being adjusted by the d.c. potential between the cathode and the helix to be slightly greater than that of the travelling wave. To align the beam along the magnetic axis, screw adjusters are provided at the ends of the magnet to adjust the position of the TWT within the magnetic field. It will be appreciated that the instantaneous velocity of the electrons at any part of the beam is affected by the electric field, due to the instantaneous voltage on the adjacent part of the helix. As the electron beam and the travelling wave progress along the tube together, those electrons coming under the influence of the positive peaks of the wave will be accelerated and those influenced by the negative peaks will be retarded. This action produces bunching of the electrons but as the beam is going forward slightly faster than the travelling wave, these electron bunches will tend to move into position, opposite negative half cycles of the wave. The field due to electron bunches therefore adds to that of the wave and increases the wave amplitude. This, of course, tends to concentrate the bunching effect and is cumulative resulting in an amplification of the wave as it passes along the helix. In order to prevent oscillation by reflected waves passing back along the helix an attenuator is coupled to it. This reduces all waves travelling along the helix to almost zero. The electron bunches however travel through the attenuator unaffected producing a new wave of the same frequency as the original input at the attenuator and of similar amplitude. The amplification continues after the attenuator to produce an output many more times that of the input wave. The final output is taken via a suitable coupling at the collector end of the helix. The gain is proportional to the number of wavelengths in the helix and is limited by the degree of attenuation of the unwanted reflected wave.

14. The input and output couplers to the helix are silver plated sleeves around the helix. The tube used in the Type 84 is the N.1017M having a noise factor of approximately 6dB when new with a suggested end of life at 8dbs, probably 5,000 hours. It has a gain of approximately 30dB.
NOTE: In this TWT maximum gain does not coincide with minimum noise factor.

15. Advantages of TWTs

a. Low noise factor.

b. Consistent low noise factor of overall receivers as the TWT saturates at 1 to 2 mw peak and protects the signal mixer crystals, therefore crystals and head amplifier can have considerable normal deterioration before overall NF is affected.

c. Wide bandwidth: covers 1200 Mc/s to 1400 Mc/s therefore no change or tuning is required when new magnetron is fitted.

d. Wide bandwidth, 200 Mc/s, making it ideal for AJ system.

Control Indicator (TWT) M2, Fig 3.3

16. Purpose. To control the supplies for the TWT grids and helix, and to route the Collector, Magnet field and TWT heater supplies.

17. Action. Two identical circuits are contained in the TWT Control Indicator but only one circuit is used. The 500V supply is routed into the unit at TB 1.4. When SwA is set to the 'ON' position 6.3V a.c. is fed to the heater of V1 and the TWT, SWA also shorts out R4 so that when the heater of V1 warms up V1 will conduct. After approximately 30 seconds, set by R9 and C1 V1 fully conducts energising RLA. The 500V supply is now routed via RLA1 and RLC1, the latter being closed when RLC is energised by the electromagnet supply to various potential divider networks which supply the grids and helix of the TWT. SWD meter selector switch for Helix current, Collector current, G1, G2, G3, helix and Collector voltages. The complete circuit action gives a delay of 90 seconds before the application of the control supplies to safeguard the TWT. RLC also ensures that the magnet supply is available before application of the HT supplies.

18. RV9 is a preset resistor for setting up the meter sensitivity against a known 250V supply.

TWT Electromagnet Power Supply M4. Fig 3.4

19. Purpose. To supply the d.c.field to the TWT electromagnet field which requires 2.8 amps stabilized current at about 15 volts.

20. Action. The bias winding supply is derived from a negative 250V reference supply. It is wound to act in opposition to the control winding of TD 1 and adjusted to set the operating point midway on the linear portion of the output characteristic when the field supply is normal. Thus an increase in the field supply which is taken through TD1 control winding in parallel with R13 will result in an increase of TD1 core permeability. This in turn increases the inductive reactance of the power windings in series with the control winding of TD2, reducing the current through the latter which are unbiased other than the standing current through them. Thus permeability of TD2 cores is also increased, the reactance of the power windings increases and as they are in series with the primary of T1 its output is stabilized to 2.8 amps. Conversely a fall in field supply is similarly stabilized. Field current can be adjusted from 2.5 to 3 amps, according to individual TWT specifications.

21. Action of Relays. RLA is a computer Relay with current through high and low impedance windings balanced to hold RLA open. If the output varies by more than ± 6% RLA contacts close energising RLB.

22. RLB 1 extinguishes ILP 1 (current normal lamp) and B2 routes 50V d.c. to the associated flashing indicator circuit on the LH light and meter assembly.

23. RLC normally energised closing RLC 1 to light ILP 1 and opening RLC 2 to stop the flashing indicator.

Signal Mixer Ring. Fig 3.5 and 3.6

24. Purpose. To give balanced mixing of the received signal from the aerial and elimination of local oscillator noise.

25. Action. The local oscillator input arrives at arm 1 and divides equally and in phase to arms 2 and 4, ~~arriving in antiphase~~ as path lengths are different. This is a constant input and will be developed across the crystal diodes D1 and D2 but as it is such a high frequency it will be filtered from the crystal to earth.

26. When a received signal arrives on arm 3, it divides equally and in phase to arms 2 and 4. Frequency mixing takes place across the crystals and as the two signal components are in phase and the two L.O. components are in anti-phase then the i.f. at these two points must be in antiphase. The two detector are connected in opposition, detection takes place the outputs of which are now in phase are combined via capacitors and are complementary.

27. One of the advantages of balanced crystal mixing is that STALO noise, one of the most active unwanted noise sources is detected in opposite polarity at the crystals and will therefore cancel out at the junction of the capacitors. In this case though the noise factor has already been established at the TWT subsequent stages making negligible difference to it.

Stable Local Oscillator System (STALO) Fig 3.10

28. Purpose. To provide highly stable r.f. at 13.5 Mc/s above magnetron frequency and controlled to maintain the i.f. to within ± 50 Kc/s.

29. Action. A quartz crystal (frequency approx 10 Mc/s) modulated push pull oscillator with a doubler circuit is further doubled at each of three stages in the Generator Harmonic M27, then twice more before leaving the Frequency Multiplier M1 for the final doubling stage and amplification in the Amplifier Frequency Multiplier M24. Outputs are taken to the Signal Mixer via the RF wavemeter and the AFC Mixer, which through the AFC and STALO control panels give correction of the STALO up to 2 Mc/s, the magnetron not drifting more than 50 Kc/s before the STALO control circuits operate and correct to centre frequency of the i.f. (Bandwidth 200 Kc/s).

Frequency Multiplier Oscillator M1. Fig 3.7

30. Purpose. Forming the first stage of the STALO, i.e. a frequency modulated quartz oscillator with six doubler stages.

31. Action. Twelve alternative crystals are available one being selected according to the number on the magnetron.

32. The tuning capacitor C3 across the crystal and grid circuits of the push-pull oscillator and doubler valves V1 and V2 in the oscillator RF unit M25 is capable of tuning the oscillatory stage to such an extent as to enable the STALO to 'follow' a magnetron drift of up to 2 Mc/s. This capacitor is driven by a 400 c/s motor which will operate only when drift exceeds ± 50 Kc/s from the centre frequency. When the circuit is stabilized by three of four hours running the position of the drum indication on the capacitor CJ should be noted and if not reasonably central the next crystal up or down, as indicated, should be fitted. On the M1 chassis there are four push pull doubler circuits and two single valve doublers. The output frequency is approximately 640 Mc/s and is taken via SKG to the M24 chassis.

Amplifier Frequency Multiplier M24 (Fig 3.8)

33. Purpose. To give final doubling stage and output amplifier stages providing the local oscillator frequency.

34. Action. The input is at crystal frequency times 64 and is fed to the final doubler, V1 cathode. Buffer amps V2 and V3 amplify this final frequency and their outputs are taken to Signal Mixer and AFC mixer respectively.

35. RLA open circuits V1 anode to mute the Local Oscillator when the crystal test button is pressed and the reverse currents of the afc mixer crystals are checked. The test button, test supply and meter are on the Control STALO M4 unit. NOTE: Inter valve cabling is resistive giving attenuation (lossy cable), and must not be shortened or interchanged. This rule applies where-ever Lossy cable is used.

AFC Mixer Ring. (Fig 3.9)

36. Purpose. To provide i.f. signal for a.f.c.

37. Action. The L.O. signal arrives on arm 3 and divides equally and in phase to arms 2 and 4 and is developed across crystal diodes D1 and D2. At this high frequency filtering takes place in the crystals.

38. A sample magnetron pulse is fed in on arm 1 and divides equally and in phase to arms 2 and 4, but as the path difference to these two arms from arm 1 is then the magnetron frequency component arrives at D1 and D2 in antiphase. The L.O. and magnetron sample mix producing two i.f. components which are antiphase.

39. The two crystal diodes are the same so therefore detection takes place in same polarity but in antiphase. The connection on Panel AFC M48 between D1 and D2 represents a delay of at the i.f. which brings these two waveforms in phase and are complementory.

Panel AFC M48. Fig 3.10 and 3.11

40. Purpose. To provide the following:

a. AFC pulses to the STALO frequency control unit.

b. AFC reflector voltage to the standby klystron local oscillator.

c. An r.f. 'lock pulse' to the COHO used in Signal Processing.

41. Action. The two inputs from the a.f.c. mixer are brought into phase with each other by passing one through a half wavelength delay line. The pulses at i.f. are amplified by V1, V2 and V3 and fed to a frequency sensitive discriminator circuit, 'Foster Seeley', tuned to 13.5 Mc/s. Any drift from 13.5 Mc/s will produce a proportional d.c. pulse output. If the frequency goes higher a positive pulse output will occur, low frequency results in a negative pulse output. These pulses are amplified and inverted by video amp V5 and fed to two cathode followers V6A and V6B. The former gives us our first requirement of discriminator pulses to the STALO control circuit. V6B output is stretched by V7A and V7B pulse stretching circuit, and further stretched due to miller action at the anode of V8 Miller integrator circuit. This output is now virtually d.c., being limited in positive and negative swing by diodes V9A and V9B before application to the output cathode follower V10, the cathode of which is taken to -600V supply. This output is used to Switch A earth the miller grid giving 'ON TUNE' conditions for the initial setting up of the Klystron reflector volts RLA also earths the grid of the miller until h.t. is fully up at the transmitter.

42. To obtain the COHO Lock pulse a tapping from the grid of V3, IF amp, is taken and amplified by V14 and V15. The latter amplifier anode being transformer coupled to the output, which will be bursts of i.f.

43. The positive envelope detected by V11A is proportional in amplitude to the unit i.f. input and is converted to provide a d.c. negative bias voltage and used as a.g.c. on the grids of the first two i.f. amplifiers. This bias voltage is derived from the amplified and inverted pulse at V12 anode.

44. The now negative pulse is integrated by V11B and the long time constant of C43 and R55; a controllable positive bias on V11B cathode is set to produce a .75 volt pulse at SKF (AGC threshold RV1).

Control STALO M4. Fig 3.12, 3.13

45. Purpose. To control the tuning motor in the Oscillator RF M25.

46. Action. The input at PLD may be either positive pulses, zero or negative pulses depending on whether the i.f. is low on tune or high respectively. This input is applied to V1A grid, V1A and V1B being a long tailed pair phase splitter.

47. Taking for example a positive pulse input to the unit, V1A anode waveform will be a negative pulse, V1B anode waveform will be a positive pulse. These outputs are taken to the grids of cathode followers V2A and V2B, respectively the positive output of V2B being applied to V3A grid via MR1, the negative output of V2A being isolated from V4A grid by MR2.

48. V3 and V4 form separate Schmidt trigger circuits V3A and V4A normally held cut off until a positive inputs cuts one or the other on. The current then passing through the valve operates a relay in its anode. The purpose of relay B in the anode of V3A when operated is to:

49. a. Complete the 400 c/s raise supply to the tuning motor: contacts B1, B2 and B4.

b. Switch off the 'On Tune' lamp and switch on the 'Low' lamp: B3.

c. Energise $\frac{RLR}{4}$ in panel M15 which results in a rise in e.h.t. lowering the magnetron frequency: B5.

d. Open circuit the remote 'On tune' indicator: B6.

50. The purpose of RLC in the anode of V4A when operated is to:

a. Complete the 'lower' supply to the tuning motor: C1, C2 and C4.

b. Switch off the 'On tune' lamp and switch on the 'High' lamp: C3.

c. Energise $\frac{RLL}{4}$ in panel M15 which results in a fall in e.h.t. raising the magnetron frequency.

d. Open circuits the remote 'On tune' indicator: C6.

51. Relay 'A' open circuits the input to V6 until the transmitter h.t. is fully run up and also open circuits the remote 'On tune' indicator with contacts A1 and A2 respectively. RLD mutes the standby Klystron LO which is mounted on the a.f.c. mixer ring unit, when the crystal test switch is operated.

52. The tuning motor supply is derived from a 400 c/s phase shift oscillator V5A with a cathode follower output V5B to a tetrode output amplifier V6. The direct 400 c/s from V6 output transformer secondary winding supplies one of the motor fields. The other field supply is taken from the same source via a series capacitor, C24, which gives a 90° phase shift. The direct supply is switched automatically to control the tuning motor, but a manual control switch is available. To prevent the tuning capacitor C3, on the M25 being

in the wrong 'phase' a cam operated contact on that unit is arranged to earth V3A anode to operate RLB until the capacitor is positioned correctly for 'Automatic' control.

Amplifier IF (Head) M21. (Fig 3.5s)

53. Purpose. To give first stage of i.f. amplification having a narrow and wideband output.

54. Action. Valves V1 and V2 are wide band low noise, low gain i.f. amplifiers the tuned circuits of which are tuned to cover single side band frequencies. V3 and V4 form the remaining stages in the unit of wideband amplification essential to the AJ channel. BW - 10 Mc/s.

55. The narrow band linear channel is tapped off at V2 anode to V5 and V6 which give normal i.f. amplification peaked to 13.5 Mc/s. BW - 2 Mc/s.

56. Inputs to the unit at SKC and SKB are from the Red and Green crystals in the Signal Mixer unit. The narrow band output to Amp Assembly (IF and VID) M28 is taken from SKE. The broadband output to the AJ channel is taken from SKD.

Amplifier Assembly (IF and Video) M28. Fig 3.14

57. General. The assembly comprises the following units:

a. Amplifier IF (filter) M30.

b. Amplifier IF M22.

The first unit is identical to one used in AJ channel.

58. Purpose. To give linear i.f. amplification for signal processing and monitoring.

59. Action. Two inputs one to SKA from linear n.b.w. channel of the head i.f. amplifier M21, the other also at 13.5 Mc/s to SKB from the wobbulator. One or the other is selected by RLC which in the de-energised condition selects the linear i.f. This is taken to input SKA on the M30 unit which has two outputs. The main output from SKC is taken via RC D1 to the radar office for signal processing. If the wobbulator is switched on RLD operates terminating this output, D1, and earths the line to the radar office D2. The other i.f. output from the M30 unit is taken from SKD to the Amp (IF) unit M22 where it is amplified, detected and its -re video output taken to V1 grid. V1 is a limiter and feeds its output to V3 cathode follower, the grid of which is DCRd by V2B. The positive video output is displayed on the monitor when selected. When the wobbulator is switched on RLB is energised, B1 reducing the input to V1, B2 increasing V1 grid base to ensure that no distortion of the i.f. response curve occurs due to limiting.

60. The flow contacts of RLA which is operated by pressing the crystal test button, applies 1 volt test voltage to the red and green crystals of the signal mixer via AMP IF head M21. Reverse currents of both crystals are metered on the M28.

Amplifier IF M22. Fig 3.15

61. Purpose. To amplify and detect i.f. signals from the AJ or linear channel for monitoring purposes.

62. Action. Either the AJ input at SKA or the linear input at SKB is selected at the monitor and taken to V1 grid via RLA1 and gain control RV1. 5 stages of i.f. amplification occur in valves 1 to 5, the output of V5 being detected at diode V6 to the grid of V7, a cathode follower. The negative video output of the C/f is to the limiter/cathode follower circuit on the M28 chassis.

SECTION 4

MONITORING

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

SECTION 4

MONITORING

Introduction (Fig. 4.1)

1. The monitoring facilities of the T84 transmitter receiver have been designed with reduction of "OFF the AIR" time in mind. The following list of quantities and waveforms are monitored without interruption of transmission. Reception is only affected on selection of a receiver i.f. response on a.f.c. discriminator response.

2. Waveform Monitor displays the following waveforms by push button operation:

a. Magnetron spectrum with STALO spectrum superimposed.

b. Video ('A' scope) display of linear and AJ IF sigs.

c. IF responses, linear and AJ channels.

d. Magnetron current pulse.

e. Magnetron voltage pulse.

f. Magnetron r.f. pulse envelope.

g. Thyratron G1 voltage pulse.

h. Thyratron G2 voltage pulses (four waveforms).

j. Thyratron current pulses (four waveforms).

k. AFC discriminator response.

l. In addition the monitor may be used with a cathode follower probe for other waveform monitoring.

m. PFN charging current waveform.

3. Noise and Power.

a. Noise factor.

b. Power output (Mean).

Monitored by two thermocouples $\frac{\lambda}{4}$ apart in launching section of waveguide.

4. Panels Test Electrical (No's 1-6).

a. Panels, Test Electrical Nos. 1-4 measure power supply current and voltages throughout the equipment.

b. Panel, Test Electrical No. 5 measures various magnetron and magnet currents and also indicates input and output temperatures for the two water circuits.

c. Panel, Test Electrical No. 6 measures the TWT magnet current and voltage also voltage of 50V power supply.

5. Air and Water.

a. Water flow (two indicators).

b. Water temperature, as in para 4b.

c. Low pressure air input pressure.

~~d. Low pressure air pressure on the output side of each circulator.~~

e. LP air pressure on magnetron launching section.

f. Flow measurement of LP air on the common output of the air circulation system.

g. HP air input pressure.

Panel Monitor (Fig. 4.1) M13

6. General. The unit comprises of a main frame on which are mounted sub chassis as shown on the block diagram Fig. 4.2 which shows inter unit supply cabling.

7. An unusual point about this monitor is its double persistance fluoroscent coating on the tube face one half being of short persistance for fast scan waveforms the other half is of long persistance for use in displaying slow scan waveforms.

8. The Panel Monitor is in the main conventional, with timebase generator, video amplifier, cal marks generator, e.h.t. power supplies, c.r.t. shift and control circuits.

9. The waveform selection is effected by push buttons each having a picture of the waveform to be selected adjacent to the appropriate button. The buttons control trembler motor driven yaxley multi-wafer switches which: select the waveform to be monitored, switch the timebase circuit to produce a timebase of the correct speed, and other settings necessary to display the waveform correctly on the appropriate half of the c.r.t. face.

Analyser Spectrum M1 (Figs. 4.2, 4.3, 4.4)

10. General. The SA Panel comprises a flat panel on which are mounted:

a. The spectrum analyser unit, on which are mounted i.f., a.f.c., and timebase circuits.

b. The SA local oscillator (a klystron) and some of its control circuitry.

c. The SA crystal mixer.

d. A heater transformer.

11. Purpose. To provide a simple and accurate means of tuning and setting up the transmitter-receiver system, having in conjunction with the panel monitor two separate functions:

a. Display of transmitter and receiver local oscillator spectra.

b. Provision of a swept signal centred on 13.5 Mc/s to display the receiver i.f. or a.f.c. discriminator response curves.

12. Action. The spectrum analyser local oscillator (SALO) is a reflex klystron, mechanically tuneable over the range 1220 Mc/s to 1370 Mc/s. This is tuned by means of a short circuiting plunger varying the length of the cavity which is in the form of a coaxial line.

13. The klystron reflector voltage is taken from the cathode of V20, a cathode follower, whose anode is earthed and cathode load taken to -600V. The reflector voltage control, RV5 feeds the cathode follower grid and is part of a potential divider chain between -600V and the anode of V19. If the reflector voltage is varied too far above or below its optimum value, oscillations cease. V21 is a limiter provided to keep the reflector voltage within safe limits. Both klystron voltage and current are metered on Panel, Test Electrical 1.

14. The SA Mixer (Fig. 4.5) is similar to the a.f.c. and signal mixers but having three inputs ie. STALO, signal sample and SALO. Of the two outputs from the mixer only one is used to provide i.f. signals for the spectrum analyser unit. The combined current of the two crystal outputs are metered on the mixer unit. The coupling loop adjustment on the klystron is set to give a reading of 50 on the meter, the actual current being 600uA per crystal.

15. The i.f. centred on 6.75 Mc/s obtained from the mixer, is fed to a two stage amplifier, V1 and V2, the i.f. output from V2 anode is fed to one mixer grid of V3, a heptode mixer, while a swept signal (described later and varying between 7.75 Mc/s and 9.75 Mc/s) is fed to the other mixer grid. The second i.f. produced at V3 anode is 2 Mc/s with a 12 kc/s bandwidth. This is detected at V4B and the video cathode follower output from V4A is amplified at V7 and the combined spectrum waveforms of magnetron and STALO frequencies fed to the monitor.

16. The Timebase Valve V5 produces a negative sawtooth at a repitition frequency of approximately 5 c/s this provides the SA timebase to the monitor. The sawtooth is also differentiated and fed to V6 grid to produce with its positive portion a large negative blanking pulse for the monitor during the flyback period.

17. The swept frequency source is obtained by mixing a frequency varied between 94 Mc/s and 96 Mc/s with a fixed frequency of 86.25 Mc/s. The swept frequency oscillator is a push-pull circuit around V10A, V10B and whose frequency determining circuit, L8, is wound on a piece of ferrite, the permeability of which is varied by the current flow through L7 which forms the cathode load of cathode follower V9 which takes its input from V5, the 5 c/s sawtooth generator. The resultant output from V10A, V10B is a swept frequency of 94 to 96 Mc/s. V11b is a Hartley Oscillator having a frequency adjusted to 8.75 Mc/s below the mean frequency of V10. The two frequencies produced by V10 and V11b are mixed in V11a producing a beat frequency of 8.75 Mc/s frequency modulated to ±1 Mc/s and fed to the mixer valve V3.

18. The AFC System is similar to that used in the Panel AFC M48. The i.f. is taken from V1 anode and fed to V13 grid in whose anode is a Foster Seeley discriminator (V14, V15) centred on 6.75 Mc/s. Any drift above or below 6.75 Mc/s results in a positive or negative pulse output to vide amplifier V16, this is "pulse stretched" (V17, V18) and fed to V19 Miller integrator grid.

19. The anode of V19 is connected to the resistor chain controlling the klystron reflector volts and the system is so arranged that the klystron frequency is moved to restore the i.f. to 6.75 Mc/s.

20. The Wobbulator (Fig. 4.6). When the system is used to examine the response curves of the i.f. amplifier or a.f.c. discriminator V5 V9 and V10 act as before but the fixed oscillator V11b and triode mixer V11a are switched out and V12b and V12a are switched in. These perform similar functions to V11 but oscillate and produce a frequency 13.5 Mc/s below V10 centre frequency ie. 81.5 Mc/s. Two outputs are taken from SKT.H and SKT.J, to feed the 13.5 Mc/s signal frequency modulated to ±2 Mc/s from the wobbulator to the a.f.c. unit M48, and to the amplifier assemblies M27 and M28. The timebase waveform frequency is increased to 20 c/s for wobbulator applications.

21. Crystal oscillator V8 provides a 6.75 Mc/s reference to provide marker pips on the spectrum analyser and i.f. response displays, the second harmonic being produced in V12B to give the 13.5 Mc/s marker pip.

Panel Noise Meter (Figs. 4.5, 4.6, 4.7)

22. General. On the Type 84 the noise figure measurement may be take at any time at the transmitter from a direct ratiometer reading, of remotely by GOOD or BAD indicator lights.

The noise factor is taken by computing the equation:

$$\frac{\text{Noise generated by Rx + Constant Added Noise}}{\text{Noise generated by Rx}}$$

The greater the value of the above ratio the less is the noise generated by the receiver and hence the better the noise factor. As the a.g.c. for the Noise Monitor i.f. strip is derived from receiver noise above, an increase in the latter results in strip gain reduction with a resultant fall in ratio. To enable the noise factor to be measured without having to switch off the transmitter a pulse method is used as follows in paras 23, 24, 25, 26, 27.

23. The NF is measured over a period of 500µs just before the firing of every tenth transmitter pulse.

24. On every other tenth pulse a noise tube is fired which injects "constant added noise" into the TWT input. (The output of the i.f. amplifier is then - noise generated by the Rx and constant added noise).

25. On the remaining "tenth" pulses the output from the receiver is sampled (over 500µs). This output will be "noise generated by the Rx"

26. The outputs of (24) and (25) are then integrated over a period of about 5 seconds.

27. The two integrated outputs are applied to the "deflection" and "control" coils of a ratiometer. (A ratiometer is a pointer type instrument which reads the ratio of the two applied inputs). The instrument indicates the ratio of the applied inputs but is calibrated to read Noise Factor. When required the integration period may be extended indefinitely so that NF appears as a steady reading.

28. Action. The positive trigger at SKT.A is stretched, amplified and inverted by V1a, V1b before application to the DEKATRON divide by 10 circuit, which reduces the p.r.f. to $\frac{1}{10}$th p.r.f. The Dekatron output is fed via SCR to cathode follower V3a grid the +ve pip output of which triggers a flip-flop V5a, V5b. The lagging edges of the square waves produced can be varied in time by RV1. The positive output of V5b is a s.c.r'd the +ve pips being clipped by V4, the -ve pips (which have been set in time by RV1 to be 3500us behind the original trigger pulse) are applied to the suppressor grid of V6 which with V7 forms an Eccles Jordan bistable multivibrator circuit. The -ve pip at 25 p.p.s. cuts off V6. A -ve reset pulse from V1b anode (at 250 p.p.s. and therefore 500µs later) resets V6 and V7 to their original state. The 500µs squarewave from V6 anode is used to gate the noise monitor i.f. strip for that period and is also used in conjunction with another input at half its frequency, at V8 to gate the noise tube. This other input is derived from V7 anode waveform passed through a s.c.r., the positive pip of the resultant waveform being amplified and inverted by V9a and fed via V12a and V12b diodes to the respective grids of V11a, V11b. The latter form a divide by two circuit. When the output from V11b grid, applied to V8 suppressor,

is positive it will be coincident with the +ve squarewave at V8 grid and this valve will conduct at the lower frequency ($12\frac{1}{2}$ p.p.s.) for the period of the shortest pulse (500µs). The negative pulse output is taken via a cathode follower V9b to the Modulation Noise Tube M1 to produce a firing pulse to the noise tube at 1/20th of the trigger p.r.f.

29. The switch valves V13, V14 are driven by the outputs of V11a, V11b so that the cathodes are alternately +ve and -ve. A carpenter relay is connected between the cathodes and its contacts are used to switch the output of the i.f. strip (after detection and integration) so that the Rx noise plus added noise and the receiver noise alone are applied to V30 and V31 respectively to enable the ratio between the two integrated outputs to be compared and read off the Noise Factor Ratiometer.

30. When the Local or Remote "Check Noise Factor" button is pressed V15 will cease to conduct. RLB in its anode load will remain de-energised for about ten seconds (due to Miller Capacitor C37), the "Thinks" light will come on and if the amplitude of the integrated Noise + Added Noise at V16a grid is sufficiently great negatively to overcome the negative bias set on V16b grid current will flow through V16b to operate RLC in its anode load. This results in V17b passing current and switching on the remote and local Good lamps. A low input to V16a results in the BAD lamp indication.

4.5 Modulator, Noise Tube M1

31. Purpose. To produce the waveform of suitable amplitude and shape necessary to start and maintain the noise tube for a pre-determined period.

32. Action. The input at SKT.E from the Panel Noise Monitor is a negative squarewave 500µs wide at 1/20th of the trigger p.r.f. This is applied to the grid of the one valve in the circuit, a beam tetrode. The anode voltage rises to h.t. and, due to the damped coil in the anode load, "rings" once producing a squarewave output with a large "spike" on its leading edge. The "spike" is considerably above h.t. and will strike the noise tube. The amplitude of the rest of the waveform at h.t. will keep the tube ionized for its duration of 500µs. Facilities exist on the Noise Monitor to switch in a negative bias output to the modulator noise tube, holding the noise tube struck for as long as the button is pressed. The M1 output is taken via SKT.F to the noise tube "anode". LT is also taken via the M1 unit to the noise tube heater.

RF Wavemeter (Fig. 4.8)

33. Purpose.

a. To provide direct measurement of the local oscillator and standby local oscillator frequencies.

b. To provide a detected transmitter output pulse sample for display on Panel (Monitor) M13.

c. To provide a local oscillator sample for the spectrum analyser M1.

d. To provide a local oscillator feed to the Signal Mixer M4.

34. Action. The frequency meter consists essentially of a concentric line resonator, closed at one end and tuned at the other by means of a variable capacitor. A pick up loop within the concentric line feeds a silicon crystal rectifier and a 250µA f.s.d. micro ammeter which functions as a tuning indicator. The frequency meter is modified to enable a detected output sample of the transmitter pulse to be taken from the crystal rectifier and fed to the cathode follower V1. The frequency meter is tuned to give maximum amplitude response on the monitor.

35. Selection of any one of three inputs for frequency measurement is accomplished by connection to the frequency meter via the appropriate plug or socket as in Table 1. The signal mixer drive input to SKT.B is normally fed to a coupler, via PLH and SKT.H, which functions capacitively to provide a local oscillator sample for the spectrum analyser fed out at SKT.D. The coupler also provides a straight through feed for the signal mixer, fed out at SKT.C.

36. TABLE 1

Function	PLE	PLG	PLL	SA
S/By LO Frequency	SKE	SKG	SKL	CW Meter
LO Frequency	SKG	SKE	SKL	CW Meter
Tx Pulse Monitor	SKE	SKG	SKM	Tx Pulse Monitor

Panels Test Electrical No's 1 to 4 (Fig. 4.11)

37. General. These panels monitor by press button selection power supply voltage and currents throughout the equipment. One panel is allocated between two of the eight gates, and monitors supplies to or from the other panels mounted on the pair of gates. eg. On gate D, Panel Test Electrical No. 2 is mounted in position 1D, and monitors the current of an incoming supply from position 5F on gate F, which supplies a panel on gate D in position 3D. Power supplies on the gates are fused at the associated test panel.

38. Action. When testing voltage the appropriate button is pressed and the voltage under test is switched to the appropriate side of the voltmeter via an individual series shunt, the other side of the meter is switched through to earth.

39. When testing current the appropriate button is pressed releasing the previously depressed button and connecting the ammeter in parallel with a low resistance shunt in series with the supply.

40. On Panel Test Electrical No. 4 Red, Yellow and Blue phase voltages are rectified and metered.

Panel Test Electrical No. 5

41. General. This panel continuously meters the following:

a. Magnetron cathode current.

b. Overswing diode current.

c. Magnetron filament current.

d. Magnetron field current.

42. A ratiometer type thermometer on the unit monitors, by press button selection, ingoing and outgoing coolant temperature, also ingoing and outgoing magnetron coolant temperature. This is an electrical thermometer controlled by temperature sensitive resistors (Thermo bulbs) one of which is inserted in each coolant point monitored.

Panel Test Electrical No. 6

43. Monitors by press button selection TWT field voltage and current also the 50V power supply voltage. This unit is mounted in the LH cabinet behind the gates.

SECTION 2

AUTOMATIC CONTROL AND PROTECTION

LIST OF CONTENTS

SECTION 5

AUTOMATIC CONTROL AND PROTECTION

LIST OF ILLUSTRATIONS

SECTION 5

AUTOMATIC CONTROL AND PROTECTION

Introduction to the System. Fig 5.1

1. Purpose. The T84 transmitter has many pieces of peripheral equipment which are an essential part of the efficient running of the equipment as a whole. It is essential therefore that before the HT is applied all these pieces of peripheral equipment are operating efficiently to avoid any possible damage to the Radar due to their absence.

2. General. The two units which control the transmitter are:

   a. Panel Control M15 (Fig 5.2, Fig 5.3 and Fig 5.4).

   b. Circuit Breaker Assembly 3M. (Fig 5.5).

3. The Panel Control contains the timing and control circuits V1 and V2 form a one minute timing circuit and V3 is a ten way dekatron used as a counter and indicator. V4 a reset circuit with a delay time of about one second. V5 provides a stabilised reference voltage for the Carpenter relay used in the magnetron current control circuit. SWA governs the extent to which the Tx runs up when the 'Tx On' button is pressed. In position 1 (Gates) the only units to be operative are the heater and h.t. supplies of the gate units. In position 2 (Warm Up) the full ten minutes warm up sequence is followed but the final stage operating pneumatic interlocks and switching on the h.t. is not carried out. In position 3 (HT On) the Tx is fully switched on.

4. In positions 1, 2 and 3, the operation of the Tx is entirely local but in position 4 (Remote), which is the same as for position 3 except that the remote 'Tx On' button is also in circuit.

5. The Circuit Breaker Assembly contains the contactors that do the actual switching of the mains to the various units and the main distribution fuses.

Switching on the Tx to HT Up (SWA in position 3 or 4)

6. When the 'Mains On' button is pressed the main isolator closes and the 3 phase supply is routed to the regulator, the Circuit Breaker Assembly where it splits through two sets of fuses and the red, yellow and blue phase lamps which are connected to the output side of FS40, FS41 and FS 42 respectively, light.

7. The supply for the 50V power unit is taken from FS22 in the Circuit Breaker Assembly, out of Tx to the SH121 (compressor unit) where it passes through the contacts of the LOCAL/REMOTE switch REMOTE and through the auxiliary contacts of the SH121 Mains ON/OFF switch. It then returns to the 'Tx On' button in parallel with it. If either of these buttons are pressed the supply is made through the normally closed 'Tx Off' button to the 50V power unit which immediately produces an output. The 50V is fed to Panel Control M15 where it energises RLA, RLA/1 contact is a hold contact across the Tx On button. The Remote 'Tx Off' button is in the earth return of RLA. With switch in position 4 the 'Remote Control Available' lamp lights.

8. On M15 RLA2 energises contactor A (3M) which supplies the valve heaters on the gates and heaters for the thyratrons. RLA/3 energises the contactor in the SH121 which supplies the dehumidifier. If SWA is set to 'Gates' the dehumidifier is not switched on. At the same time RLN is energised: contact RLN/1 being open as trip relay RLT, will not be energised until the h.t. is switched on.

9. If the Regulator is not in the up position (RLU and RLZ de-energised) RL will be energised via RLY/2: SC, RLZ/1 and RLB/1, RLR/1 open circuits RLD (HT down), RLR/2 disconnects 50V from RLL (HT lower) and RLR/3 closes and Con (3M HT raise contactor) will operate when RLC is energised.

10. When the two -250V power units have warmed up and producing normal outpu RLD and RLE (3M) will close energising Con D which supplies the h.t. transformers in all the positive power supplies (Power Supplies On Lamp).

11. When the 500V supply has reached its operating level RLC M15 will be energised via SA1B and the Tx warm up starts. This involves two independent control sequences.

a. The magnetron heater control circuit.

b. The ten minute warm up timing circuit.

12. RLC/3 closes completing the supply to Con M and the regulator starts the run up. When the preset h.t. up level is reached the regulator output will energise RLU via RLB/2. RLU/4 energises at RLZ which is held in by RLZ/2, RLZ/1 opens dropping out RLR and hence Con M and the regulator stops. RLZ/4 energises RLB which is held in by RLB/3. RLB/2 opens and RLU de-energises.

13. RLB/1 disconnects the 50V to RLR. As the h.t. contactor is in the Off Position, 50V is on TB2-10 and as RLR is now de-energised RLL will be energised. RLL will be energised via RLY1, SD, RLD/1, RLP°4, and RLR/2. RLL/2 energises CON L and the regulator runs down until RLD is energised at the normal h.t. down level. RLD/1 de-energises RLL and hence CON L stopping the regulator. RLD/2 opens de-energising RLZ RLD/4 closes lighting HT DOWN lamp.

14. This sequence has switched on the magnetron heater supply at the lowest possible level (regulator up) and has steadily increased the voltage to the normal level (regulator down). This prevents a current surge through the magnetron heater which could shorten the valve life. The whole sequence takes about 40 seconds.

15. While this has been happening the 1 minute timer has been started by RL C/1 which removes the discharge resistor from C1 in the anode of V1, and RLC/1 opens removing the bias from V1g3. This valve starts a normal Miller rundown. RLC/4 energises RLW, RLW/1 opens and removes the negative bias from cathode 10 of V3. As this bias is present when the 500V first comes on due to the inherent delay in RLC and RLW, the discharge will go to the most negative cathode and the glow will start at the zero time position. After one minute the rundown of V1, V2 (a Schmitt trigger circuit) changes over and RLE is energised. RLE/1 removes the bias from V4g3 which in turn starts a miller rundown lasting about 1 second. At the end of this rundown RLQ is energised and RLQ/1 energises RLF, RLF/5 applies a negative pulse to the guide electrodes of the dekatron V3. R22 and C2 ensure that the pulse occurs on the electrodes in the right order, first on pin 12, then pin 11, so that the glow is transferred in the right direction to cathode 9. RLQ/4 returns bias to V1g3, RLQ/3 reduces the resistance in series with C1 and the anode is reset to h.t. This causes V2 to switch back and RLE is de-energised. The bias is thus returned to V4g3 by RLE/1, RLQ is de-energised, RLQ/3 and RLQ/4 open and V1 anode starts to run down again.

16. During the second one minute period the current through V3 charges up C3 to approx 50V and when RLF is energised, as described in the previous paragraph, at the end of two minutes RLF/1 closes while RLQ is energised and the charge in C3 is sufficient to energise RLG which holds in via RLG/1 and RLC/4 RLG/2 energises RLA (3M) which in turn energises CON F (Cooling Fans), CON B (Modulator Heaters) and the contactor on the external air conditioner.

17. This process is repeated and after a period of 4 minutes RLH is energised with RLH/1 a hold contact with RLG/1. RLH/2 energises RLB (3M) which in turn energises CON G (Water Pump 1) CON H (Water Pump 2) and the contactor in the SH121 which controls Compressor 1.

18. After a total of 6 minutes RLJ is energised and holds on via RLJ/1, RLH/1 and RLG/1 RLJ/2 energises RLC (3M) which in turn energises CON J (Circulator 1) CON K (Circulator 2) and the contactor in the SH121 which controls Compressor 2.

19. The Magnetron Heater interlock should close after about 8 minutes, which makes use of the thermal overload unit of the Mag Heater contactor CON C. The Heater transformer takes a little over 6A, and with the thermal overload set to about 4.5A to 5A it will operate after about 8 minutes. When this happens a make contact on the overload unit energises RLF which holds in via RLF/1. RLF/2 is in the h.t. interlock line. The 50V supply for the relay is fed via the contactor so that the relay is released when the heater is switched off.

20. A separate overload unit is fitted in the heater circuit to guard against excessively high currents.

21. RLK is energised after 10 mins and holds on via RLM/1, RLK/1, RLJ/1, RLH/1 and RLG/1. This series connection ensures that relays G, H, J and K can only operate in the correct order. RLK/2 energises RLX, RLX/2 removes h.t. supply from the dekatron, at the same time RLX/4 closes and V1 is cut off by bias via RLU/2 in parallel with RLT2 thus stopping the timer. RLX/1 closes completing one more stage in the interlock line and the 'WARM UP COMPLETE' lamp lights.

22. If SWA is in position 2 this is as far as the warm up goes, but if it is in either 3 or 4 the h.t. will be switched on automatically.

23. When RLX/3 closes RLV is energised and holds in via RLV/4 and thus stays energised until the h.t. is switched off by SWA, or the transmitter is switched off. This is done so that the trip store system also works when the h.t. is switched off and not reset after an overload during run up.

24. RLV/2 opens in the h.t. line to the dekatron, RLV/1 opens and de-energises RLN and RLF, the timer stepping relay, so that this is out of circuit as long as the control switch is set to 'HT ON'. RLN/1 closes and puts the trip store relay into circuit.

25. RLV/3 in the h.t. interlock line closes starting the final switching on stage . The annexe doors are closed and bolted, the warning bells start to ring, the warning lights come on, the 'shorts' are removed from the h.t. line. After 15 seconds the bells stop ringing and the h.t. contactor is energised via RLP/1.

26. RLN is a slow to release type because after ten minutes, when h.t. is switched on, RLQ is liable to stay energised while RLF, then RLK, then RLX and then RLV are energised in quick succession. If RLN then dropped out closing RLN/1 the trip store circuit would be operated if RLQ/2 were still made. A trip could thus be stored every time the h.t. is switched. As it is RLQ/2 has time to clear before RLN/1 makes.

27. When the h.t. contactor operates an auxiliary switch disconnects 50V from 1F-TB2-10 and connects it to TB2-11. RLR is thus energised via RLY2, SC, RLZ/1 and RLL/1. RLR/3 energises the h.t. raise contactor and the regulator runs up.

28. When the normal h.t. level (preset by RV5) is reached, RLU is energised by the rectified output from the regulator. RLU/4 energises RLZ which holds in via RLZ/2 and SW2B. RLZ/1 opens de-energising RLR and hence CON M and the regulator stops. RLU/3 lights the 'HT UP' light. RLU/1 operates a relay on the Control Stalo which has been muting the a.f.c. system during run up.

Manual HT Control

29. If SD (Raise HT) is pressed RLR is energised and the regulator will run up further until either it reaches its upper limit or SD released. If SC (Lower HT) is pressed RLL is energised and the regulator will run down until it reaches HT down level or SC released. This does not alter the level HT UP set by RV5.

Magnetron Current Control

30. If SWE is set to 'Current Control' it will energise RLY as soon as the HT Up is reached. The four contacts of RLY disconnect RLL and RLR from the manual control circuit, connecting them to the automatic control circuit. The earth return of RLR and RLL is via centre stable carpenter relay RLA/A1 contact which is normally open and will remain so as long as the circuit for the magnetron current is set up properly by RV3. If the magnetron current increases RLAA is unbalanced, RLAA/1 closes energising RLL and ILP1 lights indicating current high. Nothing further happens until 50V is applied from the Control Stalo on TB4/5 indicating that the magnetron frequency has gone high. RLL energises and the regulator runs down. RLL/4 is a hold contact across the relay holding it in even though the 50V is removed from the control stalo, running the regulator down until the magnetron current is normal and RLAA is again balanced releasing RLL. The current low sequence is virtually the same as above, this is switched in by RLU/1 and so is switched out when the h.t. goes off and is switched in again when the h.t. is back on and up to its normal voltage.

Transmitter Control Switch

31. SWA on the Panel Control has three functions:

a. As a safety switch to prevent remote operation of the Tx whilst servicing is in progress. Only in position 4 is the remote button in circuit.

b. To enable the gate units to be switched on for servicing without running the air, water or cooling services or magnetron or modulator heater circuits.

c. To enable the modulator h.t. to be switched on and off from the Tx. In position 3 (HT ON) the Tx will run up fully, in position 2 (Warm Up) the 10 minute sequence will be completed without switching on HT. If the Tx is running normally with SWA in position 3 or 4, switching to position 2 only switches off h.t. (The switch should not be left in position 2, with magnetron and diode heaters on for longer than two hours without h.t. being applied, nor in position 1 for longer than 20 minutes.)

HT Trip and Reset

32. RLM is the overload relay and will energise when:

a. When the h.t. current reaches a preset level.

b. The overswing current exceeds a preset level.

c. The surge into the h.t. transformer exceeds a preset level.

33. For a. the current develops a voltage across monitoring resistors which is fed to panel control TB2-8. When the voltage reaches a sufficiently high level RLM energises. Similarly with b. but the voltage under overload conditions operates RLW in the overswing diode circuits which routes 50V to RLM.

34. For c. if any one of the a.c. overload relays operate, a break contact directly drops out the h.t. contactor and a make contact connects 50V to Panel Control TB2-9 and RLM is energised. The a.c. overload relay is held in by a hold on coil energised from Panel Control TB1-9.

35. When RLM is energised, RLM/2 closes energising RLP which holds on via RLP/3 and stores this first overload. RLP/1 opens and switches off the h.t. RLP/2 opens and removes the bias from V4 which runs down. RLP/4 opens and prevents RLL being energised and the regulator running down. After one second RLQ is energised and RLQ/2 energises RLT which holds in via RLE/2 and RLT/1 and stores the trip. RLQ/2 also de-energises RLP and the a.c. overload hold in coils and the h.t. is switched on again. RLT is now energised and RLT/4 lights the Trip Lamp.

36. RLT/2 is open and as the h.t. is up RLU will be energised and RLU/2 will be open, the bias is removed from V1 which starts to run down. After one minute RLE is energised RLE/2 opens, RLT is de-energised, RLT/4 opens and the Trip Lamp goes out. The trip has thus been stored for one minute. If a second trip occurs now the procedure will follow the above pattern.

37. If a second trip occurs during the minute that RLT is energised RLS will energise via RLT/3 and RLM/3 and will hold in via RLS/1. This is called the secondary overload hold relay. It has two functions:

a. To stop the reset circuit (RLQ) operating immediately. This is achieved by RLS3.

b. It ensures the regulator runs down before the h.t. is switched on again. This is achieved by RLS/2 which closes and allows RLL to be energised even though RLP/4 is open due to the second overload.

38. The regulator runs down in the usual way until RLD energises, RLD/2 opens and de-energises RLS and RLZ RLS/3 now opens and the reset sequence described follows, but the regulator this time has to run up. The one minute timer for the trip store does not start until the h.t. is up again and RLU energised.

39. If a third overload occurs after the one minute period the instantaneous reset of the above sequence is repeated.

40. In the event of a third overload during the one minute period the ~~reset sequence is as for the second trip within the minute~~. run down and stay down until HT reset button is pushed.

41. If an overload occurs during h.t. run up (before RLZ is energised) either when the Tx is first switched on or after an overload, the h.t. is switched off completely and is not reset automatically. This is achieved by RLM/1 which opens and if RLZ is not energised drops out RLK RLX will also drop out and the h.t. is switched off, the shorts put on and the doors released. The h.t. may be switched on again by the 'HT Reset' button.

42. If the overload occurs during the first run up after switching on the Tx, the button should be pressed as soon as the "trip" lamp lights, the h.t. will be reapplied at the same level at which the overload occurred.

43. If the overload occurs during the run up after a trip the regulator has to run down before the h.t. can be switched on. The h.t. reset button should be pressed after the 'HT DOWN' lamp has come on. This gives the a.c. overloads time to be reset if one of them has operated. If the trip was caused by a d.c. overload only, the button may be pressed at any stage but the h.t. will not come on again until after the regulator has run down.

44. Once the h.t. is up after such a trip and reset the same procedure as after any other trip is followed.

Pneumatic Control System. (Fig 6.5)

45. On completion of the ten minute switching on sequence the 240V a.c. interlock supply is fed to the solenoids of valves A and B and pressure switc SZ on the pneumatic control panel. The pressure switch routes the interlock supply to a warning bell which warns that the annexe doors are going to be closed and e.h.t. applied.

46. When the tell-back manifold becomes charged with air, pressure switch SZ changes over and removes the 240V a.c. interlock supply to the warning bell and routes it to control panel M.1.5.

47. From the normally closed overload contact RLP1 in control panel M15 the 240V a.c. interlock supply is routed via the "aerial turning" interlock and the a.c. overload relays to the operating coil of the e.h.t. contactor.

Aerial Interlock Turning (Fig 5.7)

48. Purpose To ensure that the aerial when stationary or rotating below a predetermined speed will only transmit over a given sector.

49. Action. With the aerial stationary and facing out of the safe sector the following conditions will exist in the circuit. The Zenner diode with C2 will maintain the voltage across VT1 at about 20V which is applied to both base and emitter and C1 will charge towards this voltage. As soon as the base is negative with respect to the emitter then current will flow through RLB which will energise.

B1 Contact closes acting as a hold contact for RLB.

B2 opens holding RLC/2 off.

50. When the aerial moves into the safe sector RLA/2 energises which starts the following:

A1 Closes lowering the potential on the emitter by discharging C1 and cutting off VT1.

A2 Opens breaking the hold line for RLB and lighting ILP2.

When VT1 cuts off RLB de-energises, B1 contact opens the RLB hold line and B2 contact completes the line, RLC/2 energises:

C1 Completes the interlock line.

C2 Lights ILP1.

If the aerial swings out of the safe sector, RLA/2 de-energises A1 contact opens and C1 then starts to charge on a time constant C1, RV1, R5. After a period of time set by RV1, VT1 cuts on RLB/2 energises, de-energising RLC/2 which opens the interlock. This circuit can be bypassed by SA1 and SA2, or it can be left in for rotation, depending on aerial site. When the circuit is left in, the operation is the same as above when it goes from unsafe to safe sector, but as it goes from safe to unsafe sector C1 starts to charge up on the same time constant and if the speed of rotation is slow enough the Tx will be switched off until it gets into the safe sector again. As the rotation speed increases so C1 will not have its top place earthed thus holding RLB/2 off again for another cycle of rotation.

EHT Interlock Circuit (Fig 5.8)

51. Introduction. The e.h.t. to the modulator becomes available when the e.h.t. contactor B in the LH annexe is operated. 240V a.c. is routed to the operating coil of this contactor via the e.h.t. interlock circuit. The interlock circuit consists of a number of series connected interlock devices which close when the various units supplies and services throughout the equipment are functioning normally. Supplies are taken from the interlock circuits at various points to feed the indicator circuits on the cabinets light and switch assemblies. These indicators provide an easy means of fault finding by indicating up to what stage the e.h.t. interlock circuit is complete.

52. Circuit Action. The 240V a.c. supply is taken from the Red phase controlled by CON A on the 3M. This contact closes making the supply available at FS4 when the 'Tx On' switch is closed. The supply is fed out of the 3M at TB1/4 and routed to the thyratron heaters, gate heater transformers and thyratron heaters indicator. From TB4/1 the supply is also looped to TB4/6 and then to the series connected, auxiliary contacts of contactors C, F, B and G. These contactors operate during ten minutes Tx ON sequence closing the auxiliary contacts.

53. From the auxiliary contact of CON G the supply is fed to thermal switch X30. The switch monitors the temperature of the air being drawn from the charging diodes and is normally closed but opens if the temperature of the air exceeds 50°C.

54. The interlock device SQ flow switch 1, is next in the line, the flow switch is in the overswing diodes and electro-magnet cooling circuit and closes when the flow of liquid coolant reaches 3 galls per minute.

55. X28, the magnet thermal switch monitors the temp of the electromagnet liquid coolant. This switch is normally closed, opening only when the temperature exceeds 70°C.

56. From X28 the overload supply goes via normally closed RLB/1 in the rectifier protection unit M1 to the operating coil of CON E on the 3M. If the d.c. current flow to the electromagnet exceeds a preset level RLB is energised and RLB/1 opens and removes the supply to CON E which controls the 3 phase supply to the electromagnet power supply, and is only operated when conditions at the electromagnet are correct i.e. flow rate (flow SW1) and temperature (thermal X28) of the liquid coolant. When CON E operates the supply is routed via auxiliary contact to the auxiliary contact of CON H.

57. CON H controls the 3 phase supply to water pump 2, which circulates the liquid coolant through the magnetron coolant circuit. When CON H closes the interlock line is routed to the next interlock device, flow switch 2.

58. Flow switch 2 monitors the rate of flow of coolant through the magnetron and closes when the flow reaches 3 galls per minute.

59. The next interlock X29, Magnetron Thermal, positioned in the magnetron coolant line, is normally closed but opens if the temperature exceeds 70°C.

60. Contacts J and K on the 3M control the 3 phase supply to the two low pressure air circulators, which, connected in parallel, circulate the low pressure air supply through the waveguide launching section. Only one of these circulators need be running to complete the e.h.t. interlock at this stage. From these auxiliary contacts ofCON J and CON K the interlock supply is routed to contact RLF/2 of RLF on 3M. RLF is energised eight to ten minutes after contactor C has operated and fed an a.c. supply to the magnetron heater transformer. This delay is introduced to allow the magnetron to reach its operating temperature before the interlock is complete.

61. Pressure switch SU is next in line and is normally open but closes when the air pressure in the waveguide launching section reaches 15 lb sq. in.

62. RLA/1 is in the trigger unit and closes when the trigger unit is functioning normally and producing the correct triggers.

63. RLD and RLE are situated in the D.C. amp M31, these relays close only when the electromagnet (magnetron) conditions are correct amd form part of the field protection system.

64. The next two interlock stages are contained in control panel M15, RLX/1 closes on completion of the ten minutes switching on sequence. When RLX/1 closes the interlock supply is routed to the 'Warm Up' complete indicator and also to RLV/3. If switch SA on M15 is in the HT ON position contact RLV/3 closes simultaneously with RLX/1 routing the supply to the pneumatic control panel.

65. When all the pneumatic devices have operated the interlock 240V is routed via pressure switch SA which completes the interlock line when the doors are closed.

66. RLP/1 in M15 is normally closed but opens, if an overload condition occurs to remove the interlock supply to the operating coil of the e.h.t. contactor.

67. The aerial turning interlock prevents the Modulator e.h.t. supply being switched on until the aerial is turning. This is to reduce any possible radiation hazard.

68. The final interlock stage is the a.c. overloads, these consist of three relays which operate on an increase of current in any of the three phases, opening the normally closed contacts.

69. When all the units, supplies and devices are functioning normally the e.h.t. interlock supply is complete and the e.h.t. contactor coil energises feeding the three phase supply to the e.h.t. transformer and the Modulator.

Magnetron Heater Circuit Breaker Assembly (Fig 5.6)

70. Purpose. To switch off the a.c. supply to the magnetron heaters when the magnetron mean current is at the correct operating level.

71. Action. A 50V d.c. supply is fed into the unit and develops 33V across MR1. This is applied via RV1 to one coil of Relay C, RLC1 is normally open. The other coil of Relay C is fed from a voltage sample of the modulator h.t. from Panel M15. RV1 is adjusted so that when the modulator h.t. reaches the required level to give a magnetron mean current of 500MA. RLC changes over closing RLC1 and energising RLB when the modulator is operating at full h.t. a 240V a.c. supply is routed from Panel M15 to the 'HT UP' indicator lamp on the RH light and switch assembly. This supply is also routed via RL31 to RLA which when energised disconnects the neutral line to Contactor A switching off the magnetron heaters. Should the modulator h.t. supply be reduced RLC will change its condition and restore magnetron heater supply.

Indicator Lamp Circuits (Fig 5.9)

73. Purpose. Lights to give visual indication of power supply faults and transmitter running up sequence. Meters to give readings of mean power, modulator h.t. noise factor, modulator h.t. current, modulator h.t. hours and modulator heater hours.

74. General. The LH light and switch assembly contains the 'Mains ON' and the 'Mains OFF' buttons. The LH light and switch assembly contains the 'Tx ON' and 'Tx OFF' buttons.

75. <u>Action</u>. LH light and meter assembly. Relays D, E, F and G are double wound, centre-stable-contact relays. When the current through both coils is the same, the changeover contact of the relay is held in the null position. If the current through the coils becomes unbalanced the centre contact will make with one of the side contacts. The -250V supply from 5F is fed via R102 and R101 to one coil of each relay fed in series. 200V d.c. from 3c is fed via RV101, R104 and R103 to the second coil of relay D. The variable resistor RV101 is adjusted so that RLD is held in the null position when unit 3c is supplying the specified 200V d.c. If the power unit fails or the output varies by more than ± 3.3% RLD will become unbalanced and RLD1 will become unbalanced and RLD1 will close routing +50V d.c. via ILP 103 and R111 to relay H. Relay H energises, (but ILP103 will not light because of insufficient current) H1 closes routing +50V d.c. to Relay J. RLJ1 closes shorting RLH and illuminating ILP 103 when RLH is shorted H1 opens removing +50V d.c. from RLJ RLJ remains energised for $\frac{1}{2}$ second due to the action of C101. ILP103 remains alight for this time. This action will be repeated for as long as unit 3C does not provide its correct 200V d.c. thus causing ICP103 to flash. Relay J2 opens the 240V a.c. supply to the Power Unit Normal Lamp, therefore this lamp will also flash for a power unit fault. Relays E, F and G operate in the same manner as RLD Indicator DC Heater, TWT field and AC Heaters flash when a +50V supply is fed to them from their respective units. The centre stable relays are contained within the individual units.

76. Switches on the LH light and Meter Panel operate as follows:

a. SWV (check noise factor) routes 50V d.c. to the panel noise meter to initiate a noise figure check.

b. SWX on the inner panel shorts RLH causing a flashing light to stay on until the supply it monitors is correctly adjusted.

77. <u>RH Light and Meter Assembly</u>. This functions in the same manner as the LH unit, the -250V d.c. supply in this case is taken from unit 4G. If this supply fails or goes out of tolerance by more than 3.3% then all eight lights will flash. SWA on the inner panel functions in the same manner as SWX on the LH unit.

SECTION 6

AIR AND LIQUID COOLING AND PNEUMATICS

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

SECTION 6

AIR AND LIQUID COOLING AND PNEUMATICS (FIG 6.1)

Liquid Coolant System (Fig. 6.2)

1. Purpose.

a. Coolant Circuit 'A' disperses heat from the magnetron.

b. Coolant Circuit 'B' disperses heat from the RF isolator overswing diodes and electro-magnet.

2. Action. Two separate liquid coolant closed circuit feed systems are used. The coolant is distilled water. Both systems have a header tank maintaining a head of coolant to feed their respective systems. If the coolant drops below a pre-determined level, a float switch removes the 240V a.c. supply to the "Water Level" indicator circuit for the appropriate system.

3. The filters consist of a cylindrical strainer to arrest any foreign matter present in the coolant. Stop cocks above and below the filters facilitate servicing. Similarly stop cocks are fitted at the r.f. isolator for the same reason.

4. The main pumps in the systems are rotary action type driven by a 3 phase $\frac{1}{2}$ horse power motor. By-pass valves are fitted to avoid damage in event of a blockage in the circuits and will open when the pressure difference exceeds 35lbs per square inch.

5. The Auxilliary pump (in coolant circuit 'A' only) is necessary to disperse the residual heat in the magnetron after the mains are switched off. If this were not done damage due to overheating would result and a dangerous pressure build-up would occur in the coolant system. Being battery driven, protection is also provided against a power failure, it will run for twenty minutes before switching itself off. To prevent the magnetron coolant circuit pump being by-passed by the standby pump a non-return valve is inserted in the delivery line of the standby pump. The flow meters give a visual indication of coolant flow and flow switches 1 and 2, in the e.h.t. interlock line are operated when the flow exceeds 3 gallons per minute through their respective circuits.

6. In addition to the flow switches in the interlock line are the thermals, X28 and X29. These are placed in the magnet coolant circuit and magnetron coolant circuit respectively. They are adjustable thermostats the contacts of which are set to remain closed unless the coolant temperature exceeds 70^{o} C.

7. Thermo-bulbs are used to facilitate monitoring of ingoing and outgoing coolant temperatures at both magnetron and electromagnet. These consist of temperature sensitive resistors, each in a 50V line to the Panel Test Electrical No. 5, where they may be metered at a ratiometer calibrated in degrees, Centigrade and Fahrenheit.

8. Magnet and Magnetron Thermals, also thermo bulbs with the exception of one, are mounted on the Magnetron Cooling Control Assembly. This assembly allows or interrupts the coolant flow to the magnetron by means of air operated valves A and B which are normally open (see Para 32).

Low Pressure Air System (Fig. 6.3)

9. Purpose. To cool the magnetron dome and pressurize the waveguide. It is also available for use in exhausting the coolant from the magnetron.

10. <u>Action</u>. Low pressure air at 15lbs per square inch is supplied from the compressor unit SH121. This LP air is introduced at the Magnetron Cooling Control Valve Assembly to make up the pressure to the magnetron launching section and high power waveguide within the transmitter cabinet. Here it is circulated for the purpose of blowing onto the magnetron dome by two, parallel connected, air circulators. These circulators are identical, consisting of twin cylinder air compressors, each driven by a 3 phase 1 h.p. induction motor, controlled by contactors H and K in the circuit breaker assembly.

11. The air outputs from the circulators are fed to the heat exchangers in the right and left cooling units. They consist of ½ inch copper pipes bent to form a "U" section with an overall length of 47 inches. Positioned along the "U" are square copper fins across which atmospheric air is drawn.

12. Air from the heat exchangers is fed into the waveguide via a filter system. The first filter stages are oil and water separators each consisting of multi-banked fibre pads supported by aluminium baffles. Any water vapour or oil passing through the filter collects on the pads and forms into droplets which run down into wells at the separator base. The liquid is then forced by air pressure into the automatic drain valves.

13. From the oil and water separators the air is passed through a second filter stage consisting of an air purifier which has a replaceable cotton filter and a manually operated drain valve. A high percentage of any moisture is removed by centrifugal action in the lower part of the filter and a bronze filter element is situated in the lower bowl.

14. After the air purifiers the two low pressure circuits combine and the air enters the waveguide launching section blowing the magnetron dome and pressurizing the waveguide section. A pressure gauge is fitted to indicate air pressure in the launching section and a pressure switch forming part of the e.h.t. interlock line closes when the pressure reaches 15lbs.

<u>High Pressure Air System (Fig. 6.4)</u>

15. <u>Purpose</u>. To provide the final stage of run up to h.t. on, mechanically interlocking fully when remotely operated and partially as required by mechanics when servicing.

16. At run down, to release interlocks and provide adequate earthing.

17. Also to assist servicing by emptying magnetron of coolant and powering the magnetron hoist.

18. <u>Action of the Control Unit</u>. The air supply from the SH121 is fed at 80-100lbs pressure to the air control unit set at 75lbs. This unit comprises three separate items; an air drier, a pressure regulator stage and an oil fog lubricator. The air drier consists of a small alloy cylinder containing felt pads through which the air passes to the high pressure regulator valve. This is manually controlled and fitted with a pressure gauge. A manual pressure relief valve is also fitted.

19. The third stage in the control unit lubricates the air with an oil fog before being fed to the pneumatic control panel. The oil fog lubricator has a reservoir, filled to an indicated level with lubricating oil. The high pressure air flowing through the lubricator causes a vacuum at the oil feed chamber, and oil from the reservoir flows up the syphon tube to the chamber above the drip gland. Here the flow of oil is controlled by a manual needle valve which permits the oil to drip from the drip gland at the desired rate. Oil passes through the feed chamber and into the air line where it is atomized into an oil fog and carried to the high pressure air circuits to lubricate moving parts.

20. Action of Pneumatic Control Panel (Fig. 6.5). The function of this panel situated at the rear of the RH cabinet is to feed high pressure air supplies, in a controlled sequence, to the pneumatic interlocks in the Radar Type 84 transmitter. The panel also shuts off the high pressure air supplies and exhausts the air lines (thus returning the pneumatic interlocks to their normal state) in a controlled sequence when the transmitter is switched off.

21. The 75lbs per square inch high pressure air supply, from the air control unit, is fed via a non-return valve to the main manifold on the pneumatic control panel. Individual outputs are taken from the main manifold, via flexible nylon tubing, to the magnetron hoise control, the magnetron interlocks, the magnetron coolant control switch, and the annexe door interlocks. An air supply is also taken to the solenoid controlled air operated changeover valve A.

22. On completion of the ten minute transmitter switching on sequence the 240V a.c. interlock supply, fed in at TB51/5, is applied to the solenoids of valves A and B. Both valves changeover and the high pressure air from the main manifold is routed via valves A and B to the interlock manifold.

23. Air outputs from the interlock manifold are taken to operate the annexe doors, which automatically close and lock, and to the cabinet gates, (which are closed manually) to lock in the closed position. A further output from the interlock manifold is fed via the first delay coil to the earthing manifold. The delay coil, of 3/16" copper pipe, introduces a delay of 5 seconds which is the time taken by the air flowing through the coil to fully charge the earthing manifold. Air outputs are fed from the earthing manifold to operate the electrostatic dischargers. The 5 second delay ensures that the annexe doors are closed and locked before the electrostatic discharges operate and remove the earth connections from the high voltage points that would normally be accessible with the doors open. From the earthing manifold an air supply is fed via a second delay coil (10 seconds) to the tell-back manifold.

24. After the second delay period of 10 seconds the tell-back manifold becomes charged with air and feeds an output to operate pressure switch SA switching off the alarm bell and routing the 240V interlock supply to the aerial turning interlock. The ten-second delay ensures that the electrostatic dischargers have had time to operate, and remove earth connections from the high voltage points before the e.h.t. interlock line is completed and e.h.t. switched on. When the transmitter is switched off the 240 volt a.c. interlock supply is removed, the solenoids of valves A and B are de-energised, and the valves changeover. Valve A shuts off the air supply from the main manifold and the exhaust line from the tell-back manifold is open to atmosphere via valves A and B. The pressure switch can now return to its normal state, the dischargers close connecting high voltage points to earth. Because the air in the interlock manifold can only exhaust via the delay coils, access to the interior of the transmitter is not possible for a few seconds giving the electrostatic dischargers time to make the high voltage points safe before the doors can be opened.

Magnetron Coolant Control (Fig. 6.7)

25. Purpose. To prepare the magnetron for removal by

   a. Shutting off the liquid coolant supply.

   b. Exhausting the coolant from the magnetron.

   c. Depressurizing the waveguide.

26. Action. High pressure air is fed from the main manifold to the magnetron coolant control switch. At the pilot valves high pressure air is switched to, or exhausted from, air valves A, B, C, D and E according to the control switch position. Conditions of pilot valves and air valves when the switch is in any of its three positions (ie. NORMAL RUN, EMPTY MAGNETRON or DEPRESSURIZE WAVEGUIDE) are listed in the table in Fig. 6.7. In the NORMAL RUN position pilot valve 1 feeds high pressure air to valve E, which is held in the open position and routes the low pressure make up air supply into the low pressure air circuit. Pilot valve 2 is shut and so are valves C and D. Pilot valve 3 is shut and valves A and B are open. With valves in this condition the liquid coolant flows via open valve A to the magnetron and returns from the magnetron via open valve B.

27. In the EMPTY MAGNETRON position pilot valve 1 and valve E are unchanged (open). Pilot valve 2 is open and so are valves C and D. Pilot valve 3 is open and valves A and B are shut. With valve D open the low pressure air supply from valve E is fed via the non return valve into the magnetron coolant circuit. The coolant blown out from the magnetron by the low pressure air is fed via open valve C to a waste sump.

28. In the DEPRESSURIZE WAVEGUIDE position pilot valves 2 and 3 and valves A, B, C and D are unchanged but pilot valve 1 is shut off, which also shuts valve E. With valve E shut the low pressure air make up supply is shut off and the air circuit is open to the atmosphere via the series circuit of: open valve D, the non return valve, the magnetron coolant circuit, open valve C and the exhaust line to the sump, which is open to the atmosphere. The non-return valve is fitted to isolate the liquid coolant from valve D. This prevents coolant entering the low pressure air circuit in the event of valve D becoming defective and not making a complete seal when closed.

Magnetron Interlocks

29. If the current switching procedure is not carried out at the magnetron coolant switch ie. switch to empty magnetron and then to depressurize waveguide prior to removing the magnetron, and the magnetron fixing screws are removed with the waveguide launching section pressurized: the pressure of air acting on the magnetron dome would blow the magnetron upwards. The air operated magnetron interlocks are proved to overcome this hazard. Two air cylinders, contained within the magnetron screen, control two stop pins positioned diametrically about the magnetron.

30. When a high pressure supply is fed to these cylinders the rams extend causing stop pins to protrude over the magnetron frame. A low pressure air supply from the launching section operates a diaphragm operated valve which routes high pressure air to the interlock air cylinders. When pressure in the launching section falls below 5lbs per square inch the interlocks are withdrawn. In event of high pressure air failure to these interlocks a "three port valve" depressurizes the waveguide.

Note. When the magnetron is not connected into the water system it is essential that the U tube provided is fitted as failure of the air pressure would allow the coolant to drain from the system.

Magnetron Hoist and Control Unit (Fig. 6.6)

31. Purpose. To facilitate the removal and replacement of the magnetron.

32. Description. A pedal controlled pneumatically operated hoist consisting of a frame containing two double acting pneumatic cylinders of 6 inch stroke connected by a yoke to a system of pulleys and cables to give a maximum lift of 30 inches. The hoist is located above the magnetron and is free to slide on extending runners so that when the magnetron is hoisted the hoist complete with load may be pulled forward clear of the cabinet.

33. The control unit which is pedal operated is interconnected with the hoist by nylon tubes carrying the high pressure air.

34. Action. The h.p. air input is at D19 on the hoist control unit. When the lower pedal is in the neutral position the plunger of valve X47 is fully depressed the outlet port A is connected to exhaust port C and the ratchet operating cylinder X43 is unpressurized and the ratchet is therefore engaged.

35. Lowering. On the initial movement of the 'lower' pedal the plunger of valve X47 extends under spring pressure and air at 75lbs p.s.i. is routed via X48 to X47. Part C is closed and air passes through part A to the hoist via B19/B18 where the flow divides. A restricted flow passes through X45 and NRV X41 to cylinders X38, X39. Simultaneously through NRV X42 and pressure regulation X40 where the pressure is reduced to 50lbs p.s.i. (approximately) to the other side of pistons X38, X39. The pressure regulator valve X40 ensures that the reduced pressure plus the load acting on the outer side of the pistons (RH side Fig. 6.6) exactly balances the air against the air pressure on the inner ends of the pistons. The sequence valve X44 operates when the pressures acting in both ends of the cylinders have been balanced and the pressure overcome the bias spring in X44 which routes air through to X43 to release the ratchet.

36. Further movement of the 'lower' pedal opens variable flow valve X46 to the atmosphere relieving pressure in the inner ends of cylinders X38, X39. Thus the forces acting at each end of the cylinders are unbalanced and the piston moves inwards retracting the piston rods and so lowering the lifting ring.

37. Raising. The first movement of the 'raise' pedal opens the two part valve X49 and air trapped in the right hand side of the main cylinders X38, X39 is released.

38. Further movement of the 'raise' pedal opens the variable control valve X50 and h.p. air passes via X51 to the inner ends of the cylinders causing the pistons to move outwards raising the lifting ring. X50 (like X46) has trickle to full bore control from the pedal. X51 is a flow restrictor set to control X50 by limiting the maximum 'raise' speed of the hoist.

Annexe Door Interlock System (Fig. 6.8)

39. Purpose. Automatically closing and interlocking the doors before the application of e.h.t. and during rundown to release the interlocks and provide earthing, before manual opening.

40. Action. There are three air cylinders in the system.

a. This cylinder is used to pull the door closed.

b. Used to unfold the door.

c. Employed to lock the door in the closed position.

41. On completion of the 10 minute switching on sequence a high pressure air supply is fed from the pneumatic control panel via the interlock manifold. There are two outputs from the manifold, one is fed via the doors automatic closing valve to the pilot line of the air changeover valve which goes to the closing position. This changeover valve feeds air via a flow restrictor to air cylinders A and B and prevents them operating too quickly. As the rams in the cylinders retract the doors unfold and close and at the same time the other high pressure air supply has been fed to cylinder C causing the hinged toggle at the end of the ram to project into the path of the top jockey wheel.

42. When the Tx is switched off the high pressure air supply to the interlock manifold in the pneumatic control panel is shut off and the air in the manifold is exhausted to the atmosphere. This removes the air supplies to cylinder C and the pilot valve of the air changeover valve. The ram of cylinder C returns on its spring to its original position thus releasing the door for manual opening. When the air supply to the changeover valve is removed the valve reverses and routes the main manifold air supply to the rear ends of A and B. As the rams extend the air ejected from the two cylinders is fed via the flow restrictor and exhausted to atmosphere at the changeover valve.

Atmospheric Air Conditioning (Figs. 6.9, 6.10, 6.11)

43. Purpose. To produce a forced flow of air to cool the units and components in the transmitter cabinets and to maintain the temperature between pre-determined limits.

44. Action. A temperature sensitive resistor, situated in the outgoing duct of the Air Conditioner to the transmitter cabinets, forms one side of the control unit input bridge, (see Fig. 6.10) circuit. Applied to the bridge circuit is 12 volts a.c. and within temperature limits the output if any, is non effective. A change in temperature of air leaving the transmitter cabinets causes the bridge to unbalance and give an a.c. voltage output, there being a 180° phase difference between the output due to a temperature rise against that due to a temperature fall. After amplification by VT1, VT2 and VT3 the output is fed to a phase sensitive detector circuit, VT4 and VT5. An a.c. supply of 18V is fed to this circuit via rectifiers MR3 and MR4 thus the negative d.c. at the collectors is pulsating at 50 pulses per second. The collector loads of VT4 and VT5 and the operating coils of RL1 and RL2 respectively. The input to the detectors will only be in phase with the pulsating h.t. on one of them; which are dependant on whether the i/p phase is the result of a rise or fall in circulating air temperature. When the input is of sufficient amplitude forward bias on one of the detectors will cause its relay to operate and the two contacts of the relay will perform three functions:

a. Short circuiting the common emitter resistor increasing the effective voltage applied to the collector circuit of the conducting transistor.

b. Connects a resistor in the emitter circuit of the non conducting transistor decreasing the effective voltage applied to it.

c. Connects the a.c. supply to the two phase motor the flap valves and the bridge balancing potentiometer slider are driven clockwise or counter clockwise.

45. When restoration of temperature and adjustment of the potentiometer re-balances the bridge circuit the signal amplitude will have fallen and the relay de-energised.

Air Compressor SH121 (Figs. 6.12, 6.13)

46. Purpose. To provide clean dry air at 15lbs per square inch and 75lbs per square inch pressure.

47. General Description and Action. The air compressor unit contains two identical air compressors and a refrigeration unit. Air from the compressors is fed through non-return valves to three air receivers, which lie across the bottom of the unit and form the chassis on which the compressors are mounted. From the receivers the air passes through a water and oil separator where the water vapour and oil mist are extracted and disposed of through a drain valve on the separator. From the separator the air is fed to a changeover valve. The changeover valve is a solenoid controlled, air operated five port valve, controlled electrically from a motor driven automatic timer. From the changeover valve the air is piped to the twin heat exchangers in the dehumidifier unit. The direction of the air flow through these series connected heat exchangers is reversed every four hours, when the changeover valve operates. Between the two heat exchangers is a second filtering system consisting of two filter and automatic drain valves. After leaving the second heat exchanger, the air is again taken via the changeover valve and split to give a non-regulated high-pressure output (75lbs) and a regulated low pressure output (15lbs). The low pressure output is controlled by a regulator valve which is controlled by a manually operated pilot regulator valve.

48. The refrigeration system is used to cool the air passing through the heat exchangers. The refrigerant used in the system is Arcton 12 or Freon 12. Liquid refrigerant is fed from the condenser unit via one of the solenoid operated shut off valves to the twin, low temperature heat exchangers in the dehumidifier unit. The refrigeration plant runs continuously, operating on an eight hour cycle; working alternately with a half hour overlap into the two separate heat exchangers for 4½ hr periods. This is also controlled by the automatic timer. The two heat exchangers have their air feeds arranged so that they always operate in series and the flow is arranged in such a way that the second heat exchanger is the one under controlled temperature conditions, the change occurring with a half hour overlap.

49.. The electrical circuit has a three phase supply controlled by the mains isolator switch: the two air compressor motors and refrigeration motor having separate contactors. Switching is either local or remote, air compressors and refrigerant compressors being brought on separately to minimize the initial surge current. A single phase supply is applied to the timer motor and solenoid circuits by the refrigeration compressor motor contactor. The timer supplies, via cam operated micro switches, in a correct sequence, feeds to the air changeover valve solenoid and both solenoids operating the refrigerant valves.

SECTION 7

MISCELLANEOUS

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS CONTINUED

SECTION 7

MISCELLANEOUS

Aerial and Feed System General Description

1. The type 84 aerial is 60 ft. long by 21 ft. 8 inches high, the reflector surface is fixed and permanent, with a surface accuracy of ∓ 40thousandths of an inch and manufactured by Handley Page Aircraft Co.

2. The aerial reflector is duplicated and mounted back to back, the second reflector being available to fulfil a possible future commitment. Within the totally enclosed framework of the reflectors are mounted two electrically powered hoists. These are available for installation or replacement of equipment either on, or in the vicinity of, the gantry e.g. aerial main bearing, turning motors, etc.

3. The V.P.D. produced by the array consists of eight interlapping lobes, three main - lower lobes and five upper ones, covering long range low to high coverage, and short range high coverage respectively. The aerial is tilted backwards $7\frac{1}{2}$ degrees of vertical, the eight stacked horn feeds being adjustable for the purpose of beam focussing.

4. The waveguide sections are individually cast in corrosion free aluminium alloy and plastic impregnated. All sections are broad bandwidth to cover the L band frequency range, with the exception of the horns which are 50 Mc/s and would have to be changed with a change of colour band frequency. It is essential that sections, removed for servicing (unlikely but possible), though apparently identical they must be replaced in the exact original position using only the approved type of gaskets and bolts are to be tightened to the torque pressure and in the sequence recommended in the S.D.4769A Vol.1, Pt 2, Section 8, Chap 2.

5. On the final 8 horn feeds, the half sized waveguide is broad band matched from vertical to horizontal polarized sections. This is achieved by twisting the waveguide through 90 degrees in a series of five steps.

6. A facility exists to enable the transmission of circular polarized r.f. as an alternative to horizontally polarized r.f. Wherever a return from a circular component (i.e. raindrop) is received it will not be accepted by the rectangular waveguide as the reflected E field of a circular target is 90° to its original orientation.

Rotating Coupling Unit (Figure 7.1)

7. General. The coupling is made in four editions as follows:

Edition	Services			
A	L-Band	S-Band	I.F.F.	Sliprings
B	L-Band	S-Band	-	Sliprings
C	L-Band	-	I.F.F.	Sliprings
D	L-Band	-	-	Sliprings

8. The rotating coupling of L-band and S-band waveguides, involves transitions of waveguide to coaxial and back from coaxial to waveguide. The i.f.f. channel is co-axial throughout. In the case of all three channels there is, in the coaxial sections an intermediate series break in the outer conductor at which rotation occurs being electrically closed by a multiple choke joint. The latter are designed to present minimum discontinuity in the coaxial and also protect ball-bearings from damage due to r.f. burning. The i.f.f. channel has also a series break in the inner conductor which is electrically closed by multiple choke sections. The slip ring unit can provide up to twenty two services between ground and aerial via the silver slip rings and silver-carbon brushes. An air bleed is taken from the pressurized L band co-axial to provide an air blast onto each of the slip-rings to keep them free of dust.

9. The services available on the slip rings are as follows:

Plug or Socket	No. of Channels	Service
A and B	2	Low noise rings between earthed screening rings.
C	1	Earthed screening ring, has brushes for use as earth return.
C	14	5 Amp. 250V a.c. working.
D	4	30 Amp. 500V a.c. working.
D	1	30 Amp. earth.

10. Action of L Band. Upon entering the input flange, power is split into two equal parts by the series splitter vane accurately positioned in the centre of the normal sized waveguide. Due to the quarter wavelength off-setting of the input flange one route is a half wavelength greater than the other route. This is necessary to ensure that the two half powers appear at the "door-knob" transition in phase and thus excite the co-axial section in the principal T.E.M. mode. The waveguides feeding either side of the door-knob present an impedance a $\frac{1}{4}$ that of normal waveguide and broad-band impedance matching by quarter guide wavelength transformers on either side of the door-knob is facilitated. Power now proceeds along the coaxial section to the upper door-knob via the intermediate series break and is again split and recombined at the output flange.

Polarizer Actuator Control (Figure 7.2)

11. Purpose. To give control of Circular/Linear polarizer selection.

12. Action. The relay polarizer unit is mounted on the wall of the transmitter hall. It contains the forward and reverse drive power switching contactor A, a thermal cut out in case of overload and a carpenter type control relay, RLA and a resistor-capacitor combination providing a phase quadrature supply to the start winding of the actuator motor.

13. The switching of the actuator is controlled by the Circular/Linear switch at the console suite desk. This switch makes or breaks 50V d.c. to RLA. Contact RLA, energises the appropriate coil of contactor A which routes power to the single phase actuator motor brake solenoid, run and starts fields. The supply to the latter being phased to give appropriate direction of operation. The motor is geared to an actuating ram linked via Bowdenex cables to the 8 polarizer units in the horns. Then take up the Linear (ram extended) or Circular (retracted) polarization position as selected. When the selected position is reached limit switches break the coil supply to contactor A, the motor stops and the break reapplied. The appropriate tellback lamp on the control desk is also switched on providing the 'fully operated' position is reached. A hand operated safety switch in series with the limit switches in the actuator compartment can be operated to isolate the actuator supply and at the same time enable the key for emergency manual operation to be inserted.

Heater and H.T. Distribution (Figures 7.3, 7.4 and 7.5)

14. The distribution charts are self explanatory and are inserted specifically to assist in fault location.

15. Purpose. To supply stabilized 6.3V a.c. to filaments in the TWT, Amp (Limiter) M29, and Amp I.F. (Filter) M30's.

16. Action. As in M4 (Figure 3.3) using transductors and relay control, RLB and RLC having only 2 contacts each, each with a contact in the interlock line and another in the "volt normal" light ILP2 line. The a.c. outputs are stabilized by transductors. A magnetic amplifier TD1 is biased negatively by V1 circuit. TD1 feeds the control windings of TD2 a transductor whose outputs are in parallel with each other but in series with the primary of the filament transformer. One output of the latter is rectified by MR5, a bridge rectifier. This d.c. acts as the supply for RL's B and C also used as the source of feedback to the magnetic amplifier control windings via the set volts control RV1. A meter M1 across one of the supply transformer outputs reads 6.3V.

Power Supply (D.C. Heaters) M5 (Figure 7.7)

17. Purpose. To supply stabilized 6.3V d.c. to filaments in the Frequency Multiplier Amplifier and the Frequency Multiplier Oscillator.

18. Action. As in the M8 but the supply transformer has only one output, this is rectified by MR5 a bridge rectifier and since it is used as a 6.3V d.c. floating supply it is heavily smoothed. The d.c. output is also fed back via RV2 to the control windings of the magnetic amplifier TD1.

Power Supply (500V) M6 (Figure 7.8)

19. Purpose. There are two of these units one of which supplies regulated 500V and unregulated 800V to P.S. M9, the other regulated +500V to the Noise Figure Monitor, Monitor Panel, Control Panel, Pulse Generator, the Control TWT Trigger Pulse Amp all via the test electrical panel No. 4.

20. Action. A full wave rectifier V1 and V2 fed by transformer T1, LC smoothed and regulated by series valve stabilization of conventional design (V3-V6). RV1 is the set 500V control, V5 the control valve, V3 and V4 act as the series valves in parallel and V6 the cathode stabilizer for V5.

Power Supply (50V) M7

21. Purpose. To supply 50V d.c. to all relays and indicators etc.

22. Action. A metal bridge rectifier fed by a transformer and capacity smoothed.

Power Supply (-600V +1200V) M9 (Figure 7.9)

23. Purpose. To supply:

a. -600V to klystrons in the STALO control and Spectrum Analyser panels via Panels Test Electric Nos 3 and 1.

b. +1200V to the Trigger Pulse Amplifier and the Pulse Generator via Panels Test Electric Nos 3 and 4.

24. Action. The -600V supply is rectified by V1, LC smoothed and regulated by V3, V6 and V7, a conventional series stabilizing circuit when voltage is set by RV2. The +1200V supply is rectified by V2 and stabilized by V4 and V5, a conventional series stabilizing circuit whose voltage is set by RV1. Both V1 and V2 are fed from transformer T1 the centre tap of the output winding to V2 being at approximately +800V to earth.

Power Supply M10 (Figure 7.10)

25. Purpose. A general purpose power pack which can supply a variable output depending on the positions of straps across the internal terminal blocks. The output alternatives are 150V, 200V, 250V and 300V. In the case of the 150V and 300V applications an external ref may be used. There are twelve M10's in use, all inter-changeable if the straps are adjusted. The outputs and loads can be found by cross-referring to the distribution charts.

26. Action. V1 and V2 form a full wave rectifier whose inputs can be varied by altering the tappings of T1. The d.c. is then LC smoothed and series stabilized in the conventional manner by V5-V8 and RV1 acting as the set volts control on the grid of V7. Internal reference is provided by V3, a fullwave rectifier fed by T2, capacity smoothed and stabilized by V4, a neon.

Fire Detection System (Figure 7.11 Figure 7.12)

27. Purpose. In the event of fire or overheating within the transmitter/receiver is to automatically:

a. Switch off the 3 phase supply.

b. Release CO_2 into the cabinets.

c. Sound a warning siren and give lamp indication of fire or over-heating with a locating facility of the latter.

28. Description. The functions are controlled by the Alarm-Monitor (fire unit) which is operated by overheat detectors and flame detectors, temperature sensitive switches at various points in the Tx/Rx.

29. Overheat detectors are all normally closed, those fitted to cabinet gates are intended to monitor air temperature, they are insulated from gate structures by fibre glass lids and the switches open at 80° C. Other overheat detectors are used to monitor temperature of oil filled components and are set to operate at 60° C or 70° C.

30. Fire detectors are all normally open and are mounted in eight pairs in the top of the Tx/Rx assembly. They operate on the differential expansion principle, the operating temperature being inversely proportional to the rate of temperature rise.

31. In both types of detector operating temperatures are pre-set by manufacturer and should not be interfered with. Overheat detectors are fixed by special screws and washers and no other type must be used.

32. Circuit Action. The 35 transmitter gate overheat detectors are series connected across TB2/1 and TB2/12. The d.c. output of FS3 is fed via this circuit to the NO OVERHEAT lamps and RLA via RLA 1 which is initially energised by RLN1 when the RESET button SE is pressed during commissioning or resetting of the system. RLA2 energises RLB extinguishing OVERHEAT lamps.

33. Should a break occur in the transmitter gate overheat detection circuit the NO OVERHEAT lamps are extinguished and RLA and RLB are de-energised, contacts RLB 1, RLB 2 route d.c. to the OVERHEAT lamps. Contact RLA 3 and RLB 3 function to switch off the transmitter and energise the motor driven siren. Contact RLA 4 which would normally operate CO2 release circuits may be short circuited.

34. For fault location purposes a d.c. is routed to the LOCATE lamps via RLA 2 and SWA when in the NORMAL position. When SWA is advanced the LOCATE lamps are lit via the fuse FS3 and via progressive points along the series detector circuit. The source of overheat or system break is indicated by the position of SWA against the scale when the LOCATE lamps are first extinguished.

35. The five indicators are each parallel connected from TB1/1, TB1/4 to line TB1/2, TB1/3. One of the 'rings' is connected to earth via RLR 3 and RLR 4 and direct to earth via TB1/4. When fire causes one or more of the detectors to close RLG energises open circuiting the NO FIRE lamps, de-energizing RLE and RLF. Contact RLE 3 trips the mains interlock relay RLS. Contact RLF 3 trips RLH sounding the siren X1. RLF 1 and RLF 2 light the FIRE indicator lamps. Contact RLE 4 will open to de-energise RLK and RLK1 in parallel with RLK 2 shorts out RLM and R3 permitting passage of current sufficient to energise the CO2 release solenoid and RLM1 open circuits the 'Ready' lamps.

36. In the fire detection circuits a facility exists to enable a continuity check of the lines TB1/1 to TB1/4 and TB1/2 to TB1/3. Switch D is put to the OFF position and the continuity test button is pressed energising RLP which energises RLQ. The delay circuit MR1, MR2, C4 and R5 ensures that RLQ is operated before RLR and RLG energise and vice versa. This is necessary to keep RLE held throughout the test and the siren will sound to indicate continuity without tripping the mains isolator contactor or operating the CO2 release solenoid.

Battery Charger Unit (Figures 7.13 and 7.14)

37. Purpose. To maintain the Emergency Standby Pump power supply in a fully charged state.

38. Action. The unit supplies a charging current which is regulated by the terminal voltage of the battery.

39. VT1 and VT2 form a long tailed pair amplifier, the base of VT2 being held at a fixed potential across R10 by Zener diodes MR12 and MR13. If battery terminal voltage falls the fall is felt at VT1 base representing a reduction in forward bias causing current through R7 to fall. VT2 emitter voltage rises and as the base potential is fixed the forward bias on this transistor increases and collector current through R19 and R9 rises during the -ve 33V pulses at 100 c/s which represents the collector supply. C2 charges towards the volts dropped across R9 and the reverse bias of VT3 emitter will decrease accordingly. Greater current through R9 will speed up the time where the top plate of C2 becomes +ve w.r.t. base point potential, resulting in a rapid discharge of C2 through R12 and the resultant -ve pulse is fed via C3 to the control electrode of the silicon

controlled rectifiers permitting them to conduct for the remaining period of the individual charging cycle. Thus the mean charging rate is adjusted by the battery terminal voltage.

Modulator Valve Conditioner M2 (Figure 7.15, 7.16)

40. Purpose. To maintain two spare Hydrogen Thyratrons in a state of constant readiness.

41. Action. The unit contains the power supplies and trigger circuit for the thratrons, S.B. determines to which thyratron the trigger is fed to, whilst the anode supply is connected either to V1 or V2 by a flying lead.

42. The input signal to the trigger circuit is taken from T3 secondary (6.3V a.c. winding). The negative half cycles cause VT1 to conduct to produce a positive pulse which is differentiated by C7 and R14. The negative spikes cause VT2 to conduct, the positive output of VT2 is further differentiated by C8 and R17. VT3 is normally conducting and is cut off by the positive spikes. The short duration negative output spikes are coupled to VT4 by C9, VT4 is an emitter follower feeding the output transistor VT5. T6 the output transformer develops pulses of 750V at its secondary. These pulses are fed to V1 or V2 according to SB. The G2 trigger pulses are fed via C3 onto a -108V bias from V3. Relay B prevents h.t. being applied before the bias supply is applied to the selected thyratron. S.G. is a microswitch which open circuits the h.t. supply if the cabinet door is open. Relay A is an h.t. trip relay dropping out contactor A for an h.t. overload. S.D. is the main cabinet interlock switch. SWC operated by S.D. is an earthing switch across the h.t. supply flying lead to V1 or V2 anode.

SECTION 8

INTRODUCTION TO SIGNAL PROCESSING

~~SECTION 8~~

SIGNAL PROCESSING INTRODUCTION

1. The function of Signal Processing in the Radar Type 84 is to allow the maximum number of targets, both in clear conditions and in the presence of clutter or jamming, to be displayed.

Types of Clutter

2. a. Hills and other large objects.

   b. Sea and ground returns.

   c. Areas of rain.

   d. Anoprop.

   e. Trees swaying in the wind.

   f. Birds (Angels).

Types of Jamming

3. a. CW jamming.

   b. Noise generators (Carcinotron).

   c. Window.

   d. Other radars or pulse sources.

Techniques Involved

4. a. Circular polarisation.

   b. Swept gain.

   c. Logarithmic Rx plus pulse length discrimination.

   d. Moving target indication (MTI).

   e. Pulse repitition frequency discrimination (PRFD).

   f. Dicke-Fix receiver.

Clutter Processing

5.	a.	Circular polarisation	14dB SCV (in rain).
	b.	Swept gain	(Angels).
	c.	Log + PLD	(Automatic against cloud).
	d.	MTI	18dB SCV.

Advantages of Log + PLD over MTI

6. a. No loss of targets due to blind velocities.

   b. Effective against moving clutter without adjustment of controls.

   c. Automatic against noise and CW jamming.

   d. Simple and inexpensive.

Limitations of Log + PLD Compared with MTI

7. a. Targets must be 5 - 10dB stronger than clutter.

   b. Permanent echoes passed at full strength.

   c. No protection against angels.

Conclusion

8. Use Log + PLD in the clear, MTI in clutter.

Processed Display

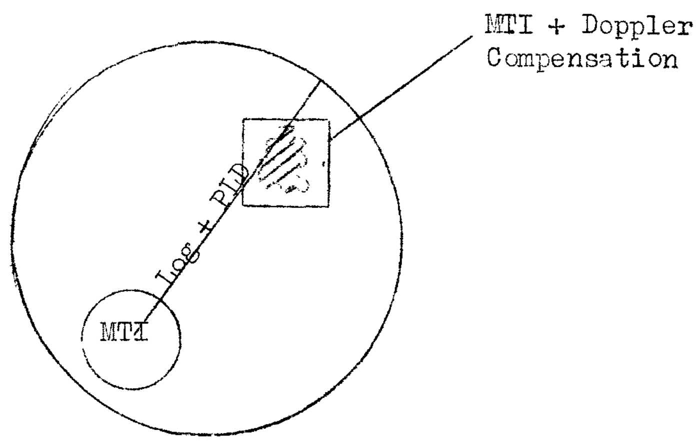

Fig. 1

9. The background of the fully processed display is Log + PLD after the MTI centre circle. The doppler compensated MTI within the rectangles is normally clutter switched to reduce the area affected by blind velocities.

Anti Jamming Processing

10. a. Noise Jamming: Log + PLD protected by Rx characteristic. MTI protected by noise operated a.g.c.

    b. CW Jamming: Log and MTI channels are both protected by their individual PLD units.

    c. Impulsive Jamming: PRF discrimination.

    d. Carcinotron Jamming: Dicke-Fix (AJ) Rx deals with this. Log and MTI channels are normally fed with Lin i.f., but AJ i.f. can be selected from the control suite.

    e. Window Jamming: This is treated as moving clutter and is cancelled by MTI with Doppler compensation.

General Principles of MTI

11. The MTI circuits will cancel echoes from fixed objects whilst retaining visibility of moving targets. The basic principles of MTI may be extended to cancel moving clutter by the introduction of Doppler compensation.

Single (or 2 Pulse) Cancellation

12. The principle of permanent echo cancellation makes use of the fact that the phase relationship between transmitted pulse and echo pulse depends upon target range. This phase relation is constant for a fixed target, but changes from pulse to pulse for a moving target with a radial velocity. The cancellation system involves phase comparison of the echo pulse with the transmitter pulse. Since the transmitter pulse does not start with the same phase every time, a sample of the pulse is used to control the starting phase of a coherent oscillator (COHO). This is known as the lock pulse. The COHO is stopped in the last 125µsecs of the pulse repetition period and restarted by the lock pulse. Echo pulses are compared with the reference frequency in a balanced phase detector. Successive outputs from which will be the same for a fixed target but will differ for a moving target with a radial velocity.

13. If two successive outputs from the phase detector for a fixed target are applied to a subtraction circuit the output is ideally zero (cancelled). For a moving target the O/P from the subtraction circuit would be proportional to the amplitude and phase difference of the two inputs; ie. dependant on radial distance travelled between pulses. This subtraction is effected by delaying the first pulse and then feeding it to a differential amplifier with the second pulse.

14. The delaying medium in this equipment is mercury in a cell desgined to give an approximate delay of 4 milliseconds (PRF 250p.p.s.). In practice the delay of the cell controls the p.r.f. so that temperature variations can be ignored.

15. The output of the phase detector is bi-polar, being either positive or negative according to the phase of the incoming signals related to the reference frequency.

16. The degree of cancellation obtained is limited by the stability of the system, the fluctuations of the clutter returns and the scanning effect due to aerial rotation. These effects can be minimized by the use of a long wavelength, high PRF large number of pulses per beam width. In the Type 84, with a low p.r.f. 0.9° beam width and rotation of 4 r.p.m., scanning effect is severe. With 2 pulse cancellation the cancellation effect is only 15dB with perfectly stable clutter so a double (or 3 pulse) cancellation system is used.

Double (or 3 Pulse) Cancellation

17. The effects of pulse amplitude variations due to scanning and other effects is reduced by the use of double cancellation, which employs the use of two cancellation systems in series. Fairly stable ground clutter of up to 21dB can be cancelled. The signal to noise ratio is therefore limited to 20dB before the phase detector. The sub clutter visibility of an optimum velocity target is about 22dB, but the average for all phases is 17-18dB. When dealing with moving clutter cancellation may be switched to limit at 14dB or 8dB so as to provide sufficient width of blind velocity band to cover random internal motion of the clutter. This gives sub clutter visibilities of 12 and 6dB respectively.

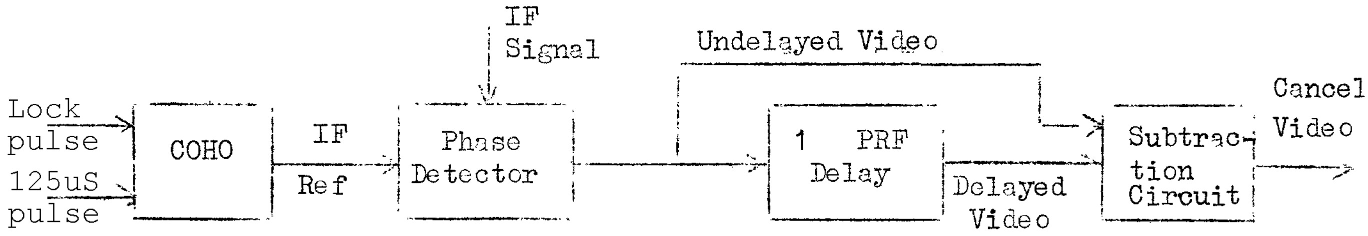

Fig. 2. Single Cancellation System

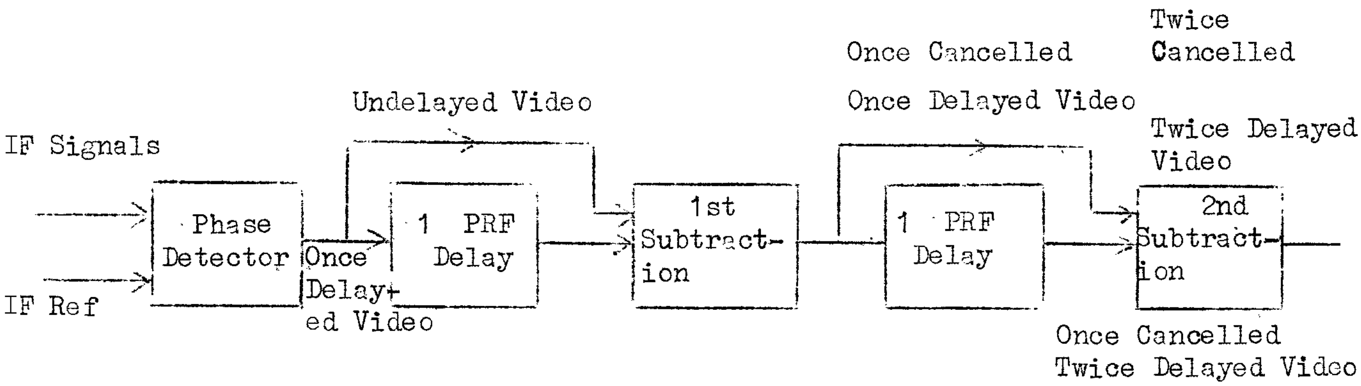

Fig. 3. Double Cancellation System

Blind Velocities

18. If a target moves radially a distance equal to a whole number of half wavelengths between pulses the distance travelled by the pulse from aerial to target and back, changes by a whole number of wavelengths. There is no change of phase between successive echoes and therefore the target return is cancelled. Radial velocities at which this occurs are given by the expression $V = .0097\, n\lambda fr$

V = velocity in knots

λ = wavelength in centimetres

fr = PRF

n = any whole number including zero

19. For a system having a p.r.f. of 250, wavelength of 23 cms, blind velocities occur at multiples of 56 knots.

Optimum Velocity

20. Radial velocities which occur midway between blind velocities, odd multiples of 28 knots, produce 180° phase change between successive pulses at the o/p of the phase detector thus giving maximum o/p from the subtraction circuit.

Blind Velocity Bands

21. The response of an MTI circuit as a function of radial velocity is shown in Fig. 4.

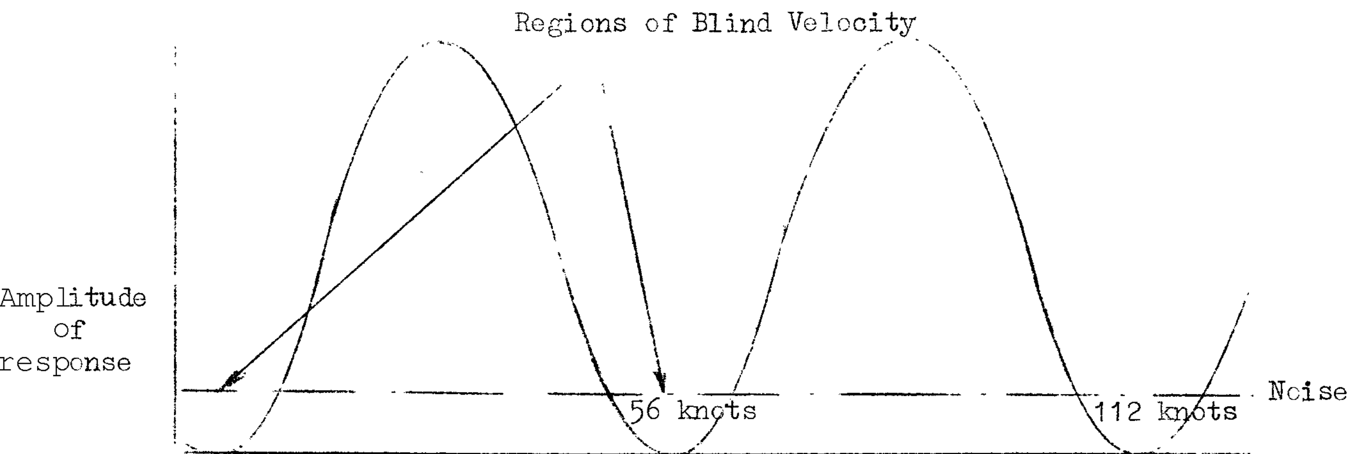

Fig. 4. Radial Velocity (Knots)

22. The target is submerged in noise over a band of velocities occurring every 56 knots. The widths of blind velocity for a double cancellation system are 9, 13 or 19 knots for an i/p signal to noise ratio of 20, 14 and 8dB.

Blind Phases

23. The response of a balanced phase detector is shown in Fig. 5 and is such that a target at optimum velocity causes a phase change between pulses of π radians.

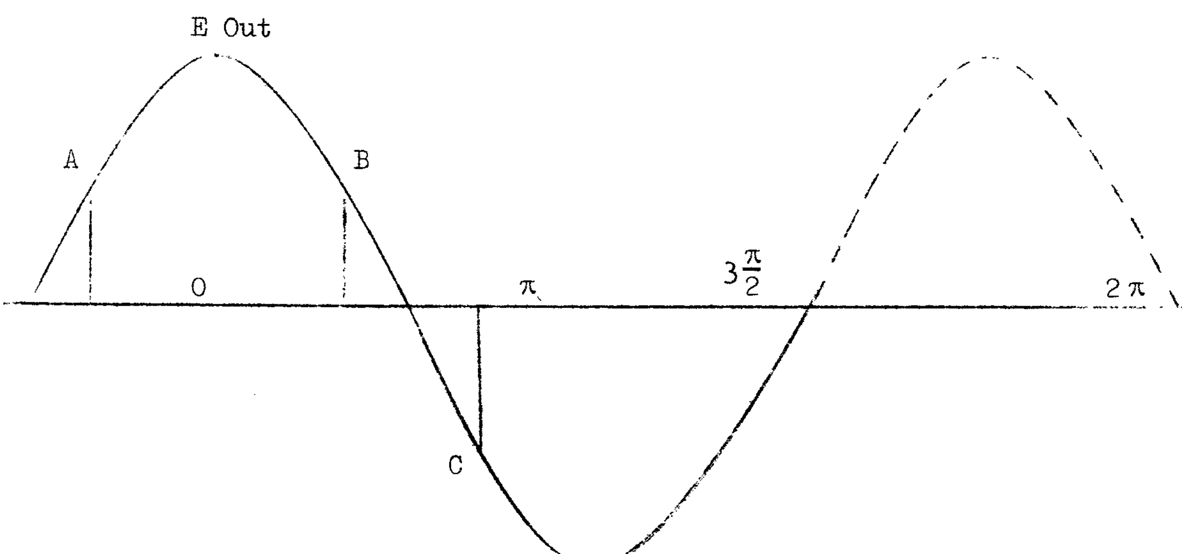

Fig. 5. Response of Phase Detector

24. If the first pulse occurs at 0 radians and the next at π radians the results after subtraction will be a large O/P. This is optimum velocity with optimum phase. If the first pulse occurred at $\pi/2$ radians and the next at $3\pi/2$ the O/P from the phase detector would be zero and would remain so for optimum velocity. Blind phases may occur at velocities other than optimum. If a pulse occurred at A and the next at B the result after subtraction would be zero.

25. If the COHO is off set from the i.f. frequency, the effect of blind phases is avoided, for by de-tuning the oscillator by 100 kc/s all phases are passed through for a 10us pulse. This facility is known as Coherent Low IF (CLIF).

Doppler Compensation

26. The output of the phase detector for a moving target is fluctuating at fd but this could also be the O/P from moving clutter. If the frequency of the reference oscillator is changed by an amount equal to fd the resultant output from the phase detector would be constant and the clutter would be cancelled.

27. If an area of rain surrounds the station with a set velocity, the radial velocity will vary according to a cosine law as the aerial rotates, the reference frequency must therefore be made to vary in the same manner.

28. Three different values of doppler compensation can be applied in three rectangles which are variable in size and position.

Electronic Gates Used in Signal Processing

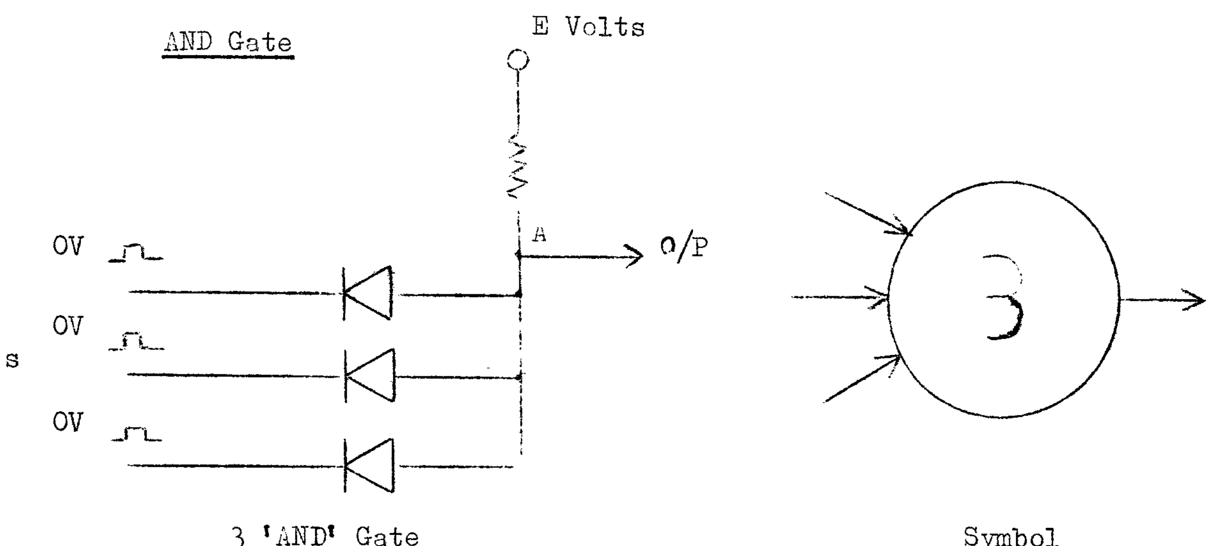

Fig. 6

29. An 'AND' gate is a circuit that will only give an O/P when all I/P's are present. Without any inputs all three diodes will conduct. If a pulse is applied to any one of the inputs cutting off the diode the current through that band will cease, but point A will be maintained at approximately OV by the current flowing through the other two diodes. Only when all three I/P's are present will point A rise to E volts.

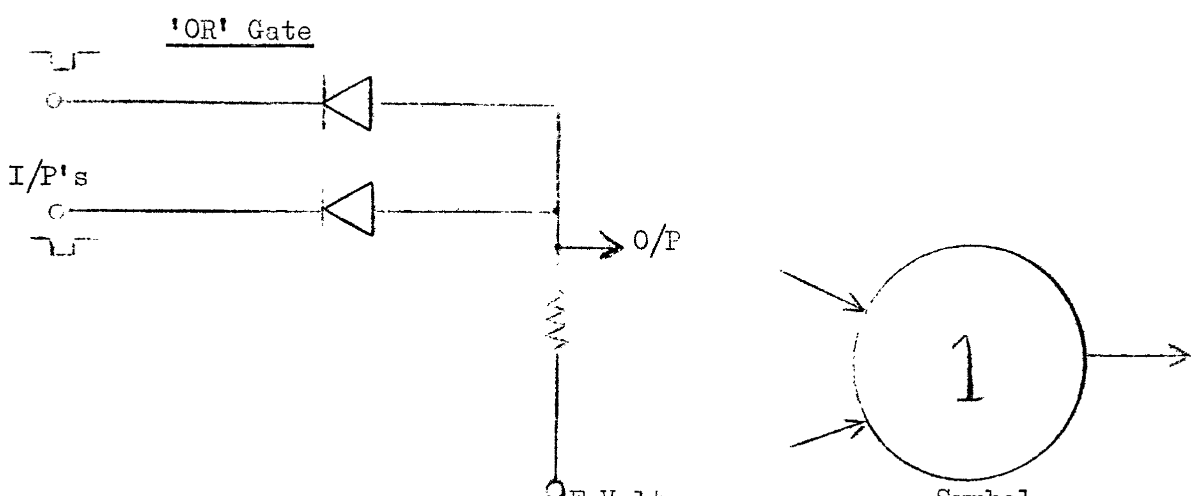

Fig. 7

30. An 'OR' gate is a circuit giving an output when a signal is at one or other of the inputs. When an input is present at one or other of the two diodes, the diode will conduct more heavily and the input waveform will be passed to the output.

Differential Amplifier

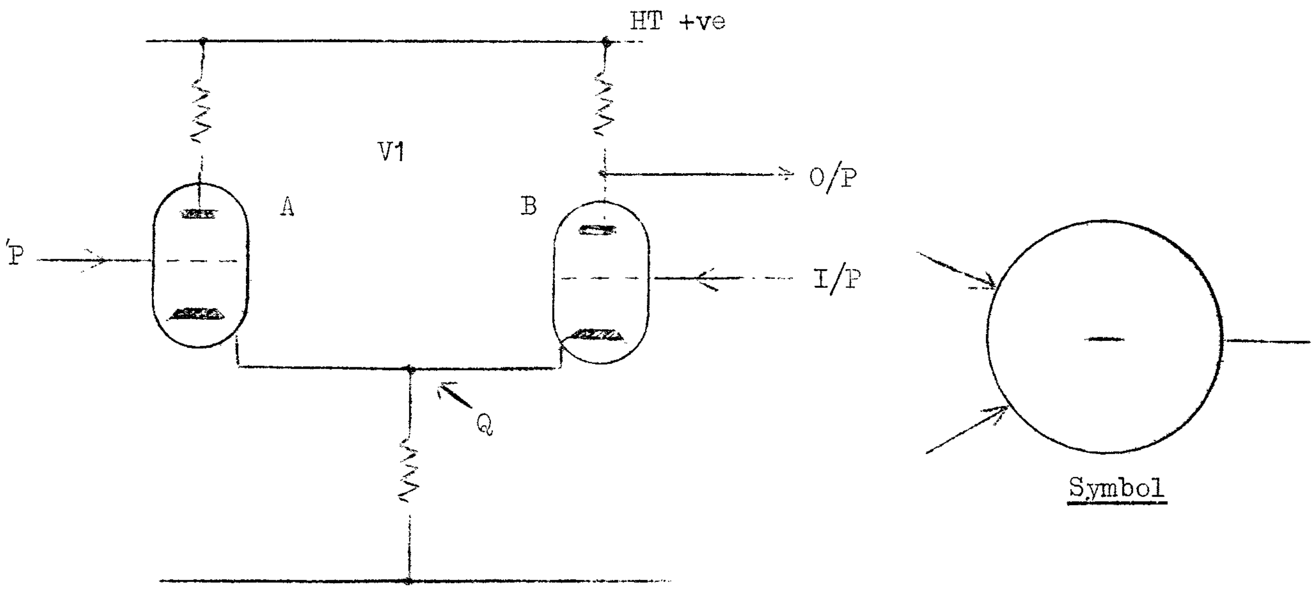

Fig. 8. Differential Amplifier

31. An input to V1A of 1V would cause point Q to rise approximately 1V, the rise of 1V at point Q V1B cathode is effectively the same as an input of -1V to V1B grid. The reverse action would take place for an input of 1V to V1B grid. When the two inputs are simultaneous they effectively cancel each other out. If the inputs are not simultaneous there will be an output from the circuit.

Equipment Racks

32. There are seven equipment racks associated with the Type 84, the p.r.f. cabinet being duplicated.

a. IF cabinet.

b. Cancellation cabinet.

c. Doppler cabinet.

d. Video cabinet.

e. PRF cabinet (2).

f. Power supply cabinet.

33. Apart from the power supply cabinet each cabinet has three frames mounted vertically on runners, making for easy access to both front and rear of the units. Each cabinet is numbered and each unit in a frame is numbered. When using the Vol. 4 a reference number is given for each unit to be set up ie. 4/102 4 = IF cabinet.

1 = 1st frame (from left)

02 = 2nd unit (from top)

Rack Numbers

1 = Power supply cabinet.

2 = Cancellation cabinet.

3 = Video cabinet.

4 = IF cabinet.

5 = Doppler cabinet.

6 = Main PRF cabinet.

7 = Standby PRF cabinet.

SECTION 9

IF CABINET

SECTION 9

IF CABINET

Switch Electronic (IF) M2 Figure 2.3

1. Purpose. To enable the input to the m.t.i. and Log + PLD channels to be selected from three inputs; AJ IF, LINE IF from the head and locally generated test signals.

2. General. The AJ i.f. is attenuated by 6dB within the unit to compensate for different input levels between the AJ and line i.f.'s. All signals fed to the m.t.i. channel are attenuated by a further 15dB. The unit also provides two unswitched outputs, one from the unattenuated AJ input to the Demodulator (Linear) M2 of the AJ channel, the other from the lin input, attenuated by 15dB for the Amplifier Assembly (Linear) M9 in the video cabinet.

3. Action. The unit comprises three single stage i.f. amplifiers each of unity gain and sharing the primary of an output transformer as a common anode load. When RLA is energised V1 is cut off, V2 is conducting and linear i.f. is passed through to the m.t.i. and Log + PLD channels. On the operation of the AJ switch on console 2 of the control suite, RLA de-energises; V2 is cut off, and V1 conducts passing AJ i.f. to the m.t.i. and Log + PLD channels. An override switch 'RADAR SIGS' ON/OFF is provided to enable AJ and Lin channels to be muted to allow test signals to be switched through; 'Test Sigs' switch. It is also possible to obtain the condition where one of the i.f. signal channels is biased off leaving the other channel and the test signal channel still operative.

4. A two position Test/Normal switch enables test lock pulse to be selected during test in place of the Tx lock pulse to initiate the coherent oscillator.

Amplifier Assembly IF (Log) M10 Figure 2.4

5. Purpose. To provide an automatic control over strong noise, or clutter, thus preventing saturation of the signal channel.

6. General. The Log i.f. amplifier M10 consists of a main chassis on which is mounted the Log i.f. amplifier M7. The main chassis contains a series regulator valve stage to reduce the incoming h.t. to +100 volts before applying it to the Log amplifier.

7. Action. The unit consists of 6 stages of i.f. amplification each stage followed by its own detector, the outputs from the detectors are fed via compensating delays to form a final added output of negative video on a d.c. level proportional to the noise, or clutter input. The output from V7, 8 and 9 is not used in this application.

Generator Sweep (Video) M3 Figure 2.5

8. Purpose. To apply a form of swept gain to the Log amplifier video output. There is also a facility to reduce the swept gain in the presence of noise jamming.

9. Action. The circuit consists of three parts, one to produce the swept gain waveform, the second produces a d.c. level proportional to the noise present in the video input, whilst the third part adds the d.c. level and swept gain waveform to determine the amount by which video signals are clipped.

10. The swept gain waveform is initiated by the 0 µsec pulse which is stretched and applied to V1, where it is amplified, inverted and used to charge C5, C6 via V2. C5 and C6 discharge exponentially until V4A conducts holding C6 at a charge of -2.5V. C5 continues its discharge for a further 500µs until V4B conducts. The rising voltage at the grid of V5 is felt as an amplified positive rise at V6 cathode. This rise cuts off V4A thus allowing C6 to continue its discharge. The resultant waveform is -30V in amplitude with an initial rise over 500µs followed by a step of 500µs ending with a further rise of 500µs. This waveform is fed to V9, which is biased by the incoming noise level. The output of V9, which can be selected at three levels is fed to V10B where it is used to dip signals of a certain amplitude. V10A V11 form the output stage for the gain swept video. The output level of V9 is controlled by the four position swept gain switch on console 1 of the control suite. Position one - No swept gain.

Pulse Delay Network

11. Purpose. To compensate for overall delays in the signal processing channels thus achieving an aligned final display.

Comparator Signal (Video) M4 Figure 2.7

12. To reduce unwanted clutter by rejecting all pulses equal to or greater than twice the transmitter pulse length and partial rejection of all pulses between 10 and 20 µsecs.

13. Action. The input from the pulse delay network is fed to a short circuited 5 µsec delay line, the output from which forms a composite pulse with the input. This waveform is amplified by V1 and V2 and applied to a phase splitter V3A. The outputs of V3A are fed to the coincidence detector, the cathode output being delayed by 10 µsec delay line. Pulses of 20 µsec or greater will not be coincident and will give no output, pulses of 10 µsec will be coincident and will produce a 10 µsec pulse output delayed on the original input pulse by 10 µsecs.

14. The video output from the coincidence detector is fed out to the Switch Electronic M3 in the Video cabinet via a d.c. amplifier V5, V6, A log/Anti log switch is incorporated in the final d.c. amplifier. In the log position the feedback is fixed by R52 and the gain of the amplifier is kept to a minimum giving an overall response which is linear. In the Anti-log position the feedback is proportional to pulse amplitude. If the pulse amplitude is less than +2.1 V full feedback is applied, over 2.1 V the feedback path is slanted by R57, V13 which reduces the feedback and increases the gain. The overall response therefore approximates to a logarithmic law.

15. In the log channel the switch is set to Anti-log and in the m.t.i. channel to log.

Limiter Electrical-Noise M1 Figure 2.8

16. Purpose. To produce and apply swept gain and/or noise bias to the m.t.i. channel.

17. Action. Bi-polar Video is fed into the noise circuit, from the demodulator coherent for channel B, where it is rectified by V15 to V18, amplified by V2A and V3 and applied to a gated sample circuit V20, 21 and 22. The 0 µsec pulse cuts V4B off by the action to conduct and passes the 1 V sample from the gated circuit to an integrator circuit V5, C11 and C12. The output of the integrator circuit is passed via V6 and V7 to the switched 'OR' gate V13.

18. The Swept gain waveform generator has a similar action to that in the generator sweep video, the amplitude of output being selected by Relay action dependant on the position of the swept gain control on the control suite. The swept gain output is applied to the other side of the switched OR gate V13. SWA is a four position switch giving: OFF, Noise Control, Swept Gain. The output of V13 is used to bias the i.f. amplifier stage V14.

Amplifier Assembly IF (IAGC) M2 Figure 2.9

19. Purpose. To amplify but retain phase characteristics so as to give a useful output from the demodulator coherent for a signal in comparitively strong clutter.

20. Action. The amplifier has six stages of amplification, V1 and V2 having a manual gain control. V3 and V6 having their own stage of IAGC. The output from V8 is passed to the Amplifier (IF) M1.

Amplifier (IF) M1 Figure 2.10

21. Purpose. To provide pre-cancellation limit levels of 6, 14, 20 dB's corresponding to blind velocity bands of 9, 13 and 19 knts respectively.

22. Action. As soon as the signals at V1 anode reach 20 V p to p diodes V3 to V6 conduct and the tuned circuit is damped by R12 in parallel with R20 for both +ve and -ve excursions of the signal.

23. With the control switch in the 13 knt blind gap position contacts RLA 1 and RLA 2 close and the voltage at the cathode of V3 becomes 0.3 V and the voltage at the anode of V4 0.8 V. Therefore the anode of V1 is damped by R12 for signals greater than 1.6 V p to p. The same technique is applied for the 19 knt blind gap position, the anode of V1 being damped by R20.

Demodulator (Coherent) M1 Figure 2.11

24. Purpose. To compare the amplified i.f. signals with a CW reference frequency in a phase sensitive detector thus producing Bi-polar video whose amplitude and polarity depend upon the instantaneous phase difference between the i.f. and reference signals.

25. Action. IF signals are fed in at SK K of the demodulator for channel 'B' and out at SK Q for SK K of the demodulator for channel A. The i.f. reference signal for channel A and B is fed into their respective SK N's via independant mixer units. The incoming i.f. signals from the Amplifier (IF are fed via RV1 A gain control, to the grid of V2 on i.f. amplifying stage. Both the output of V2 and the input reference frequency, from the Mixer Stage Frequency, are fed into the phase sensitive detector. The resulting Bi-polar video is fed out via V4, V5 to the Driver Delay Line, also to the Limiter Electrical Noise from channel 'B' Demodulator.

26. Provision is made to blank off the i.f. signals for -125 µs before the transmitter pulse so that a timing pulse free of signals and noise may be passed through the cancellation system. The -125 µs pulse causes V1 to conduct cutting off V2, the circuit is returned to normal on the arrival of the 0 µs pulse.

Demodulator (Linear) M2 Figure 2.16

27. Purpose. To detect i.f. in the AJ channel (IF Cabinet). To detect i.f. in the linear channel (Video Cabinet).

28. Action. The 13.5 Mc/s input is fed to the grid of V1 via RV1 gain control. The amplified signals are detected by V2A and passed to V3, a long tailed pair, whose second grid receives -ve feedback from the output stage. The video output of the long tailed pair is fed via limiter V2B to the cathode follower output stage V4.

Oscillator (Coherent) M1 Figure 2.17

29. Purpose. To provide a c.w. reference i.f. locked to the starting phase of the transmitter pulse or test signal phase.

30. Action. The i.f. Lock Pulse input from the i.f. s.v. is fed to the grid of V1 on amplifier. The output of the amplifier feeds both V3 and V8. The -ve going envelope of the i.f. is detected by V8 and passed via cathode follower V2A and the switching diode V6, to V2B the switching valve of the oscillator. V2B is then cut off and the bias is lifted from the screen grid of the oscillator. The other output from V1 is fed via the amplifier V3 to the grid of the oscillator, hence the oscillator is shocked into oscillation by the i.f. pulse which is phase related to the transmitter pulse. The 13.4 Mc/s c.l.i.f. reference frequency from the oscillator is fed out via amplifier V5 to the frequency mixer.

31. To ensure that the reference frequency is again phase related to the next transmitter pulse, with SWA in the normal position, the -125 μs pulse causes V2B to conduct and the screen grid of the oscillator to fall cutting it off so that 125 μs later when the i.f. lock pulse arrives the oscillator may once again be shocked into oscillation with a correct phase relationship.

32. A facility is provided with SWA in the c.w. position to keep V2B cut off thus allowing the oscillator to run continuously.

Mixer Stage (Frequency) M1 Figure 2.18

33. Purpose. To pass the reference frequency to the demodulators at 13.4 Mc/s or at a frequency selected by the doppler compensation circuits. There are two of these units one for each cancellation channel.

34. Action. V1 is a mixer which accepts 13.4 Mc/s from the oscillator coherent and 5.251 Mc/s or 5.25 Mc/s ±fd. The output is 8.149 Mc/s or 8.15 Mc/s ±fd and is passed to V2, the second mixer where it is combined with 5.251 Mc/s which for fixed m.t.i. gives an output of 13.4 Mc/s, for doppler compensation 13.401 ±fd. The output of V2 is passed to V3 and V4 the amplifier output stage.

35. V5 and its associated circuit give a detected output for monitoring purposes.

Control (IF Level) M7

36. Purpose. To provide remote gain control of the AJ and Lin receivers in the head.

37. Action. The unit contains a switched meter for AJ limit level setting and is used in conjunction with the AJ limit control (operative on AM/Limiter M29) AJ gain control functions on the amp i.f. filter. Lin gain control functions on the amp i.f. filter of the Lin Rx.

Signal Generator (Video) M2 Figure 2.12 and 2.13

38. Purpose. To provide video test signals and switching waveforms for i.f. signals.

39. Action. The unit consists basically of two pulse generators, both triggered by the 0 μsec pulse from the i.f. signal generator.

40. The 0 μsec pulse is first amplified and inverted and then applied as a trigger pulse to two flip flops. Flip flop V2 is fixed to produce a square wave with a duration of 1000 μsecs but by inverting this output and d.c. restoring the pulses to the same level, a choice is given by SWB between a 1000 μsec pulse, starting at 0 μsec, or a 3000 μsec pulse starting 1000 μsecs later. The selected pulse is fed via a cathode follower (V3B) to SKR from where it is routed to the i.f. signal generator. The 1000 μsec pulse is also routed via a cathode follower (V4B) and SWA to a diode mixer circuit.

41. The other flip flop (V9) produces an output pulse which is adjustable in duration from 50 to 1,500 μsecs. After differentiation the trailing edge pulse is used to trigger a flip flop (V10) which produces a 10 μsec pulse, the time occurance of which is determined by the duration of the pulse from V9. The resultant pulse is fed via a cathode follower (V11) to SKS and via another cathode follower (V4A) to the diode mixer circuit.

42. The 1000 μsec and 10 μsec outputs (V4 AB) are fed to the diode mixer circuit (V16, V17) which comprises an 'OR' gate. The output of the mixer circuit is amplified (V5) and coupled via cathode followers (V6 and V7) to the parallel-connected outputs SKP and Q, where they are available for use as video test signals.

Signal Generator (IF) M9 Figure 2.14

43. Purpose. To produce test signals and clutter at the i.f. frequency.

44. Action. The unit consists basically of a crystal controlled Hartley oscillator of 13.5 Mc/s driving three independant 13.5 Mc/s output amplifier stages, each stage being gated by video operated r.f. switches.

45. The output at SKV is gated by the 10 μsec pulse (moving target), the output at SKW is gated by the 1000 μsec or 3000 μsec pulse (clutter block).

46. The third o/p at SKX is a pulse of 9 μsecs duration and is used during testing to replace the transmitter lock pulse for the COHO. The gating pulse is derived from a flip flop, in the unit, which is triggered by a 0 μsec pulse.

47. The output at SKY is representative of impulsive jamming and is produced by a squegging oscillator the nominal duration of the pulse being 10 μsecs, which is determined by the natural time constant of the circuit. The p.r.f. can be varied between 1000 and 7500 by the p.r.f. control RV2. The h.t. can be removed from this oscillator by means of SWA (Impulsive Jamming on/off switch).

48. In operation the simulated signal output is taken from SKZ, which is the output point of a signal mixing network. The outputs from SKV and W are coupled into this network via SKAB and SKAA respectively. A noise input to the circuit can also be made via SKAC from the amplifier noise M58.

Amplifier Assembly (Noise) M58 Figure 2.15

49. Purpose. To generate a set noise input to the i.f. switch unit during test conditions.

50. Action. The noise amplifier operates at a centre frequency of 13.5 Mc/s and has a bandwidth of 600 Mc/s. The noise output is greater than 200 milli volts at maximum gain. The input at SKD provides a means of injecting 13.5 Mc/s for alignment of the tuned circuits.

SECTION 10

CANCELLATION CABINET

SECTION 10

CANCELLATION CABINET

1. General Information. The units contained in this cabinet comprise of the circuits necessary for two complete systems of double cancellation. Both channels are identical except that channel β is also used for checking and controlling the p.r.f. of the Radar T84 with respect to the fixed delay cell.

2. If during processing of the final display it proved necessary to place a Doppler rectangle over the centre circle, channel 'A' would cancel fixed clutter within the circle whilst channel 'B' would cancel moving clutter. With no rectangle over the centre circle both channels would cancel fixed clutter. Outside of the circle but within a rectangle both channels will cancel moving clutter.

3. For the first case the final results on the display would be the minimum of clutter from the two channels.

Driver (Delay Line) M1 Fig 3.3

4. Purpose. To modulate two carrier frequencies with bi-polar video so that signals may be passed through the mercury delay cell without distortion.

5. Action. The unit consists of two similar circuits corresponding to the two stages of cancellation. One circuit accepts the 8.19 Mc/s carrier and the other accepts the 6.14 Mc/s carrier. Both circuits accept bi-polar video which amplitude modulates the carriers. In channel 'B' provision is made for the -8μ sec pulse to modulate the 8.19 Mc/s carrier for p.r.f. timing purposes.

6. The bi-polar video from the Demodulator (Coherent) M1 will vary the current through V4 and hence vary the damping of L2 therefore the signals will modulate the 8 Mc/s carrier.

Hybrid Networks M2 and M3 Fig 3.4

7. Purpose. The M3 provides a mixing and matching network for the 8 and 6 Mc/s carriers at the input to the delay cell. The M2 forms a splitting and matching network for the combined 6 and 8 Mc/s carriers at the output of the delay cell.

8. Action. M3. The delay cell present an input capacitance of 100 p.F., the secondary of L1 is tuned to 8.19 Mc/s by C1 and the 100 p.F. capacitance of the delay cell in series with it. L2 (Auto-transformer) is tuned to 6.14 Mc/s by C1 is equal to the capacitance of the delay cell, therefore L1 is tuned by a centre-tapped earth, capacitor.

9. When L1 is tuned correctly terminals 1, 2 and 3 will provide a balanced 8.19 Mc/s output with terminal 2 at earth. The tuning of L1 should give a minimum of 8 Mc/s breakthrough at SK.D., but there will be some. Both L1 and L2 provide a voltage gain of 2 by transformer action, but this is lost in the Hybrid M2. The main functions of the transformers is impedance matching. The action of the hybrid M2 can be considered as the reverse of the M3.

Delay Line (Variable) M1 Fig 3.9

10. Purpose. To compensate for mechanical tolerances in the 4 m.sec delay cell.

11. Action. The delay is adjustable from zero to 0.7 microsecs in 0.1 microsecs steps by 3 switched stages.

Comparator (Signal) M1 Fig.3.5

12. Purpose. To provide the first stage of cancellation.

13. Action. The unit accepts delayed and undelayed amplitude modulated 8 Mc/s carriers which are amplified and detected to produce bi-polar video by two Amplifier Delay Lines M6., mounted as sub units on the main chassis. The detected outputs of the two amplifiers are applied to a differential amplifier which gives a cancelled output. The cathode of the differential amplifier gives an added output which is passed to the Switch Electronic (Clutter) M1. Two outputs are tapped off from the delayed and undelayed inputs of the differential amplifier and fed to the Controller (PRF) M1 via cathode follower stages. The unit also incorporates two a.g.c. circuits for the Amplifier Delay Line M6.

Comparator (Signal) M2

14. Purpose. To provide the second stage of cancellation.

15. Action. The unit accepts the once delayed and twice delayed amplitude modulated 6 Mc/s carrier. The input stage comprises two Amplifier Delay Lines M5's which amplify and detect the carrier. The differential amplifier V2, V3 gives the twice cancelled twice delayed output the unit also gives a once cancelled twice delayed output V6, 7 and 8.

16. A.G.C. for the undelayed amplifier is taken from the cathode of V4, the output stage of the twice cancelled twice delayed differential amplifier, whilst a.g.c. for the delayed amplifier is taken from the cathode of V8.

Switch Electronic Clutter Fig. 3.10

17. Purpose. To discriminate between target and clutter pulses and to produce outputs of clutter pulses only to be fed to the Panel (Area Switching).

18. Action. The unit consists of a two stage amplifier and cathode follower, whose gain can be controlled by RV1. The output of the cathode follower V2A is fed to a long tailed phase splitter, V3 and V4. The anti-phase outputs from the anodes are applied to a full wave bridge rectifier. The unipolar output of the rectifier is divided into two paths, one direct to the coincidence gate and the other via an 18 microsec delay line. Only pulses longer than 18 microsecs will be coincident at the 'And' gate and produce an output which will be fed through the output stage to the Panel (Area Switching). In the output stage there is a stretching circuit to replace the 18 microsecs of each clutter pulse which is lost by the action of the delay line and the coincidence detector. This stretching circuit will replace the 18 microsecs on the lagging edge of the pulse therefore the leading edge is still delayed by 18 microsecs.

19. For angel cancellation the 'Cancel Angel' key on the control suite is operated and on additional circuit is brought into operation which allows pulses spaced 125±25 microsecs or less apart to be passed through the coincidence detector. These pulses are then stretched and passed to the Panel (Area Switching).

Controller (P.R.F) M1 Fig. 3.11

20. Purpose. To control the p.r.f. of the radar type 84 to coincide with the overall delay of the 'fixed' delay cell.

21. Action. As the cancellation system uses a fixed mercury delay cell it is necessary to control the p.r.f. to match the delay time of the cell. A 125 microsecs pulse gates the signal channel allowing a -8 microsec timing pulse to be passed through the cancellation system free of clutter.

22. Delayed and undelayed -8 microsec timing pulses are passed from the Comparator (Signal) M via SKTS U and T on the Controller (PRF) to the grounded grid amplifiers V3A and V3B. The output of each amplifier is fed to the pulse separator V4 which until the arrival of the -125 microsec pulse is held cut off. The -125 microsec pulse changes over the Bi stable pair, releasing the bias from V4, and is returned to its stable condition by the first -8 microsec pulse to arrive at V4, hence the late -8 microsec pulse will not be passed through the circuit. If the p.r.f. is not correctly matched to the delay of the fixed delay cell the first of the -8 microsec pulses to arrive will be passed by V4 via a stretching circuit to the differential amplifier V7, whose output, after integration, provides a d.c. level to the balanced long tailed pair V9. Under normal conditions the inputs to the differential amplifier are equal resulting in no output. When there is an output from the differential amplifier the resulting d.c. to the balanced long tailed pair will cause the circuit to unbalance and a 500 c/s output will be passed via V10, an amplifier, to the motor driving the p.r.f. crystal oscillator. The phase of the 500 c/s is dependent upon which -8 microsec arrives first.

Generator (Reference Signal) M2 Fig. 3.12 and 3.13

23. Purpose. To produce a 500 c/s sinewave phased to a 500 c/s waveform from the Divider Unit M1 (P.R.F. cabinet) to drive two-phase motors for p.r.f. control and doppler rectangle production, also to feed the magslip resolver for doppler frequency control.

24. Action. The somewhat distorted 500 c/s input from the divider unit M1, is fed to V1,a phase shift oscillator, which produces a distortion free 500 c/s oscillation. V1 has two outputs, one to the Controller Motor, M3 and the other to amplifier V2. The output of V2 is fed to V3, a phase splitter, whose antiphase outputs feed V4 and V5 a push-pull amplifier. Two feedback paths are taken from the output stage, one fixed to the phase splitter and one variable via RV1 to the amplifier.

SECTION 11

VIDEO CABINET

LIST OF CONTENTS

SECTION 11

VIDEO CABINET

General Information

1. This cabinet contains the final section of the m.t.i. channel, the p.r.f.d. circuits, the linear channel with provision for reverse swept gain, selection relays for video display and monitoring and the output video amplifiers.

Amplifier (Video Rectifier) M3. Figure 5.3 (4 parts)

2. Purpose. This unit accepts a total of six video inputs (bi-polar) from the two channels in the cancellation cabinet, it then rectifies and combines them via an 'And' gate to form one unipolar output.

3. Action. This unit is part of the m.t.i. channel, it contains six similar circuits, three for each channel, which accept the 1C 1D input from the Comparator (Signal) M1 and the 1C, 2D, 2C, 2D inputs from the Comparator (Signal) M2. These inputs are amplified, limited then full wave rectified to form unipolar video. The three resultant outputs for channel B and the three for channel A are applied to their respective 3 AND gates. The outputs of the 3 AND gates are then applied to a 2 AND gate where the coincident pulses for each channel are passed to form the single output. This 2 AND gate is followed by a noise attenuator because non coincident pulses cause an increase in noise level. The output of the video rectifier is then passed to a p.l.d. circuit.

Comparator Signal (Video) M4 Figure 2.7

4. This unit is the same as that contained in the Log Channel Section 9 para 11.

PRFD

5. This consists of seven units:

   a. Gate, electronic blanking.

   b. Comparator signal (coincidence).

   c. Driver (delay line) M1.

   d. Two hybrid networks.

   e. Variable delay line.

   f. Controller (p.r.f.)

Gate Electronic (Blanking) Figure 5.12

6. Purpose. To blank out any video signals between -125 and 0 µsecs so that a -8 µsecs timing pulse, for delay correction of the variable delay cell, is free from clutter.

7. Action. The unit consists of a flip flop triggered by the -125 µsec pulse and reset by the 0 µsec pulse. The resultant output is used to gate a video clamping circuit which cuts off the video output for the required time period.

Driver (Delay Line) M1. Figure 3.3

8. Identical to that used in the cancellation cabinet section 10 para 4 except that it is only fed with one carrier frequency (8.19 Mc/s)

Hybrid Networks M2 and M3. Figure 3.4

9. These are identical to those used in the cancellation cabinet section 10 para 7, except that in this application they are only used as matching devices.

Variable Delay Cell

10. This is a mercury delay cell designed for a nominal 4 M secs delay, whose delay is varied by a motor adjusted reflecting block at the end of the delay path. Control of this motor is by the action of the -8 µsec timing pulses in the controller, p.r.f. M2.

Controller (PRF) M2 Figure 5.10

11. The circuitry of this unit is identical to the one used in the cancellation cabinet, the only difference is that the modulator stage is fed with a 50 c/s waveform.

Comparator Signal (Coincidence) M3 Figure 5.4

12. Purpose. To compare the delayed and undelayed video and to produce an output for coincident pulses only, thereby rejecting all pulses not locked to the station p.r.f.

13. Action. The inputs to this unit are undelayed video from the Gate Electronic (Blanking) and delayed video from the Hybrid Network M2. The delayed video is first passed to Amplifier Delay Line M6, which is mounted as a sub unit on this chassis.

14. The delayed and undelayed signals are applied to the coincident detector, synchronous pulses being rejected. After the detector the video is passed via a noise attenuator, non synchronous pulses cause a rise in noise level, to the output video amplifier which then passes it to the Relay Assembly M2. The unit also provides a delayed and undelayed output to the Controller (p.r.f.).

Pulse Generator (Switching) M7 Figure 4.7

15. Purpose. To provide a gating pulse for the Generator (Reverse Sweep M8) and for video switch number 3.

16. Action. The rectangular output waveform is derived from the output of a sanatron, this negative going sawtooth is converted into a rectangular waveform by the action of two d.c. amplifiers. The mark to space ratio is governed by the setting of the bias to the first amplifier, whilst the amplitude is limited by the circuit action of the input to the cathode follower output stage.

Generator (Reverse Sweep) M8 Figure 5.7

17. Purpose. To provide a negative going sawtooth waveform for applicatic to the linear i.f. amplifier general. The sawtooth is initiated at a range of 200 N miles and reduces the gain of the i.f. amplifier for the remainder of trace time, so that jamming signals beyond 200 N miles are decreased with the effect that the radar display is provided with a pointer indicating the bearing of the jammer.

18. <u>Action</u>. The input to this unit is a rectangular waveform from the pulse generator, the trailing edge of which is used to control a flip flop, which in turn controls the operation of a miller integrator circuit. The output of the miller circuit is a negative going sawtooth which is applied as a gain control voltage to the linear amplifier. The reverse swept gain output is governed by relay switching controlled by the LIN INJECT key on the control suite.

<u>Amplifier Assembly (Linear) M9. Figure 5.8</u>

19. <u>Purpose</u>. To provide i.f. amplification in the linear channel, also to incorporate the reverse swept gain facility.

20. <u>Action</u>. The amplifier receives unswitched Lin i.f. from the i.f. Switch Unit. The first two stages are manually controlled by RV1 gain control. The next two stages are manually controlled by the reverse swept gain voltage when it is selected by the LIN INJECT key. The final two stages are normal i.f. amplifiers feeding an output to the Demodulator (Linear) M2.

<u>Demodulator (Linear) M2. Figure 2.16</u>

21. This is an identical unit to that previously described for the AJ Channel (IF cabinet).

<u>Switch Electronic (Video) M3. Figure 5.5</u>

22. <u>Purpose</u>. To provide a selected output from two inputs. There are three of these switches each identified by a number.

a. Controls fully processed display.

b. Controls semi processed display.

c. Controls linear injection.

23. <u>Action</u>. Each switch, depending on the settling of SWA provides automatic selection of two video inputs. With SWA in the switched position and a rectangular switching waveform is present, the diode gating circuits will select one of the video inputs and pass it to the output. For manual operation SWA can be placed in the VID 1 or VID 2 position to select either input regardless of the rectangular switching waveform.

<u>Relay Assemblies M2 and M3. Figure 5.6 and 5.9</u>

24. <u>Purpose</u>. These relay assemblies are controlled by the action of the Video Selector Switch and the Monitor Selector Switch on the console suite desk. They provide the routing of the video signals for the final display for Channel 1 and the Monitor console.

25. A full exploration of their action can be found by studying tables 1 and 2.

Note: All relays contained in RL assembly M2 unless otherwise stated.

TABLE ONE: VIDEO SELECTOR SWITCH

Position	Relay Energised	Video Output
One	C	In circle area, fixed m.t.i. Rectangle Area, Doppler m.t.i. Overlapped area, minimum clutter the resultant of Doppler m.t.i. plus fixed m.t.i. Outside of circle and Rectangles LOG + PLD.
Two	B and C	Circle area fixed m.t.i. Remainder of trace LOG + PLD.
Three	A and C	LOG + PLD.
Four	A (M3) A and C (M2)	Linear.
Five	Nil	AJ Linear.

TABLE TWO: MONITOR SELECTOR SWITCH

Position	Relay Energised	Video Output
One	D and E	As selected for channel 1.
Two	E	Linear Video (Limited)
Three	Nil	M.T.I. fixed or with doppler if a rectangle is selected. No PLD.
Four	F	LOG + PLD.
Five	D and F	AJ Linear.
Six	E and F	Fully Prac if ch1 on semi prac Semi " " " " Fully "

Note: PRFD is selected for positions one to four of the Video selector switch for channel 1, and is only selected for the monitor console for position one of the monitor switch.

SECTION 12

DOPPLER CABINET

DOPPLER CABINET

1. General Information. In the Radar Type 84 there are two cancellation channels differing only in the type of cancellation in the centre circle with a rectangle overlapped. The cancellation of moving clutter is effected within three rectangles which are adjustable in size and position. Doppler compensation can be applied to each rectangle according to the wind speed and direction of the particular area. In order to prevent loss of wanted echoes due to blind velocity the doppler compensation may be clutter switched. With clutter switching in operation the whole of the rectangle area is still doppler compensated but it is not switched out to the final display except when a clutter switch is present at video switch number one. Use is made of the fourth blind velocity band to cancel moving clutter and the effect of applying doppler compensation isto move this band along the velocity axis of the response curve. As the aerial rotates the effective radial velocity of the clutter changes according to a cosine law, the doppler frequency must therefore be made to follow this so as to provide continuous cancellation. This is achieved by modulating the doppler by aerial rotation. The response pattern is therefore moved sinusoidally along the velocity axis about a mean position set by the compensation controls.

2. The rotor of the Resolver, Electrical M1 is fed with 500 c/s, from the Generator (Reference Signal) and rotates at aerial speed. The outputs from the stator windings are 500 c/s modulated at aerial speed. These waveforms are then fed to the stators of three magslips on the Control (Wind Speed and Direction) M3 of the control suite. The rotors are set to an angle appropriate to wind direction, the maximum output from the rotors being set by potentiometers setting wind speed.

Production of Doppler Frequency

3. General. Doppler frequency is generated in three independant circuits each controlled by its own wind speed and direction controls, the resultant frequencies are fed to a switching circuit for application to the m.t.i. channel during the presence of a rectangle.

4. Oscillator (Reference) M3 Fig. 4.11. There are four of these units, one used as a fixed oscillator and three as variable oscillators.

5. Purpose.

a. To provide a frequency of 5.251 Mc/s for normal m.t.i. from the fixed oscillator.

b. To provide a frequency of 5.25 ±fd Mc/s for doppler compensation from the three variable oscillators.

6. Action.

a. Fixed Oscillator. The circuit consists of a crystal controlled oscillator of 5.251 Mc/s feeding two outputs, one to panel distribution (Ref freq) M2 and one to the Switch Electronic (Ref freq) M2.

b. Variable Oscillators. These are crystal controlled oscillators with reactsnce valve control over the final output frequency. The reactance valve V2 is controlled by the output of the Control, Electrical Frequency M1 which is a maximum ±-2.5V. The output frequency with no doppler compensation is 5.25 Mc/s via two buffer amplifiers. One output is passed to the Control, Electrical Frequency where it is combined with the frequency of the fixed oscillator to produce a control voltage for the reactance valve to keep the frequency 1 kc/s away from the fixed oscillator frequency compensating for temperature variations. The other output is passed to the Switch, Electronic (Reference Frequency) M4 for selection by the appropriate rectangle.

7. Panel Distribution (Reference Frequency) M2 Fig. 4.12. This unit distributes the frequency of the fixed reference oscillator to the three Control, Electrical Frequency units and to the two frequency mixer stages in the IF cabinet.

Control, Electrical Frequency M1 Fig. 4.14

8. Purpose. This unit provides a control voltage to the reactance valve of its associated reference oscillator, there are three of these units.

9. Action. This unit provides frequency control from five separate inputs. With no doppler compensation two inputs are available, 5.251 Mc/s from the fixed reference oscillator and 5.25 Mc/s from its associated variable oscillator. The two inputs are fed to an additive mixer the output of which is filtered to leave the 1 kc/s difference. This is amplified and squared off and passed to a phase splitter, the output of the phase splitter being differentiated and full wave rectified. The resultant positive spikes are applied to the bias capacitor of a d.c. amplifier. For 1 kc/s difference between fixed and variable frequencies there will be no change in d.c. output. Should the frequency vary the charge on the bias capacitor will vary, thus causing the control voltage output to alter the reactance valve bias to bring the reference frequency to the 1 kc/s difference.

10. The other three inputs are at 500 c/s one amplitude modulated by aerial rotation whose phase and amplitude are controlled by the wind speed and direction controls. The two remaining inputs are fixed amplitude 500 c/s 180° out of phase. These three inputs are applied to a phase sensitive rectifier, the resultant output of which follows the envelope of the modulated 500 c/s. This is applied to the bias capacitor of the d.c. amplifiers to vary the control voltage of the reactance valve.

Rectangle Production

11. General Information. There are three rectangle production circuits, each of which provides a rectangle which is adjustable in position and size. The three rectangles have an order of precedence, this is set up during the switching of the doppler frequency to the mixers and to the production of rectangle outlines for display on the monitor console of the control suite. Rectangle 1 has precedence over rectangles 2 and 3. Rectangle 2 has precedence over rectangle 3. This is explained more fully in the actual units concerned.

Controller, Motor, M3 Fig. 4.6

12. Purpose. To provide a fixed and variable 500 c/s for supply to the two phase motors in the Motor Assemblies M1.

13. Action. The unit receives one 500 c/s input from the generator (Reference Signal) M2 this is amplified and passed to a phase splitter. Another output is taken from the amplifier, further amplified and fed to two output stages, these feed fixed 500 c/s to the Switch Electronic Joystick. The outputs of the phase splitter are fed to two phase modulators the bias for which is derived from the X and Y d.c. voltages from the remote joystick during operational conditions or from the local joystick control RV1 during test conditions. The phase output of the modulators depends on the bias d.c. the resulting output being fed to an output stage to provide phase variable 500 c/s for application to the X and Y motors in the motor assembly. Selection of the remote or local joystick is by the action of SWA. During reset conditions of the motors RLA is energised and feeds a fixed d.c. to the phase modulators.

Switch Electronic (Joystick) M5 Fig. 4.7

14. Purpose. To create dead zones in the joystick so that only a deliberate movement of the joystick (over 6V) will result in movement of the X and Y motors of the motor assemblies.

15. Action. The unit contains two identical circuits one for X control and one for Y. The circuit consists of two Schmitt trigger currents controlling two relays. Under static conditions RLA will be energised and RLB de-energised (or vice versa). The current conditions of the trigger circuits are set such that only an input greater than ±6V will cause them to change their conditions. On reception of a +ve voltage (over 6V) the trigger circuit for RLA will change over causing RLA to de-energise thus completing the path for the fixed 500 cycle supply to the Y motors. A -ve voltage would cause RLB to energise once again completing 500 c/s path to the Y motors. Identical action takes place in the X control circuits. The inputs to the unit are controlled by RLE, which is operated by the push button on the joystick or the reset switches.

Motor Assembly M1 Fig. 4.5

16. Purpose. To produce a d.c. potential for gating the resolved timebase so that a rectangle may be produced of the required size in the required place.

17. Action. There are three motor assemblies, one for each rectangle, each containing four two phase motors, two for X and two for Y direction. Each motor is controlled by its own relay which is in turn controlled by the Move/Size key for the associated rectangle. For rectangle one with the Move/Size key in the Move position, the joystick output more than 6V and the button pressed, RLA would energise and M1 would turn until the joystick push button was released. This would vary RV1 (X Move) and at the same time very the potential at RV2 slider proportionally. This has the effect of moving the X components of the rectangle whilst maintaining the distance between the two components. This action is the same for all 'Move' motors, 'Size' motor varying will not effect the 'Move' d.c. On reset conditions RLE and RLF will energise, X and Y 'Move' motors will turn until they reach a preset level controlled by a cam which is driven from the motor gearbox. On operation of the cams the 'Size' motors will come into operation until they also reach a preset cam operated position; all motor will then remain inoperative until the reset switch is released and a Move or Size operation is carried out.

Pulse Generator (Rectangle) M11 Figs 4.3 and 4.4

18. Purpose. To produce a rectangle output at the required position of trace time. There are three of these units each controlled by its own motor assembly.

19. Action. The inputs to this unit are X and Y resolved timebases, X moves and size d.c., Y move and size d.c. There are four initial circuits each identical. The move and size d.c.'s are fed in and are then made available through relay switching for the intertrace circuits. The d.c. is also applied to a gating circuit supplied with the resolved timebase. The resultant output of the gate circuit is then amplified and squared. The resultant waveforms for the move and size are then combined and fed to an 'AND' gate. This 'AND' gate receives the resultant waveforms for the X and Y components. Coincident waveforms are then amplified, limited and passed to the Panel (Area Switching) M1.

Panel (Area Switching) M1 Fig. 4.9

20. Purpose. To provide precedence of the rectangles for outline display during trace time. Also to provide the switching waveforms for rectangle and circle area for Video Switch 1 incorporating clutter switching when required.

21. Action. This unit is controlled by the Local/Users keys and the Clutter switches, which govern the relay operation in the unit.

LOCAL POS.

22. Relays D, E and F will energise according to which 'Local' key is operated. The three rectangle inputs are then fed through their input circuits which set up precedence for the marker generator circuit, due to built in attenuators. If rectangle one is present rectangles 2 and 3 will have no effect, if rectangle 2 is present rectangle 3 will have no effect. The marker generator circuit will then produce +ve going pips for the leading and lagging edges of the rectangles. The switching waveform generator will not receive rectangle inputs so will only produce the centre circle waveform for video switch No. 1.

23. Users Position. Relays A, B, C, D, E and F will energise, the action of the marker generator will be as for local operation; relays G, H, J and K will be energised with clutter switches in the off position. This causes the rectangles and circle to be fed to the switching waveform generator which produces a switching pulse for video switch No. 1 delay on the inputs by 26us. This is to compensate for the delay undergone in the video circuits.

24. Clutter Switches. With clutter switches operated relays G, H, J and K will de-energise and clutter waveforms will be fed to the switching generator with the rectangle and circle waveforms, the resultant output is a rectangle or circle chopped up by the clutter waveforms.

25. Pulse Generator (Switching) M7 Fig. 4.8. This unit produces the centre circle and is identical in operation to that used in the video cabinet for linear injection.

Switch Electronic (Reference Frequency) M4 Fig. 4.7

26. Purpose. There are two of these units one for rectangle switching and one for circle switching. They are used for routing the fixed or doppler frequencies to the two mixer circuits.

27. Action. Rectangle Switching. This unit receives the three rectangle switching waveforms from the Panel (Area Switching), and feeds them to three diode switching circuits. When rectangle one is present rectangles 2 and 3 will have no effect on the output which will be the doppler frequency to the mixer. Rectangle 2 will take precedence over rectangle 3. With no rectangles present fixed frequency will be routed to the mixers.

28. Circle Switching. This unit receives the circle waveform from the Panel (Area Switching) and during circle time routes fixed frequency to the mixer for channel 'A'. With no circle the unit will pass the output of the rectangle switch to the mixer of channel 'A'.

<u>PRF CABINET</u>

SECTION 13

PRF CABINET

Comprehensive Station Timing

1. The T84 forms part of a comprehensive station with a common p.r.f. and in view of the T84 requirements the triggering pulses for the station are generated centrally in the signal processing racks of the Type 84. The timing relationship of the pulses are determined from a selected pulse designated 0 µsecs and all pulses selected before this time are prefixed with a negative sign i.e. -8 µsecs: this is a pulse occurring 8 µsecs before the 0 µsec pulse and not a negative going pulse of 8 µsecs.

2. In order to ensure a minimum of interference between the radars on a comprehensive station the triggering to the transmitters has been time staggered Only one range timebase has been generated for all the radars on the same p.r.f. and the trigger for this has been derived from the 0 µsec pulse, after a variable delay of 26-36 µsecs. This delay is to compensate for the 26 µsec delay undergone by the video in the signal processing racks, and ensure that the timebase initiation coincides with the start of the T84 video. Thus the monitor consoles in the R12 building are aligned with respect to video and time-base, and the operators consoles in the R3 building will be similarly aligned as both video and timebase triggers will undergo the same cable delay to the R3 building.

3. The other radars in the comprehensive station have their video adjusted by variable delays to ensure alignment both at the R12 and R3 building with the same trigger timebase. The radar T85 transmitter for example, is triggered a considerable time before the T84 (-750 µsec pulse) to take account of the long delays encountered between the LO trigger and the firing of the last T85 transmitter. The variable delay (110 µsec ±10 µsec) is adjusted to ensure coincidence of the video and common timebase trigger.

4. The complete triggering arrangement for a comprehensive station is all tied in with the variable delay units of the p.r.f. cabinet. The -8 µsec pulse from signal processing equipment is passed to the radar head, which may be up to 1000 yds from the R12 building. The cable delay involved in the transit of the -8 µsec pulse to the radar head is T1. On reception of this pulse the transmitter fires (after a further delay of 8 µsec) at time after the arbitrary time 0. The i.f. signal returns from the head are delayed by T1 in their return to the R12 building and arrive at time 2T1. The signal processing delays, which are mainly caused by clutter switching, are of the order of 26 µsecs and the video is passed to the monitoring consoles at the time 2T1 + 26 µsecs. The timebase trigger is initiated from the 0 µsec pulse and is passed through a variable 26-36 µs delay, which enables coincidence to be achieved between the timebase trigger and the video.

Production of Triggering Pulses.

5. The T84 p.r.f. generator consists of a crystal oscillator operating at approximately 4 Mc/s, a series of frequency dividers and circuits which add certain harmonics of the 4 Mc/s to produce the trigger pulses required for the T84 at a normal p.r.f. of 250 p.p.s.

6. The frequency of the crystal oscillator is controlled by a two phase motor driven condenser, the motor being controlled by a time error detector. This compares a pulse generated at -8 µsec with one generated at -8 µs in the previous pulse period, the pulse having been passed through the fixed length mercury cell used in the m.t.i. equipment. Hence the p.r.f. is automatically adjusted to equal the delay time of the mercury delay cell.

7. An identical cabinet of p.r.f. equipment is provided to give standby facilities and a change over switch is provided so that 'Main' or 'Standby' outputs may be used. The changeover switch is remotely controlled from the T84 control panel in the R12 building or locally at relay assembly M1.

8. On each trigger output there is a lamp indication to indicate a fault or complete loss of the trigger. These lamps are displayed on the trigger panel of the T84 control panel.

Production of Statmon Trigger

9. The production of the comprehensive station triggers is taken from four basic pulses (0. -125 -500 and -750 μs) which are fed from the timing circuits via a cathode follower unit to four sweep generators. These produce a negativ going sawtooth approximately 180 μs wide, for application in the case of the 0 as pulse of up to four pulse generators. An output is produced from each puls generator at any time from 5 to 170 μs after the start of the sawtooth. These pulses are fed to the changeover unit, relay assembly M1.

Oscillator Crystal M2. Figure 6.5

10. Purpose. To produce a frequency of approximately 4 Mc/s which is dependent on the delay time of the fixed Mercury delay cell.

Action

11. V1 is a crystal oscillator at 4.096 Mc/s the frequency of which is variabl and is controlled by a motor driven condenser. The output of V1 is fed via amplifier V3 to a divide by two stage V7 whose output is fed via amplifier V10 to the divider unit M1. The unit also incorporates two independent push-pull oscillators V4 and V8, 8.19 Mc/s and 6.14 Mc/s respectively, to provide the two carrier frequencies used in the cancellation system.

12. The divde by two stage in the crystal oscillator and those in the divider unit have similar actions, except that in the case of the crystal oscillator the output of the divider stage is grid coupled to the following stage and the anode is decoupled, where as in the divider unit the outputs from the dividers are taken from the cathodes, hence no decoupling is necessary.

13. Consider the circuit 'working', the input to V7A grid is an oscillation at 4 Mc/s and V7B grid is tuned to oscillate at 2 Mc/s. When L8 wavefrom is positive going, V7A is cut off, when the waveform at L8 is negative going and the grid of V7A is falling, the falling voltage is passed by cathode follower actior to L8, hence there is positive feedback to maintain oscillation. It can be seen that energy is passed to the divided tuned circuit every other full cycle of the input oscillations when V7A is conducting. This action, using relative input and output frequencies may be applied to the divide by two stages in the divider unit M1. The dividers give no output for no input.

Divider Unit M1. Figure 6.6 and 6.7

14. Purpose. The divider unit is designed to give several outputs, delivering pulses at a precise rate which are accurately related in time to each other. The unit is driven by a stable frequency (2.048 Mc/s) which is not aggected by spurious pulses, the ageing of the valves or temperature changes.

15. Action. The sine waves are divided down in stages of two to 250 c/s (13 divider stages). By feeding selector sine waves into an 'And' gate, pulses at p.r.f. 250 and duration about 4 μs are obtained at arbitrary time 0 μsec. If selected sine waves are suitably phase shifted before feeding into the 'And' gate, pulses of the same duration and p.r.f. result, but at some other time othe than 0 μs. These pulses are very free from jitter and the p.r.f. is very closely controlled.

Gate Electronic M1. Figure 6.8

16. Purpose. This is a continuation from the divider unit and produces outputs of the required width.

17. Action. This unit contains the 'And' gates not in the divider unit, with grounded grid amplifiers feeding the inputs to the gates and cathode follower outputs to the Cathode Follower unit M1.

Cathode Follower Unit M1 Figure 6.9

18. Purpose. To provide cathode follower outputs for distribution of the various timing pulses.

19. Action. The following valves are used as cathode followers within the unit:

a. CV 4039s. These are intended to feed medium lengths of coaxial cable, terminated in 75 ohms. The valves are driven into very heavy grid current.

b. CV 4024s. The outputs from one half of these valves are intended to be fed into short lengths of coaxial cable terminated in 220 ohms.

c. CV 4018. This valve is V32 and is a thyratron. It is normally held cut off by negative bias. The -9 μs pulse from the gating unit causes the valve to conduct, which enables the charged capacitors in its anode circuit to discharge through the valve into the output cable at SKB2. This output is used for long lengths of coaxial line (up to 1 mile) terminated in 75 ohms.

Relay Assembly M1

20. Purpose. To switch out the trigger pulses from the 'Main' or 'Standby' p.r.f. cabinets as selected by the changeover switch. It also provides trigger presence circuits and fault indication circuits.

21. Action. The changeover from 'Main' to 'Standby' p.r.f. cabinet is operated by ganged switches controlled by Ledex motors. The changeover switch which actuates the Ledex motors is on the trigger panel in the control suite or locally by switch C.

Generator Sweep M4 Figure 6.10

22. Purpose. There are four of these units each producing a sawtooth waveform for feeding to their associated pulse generators.

23. Action. The input pulse initiates a Miller transitron circuit which produces a sawtooth of up to 180 μsecs in duration.

Pulse Generator M6 Figure 6.11

24. Purpose. There are nine of these units and they produce a variable delayed pulse from a sawtooth input obtained from an associated Sweep Generator.

25. Action. The miller waveform from the Generator Sweep M4 is fed to V1A, a cathode follower, a portion of this waveform is passed by diode V1B to amplifier V2. The portion of the miller waveform passed by V1B may be varied by RV1 (set display). The amplified squared output from V2 is differentiated and passed to a thyratron whose output will be a positive going 4 μs, 35 V pulse fed via Relay assembly M1 to trigger its associated equipment.

SECTION 14

CONTROL POSITION CONTROL DESKS

LIST OF CONTENTS

SECTION 14

CONTROL POSITION CONTROL DESKS

Control Positions

1. Function.

a. Remote control of the transmitter and signal processing.

b. Assess the serviceability of the radar.

c. Technical operation of the radar.

Equipment

2. a. Console Suite. To assess serviceability and for technical operation.

b. Rack Electrical consisting of:

(1) Panel indicator (Mimic Diagram).

(2) Panel Trigger, remote operation of the transmitter and fault indication to frame level for all cabinets.

(3) Panel Area turning. Remote control of the aerial turning.

Console Suite

3. Comprises three T64 consoles; console 1 displays the output of channel 1. Console 2 is the monitor console for processing and checking serviceably. Console 3 displays raw video, but may be used in place of console 2 on operation of the emergency changeover switch.

Control Desks

4. Console 3. Clutter switches for the three rectangles and the centre circle.

5. Console 2.

a. Video Mark Key. To display the circle marker and rectangle outlines on operation of the local/users key.

b. Anti Jam Key. This changes over from the Linear i.f. to the AJ i.f.

c. Linear Injection Key. This injects Lin i.f. with reverse swept gain over 200 N miles.

d. Rectangle Reset Keys (3) these reset the rectangles to a predetermined position on the display at a predetermined size.

e. MOVE/SIZE Keys, one for each rectangle, only one rectangle can be moved or sized at a time, precedence again for rectangle 1.

f. Local/Users. These keys allow doppler compensation on the monitor console only (Local) or channel one and monitor console (users).

g. Cancel Angles, this key operates a relay in the switch electronic clutter to enable m.t.i. to be applied to angels.

h. Joystick push button. When this button is pressed the rectangles will move or size according to the position of the move/size keys and the position of the joystick.

j. Channel Selector Switch controls the output for channel one.

k. Monitor Selector Switch controls the display on console 2.

Console One

6. a. Swept Gain a four position switch controlling the amount of swept gain applied to the limiter electrical noise and the generator sweep video.

b. Blind Velocity, a three position switch controlling the blind velocity gaps 9, 13 or 19 knots.

c. Check Noise Factor a remote control of the noise monitor circuits giving a good or poor lamp indication.

d. Circular Polarisation operates the polarisers on the horn stack, with lamp indication of linear or circular.

e. Emergency C/O Key changes the function of consoles 2 and 3.

SECTION 15

OPERATING TECHNIQUES

SECTION 15

OPERATING TECHNIQUES

Introduction

1. This section gives a suggested method of operating the processing facilities of the T84. The rules, where they are given, are not intended to be mandatory but to act as a guide.

Policy

2. The guiding policy should be to maintain maximum target response whilst eliminating unwanted clutter. Always use the minimum amount of processing required to eliminate clutter.

Guiding Notes

3. Rain, Cloud and Window Processing.

   a. Circular Polarisation: very good against rain and some cloud.

   b. Log + PLD: good against rain and cloud, no good against window.

   c. Doppler Compensated m.t.i.: very good against all three types of clutter.

Small Area of Rain and Cloud

4. Log + PLD.

Small Areas of Rain and Cloud (Painting Strongly)

5. Doppler compensated m.t.i. keeping rectangles as small as possible and using clutter switching.

Angels

6. a. Swept gain (lowest position possible).

   b. Doppler compensated m.t.i. using clutter switching incorporating angel cancellation.

SECTION 16

POWER SUPPLIES

SECTION 16

PO'ER SUPPLIES

Regulator Voltage (-250V) M4

1. Purpose. The purpose of the regulator unit is to produce a -250V regulated supply from a -425V input. Two of these units are used in the signal processing equipment, one being located in each of the main and standby p.r.f. cabinets. The unit provides the -250V supply for the units in the particular p.r.f. cabinet, it also provides the reference voltage for the +250V regulators in that cabinet.

2. Fault Indication. In the regulator unit the -250V output and the +450V, -425V and -625V d.c. inputs act directly or indirectly as hold voltages for two relays which will be de-energised for any failure of the supplies. The circuits of two fault lamps are closed to give indication of failure of the -250V supply; the 6.3V a.c. supply is disconnected from the +250V regulators to prevent illumination of the fault lamp on these regulators and h.t. supplies are disconnected from the regulator.

Regulator Voltage (-250V) M3

3. Purpose. The purpose of this unit is to produce a -250V regulated supply from a -425V input. Two of these units are used in the power supply cabinet. The upper of the two provides the -250V supply and the reference voltage for the +250V regulators in the Cancellation and i.f. cabinets, whilst the lower provides similar supplies for the doppler and video cabinets.

4. Fault Indication. In the regulator the -250V outputs and the +450V, and -625V inputs act directly or indirectly as hold voltages for the fault relays. These relays are de-energised under fault conditions. Each regulator circuit has an associated fault lamp which is illuminated under fault conditions via contacts of the fault relays. In addition the cabinet fault lamp is also controlled by these relays and 6.3V a.c. is routed from the lamp holder assembly via further contacts to provide a supply for fault indication on the +250V regulators in the cancellation, IF Doppler and Video cabinets.

Power Supply M1

5. Purpose. The purpose of the unit is to provide +250V and -250V for the demodulator Linear M2 in the anti jamming channel. This ensures that in the event of a failure of the signal processing system some form of radar display is available to the operators.

6. Fault Location. A relay is included in each output to provide fault indication facilities. In addition the relay in the -250V output controls the +250V output.

Lamp Holder Assembly (Power Supply Cabinet)

7. **Purpose.** To distribute and provide fusing facilities for the +450V and -50V outputs from the bulk power supplies. Is also provides 6.3V a.c. for the cabinet fault lamps, power cabinet -50V fault lamp and the fault lamps for the +250V regulators in the cabinets.

8. Fault Indications. A realy connected across the -50V input provides facilities for -50V fault indication and also controls the 6.3V fault lamp supply to the -250V regulators.

SECTION 17

"NO BREAK" TRIGGER SYSTEM

CONTENTS

LIST OF ILLUSTRATIONS