Training Note

FIXED COIL EQUIPMENT
(CAT III)
PART 1

This training note is issued for the guidance of students 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.

AC. A. Rose.

TRAINEE NOTE

FIXED COIL EQUIPMENTS (CAT III)

PART I

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DIAGRAMS CONTAINED IN THIS NOTE

THE FIXED COIL PPI SYSTEM

Introduction

1. Purpose

a. To provide PPI displays with a high degree of accuracy, linearity and stability on ground radar stations.

b. To be flexible in its application to the various types of station, and to dovetail with other equipments.

c. To be reliable in operation and convenient to service.

2. General. To facilitate the above, a minimum of equipment is located in the consoles, the majority being housed in racks remote from the operating cabins. Consoles and other units are duplicated, with provision for rapid change-over.

Principles of Operation

3. Deflection. The deflection system consists of two pairs of coils, fixed in relation to the c.r.t. neck, and at right angles to one another. Current in one pair of coils produces deflection in the X axis, whilst current in the other pair produces deflection in the Y axis. Direction and amount of deflection are proportional to direction and magnitude of current.

4. Rotation of Trace. To obtain trace rotation in synchronism with the aerial system, two sawtooth currents are fed simultaneously to the X and Y deflection coils. That fed to the X coils is caused to vary in amplitude and polarity as the sine of the angle of aerial rotation, whilst that fed to the Y coils is caused to vary as the cosine of that angle. Each trace is thus the resultant of two forces in quadrature, the trace angle depending on the relative magnitude and the direction of these forces. (refer Fig 2)

5. Resolving. The production of the two timebase components, the sine and cosine waveforms, derived from a linear sawtooth of voltage of constant amplitude called the master-time base. The resolver is rotated electro-mechanically in synchronism with the aerial rotating system.

6. Intertrace Display. During the time interval between traces, by using suitable deflection currents the spot may be deflected to any position on the screen, there to provide an ancillary display known as the intertrace display. This would be impossible with a rotating coil system, as such a system permits deflection to take place only in a direction at right-angles to the coil axis.

7. Types of Intertrace Display. The display most commonly used in the Azication Marker, a short trace used to indicate the heading of an associated height finding aerial system. The range at which this marker appears is variable. Alternatively, a 'strobe marker' or 'ring strobe marker' may be used. (Refer Figs 3, 4 and 5)

In all cases the deflection waveforms (sawtooth, d.c. or sinewave) occur during the intertrace period and are combined with a 'd.c. ranging voltage' and fed to a resolver driven by the rotable height-finding aerial. From this resolver are taken the sine and cosine components (ie the amplitudes) and d.c. levels of the outputs varying as the sine and cosine of the angle of rotation of the height-finding aerial).

8. Gating. During the intertrace period, all radar scan inputs (deflection and video) are gated out and intertrace deflection waveforms and intertrace bright up (ITBU) fed to the c.r.t.

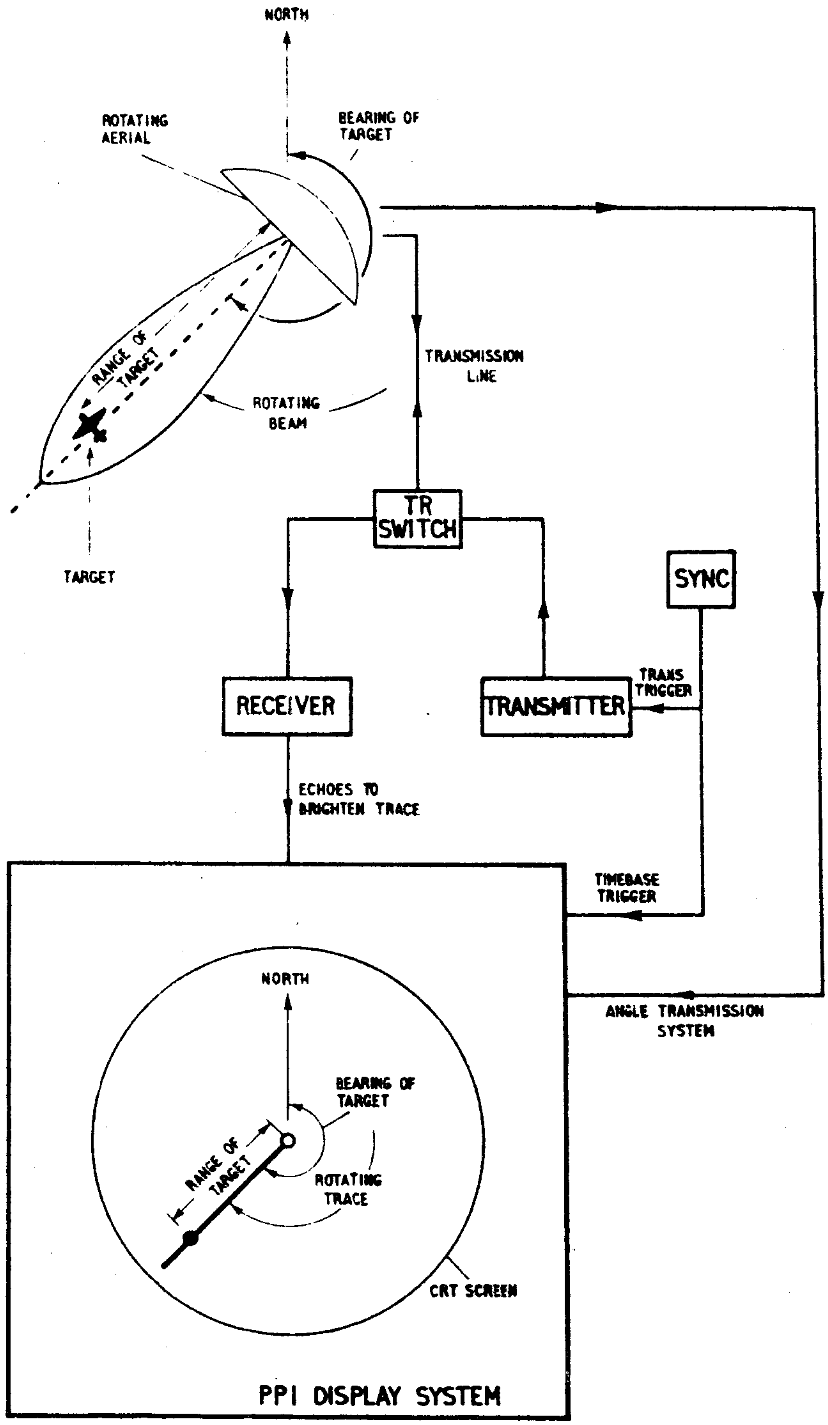


Fig 1 OVERALL SCHEMATIC

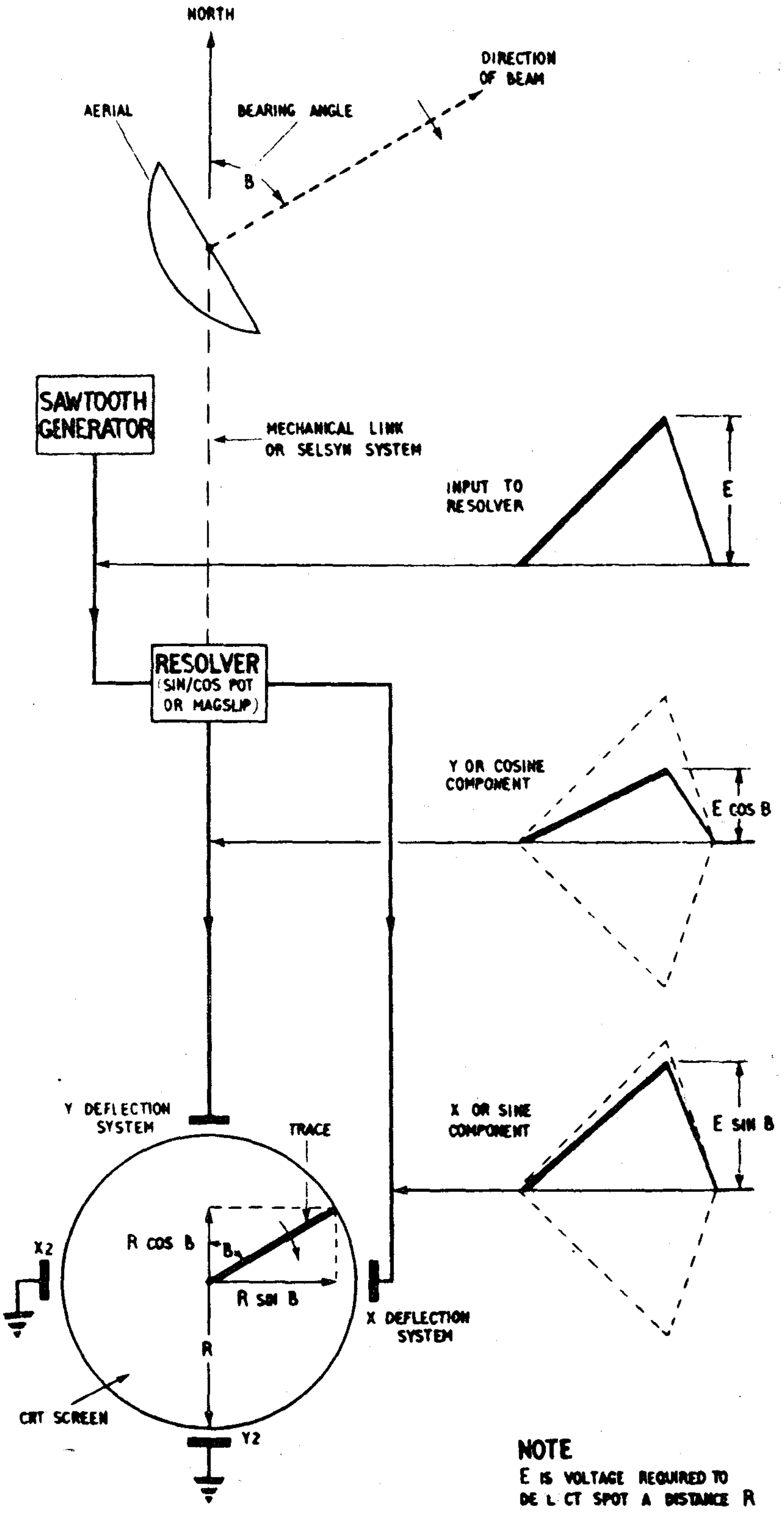


Fig 2 ELECTRONIC TRACE RO TION

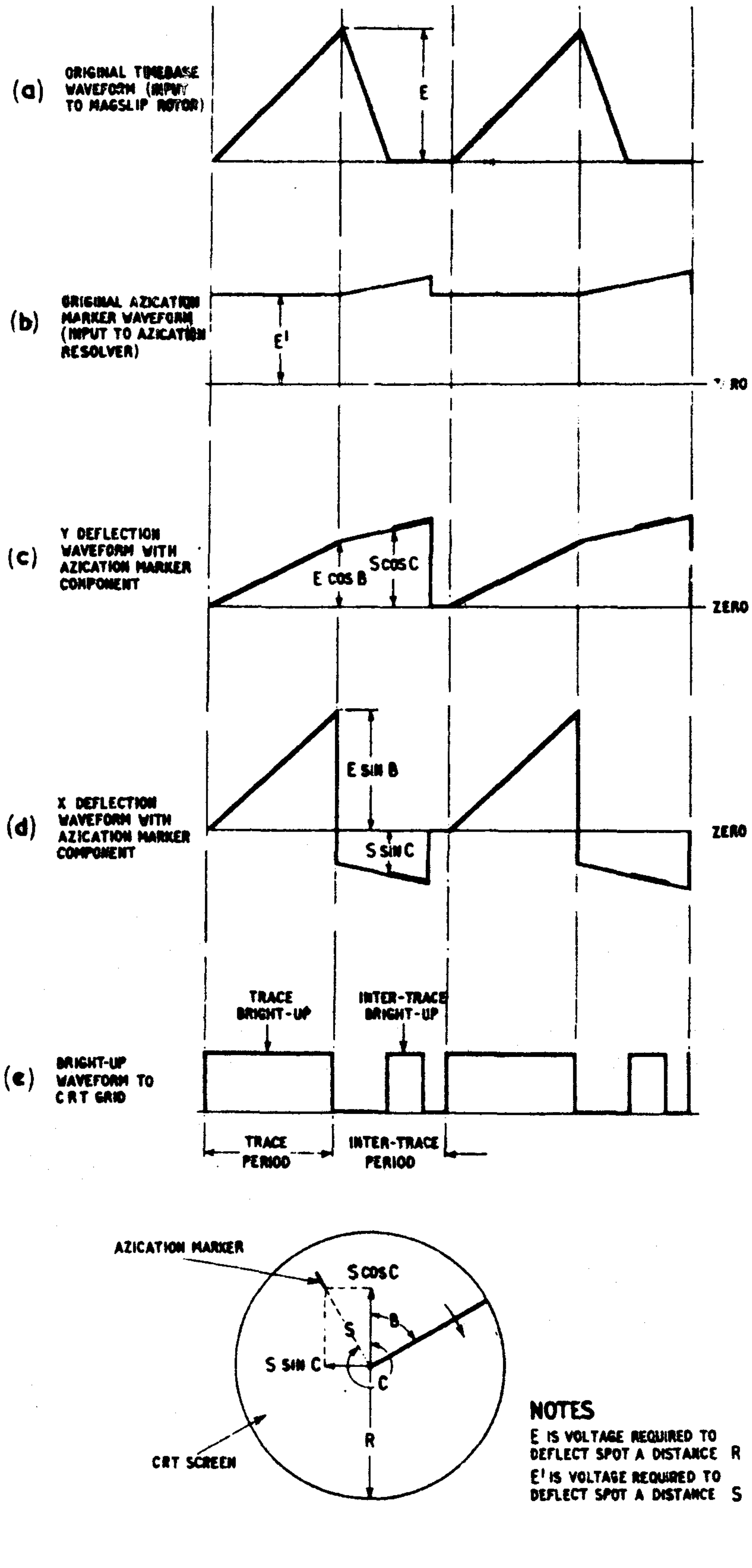


Fig 3 FIXED COIL-AZICATION MARKER

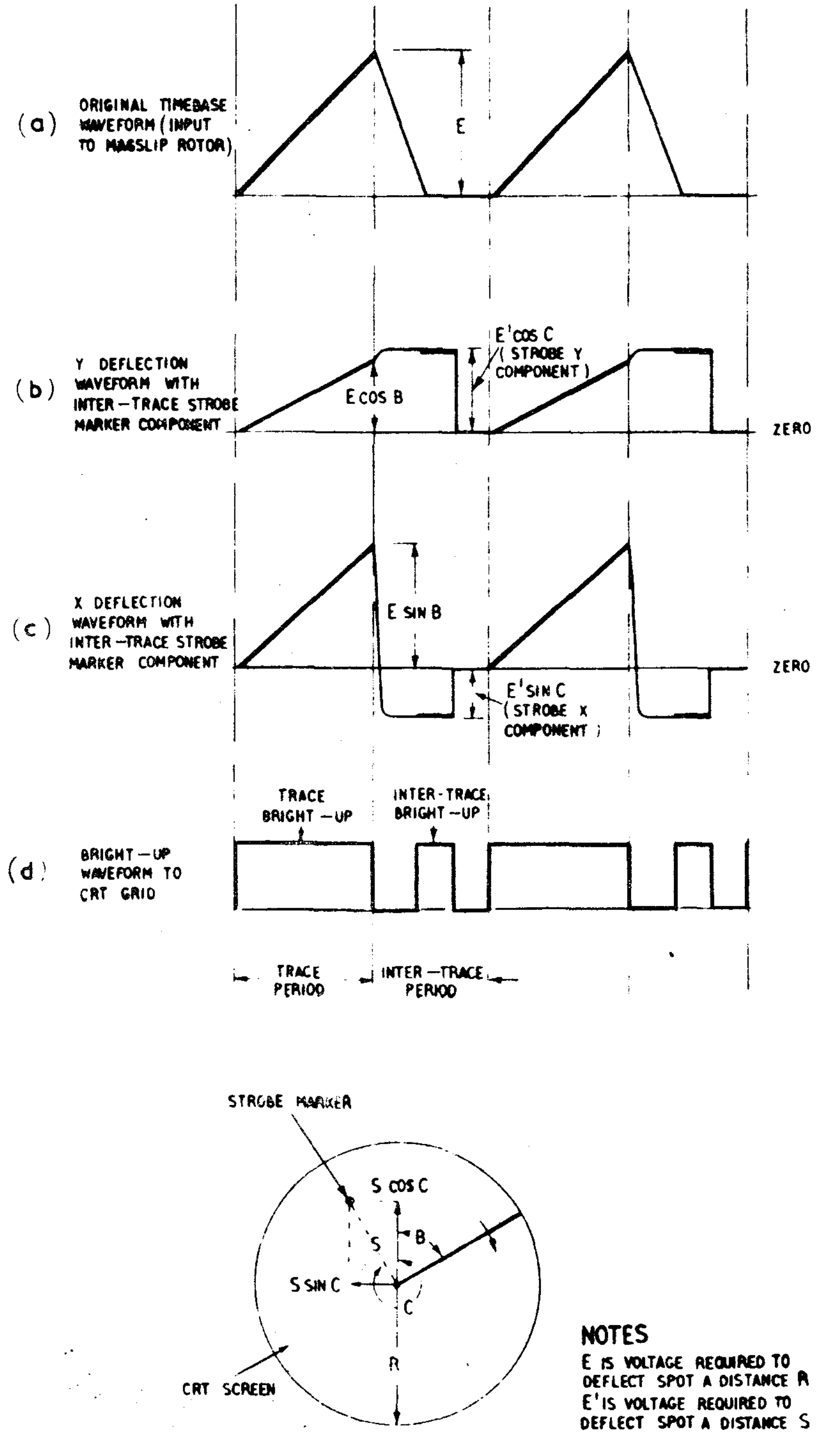


Fig 4 FIXED COIL-INTER-TRACE STROBE MARKER

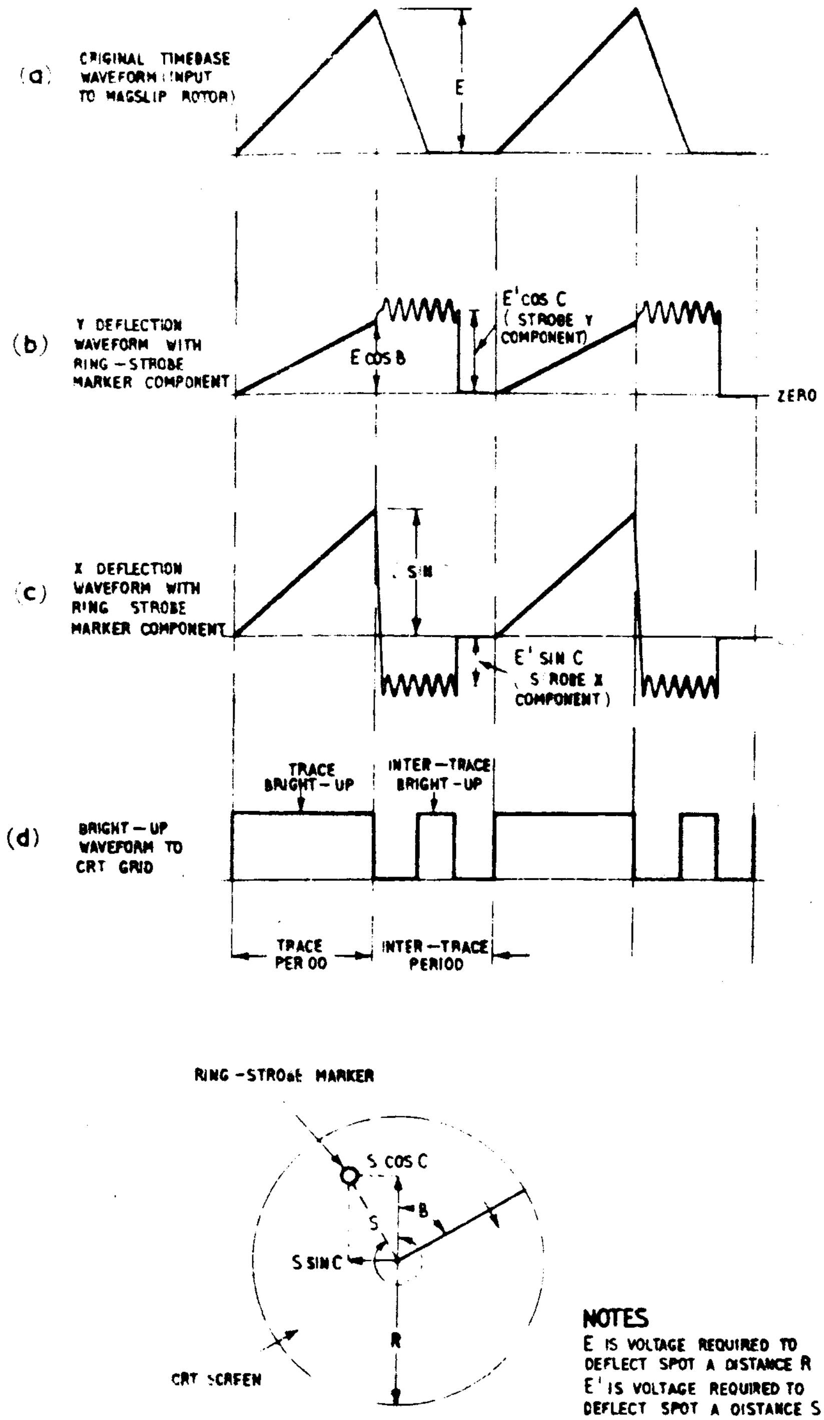


Fig 5 RING-STROBE MARKER

9. Video. All video (sigs, cal, IFF etc) come from the IG rack via the HSU to the console and are fed to the grid of the c.r.t.

10. Trace Expansion. Four degrees of display expansion are obtained by changing the timebase velocity. On expansion, only part of the display appears on the screen, but any portion may be shown by off-centring.

11. Blanking. That portion of the display beyond the limits of the c.r.t. screen is blanked off.

12. Accuracy. Obtained by extensive use of direct-coupled amplifiers with a high degree of negative feedback to maintain accurate wave shape.

13. Stability. HT supplies are highly stabilised, and other precautions taken to minimise d.c. level drift.

14. Details of Equipment

a. Units employed:- Console Type 64 and rack assemblies Type 300; 301; 302; 304, 305; 306; 338.

b. Can be used with transmitters operating at 250 or 500 p.r.f.

c. Maximum Range:- 240 nautical miles (250 p.r.f.)
120 nautical miles (500 p.r.f.)

d. Up to 36 consoles can be fed from one head.

e. Test Equipment:- Rack assembly (Monitor Type 339)
Test oscillator Type 101
Multimeter Type 100.

15. Resolvers. Used to produce the two timebase deflection components, one varying in amplitude and polarity as the sine of the angle of aerial rotation whilst the other varies as the cosine of that angle.

There are two types of resolver:

a. The magslip.

b. The sine/cos potentiometer.

Each has a rotating part which is selsyn driven so that it revolves in synchronism with the aerial.

16. The magslip. Bascially a rotor coil and two fixed coils.

The two stators, known as X stator and Y stator have their axies at right angles to each other. (Fig 6(a)).

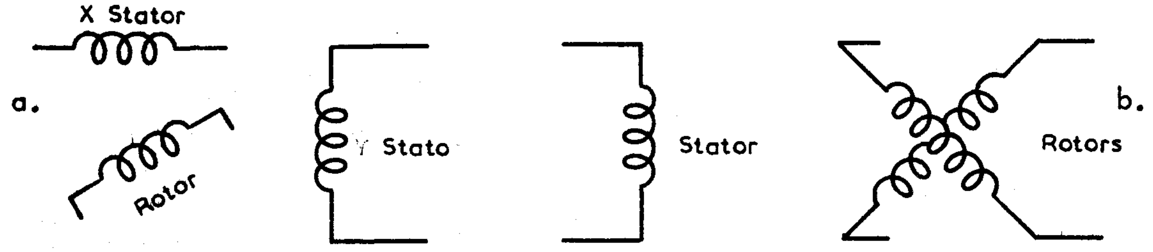


Fig 6 THE MAGSLIP

Alternatively the design can be changed so that there is one stator and two rotors, the two rotor windings being at right angles. (Fig 6(b))

In the first case the input is applied to the rotor, the sine component taken from X stator, and the cosine component from the Y stator.

In the second case the input is applied to the stator whilst the outputs are taken from the rotors.

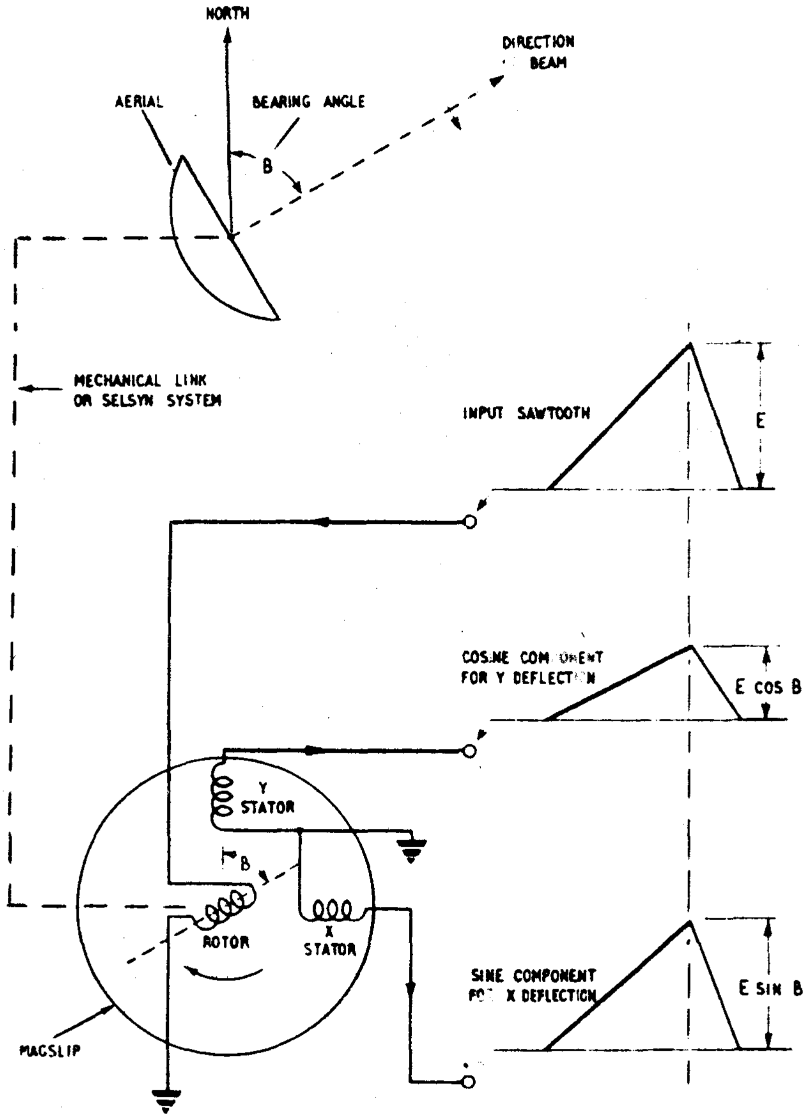


Fig 7 FIXED COIL-MAGSLIP RESOLVER

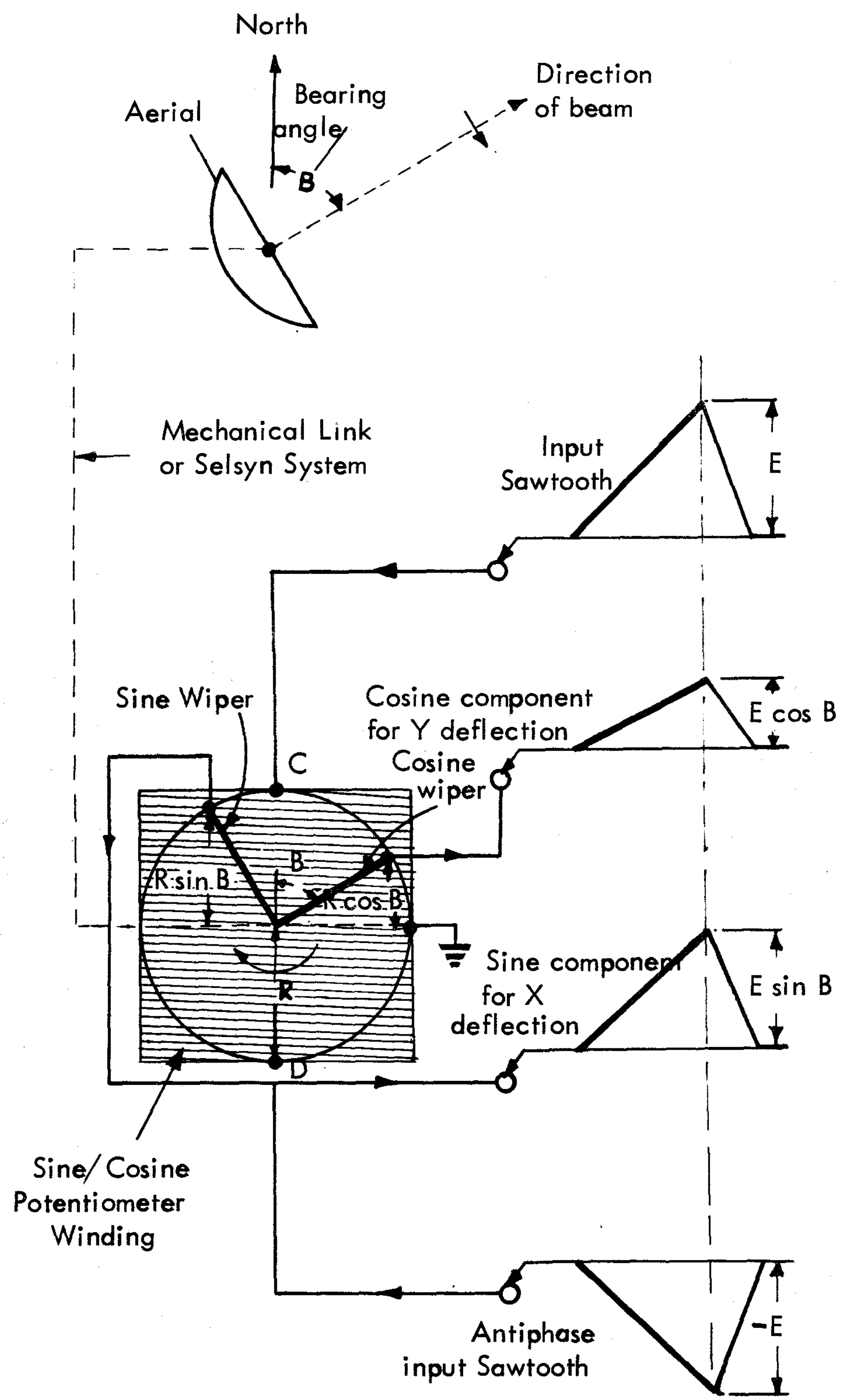


FIG 8 FIXED COIL-SINE/COS POT RESOLVER

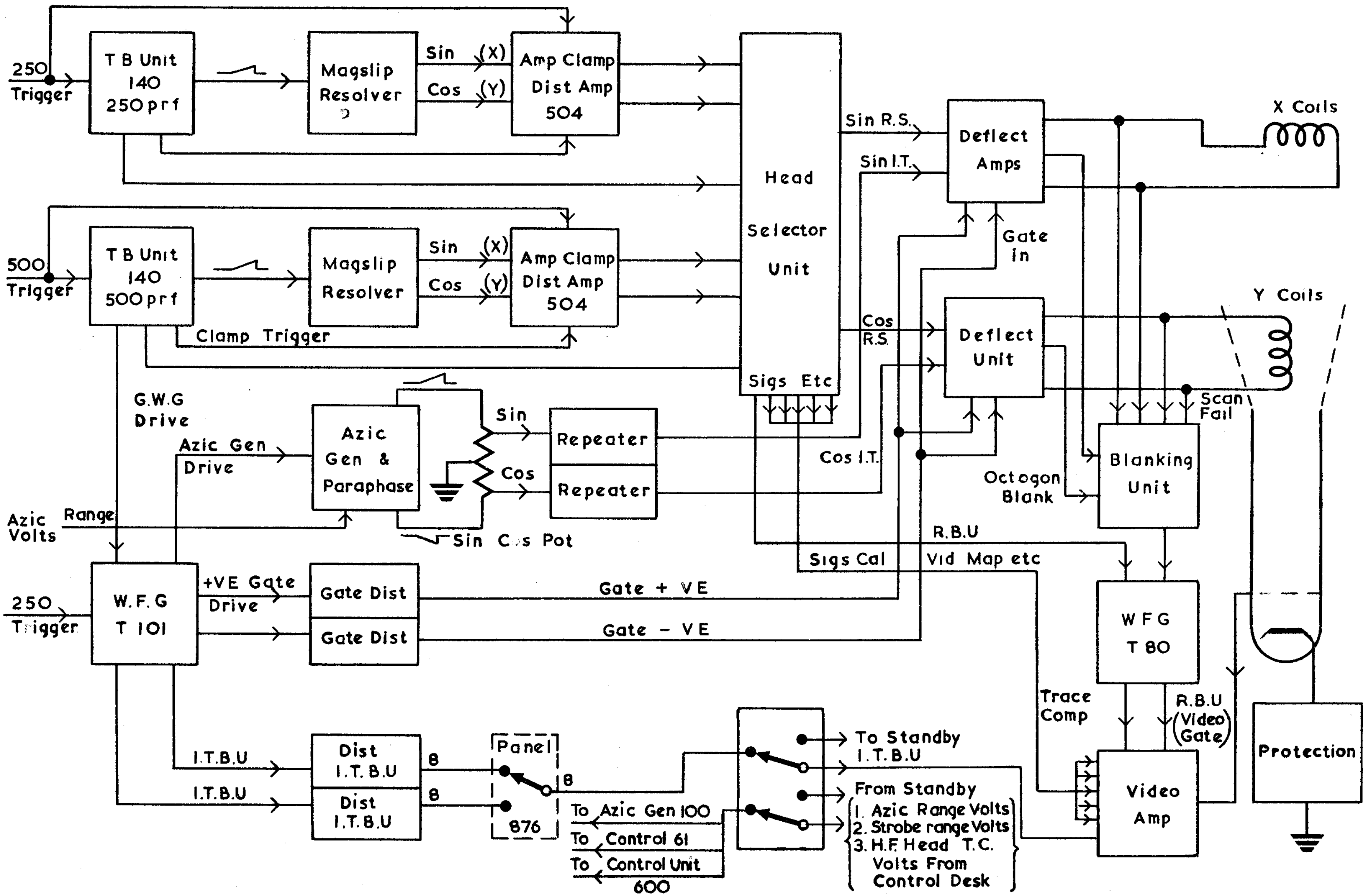


Fig 9 FIXED COIL BLOCK DIAGRAM

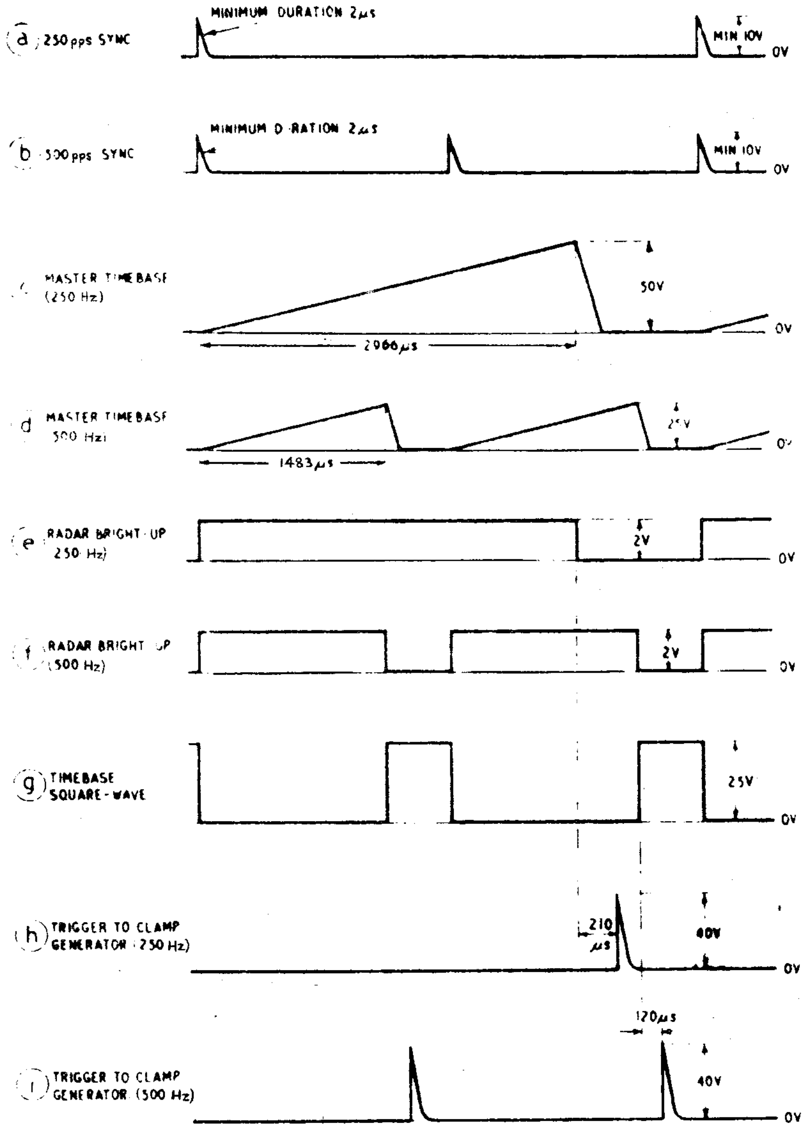


Fig 10 PRINCIPAL WAVEFORMS, 1

17. Advantage. Smooth and continuous rotation, wear being confined to bearings and brushes. The input is a single waveform.

Disadvantage. Due to combined inductance and resistance it is difficult to keep the sawtooth voltage waveforms linear. As it is an a.c. coupling, d.c. levels are lost.

18. The Sine/Cos Potentiometer. (Ref Fig 7) Bascially a wire wound potentiometer on a square frame with the centre tap of the winding earthed.

The sawtooth to be resolved is applied in push-pull to opposite ends of the winding.

Two wiper arms at right angles and insulated from each other, revolve in synchronism with the aerial.

The outputs are taken between earth and the wiper arms, so that they are proportional to the width of winding and the centre tap.

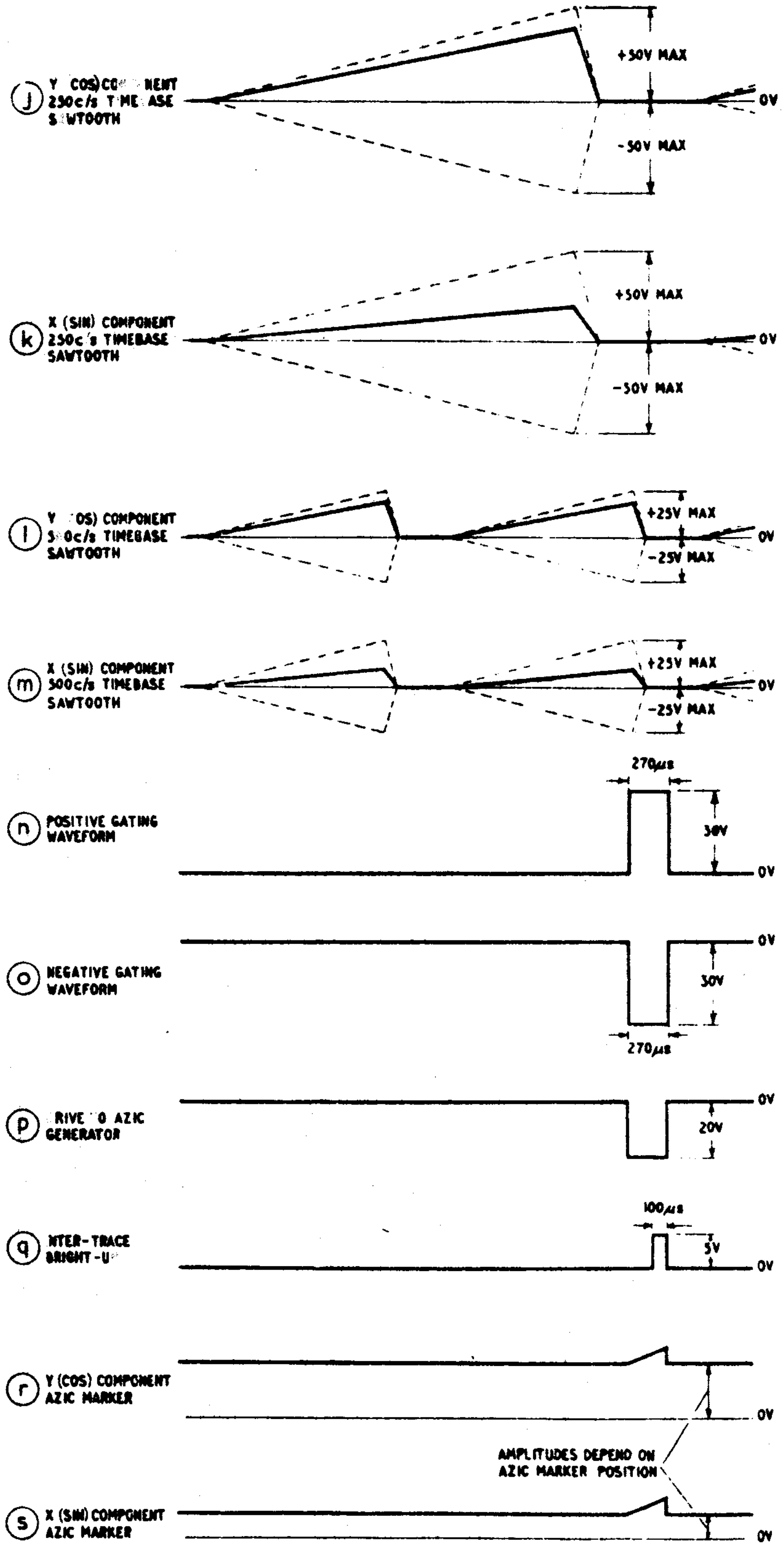


Fig 11 PRINCIPAL WAVEFORMS, 2

1. Purpose. Provides a minus 500V reference supply for maintaining the calibration accuracy of all fixed coil units. All other circuits being referred to -500V. Special circuits are incorporated to reduce the risk of failure and maintain full operation by automatic change over to a duplicate or standby unit if faults occur.

2. Rack Contents. The rack assembly contains the following units.

a. Power unit (Reference) - T906. Supplies a very stable, ripple free -500V. This unit is duplicated, one being standby.

b. Relay unit (Changeover) - T 186. Switches from main to standby if the main unit fails or stabilization is faulty.

c. Relay unit - T185. A separate switched and fused output line to each fixed coil unit. Switching is done from the unit using the reference supply.

3. Power unit (Reference) - T906. The primary circuit is dealt with fully in para 7. FS4 and FS5 are thermal switches mounted on the transformer so that if overload occurs they operate and break the input circuit. V1 and V2 form a full wave rectifier circuit with smoothing by L1 C14, C1 L2 and C2. The parallel combination L1 C14 form a rejector circuit at 100 Hz (2 x f_{in}) to improve elimination of ripple.

a. Stabilization circuit. Three tetrode valves V3, V4, V5 are connected as triodes and paralleled to pass a current of 350 mA. The conduction of these power valves is determined by the control amplifiers V6, V8. V8 a grid is held by V7 at +83V w.r.t. -500V. V8b grid is set by RV1 the VOLTAGE SET -500V control, fed from the -500V output line. To explain stabilizing action assume the output changes from -500V to -480V.

(1) V8b grid potential change is less than 20V due to RV1 and its associated resistor chain. Thus the grid to reference line voltage is reduced; ie the grid potential moves negative.

(2) V8b anode current is reduced and the common cathode voltage falls. Since V8a grid is held by V7, V8a anode current rises.

(3) Thus V8a anode voltage falls and V8b anode voltage rises. These changes are fed to V6 grids, amplified and inverted so that V6b anode voltage rises as V8b anode voltage rises.

(4) Rising voltage at V6b anode causes rising voltage at V3, V4, V5 grids and consequent increase in conduction. This increases the output voltage to restore the -480V to -500V.

(5) Reverse action takes place if the output increases; ie V8b anode voltage falls feeding a fall to the grids of control valves V3, V4, V5.

(6) To prevent oscillation in the high gain amplifier loop V8-V6-V3, V4, V5-V8; C3, C4, R8 provide negative feedback from V6b anode to V8b Grid.

(7) V12 stabilizes the h.t. voltage to V6b anode and thus the grid voltage of the control valves V3, V4, V5.

b. Protection circuit. This circuit effects the changeover from one power unit to the other in the event of failure or if the -500V varies by more than 2.5V. The circuit comprises V10, V11 and two changeover relays RL D/1 and RL E/1. Normal operation results in equal currents in both valves, ie both relays are energised. To explain changeover action assume the output (-500V) changes to -460V, then

(1) As for the stabilising circuit (para 3a1) this causes V11 anode current to fall.

(2) The fall of Ia reduces the common cathode voltage and V10 anode current increases. Thus RL E/1 is de-energised and RL D/1 is held hard on.

(3) The reverse happens if the output voltage increases, ie V11 anode current increases, V10 anode current falls and RL D/1 is de-energised.

(4) De-energising RL D/1 or RL E/1 will break the circuit to relay C/4 and operate the changeover switching.

4. Relay Unit (Changeover) T186. Effects the changeover from main negative reference supply to the standby supply when the main reference supply fails, and changes over from the main -50V supply to the standby -50V supply in the event of main -50V supply failure. When either of these occurs an alarm is ounded

Except that they use the same alarm sy tem, the changeover systems for -500V and -50V are independent. It is possible to use either -500V supply with either of the -50V supplies. In each changeover system, the changeover and indicator lamp action is independent of the alarm bell system, so that even if the alarm circuit goes wrong, changeover will still take place.

It is impossible for both reference power units to be switched off by the changeover action, even though both are unserviceable. The interlock (relay C) in both power units ensures that the station cannot work off a defective power unit whilst there is a good one available.

5. -50V Changeover Action. Relay L has two opposing windings. If both -50V supplies are serviceable then opposing currents flow and the relay remains de-energised. Either relay M or relay N will energise if the -50V changeover switch is in the central position. Assume RLM energises, M2 opens preventing RLN from energising. M1 closes switching the -50V to the two power units T906.

If the -50V supply fails then RLM de-energises, M2 closes and RL.N is energised by supplying No 2. M1 opens, N1 closes and the standby supply is fed to the two power units. The 250μF capcitor holds the -50V supply to these units during the changeover.

6. Alarm Action. Failure of one of the -50V supplies unbalances RL.L which energises, closing L.1. The resulting surge of current into C1 (8 μF) energises RL.0, closing 0.1 and energising RL.K. Contact K.1 holds RL.K on and K.3 completes the alarm circuit. Capacitor C.1 charges to -50V, RLO de-energises, 0.1 opens so that when the ALARM RELEASE button is pressed, RLK will de-energise, switching off the alarm.

7. Switching on Power Unit 906. The order of switching on the power unit and circuit action is as follows.

a.	Close SW.A	230V to l.t. transformer supplying heater voltages to all valves in the rack. -50V switched in from relay unit T186.
b	Press START button	-50V applied to RL.B. Contact B1 closes and holds relay B. Contact B2 closes and applies 6.3V to the heater element of the thermal delay XA.
c.	After $\frac{1}{2}$ min	Thermal delay contact changes over. RLA energises via 150Ω resistor. Contact A1 closes protection line. A2 changes over, de-energising RLB and holding RLA independent of thermal contact. B2 opens the heater circuit of relay XA. A3 energises RL.F whose contacts F1 and F2 apply 230V mains to the h.t. transformer and so start the -500V supply. Contact A4 lights lamp in relay unit T186 showing that this power unit is producing h.t.
d.	After 1 min	Relay XA contact changes back and, provided SW.D (PROTECTION ON/OFF) is closed, the protection line becomes effective. If SW.D is open a warning neon blinks continuously at 2 p.p.s., operated by the repeated charge and discharge of C11.

8. In the normal state the power unit runs with SW.A and SW.D closed. Relays A,C and F energised. RLB is not energised. To switch off -500V without switching off the valve heaters, press "RELEASE" button so that RL.A de-energises. If the protection circuit in the power units are set up, RLD and RLE energise. D1 and E1 close energising RLC. Contact C3 changes over. Either RL.H or RL.J will energise, its contact closing, switching the -500V out to the units in fixed coil via relay unit T185.

9. <u>-500V Changeover.</u> If a fault occurs in the main power unit, the protection circuit operates. Either RL.D or RL.F de-energises. RLC de-energises. Contact C3 opens. RLH de-energises. Contact H3 closes. RLJ energises. Contact H1 disconnects the failing supply and connects it to the 3.3 kΩ dummy load. Contact J3 opens and keeps RLH off. Contact J1 disconnects the standby supply from 3.3 kΩ dummy load and connects it to the output.

Contact C1 on the failing power unit closes and as SW.D and contact A1 are closed, relay K energises. K1 contact holds on relay K and contact K3 switches on the alarm.

Contact C2 in the failing power supply closes short circuiting RL.A to earth via contacts C4 and K2. Relay A de-energises and switches off the failing power unit. Contact C4 opens ensuring that if the standby power unit should now fail, no further changeover can take place.

10. <u>Relay Unit T185.</u> Each unit consists of five relays.

Each relay switches -500V out to an external unit, when the relay is operated by -50V. The -50V comes from the unit which requires the -500V.

In order to maintain a steady load on the P.U.906 a dummy load is connected in place of the external load.

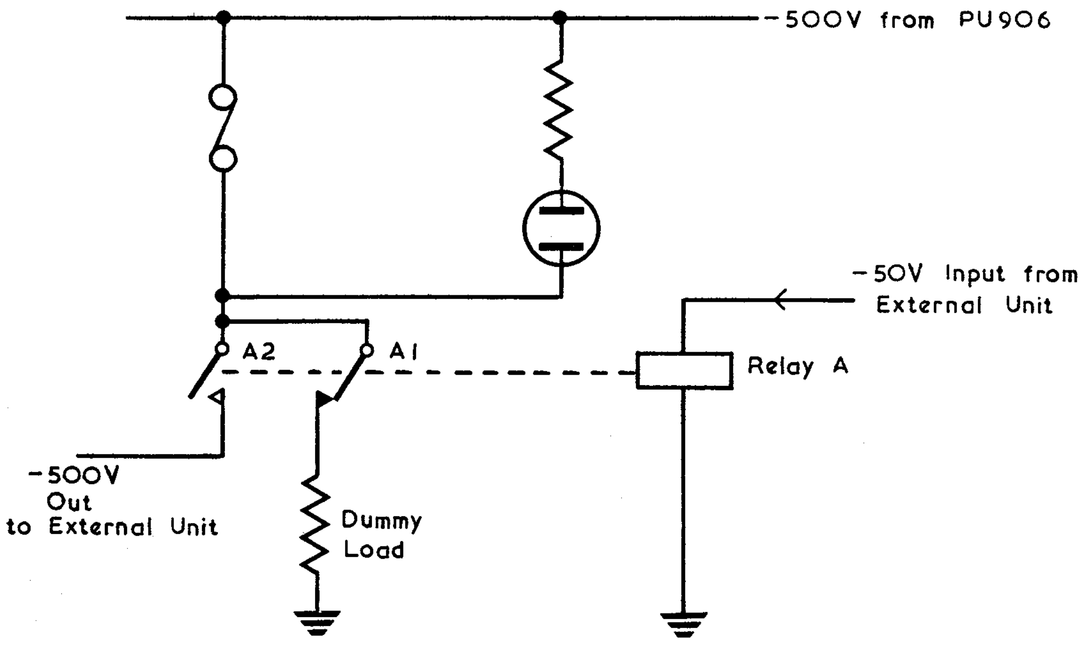


Fig 12   RELAY UNIT T185

There are four other similar circuits, operated by Relays B, C, D and E respectively. Maximum number of relay units T185 to a rack is thirty.

1. This unit provides the master timebase and certain associated waveforms for the p.p.i. display system. The p.r.f. of these waveforms will be decided by the associated head, eg A p.r.f. of 250 when used with Type 7 or 500 when used with T14. It contains:

a. Six timebase units T140 which can be set up as follows:

(1) Two sets for 250 p.r.f. (A main. B standby)
(2) Two sets for 500 p.r.f. (A main. B standby)
(3) Two spare.

b. Six power units T903.

2. The panel (Distribution and Switching) T868 at the bottom of the rack handles outgoing waveforms with a selector switch for A and B units and also feeds out selected waveforms to the waveform monitor rack T339. Input supplies are 230V, 50 Hz -ve 500V reference and -50V d.c. for relays.

3. Timebase unit T140. All these units are alike but the duration of the output waveforms (and thus the range represented by the timebase) are determined by the RANGE switch (SW.A). As the circuits are not free-running, the correct combination of trigger input and range switch setting are necessary to establish the required outputs.

The sawtooth generator stages produce the master timebase waveform. This is a linear sawtooth of accurately determined velocity, which reaches an amplitude of 25V in 1483 μsecs at a trigger input p.r.f. of 500 p.p.s. or an amplitude of 50V in 2966 μsecs, at a p.r.f. of 250 p.p.s. These timings correspond to absolute maximum radar ranges of 120 and 240 nautical miles respectively.

4. The output waveforms are:

a. Master sawtooth waveform 50V or 25V in amplitude. +ve going, with linear flyback of 150 or 75 μsecs.

b. A negative going version of this (not used).

c. Radar bright up.

d. The drive waveform for waveform generator T101.

e. Delayed clamp trigger pulse required in amplifier T504.

5. Trigger Amplifier V1. This circuit amplifies the trigger input to 35V. The input can be either 250 or 500 p.r.f. trigger pulse from the master trigger unit (MTU) and should not be less than 10V in amplitude. V1b is a cathode follower, cathode coupled to V1a. V1a grid is fixed at +50V. The trigger input causes V1a cathode to rise, cutting off V1a and producing a 35V amplitude pulse at the anode.

6. Square Wave Generator V2b, V3, V4, V5b. This circuit is a bi-stable flip-flop whose triggering inputs are obtained from V1 anode and part of the sawtooth feed back from V9 cathode via V2a. Its operation is as follows:

a. Static Condition. V2a is cut off, its anode being returned to a negative potential in V9 circuit. V5b is conducting, its cathode at +110V. V4 grid taken to

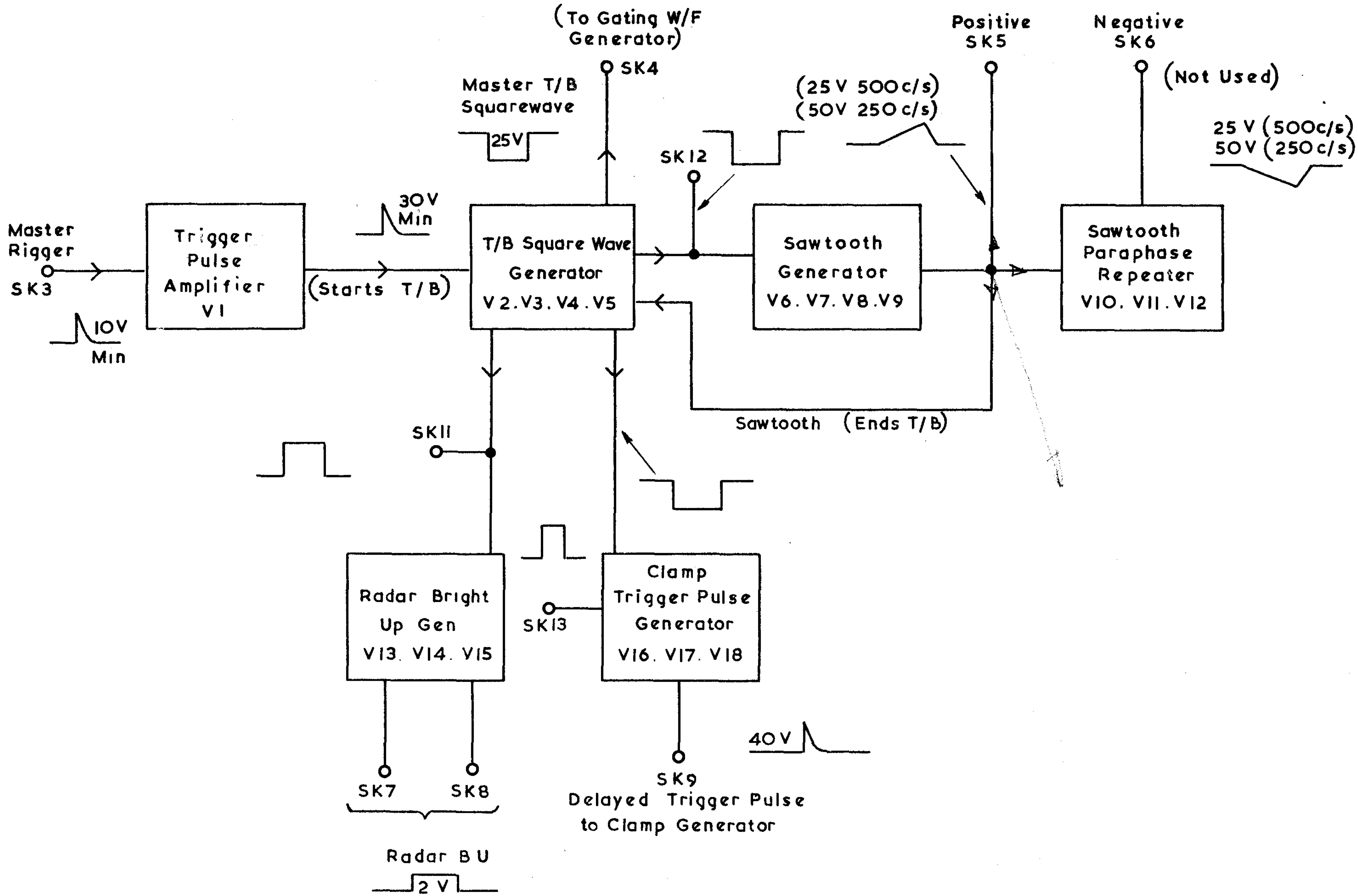


Fig 13 TIMEBASE UNIT TYPE 140 - BLOCK DIAGRAM

this potential so V4 conducts, its anode voltage will therefore be a low value. This makes V3 grid negative but it will be held at -15V by V2b. V3 will be cut off.

b. Action No 1. The input from V1 causes V3 to conduct and its anode potential falls. V5b grid potential falls, driving V5b cathode to -35V cutting V4 off. The rise at V4 anode lifts the potential on V3 grid to a +ve value. The circuit now has V2b cut off, V3 conducting and V4 cut off. V2a may be conducting (120 mile range) or cut off (240 range).

c. Action No 2. The fall at V5b cathode starts the timebase waveform and V9 cathode commences to rise from 0V to a positive value, taking V2a anode a proportionate amount with it. V2a will eventually conduct (if it was not already doing so) and its cathode and V4 potential now depend on V9 cathode potential. After 2966 μsecs or 1483 μsecs V9 cathode has reached a potential which causes V4 to conduct and the square wave generator reverts back to its original condition with V5b cathode at +110V. This rise terminates the sawtooth. The outputs from this circuit are:

(1) +30V square wave from V3 cathode.
(2) -145V square wave from V5b cathode
(3) -100V square wave from tapping on V5b cathode.

7. Gating Waveform Generator Drive C/F V5a. The 145V negative square wave is attenuated and fed to this cathode follower. The resultant 25V negative square wave is fed to the gating waveform generator (GWG) T101. The CR network in the cathode prevents the cathode load from being short circuited.

8. Sawtooth Generator V6, V7, V8, V9. This section produces a linear sawtooth waveform of the required p.r.f. width and amplitude and functions as follows:

a. Static Condition. V9 and V7a cathodes are at 0V, set by the DC SET controls. V7a is conducting, its anode voltage is approximately 0V. V7b is conducting, its anode at same potential as V7a anode so that its cathode is at 0V. The capacitor C14 will be completely discharged. V6, V8 and V9 form a normal d.c. amplifier with a gain of 2500.

b. Scan Period - 250 p.r.f. (500 p.r.f.) The potential to which V7 anodes are taken falls to -35V and V7a and V7b cut-off. V7a cathode is now no longer held at 0V so that C14 tends to charge towards the potential set by the VELOCITY CONTROLS. (-215V approx). V6b grid therefore tends to fall exponentially causing V9 cathode to rise from 0V towards +50V (+25V). V2a anode rises with it from -44V (-25V). After 2966 (1483) μsecs V4 conducts, V5b cathode rises to +110V, V7b conducts stopping the sawtooth action. eg If the output voltage is 50V and the amplifier gain is 2500 then the input to the amplifier must be 20 mV, ie the 1st 20 mV of a 215V exponential fall.

$$\text{Rise in V} = \frac{V}{T} = \frac{E}{CR} = \frac{215\text{V}}{2.5\text{M}\Omega \times .005\ \mu\text{F}} = \frac{215}{12.5\text{ msec}}$$

$= 16.8$ per millisec so that in 3 millisecs the output rises to 50.4V. The output impedance of V9 is very low $\frac{1}{Agm}$ so that loading the circuit has no effect on the waveform.

c. Flyback. As V7 anodes are returned to +110V again, V7b conducts so that V6a is now returned to an aiming potential of +110V through 68 kΩ resistor and Miller action takes place in the opposite direction. V7B current holds V7A cut off until V9 cathode is at 0V, when V7A conducts and the Miller action ceases. The circuit is now back in its original condition with C14 unable to change its charge. The flyback time will be considerably shorter than the timebase.

$$\text{eg Rise in V} = \frac{110\text{V approx}}{68\text{k} \times .005\ \mu\text{F}} = 330\ \mu\text{secs approx}$$

Rise in V = 1 volt per 3 μsecs

ie 50V in 150 μsecs. ie Flyback time is 150 μsecs approx.

9. Sawtooth Paraphase Repeater. This circuit provides a paraphase version of the main timebase waveform. The output from this circuit is not used. It is a see-saw amplifier driven from V9 cathode via a fixed input arm of 154.7 kΩ. The feedback arm is variable with a 150 kΩ fixed in series with 10 kΩ variable giving control of overall gain which is adjusted for unity. The circuit is similar to the high gain amplifier of the sawtooth generator; V10, V11 and V12 being the equivalent to V6, V8 and V9.

10. Radar Bright-up Generator V13, V14, V15. These valves form two identical circuits which feed a 2V square wave, the width of the timebase, to the head selector units (HSU). This waveform is used to brighten the trace during the timebase period.

a. Static Condition. V13 is conducting holding the junction of 300 kΩ and 33 kΩ resistors at 0V. This makes V14 grid approx -20V so that V14 is cut off.

b. Action. As V3 cathode potential rises to +30V the diode anode voltage and that at the junction of the two resistors follows it. V14 grid potential rises, V14 conducts. Negative feedback from anode to grid limits the current through the valve to 20 milliamps and prevents the diode anode voltage from rising higher than +2 V. V13 is therefore cut off, isolating the bright up stage from the rest of the circuit. The output from V14 cathode is a two volt pulse, the width of the timebase. At the end of the timebase, V3 cuts off, V13 conducts, V14 grid potential falls to -20V cutting off the valve.

11. Clamp Trigger Pulse Generators V16, V17, V18. This circuit provides a +40V pulse to trigger the clamp generator circuit in the amplitifer T504. It occurs 210 μsecs or 120 μsecs after the end of the timebase depending on the position of the range switch.

a. Static Conditions. V17a and b are conducting holding V16a grid potential at approximately -40V. V16b grid at 0V so conducting making the common cathode potential of V16 at 0V. V16a will be cut off. V18 is cut off with its grid returned to -12 volts.

b. Action. The input, a negative square wave of 100V amplitude from V5b cathode, is differentiated by 470 pf and 100 kΩ and applied to V17a anode. The negative spike, coinciding with the beginning of the timebase, has no effect on V16. The positive spike at the end of the timebase is passed to V16a grid where it causes:

(1) V16a to conduct, lifting the cathode voltage to +55V.
(2) V17b to cut off.
(3) V16b to cut off, the rise in voltage at the anode is applied to V16a grid through 560 pf capacitor.

The 560 capacitor now charges up. The potential of the plate connected to the V16a grid will fall exponentially towards the potential set by the PULSE DELAY control. The common cathode potential will fall with the grid and eventually V16b conducts. This is timed to occur 120 or 210 µsecs after the end of the timebase. V16a cuts off, causing the anode circuit to ring. The positive peak causes V18 to conduct, producing a 40V pulse at its cathode. The fact that V18 conducts helps to damp out the ringing at V16a anode so that only the first positive pulse is of sufficient amplitude to cause V18 to conduct.

Power Unit Type 903.

12 This unit produces the following supplies for use in its associated unit.

a. +300V stabilised.

b. -300V stabilised.

c. 6.3V heater supply for all valves in the unit.

To provide these the power unit must be supplied with:

d. 230V a.c. mains supply.

e. -500V negative reference voltage.

f. -50V d.c. for relays and lamps.

The circuit consists of two similar full-wave rectifiers followed by series regulators. There is a protection circuit to switch off the whole unit if either h.t. output changes more than 20V.

13. Interaction of Positive and Negative HT Outputs. Because the supplies are used for d.c. amplifiers where maintenance of d.c. levels are important, the +ve h.t. is referred to the -ve h.t. so that if the one should change then the other changes by an equal and opposite amount, maintaining fixed d.c. levels in the amplifier.

14. -300V HT. Consists of a full wave rectifier, the output of which is smoothed and regulated. The regulator, V10 and V11, is of the series hard valve, pentode control type. V11 grid is held at a constant potential from the VOLTAGE SET -300V control connected between -500V reference line and earth. Assume the -300V supply decreases then V11 anode current decreases, reducing the grid to cathode potential of V10 and thus increasing the h.t.

15. +ve 300V HT Supply. Consists of a full wave rectifier, the output of which is smoothed and regulated. V5 grid is held at the potential set by the VOLTAGE SET +300V control between +300V and -300V. Thus any variation of -300V or +300V supplies will cause V5 anode current to change, and vary the voltage drop across V4. V12 stabilises the h.t. supply of V5.

16. Protection Circuit. This circuit comes into operation and switches off the power unit if the +300V varies more than 20V. The +300V can be varied by the -300V as explained in the previous paragraph.

Adjust the SET-CUT OUT control so that V8 cathode potential is at zero. V6 and V7 will be non-conducting, Relay A will be de-energised and the h.t. supplies can be switched out to the external unit. Assume -300V supply fails then V5 grid potential will rise, V5 anode

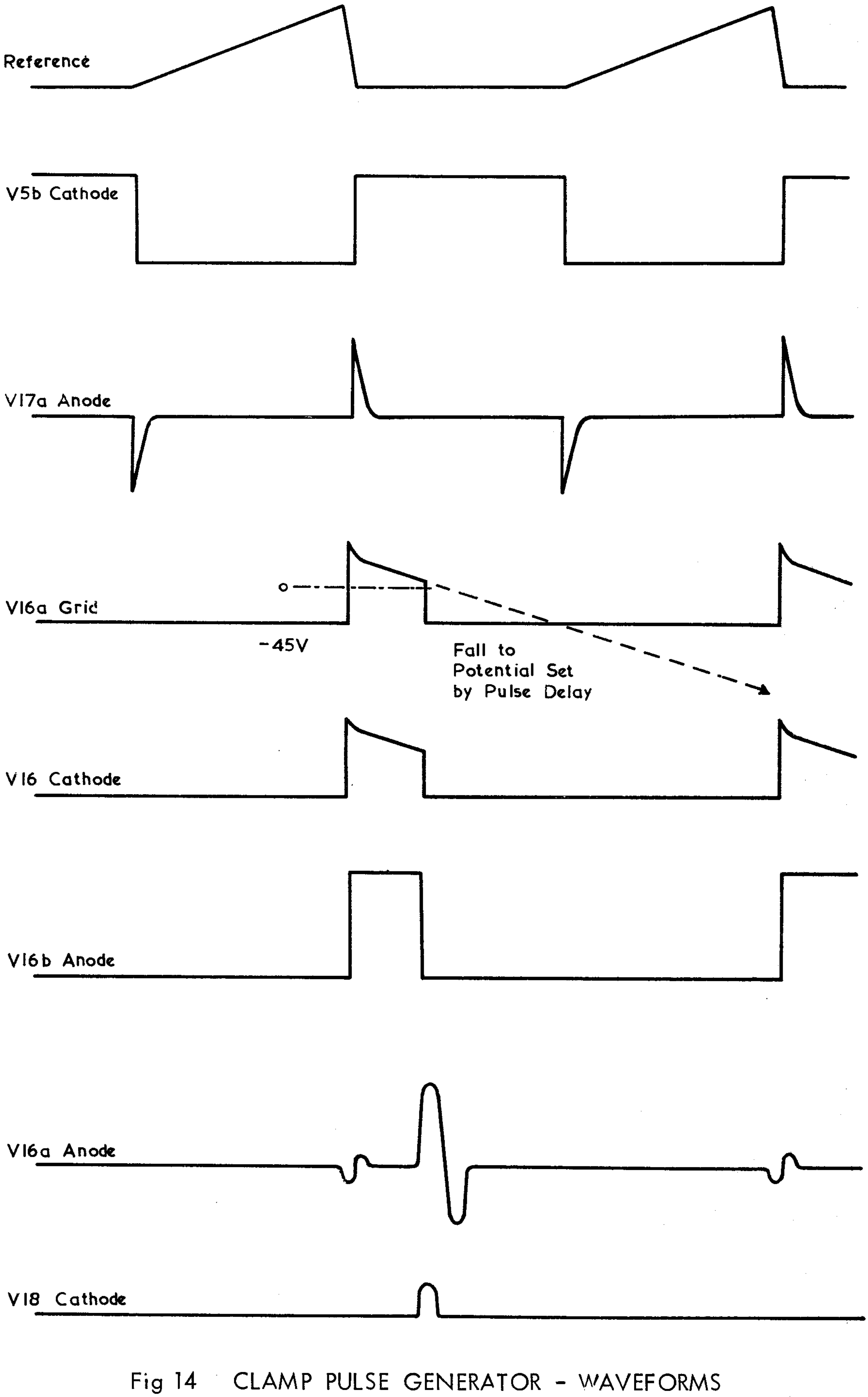


Fig 14 CLAMP PULSE GENERATOR - WAVEFORMS

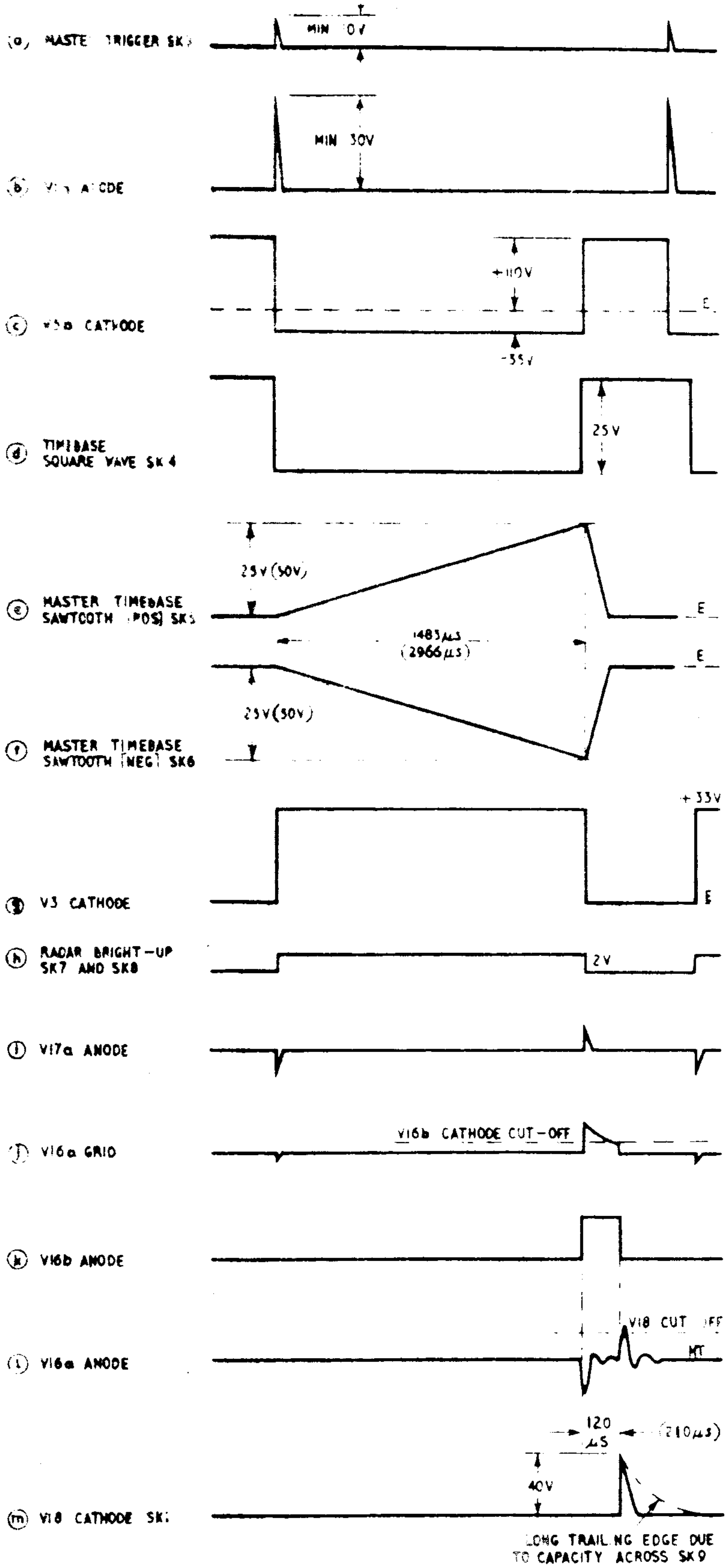


Fig 15 FIXED COIL-TIMEBASE UNIT TYPE 140 - WAVEFORMS

current increases causing the +300V to be reduced by a considerable amount. V8 grid potential falls, causing the cathode to go negative. V7 conducts, Relay A energises, A1 contact opens causing the power unit to switch off. If the +300V increases then V6 conducts as V8 cathode goes positive, causing RLA to energise.

17. Switching on Power Unit

a.	Switch on SWA	230V a.c. fed to l.t. transformer TR.2 -50V fed into power unit.
b.	Switch B to SET	Relay B energises. Contact B1 closes. 230V to h.t. transformer. Contact B2 closes. HT ON lamp on. Contact B3 closes. -50V fed out to the negative reference rack. -500V fed back to this power unit. The protection circuit not effective as contact A1 is short-circuited by wiper of SWBa. HT supplies and -500V are fed to dummy loads. The set cut out control and h.t. controls can be set up.
c.	Switch B to CHECK	Only relay B circuit alters. Providing the controls have been set up correctly then relay B is energised via contact A1 and its own contact B2.
d.	Switch B to LOAD	The output voltages (-300V, +300V, -500V) are fed to the external unit and the dummy loads switched out. LOAD ON lamp goes out.

1. <u>Purpose</u>. Resolves the master timebase sawtooth waveform into two sawtooth components required to produce a rotating timebase. The two waveforms are 90° out of phase with each other and are known as the SINE and COSINE components. The amplitudes of these waveforms varies sinusoidally, being functions of the sine and cosine of the angle of rotation from North (0°) of the particular aerial head whose trace they produce. (See Fig 17).

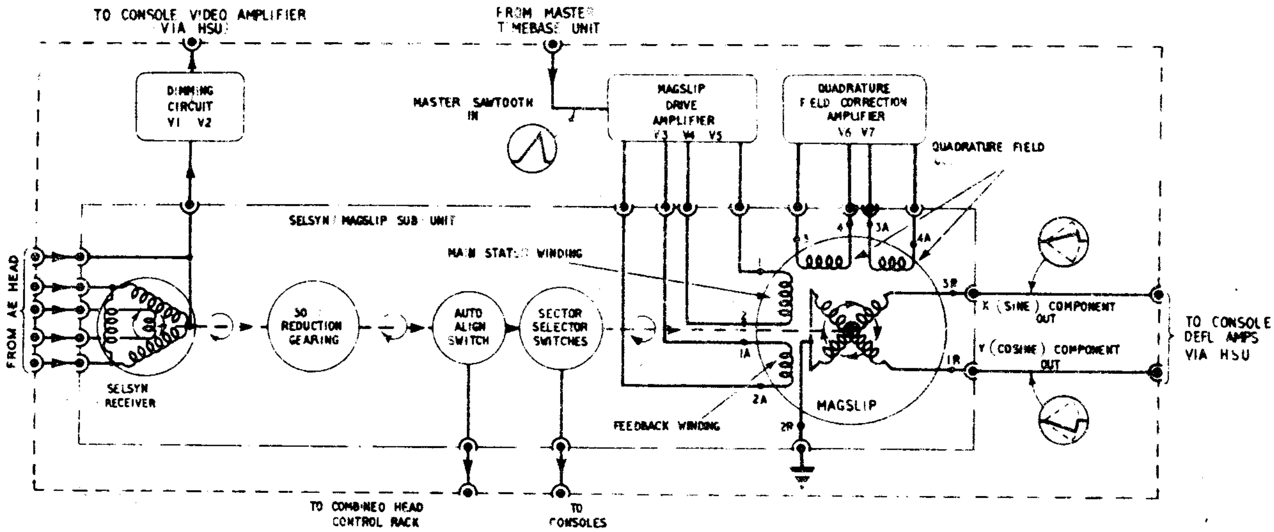


Fig 16 RESOLVER UNIT (MAGSLIP) - BLOCK DIAGRAM

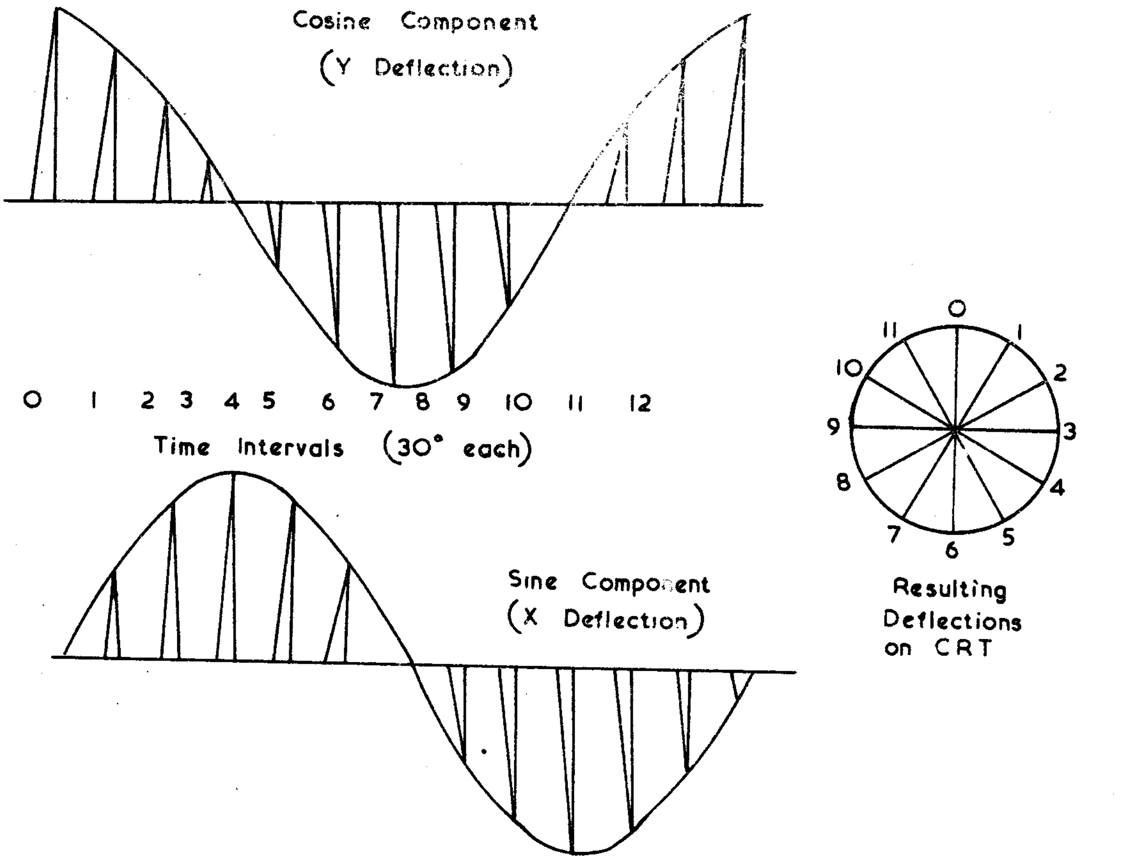


Fig 17 COSINE AND SINE COMPONENTS OF RESOLVED TIMEBASE SAWTOOTH

2. The rack contains:

Resolver unit magslip.

Amplifier (clamp and distribution) T504.

Power unit T904.

These three units are required for resolving the sawtooth. There are three complete sets in each rack.

a. Any number of consoles can be operated from the same sine and cosine components so that the number of resolvers required varies and depends entirely on the type of station. These requirements will be:

1 or more resolvers for 250 p.r.f. heads.
1 or more resolvers for 500 p.r.f. heads.
1 resolver for the backward looking head.
1 resolver for the stop and look head.

3. Resolver Unit Magslip. (Refer Fig 16). Produces the sine and cosine components of the timebase waveform and ensures that they are linear. It other purposes are:

a. To maintain, by the auto-align system, correct alignment between the aerial head and magslip rotor.

b. To provide, by sector selection switches, facilities for operating the sector relays in the head selector unit (HSU) when head combined operation is used.

c. To effect trace dimming when the magslip ceases to rotate due either to the aerial stopping on selsyn failure.

4. a. The unit consists of normal selsyn whose rotor follows the selsyn rotor in the aerial head and drives the magslip rotor. The selsyn rotor is driven at a speed 30 times aerial speed, allowing transmission of greater torque without heavy current flow and more accurate following. A 30:1 reduction gear reduces the speed of the magslip rotor to that of the aerial.

b. An auto align system to keep aerial and magslip rotor in synchronism.

5. Auto alignment.(Refer to Fig 18).

a. If they are in synchronism the 8° aerial cam closes the aerial switch energising relay C2, contacts C1 and C2 open, the 4 1/2° magslip closes and relay A cannot energise. Then the magslip cam switch opens and 2° later the aerial cam switch opens de-energising relay C.

b. If the two are not in synchronism then the magslip cam switch closes first. Relay A energises, A1 and A2 close and short circuit a selsyn winding which prevents the rotor from turning. The magslip rotor is therefore held stationary while the aerial carries on turning. When the aerial is in line with the timebase then the 8° aerial cam switch closes, relay C energises, contacts C1 and C2 open, relay A de-energises, A1 and A2 open and connect the two selsyns. The rotor of the magslip will commence to rotate, the timebase and aerial now being in synchronism.

6. <u>Sector Selector Switching</u>. (Refer Fig 19). These switches are only connected on the magslip unit associated with the backward-looking head.

When head combining operation is in use, the backward-looking head and a forward-looking head are alternately caused to feed their signals, appropriate timebase and radar bright up to a console. This information is switched by the sector relays in the HSU which are energised over 180° (the chosen sector) when the backward-looking head scans it, and de-energised when the forward-looking head scans the same sector.

7. The sector relay circuit will be: -50V, the relay, the head combining switch (on console), the SECTOR SELECTION switch (at console), the micro-switches of the Sector Selector cam in the backward-look g heads resolver unit, the contact B3 of the dimming re ay to earth. The magslip a s mbly rotor ensures that this circuit is complete to energise the relay by closing the micro-switches over the predetermined 180°. By parallel connections from all consoles, any operator can use this facility w h any forward-looking head and over any of the eight sectors availab e.

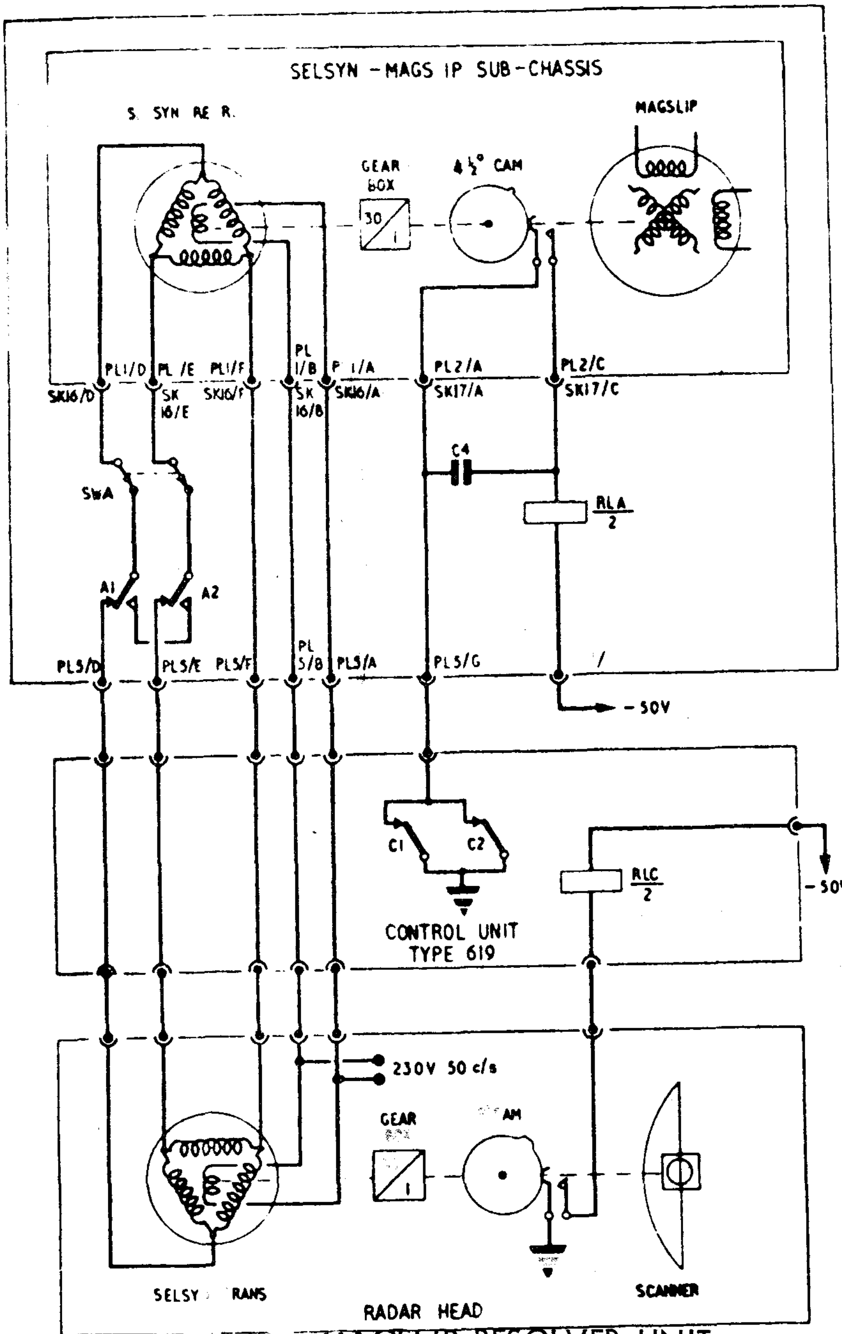


Fig 18 MAGSLIP RESOLVER UNIT

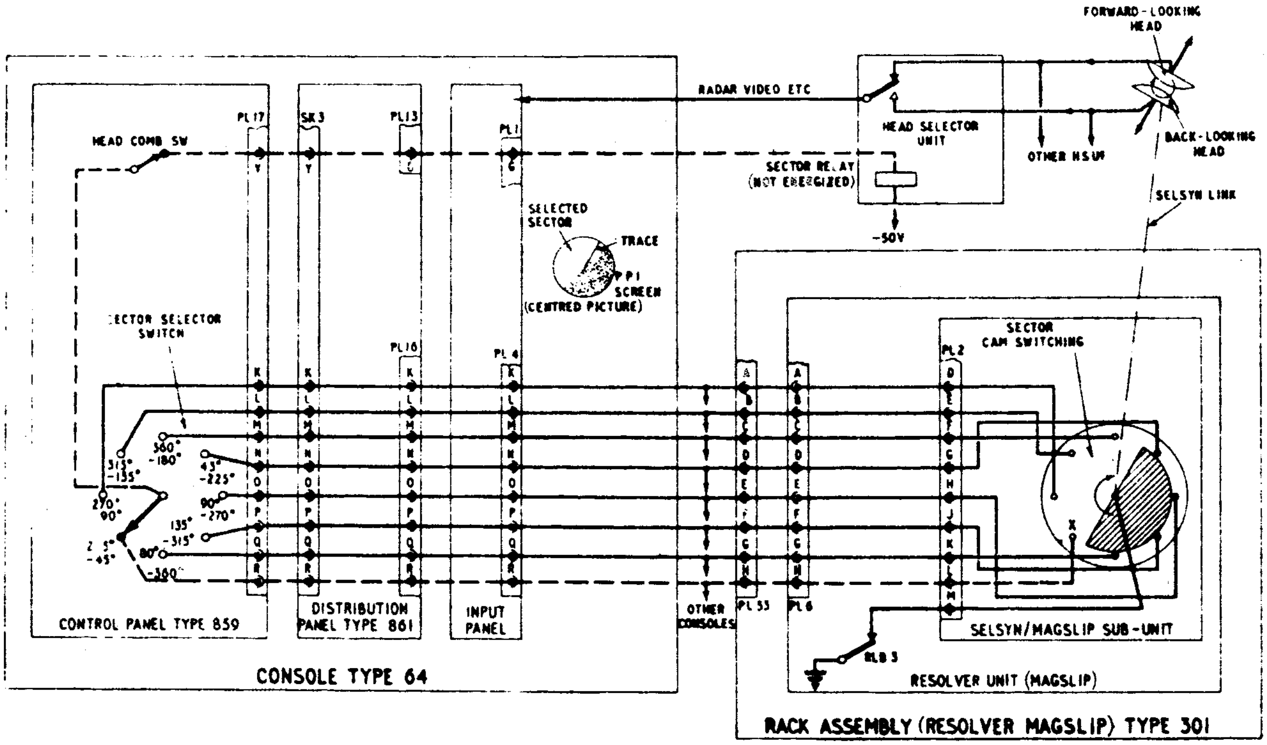


Fig 19 SECTOR SELECTION SWITCHING

8. The Dimming Circuit. Reduces the brightness of the trace when the magslip rotor ceases to rotate. (See Fig 20)

a. Whilst the aerial is turning, input to the infinite impedance detector V1b is 50 Hz modulated at a frequency dependent on selsyn speed. (eg aerial speed 6 rpm gives a modulation frequency of 3 Hz).

The output from the cathode is the modulation frequency which is fed via C2 to V2b.

b. V2b conducts on the positive half cycles and gives an output with a mean value to the +7V at its cathode. The negative voltage is smoothed by R8 and C3 and applied as bias to V1a, cutting off the anode current and keeping relay B de-energised. Contact B2 is closed and -50V fed via HSU to the video amplifier to energise relay F. Contact F1 is closed making the video amplifier gain high.

c. When the aerial stops turning, V1b input is unmodulated 50 Hz, so the bias on V1a is lifted causing it to conduct and relay B energises. As a result,

(1) Contact B1 opens, inserting 15 kΩ current limiter into the anode circuit.

(2) Contact B2 opens, breaking the dimming line. Relay F de-energises and the video amplifier gain is reduced thus reducing the brightness of trace.

(3) Contact B3 opens. This is only going to affect the backward-looking head, ie if the backward-looking head fails to rotate, contact B3 on its magslip unit will open and the sector selection circuit fails to operate so that head combined operation will automatically revert to normal p.p.i. operation.

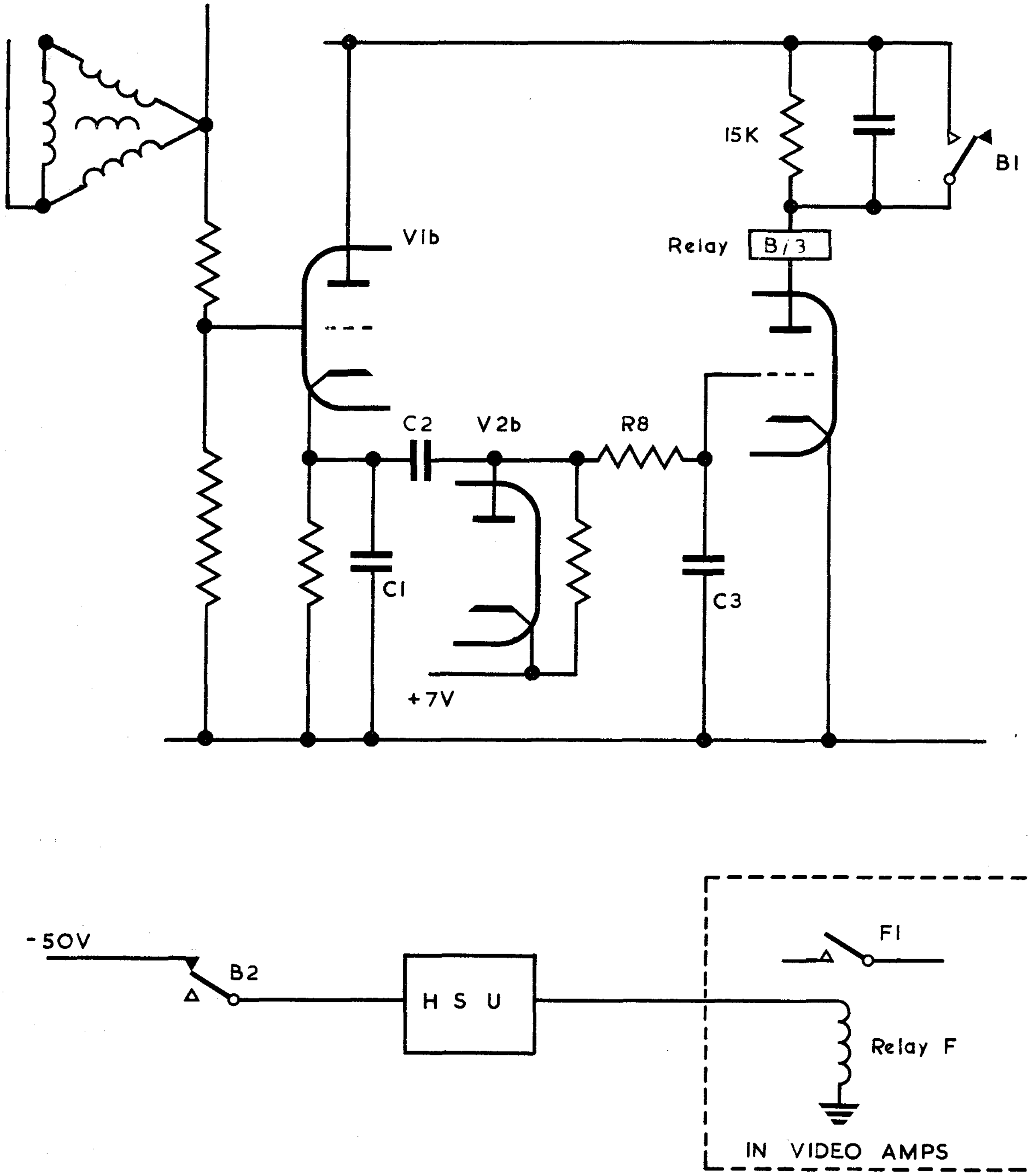


Fig 20 DIMMING CIRCUIT

9. Magslip Drive Amplifier. (Refer Fig 21) This circuit accepts the master timebase waveform and from it, drives such a current in the main magslip stator coil as will induce a linear sawtooth of voltage across the rotor.

a. The circuit arrangement is that of a see-saw amplifier, feedback being taken from an auxiliary stator winding which will always provide negative feedback irrespective of the amplitude and phase of rotor output. This feedback compares the output waveform with the linear input and adjusts the amplifier input for best output linearity. To avoid magnetic saturation in the rotors, or the need for a large rotor assembly, the overall gain is half. Thus maximum amplitude of output from the rotor is 25V. The feedback winding is connected into the cathode circuit of the output stage in order that d.c. conditions of the circuit are stabilised and DC SET controls eliminated.

b. V3 is an amplifier with very high gain, using triode V4 as the anode load. This provides V3 with an anode load of very high impedance (600 kΩ) yet has a reasonably low d.c. path (50 kΩ). A high frequency stabilising network is connected between V4 cathode and V3 grid. The 1 MΩ resistor (R25) is not in the a.c. feedback loop as the 1 μF capacitor (C19) effectively earths the feedback winding, but prevents this winding from being short circuited by R29.

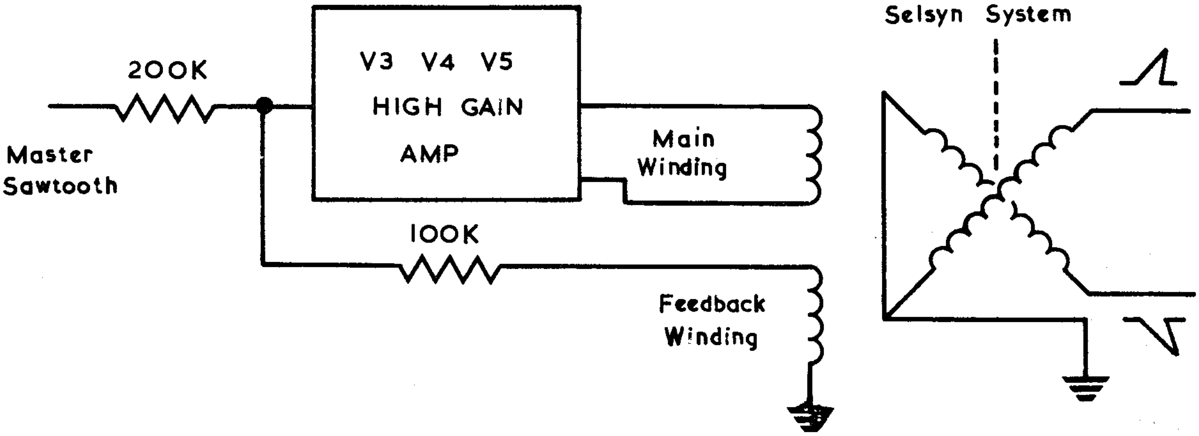
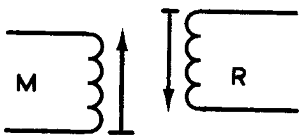


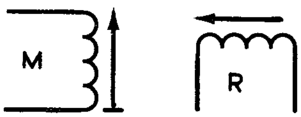
Fig 21 BLOCK DIAGRAM - MAGSLIP DRIVE AMPLIFIER

10. Quadrature Field Correction. Loading the rotor of the magslip causes a current to flow and introduces distortion of the waveform.



a. When the rotor is parallel to the main winding then the current flowing in the rotor sets up a magnetic field which is parallel to that of the main winding. Any distortion introduced will be cancelled by the feedback winding.

Fig 22a



b. When rotor is at 90° to main winding then there will be no voltage in the rotor and no distortion occurs.

Fig 22b

c. When the rotor is at an angle less than 90° to M the rotor field will interact with the main field causing incorrect voltages in the rotor.

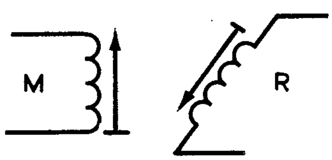


Fig 22c

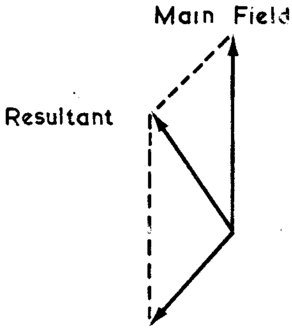


Fig 22d

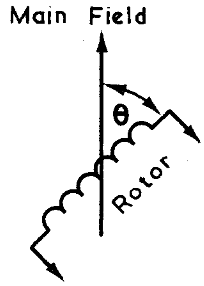


Fig 22e

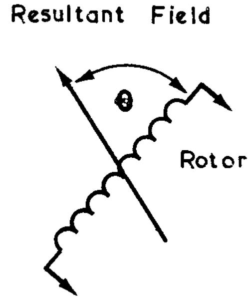


Fig 22f

Fig 22 QUADRATURE FIELD CORRECTION

11. From Fig 22d it will be seen that the resulting main field is no longer vertical. The effects of this are shown in Figs 22e and 22f. In Fig 22e, the voltage which should be induced in the rotor is of a certain value depending upon the angle Ø. In actual fact this angle would be larger (f) and the output voltage therefore no longer be varying in amplitude as the SINE or COSINE of the angle of aerial rotation. Thus the trace will not be in line with the aerial, except when at aerial points N, S, E or W.

12. In order to correct this a third field must be introduced which will pull the main field back to the vertical position.

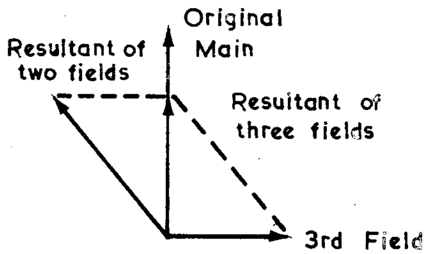


Fig 22g

The main field will now not be so strong as the original but it will be vertical and thus induce correct voltages in the rotor (see Fig 22g)

The third field must always be at right angles to the main winding and varies in strength with the angle of rotor. It is known as the quadrature correction field and is produced by the quadrature field winding driven by the quadrature field correction amplifier.

13. <u>Quadrature Field Correction Amplifier</u>. (Refer Figs 22 and 23) V6 and V7 form a see-saw amplifier similar to the magslip drive amplifier with V6 having resistive load and correspondingly lower gain.

The input to the amplifier is earthed by C20 so that under static condition, or the rotor at right angles to the windings, the circuit is balanced with a weak standing field due to current through the main winding. When the rotor is at an angle to the windings it will induce into the feedback winding, a voltage porportional to the angle of rotation. The amplifier is now unbalanced and so, due to see-saw action it will compare the induced voltage with earth (i/p to AMP) and drive a current through the main winding in such a direction as to cancel out the voltage induced in the feedback winding. A magnetic field will be set up round the main winding which is proportional to the angle of the rotor. The direction of this field is at right angles to the magslip drive amplifier main winding, so that the field fulfills the requirements set out in paragraph 12.

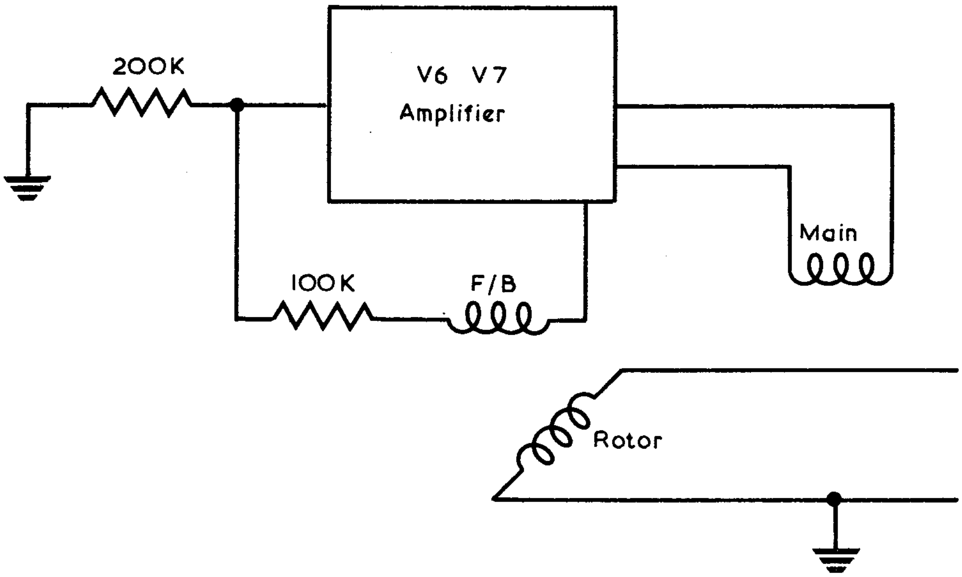


Fig 23 BLOCK DIAGRAM - QUADRATURE FIELD CORRECTION AMP

14. Magslip Outputs. The rotor consists of two coils at right angles to each other. Across each coil is a resistor which damps out any tendency for coils to ring and provides a permanent load for the rotor. From the coils, come two sawtooth waveforms, varying in amplitude sinusoidally, 90° out of phase with each other.

a. Coil 3R.2R provides the sine component.

b. Coil 1R.2R provides the cosine component.

Both outputs are fed to the amplifier 504.

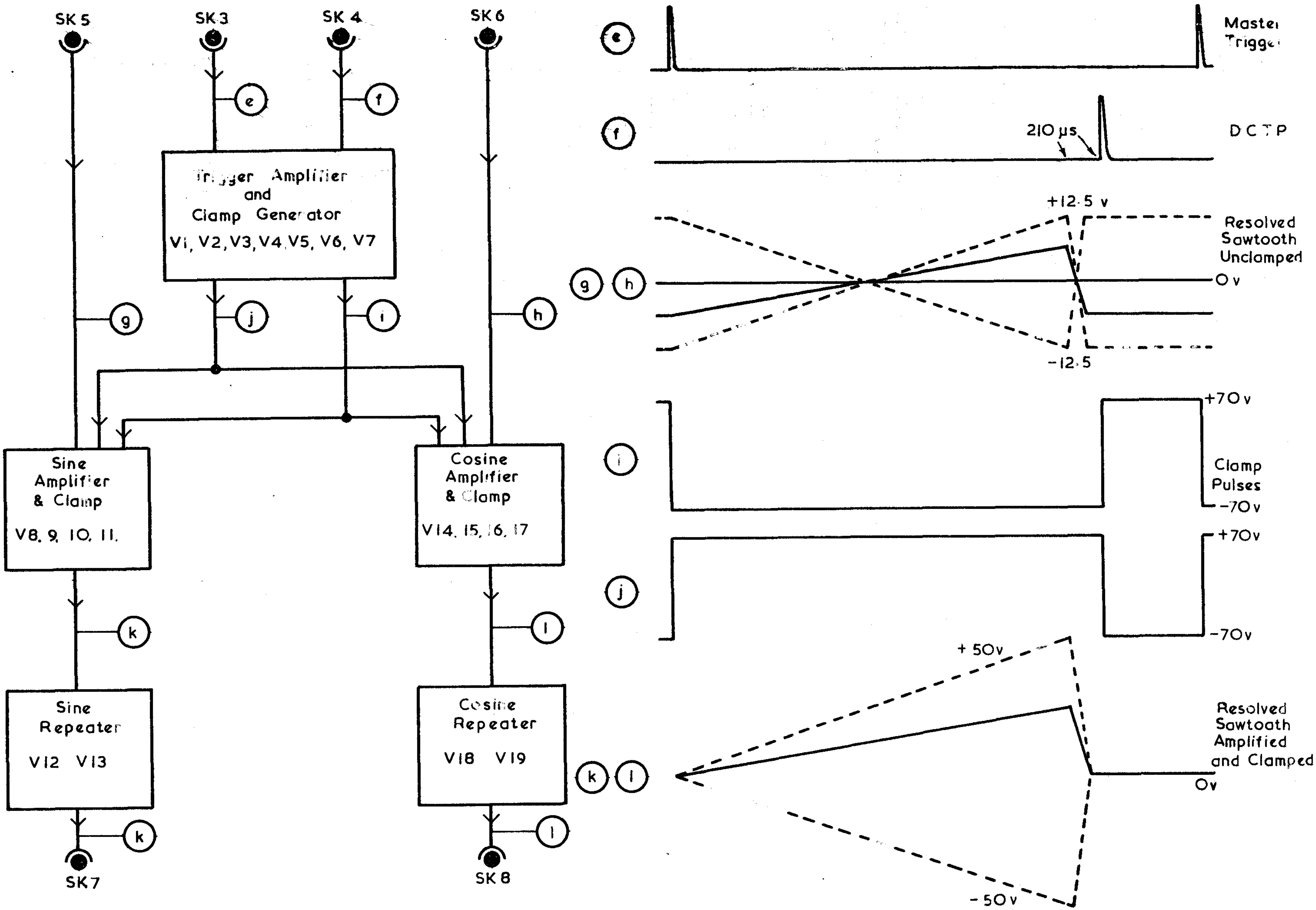
15. Amplifying Unit (clamp and distribution) Type 504. This unit accepts the sine and cosine timebase components from the magslip rotor, amplifies them so that they are brought back to the original maximum amplitude of 50V (25V) and clamps the rest level to 0V.

This is necessary because:

a. The amplitude of the sawtooth was reduced by approximately half in the magslip drive amplifier.

b. The magslip is an a.c. coupling device and does not preserve d.c. levels. If the rest level of the timebase waveforms are not clamped, the origin of the trace is displaced on the tube.

16. The unit feeds out the sine and cosine timebase waveforms from a low impedance source to all the HSU's. Provided correct trigger pulses are applied the unit is equally effective on 250 or 500 p.r.f. and no re-adjustment or switching is necessary.


SK 5
SK 3
SK 4
SK 6
Trigger Amplifier and Clamp Generator
V1, V2, V3, V4, V5, V6, V7
Sine Amplifier & Clamp
V8, 9, 10, 11.
Cosine Amplifier & Clamp
V14, 15, 16, 17
Sine Repeater
V12 V13
Cosine Repeater
V18 V19
SK 7
SK 8
Master Trigger
210 µs
DCTP
+12·5 v
-12·5
Resolved Sawtooth Unclamped
0 v
+70 v
-70 v
Clamp Pulses
+70v
-70v
+ 50v
- 50v
Resolved Sawtooth Amplified and Clamped
0v

17. Trigger Amplifier and Clamp Generator. This circuit produces positive and negative clamp pulses timed to occur 210 µsecs after the end of the 250 p.r.f. timebase (or 120 µsecs after the end of the 500 p.r.f. timebase) and finish at the start of the next sweep.

18. Circuit action of Clamp Generato .

a. Cathode-coupled Bistable Trigger circuit. Initially V2b anode and cathode are at 0V. V3a grid is at 0V, V3b grid is positive and the valve conducting heavily. V3 cathode is approximately +50V so that V3a is cut off

(1) The input trigger pulse from V1 causes V2b and V3a to conduct. V3a anode voltage falls, the fall cutting off V3b.
(2) 120 or 210 µsecs after the end of the timebase the delay clamp trigger pulse from the timebase unit T140 is applied to V3b grid via V2a causing V3b to conduct and the circuit returns to its original state.
(3) The output from V3b anode is 140V square wave, d.c. restored by V4a to +70V. Thus V5 input is a square wave of 70V amplitude centred about zero.
(4) V5 is a cathode follower which feeds this 70V square wave to V11, V17. The waveform is known as the negative clamp.
(5) V6 and V7 form a see-saw amplifier prod ving an antiphase output. This is known as the positive clamp.

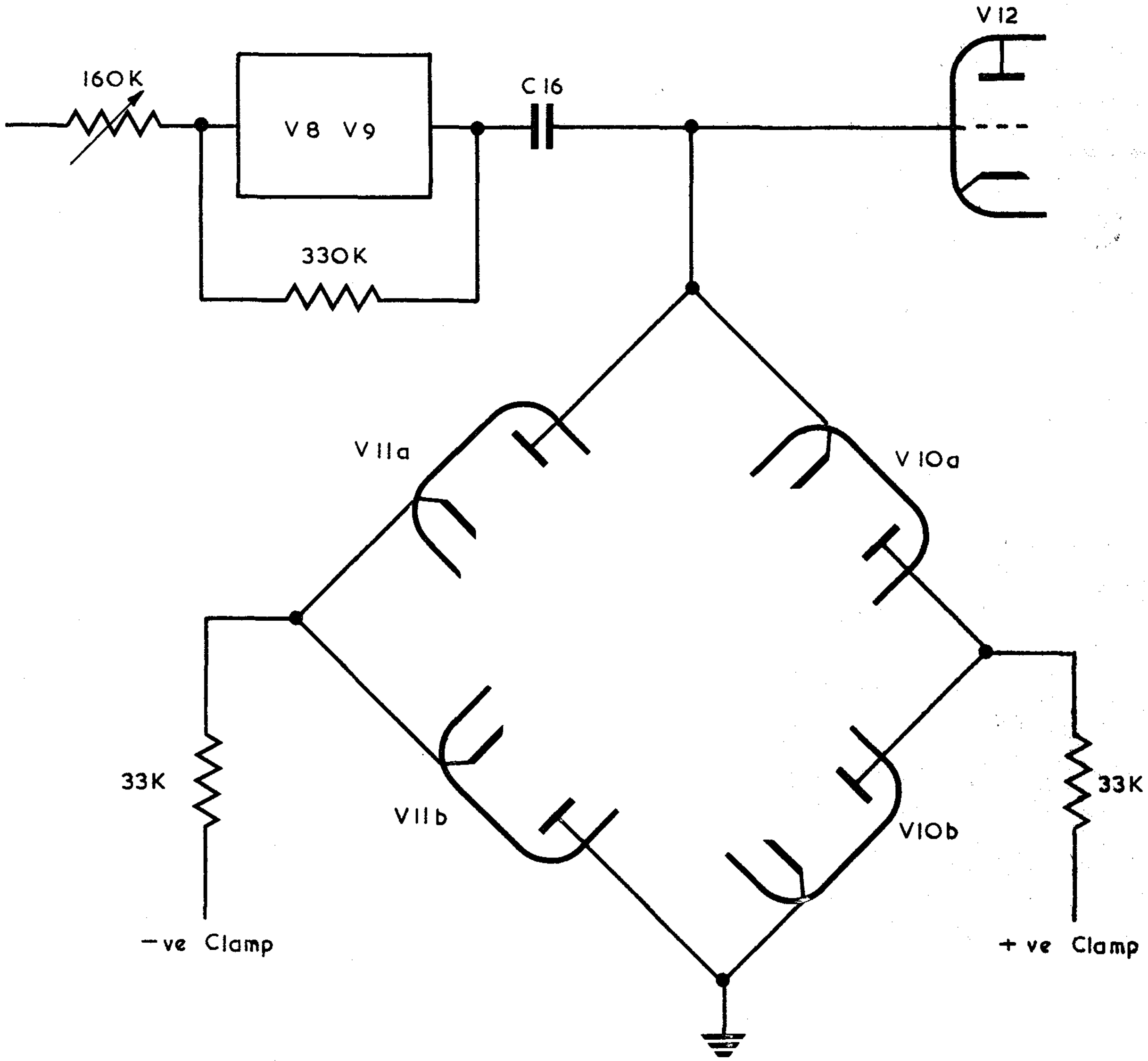


Fig 25 CLAMP CIRCUIT

19. Sine and Cosine Amplifier. These two circuits are identical, therefore only the first will be described.

a. Sine amplifier. V8 and V9 form a see-saw amplifier with gain adjustment to allow output to be set to 50V. Linearity is maintained by C31

b. Clamp Circuit. (Refer Fig 25) During timebase sweep (non-clamp period) V10 anodes are at -70V and V11 cathodes are at +70V All diodes are non-conducting and have no effect on the input to V12.

During clamp period, V10 anodes are at +70V and V11 cathodes at -70V. All four diodes conduct forming a balanced bridge so that V12 grid will be held at earth potential.

Differences in diode resistances cause inaccuracies which will remain constant and may be taken up later in the circuit with DC LEVEL SET controls.

20. Sine Repeater V12, V13. This forms a d.c. amplifier with 100% feedback giving an output impedance low enough to feed the sawtooth waveform to 36 HSU's without distortion. The DC SET controls (RV3 and RV5 are adjusted to give zero volts at V13b cathode.

21. Power Unit 904. This unit provides the power supplies for a magslip resolver unit and its amplifier 504.

The outputs are:

a. +570V unstabilised d.c.

b. +400V stabilised at 50 mA.

c. +300V stabilised at 200 mA.

d. -300V stabilised at 100 mA.

e. 6.3V for heaters.

The circuit is similar to that of the PU903, the -500V station reference voltage being used to control the -300V output. The -300V controls the +300V and +400V. Switching on action and protection circuit are the same as in PU903.

1. Purpose. Produces gating waveforms required in the fixed coil console to effect changeover in the deflection amplifiers between radar scan and intertrace, together with other waveforms required for intertrace.

Gating is carried out at 250 p.r.f. irrespective of the timebase p.r.f., so that the same set of gating waveforms may be used for all p.p.i. consoles.

2. Rack assembly T304 contains:

3 Waveform Generators (Gating) T101 (main, standby and spare).
3 Distribution Units (Gating) (main, standby and spare).
3 Power Units T903 main, standby and spare).
1 Panel (distribution and Switching) T879.

a. Waveform Generator (Gating) T101. (Refer Fig 27). This unit produces the following outputs.

(1) +ve and -ve gating pulses which are fed to the deflection amplifiers.
(2) Intertrace bright up pulse (ITBU) which is fed to the console via RA306.
(3) Half Intertrace bright up pulse - not used.
(4) Azication generator drive pulse which is fed to RA302 for production of intertrace deflection waveforms.

b. Distribution Unit (Gating). Provides a number of low impedance outputs for the gating waveforms.

c. Power Unit 903. Supplies h.t. and l.t. to the above units.

d. Intertrace Timing. As the intertrace marker can be used with transmitters of 250 or 500 p.r.f. then the p.r.f. of the intertrace must be 250. (See Fig 26(a)). For p.p.s. stations only, the timing of the intertrace is slightly different - owing to the long flyback time of the 250 p.p.s. timebase. (See Fig 26(b)).

Waveform Generator T101.

3. Trigger Amplifier V1. All waveforms are timed from the 250 p.r.f. master trigger pulse. The circuit is described for V1 in the master timebase unit T140. The output is a positive going pulse 35V in amplitude.

4. Delay Flip-Flop. (Refer Fig 28) V2, V3b produces a negative going square wave 2800 μsecs wide which is used to gate out every other 500 p.r.f. positive square wave from Timebase Unit 140 and thus give the correct intertrace period for 250 and 500 p.r.f. timebases.

a. Static Condition. V2a grid is taken to a high positive potential, set by RV1. V3b conducts holding V2a grid at +60V. V2b grid is held at +30V. V2 cathode will be at +60V so that V2a is conducting, V2b is cut off.

b. Action. The 250 trigger pulse from V1 drives V2b into conduction, the fall at the anode causing V2a to cut off. The grid side of C7 charges towards the potential set by RV1 on a CR of .0022 μFd x 2.7MΩ. After 2800 μsecs V2a cuts on and V2b cuts off.

The negative going waveform from V2b anode is negatively d.c. restored by V13b to earth potential and applied to the suppressor of the gating valve V4.

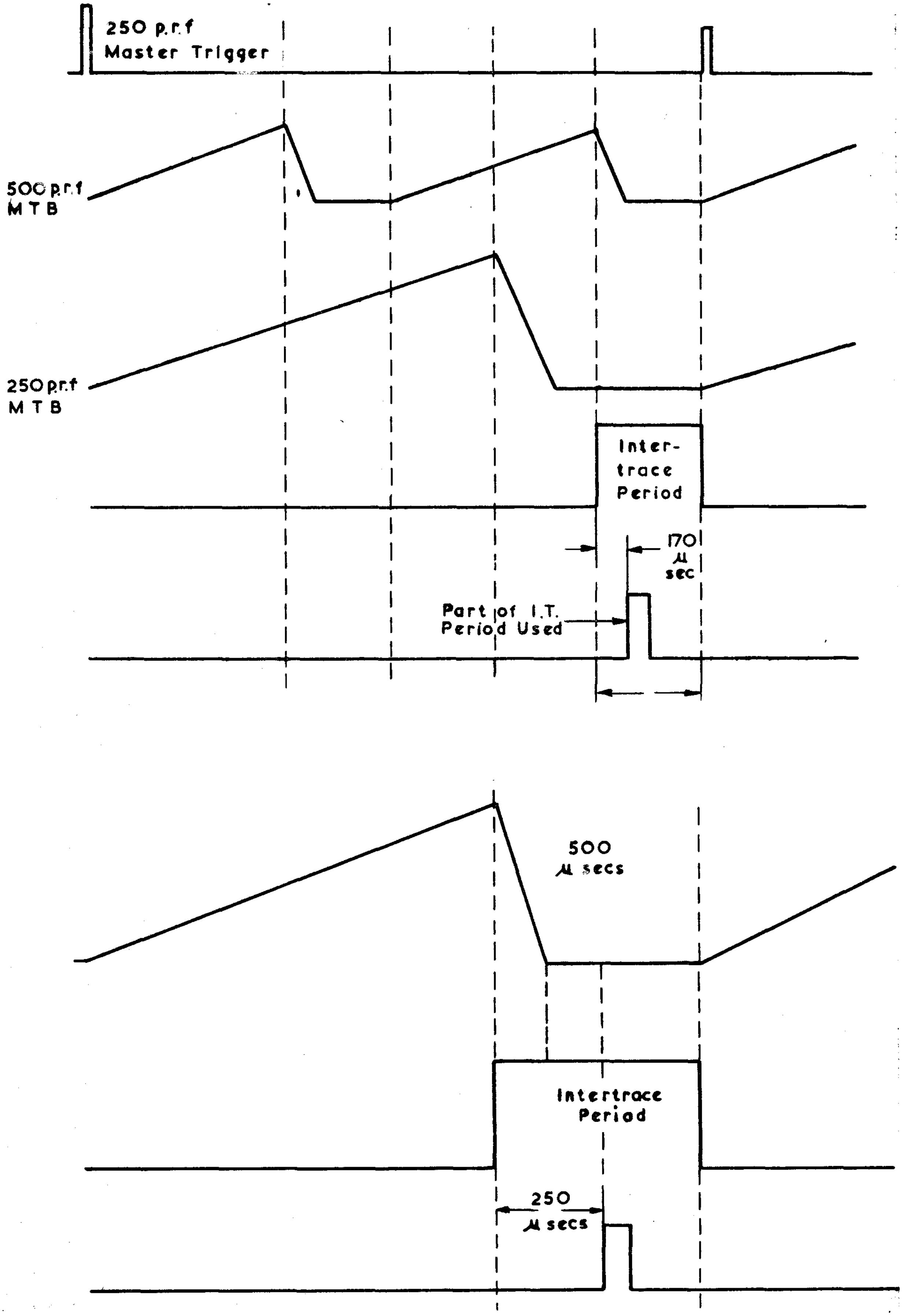


Fig 26b INTERTRACE TIMING

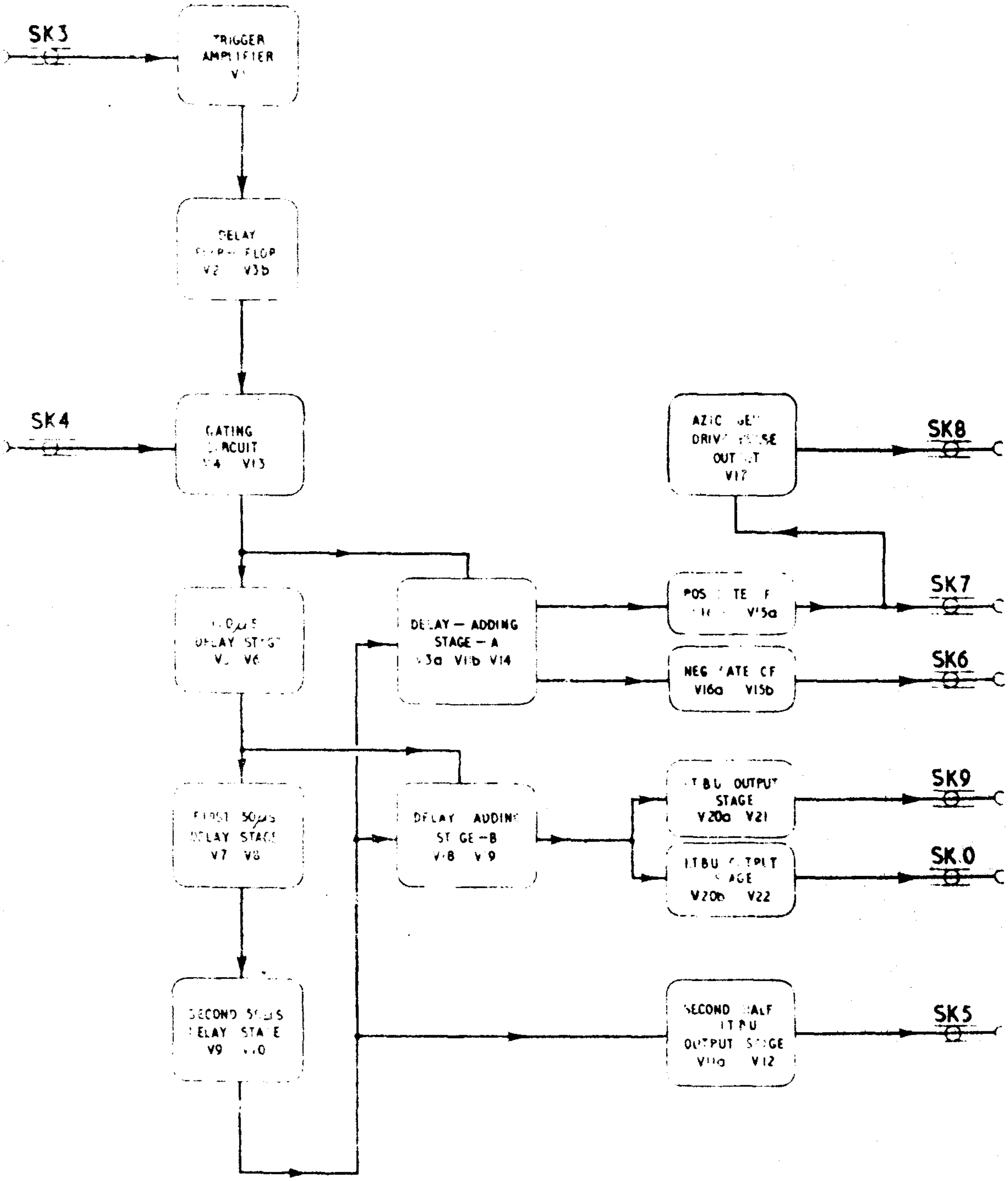


Fig 27 WFG T101 BLOCK DIAGRAM

5. Gating Circuit V4, V13A. (Refer Fig 29) Input to suppressor grid is the waveform from V2. The input to control grid is the gating waveform generator (GWG) drive from timebase unit 140.

a. Static Condition. V4 is normally cut off with -12V on the control grid. V13a is is cut off, its anode at -12V, its cathode at a high positive potential.

b. Action. When both inputs are positive going then V4 conducts. The fall in anode voltage causes a fall in the potential of V13a cathode and V13a conducts. The cathode potential will settle between 0V and -5V (the grid base of V4, the actual potential being decided by the setting of the BU DELAY control. Assume V13a cathode settles at -3V. Then V13a conducts, holding V4 grid at -3V. The waveform fed to the grid will be limited at this level, the rest of the waveform being developed across R.34 (see Fig 30).

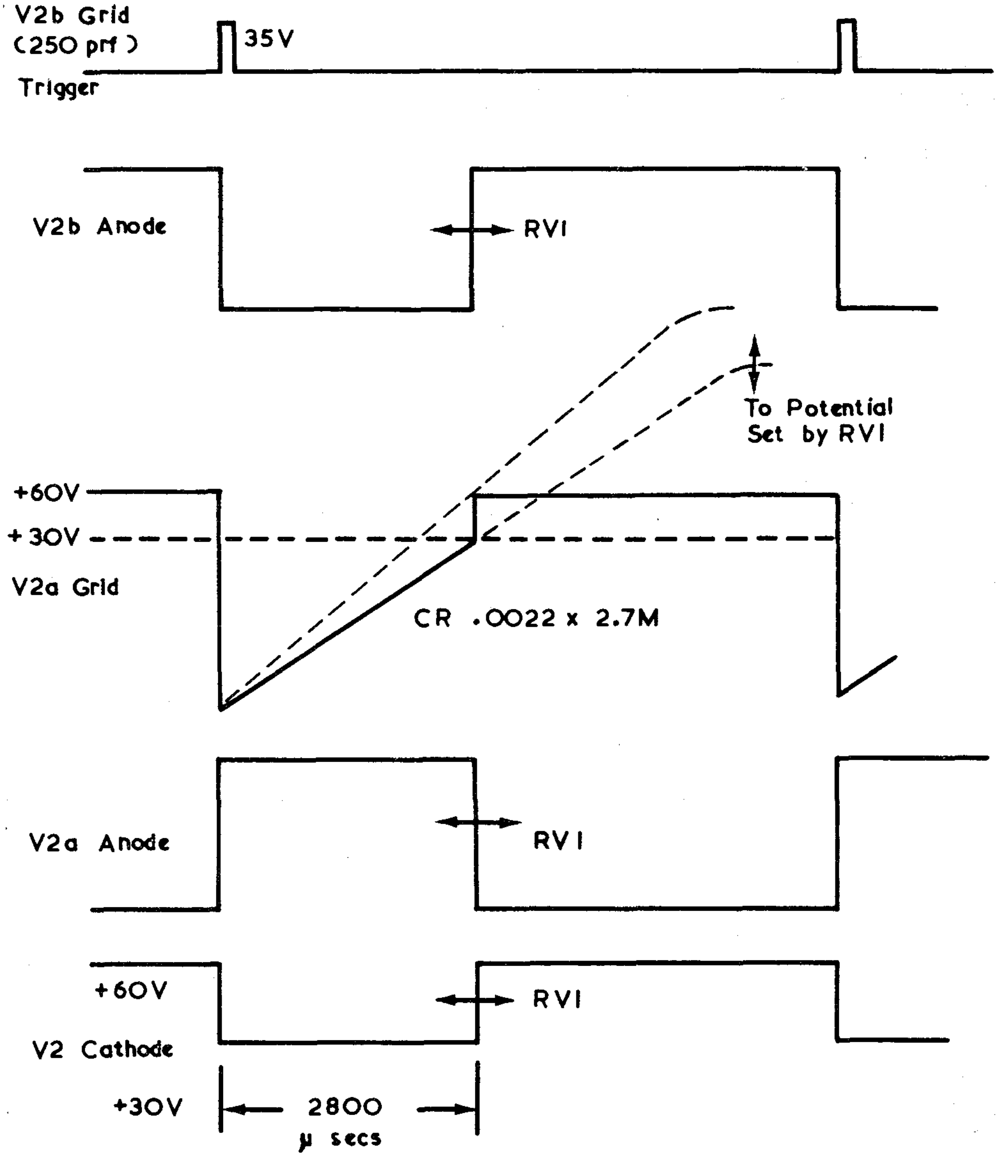


Fig 28 DELAY FLIP-FLOP - WAVEFORMS.

The BU DELAY (see Fig 30) control will set V4 grid potential when V4 conducts, so that this control varies the amplitude of the output. This output is fed to the delay stages, the outputs of which are used to produce all waveforms used for intertrace. The three delay stages all operate in the same way thus only one is described in the following paragraphs.

6. <u>170 µsecs Delay Stage.</u> (Refer Figs 31,32) The purpose of this delay is to introduce the interval of 170 µsecs required between the start of the intertrace gating waveform and the ITBU pulse.

a. <u>Static Conditions.</u> V5 grid to +h.t. so V5 conducting fairly heavily. V5 anode voltage is low making V6a grid negative, the actual potential being decided by RV3. V5 grid potential will be approx 0V so that V6b will conduct, its cathode potential rising to approx 0V. V6a cathode will therefo e be at 0V approx. and V6a cut off.

b Operation. The negative going waveform from V4 anode is applied via the medium CR of 1.5 MΩ and 330 p.f. to V5 grid. The negative edge causes V5 to cut off, the rise at the anode causing V6a to conduct and V6b to cut off. V5 grid voltage rises on the medium CR as the 330 p.f. capacitor charges. After 170 μsecs V5 conducts and the circuit reverts to its original condition.

The amplitude of the input pulse decides the time V5 is cut off and is adjusted by RV2. RV3 alters the amplitude of the output from V6a cathode.

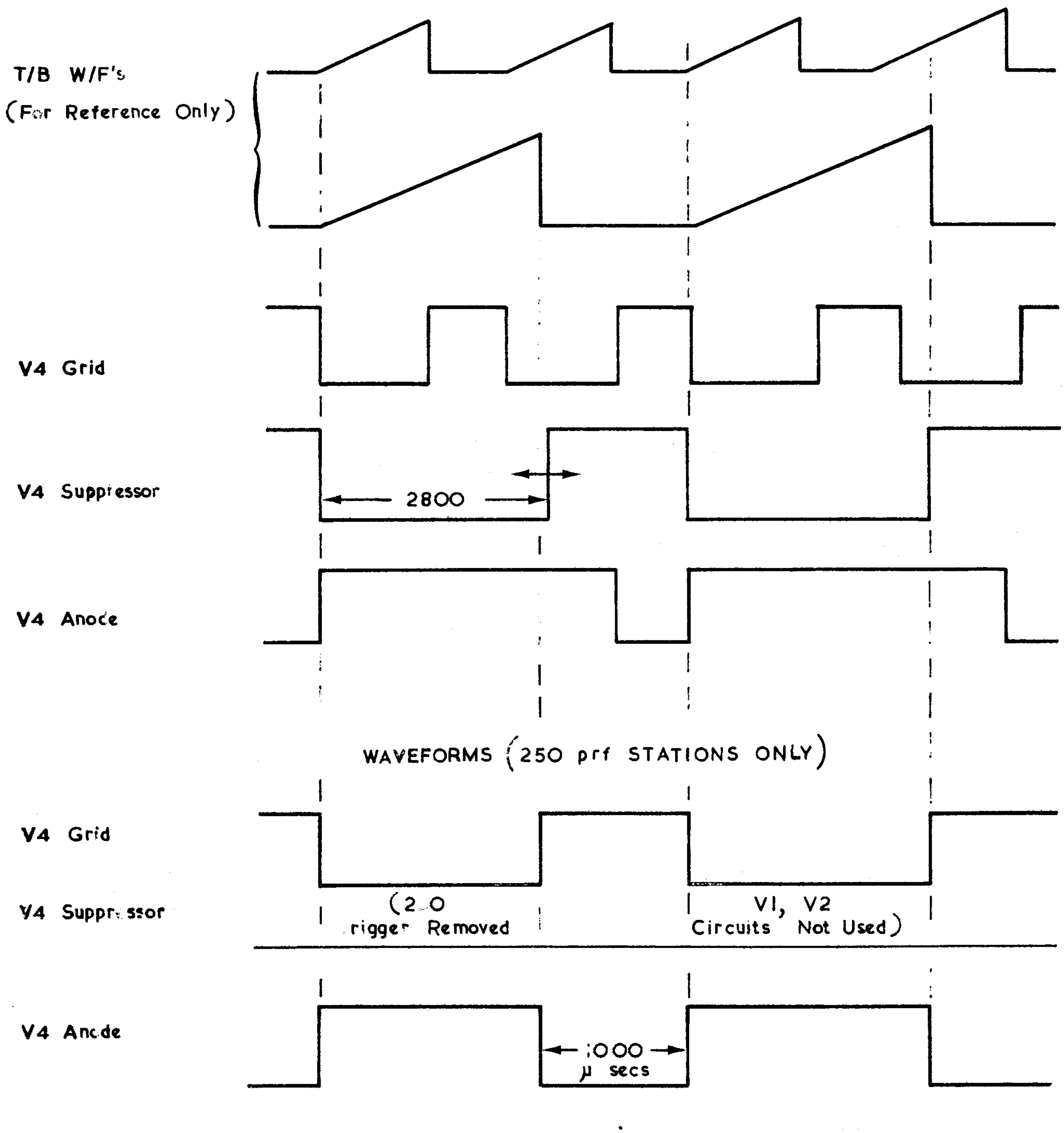


Fig 29 WAVEFORMS FOR 250 AND 500 p.r.f HEADS

WAVEFORMS TO SHOW EFFECTS OF V13A ON GRID W/F

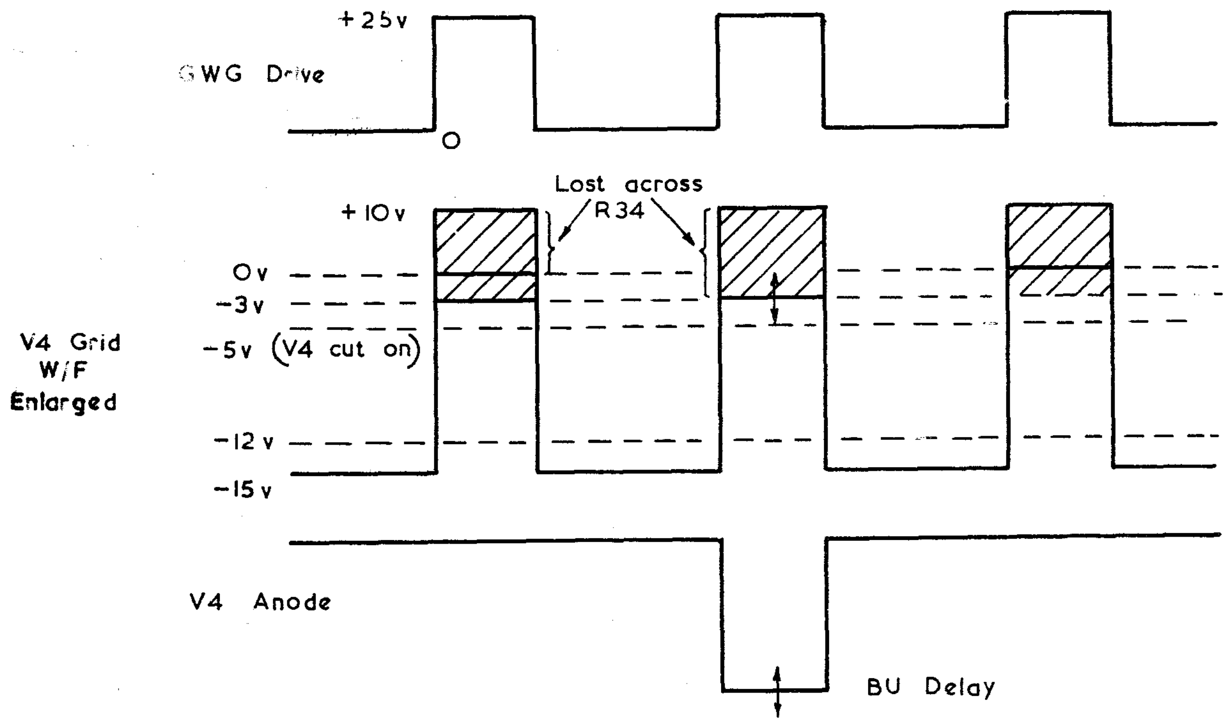


Fig 30

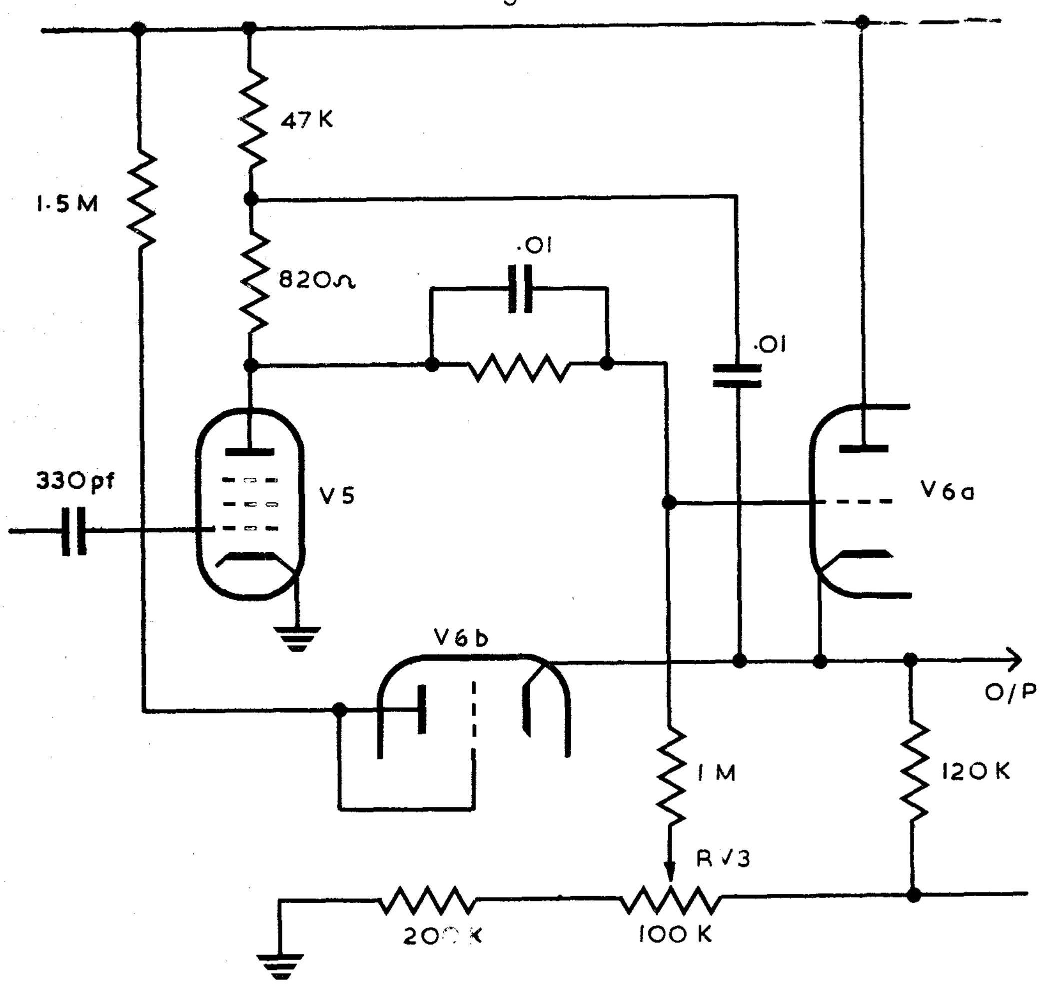


Fig 31

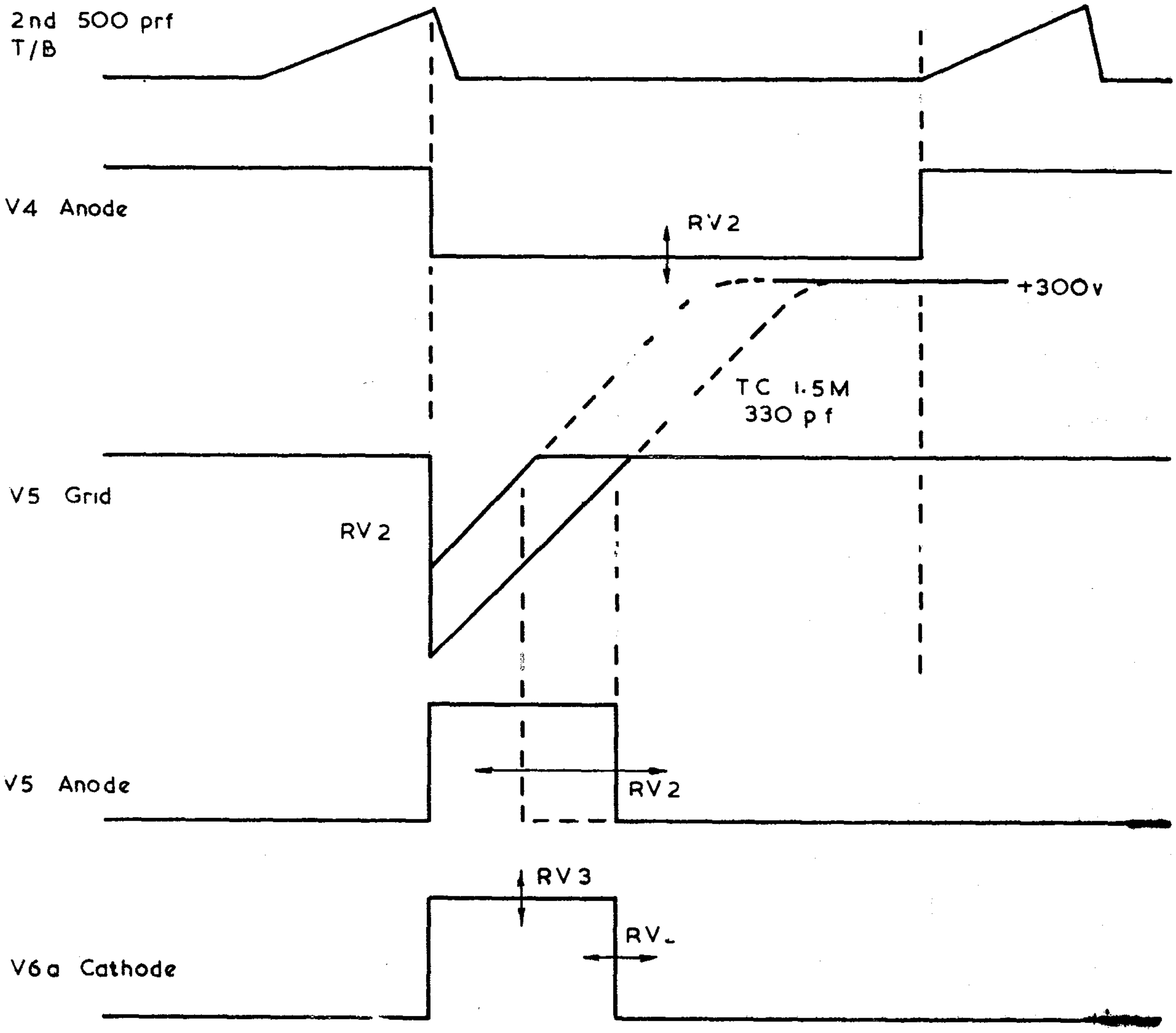


Fig 32 170 μsec DELAY STAGE - WAVEFORMS

7. 1st 50 μsecs Delay. V8B, V7 and V8A. (Refer Figs 33,34) Circuit action as for the 170 μsecs delay stage.

BU DURATION NO 1 control (RV3) is set to give a 50 μsecs pulse at V8A cathode.

BU DURATION NO 2 control (RV4) alters the amplitude of the output.

8. 2nd 50 μsecs Delay. V10A, V9 and V10B. (Refer Figs 33,34). Circuit action as before.

BU DURATION NO 2 control (RV4) is adjusted to give a 50 μsecs pulse at V10B cathode.

9. Delay Adding Stage A. This stage adds the three delays of 170 μsecs, 50 μsecs and 50 μsecs, producing a 270 μsecs waveform which is used for gating and the production of the azication marker deflection waveforms.

10. Bi-stable Flip-Flop. V14A and V14B. (Refer Figs 35,36) In the static condition either V14A or V14B can be conducting and the other cut off. Assume V14B is conducting. V4 anode waveform is differentiated and the negative part of this is applied to V14B grid via V3A. V14B is cut off and V14A conducts. 270 μsecs later, the negative waveform from

V10B cathode (ie last 50 µsecs delay pulse, differentiated and applied via V11B) will cause V14A to cut off and V14B to conduct. A 270 µsecs waveform will be produced at each anode.

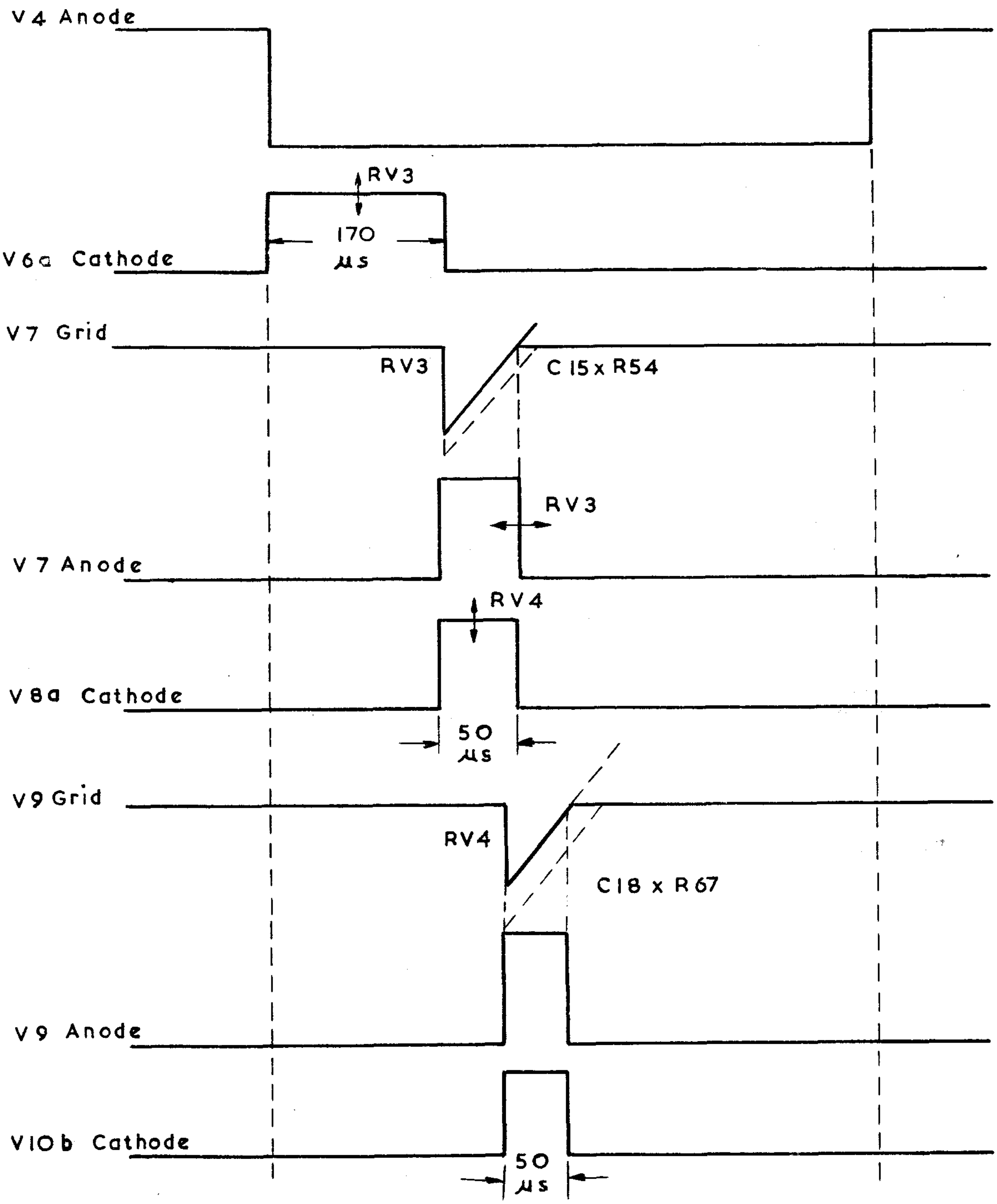


Fig 33 DELAY TIMING WAVEFORMS

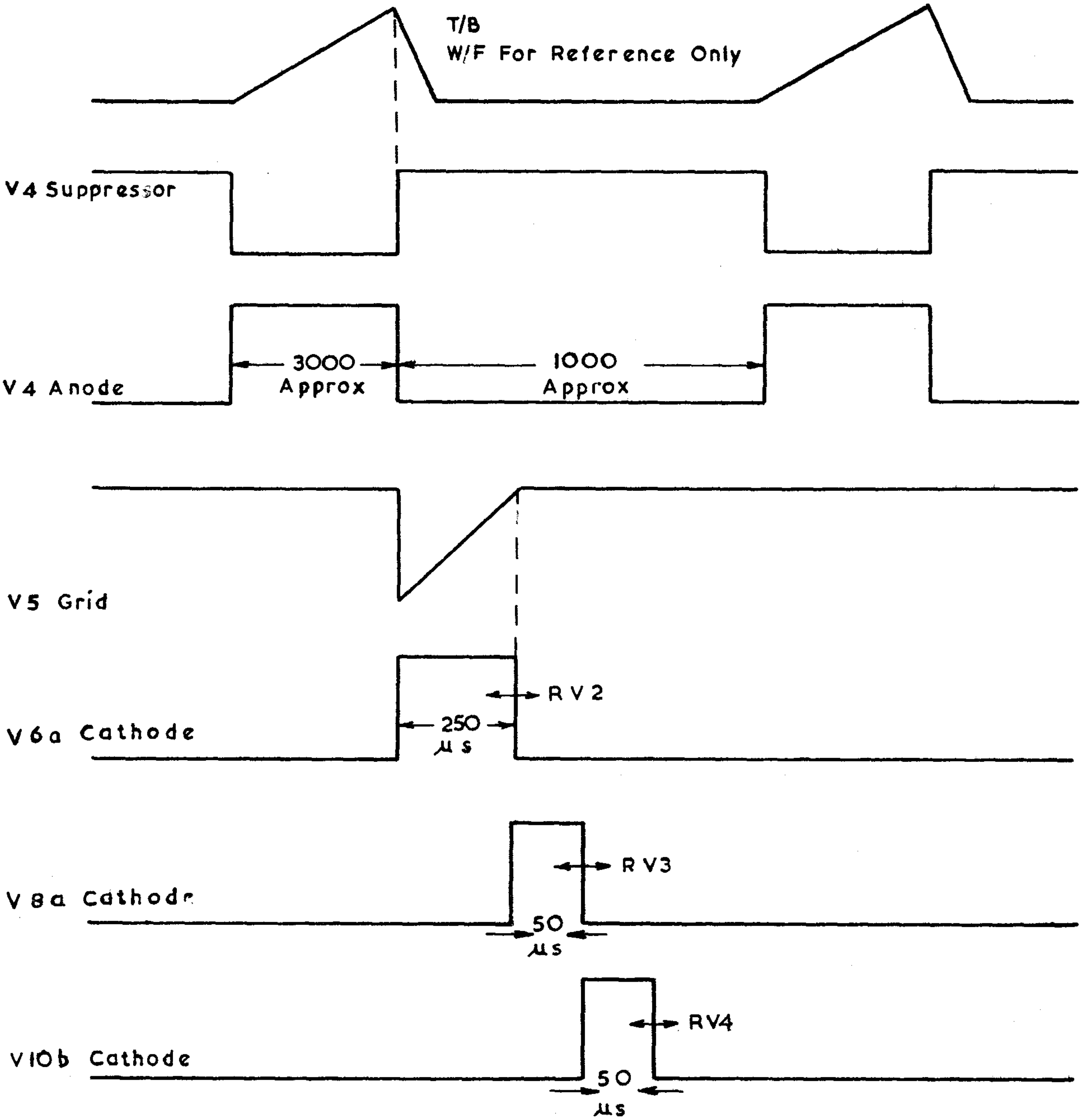


Fig 34 DELAY TIMING WAVEFORMS 250 PPS STATIONS ONLY

To get the same amplitude waveform from each valve the output from V14B is taken from a tapping on the anode load.

11. The waveforms from V14A and V14B anodes are d.c. restored by V15B and V15A respectively to +35V and applied to the cathode followers V16A and B. As the input waveforms to V16 are about 140V in amplitude, they cause V16A to be cut off during 270 µsecs pulse time and V16B to be cut on during the 270 µsecs pulse so as to obtain a steep sided waveform. In order to achieve this result with the positive waveform from V14B, the d.c. restorer resistor (R1[illegible]) is returned to earth.

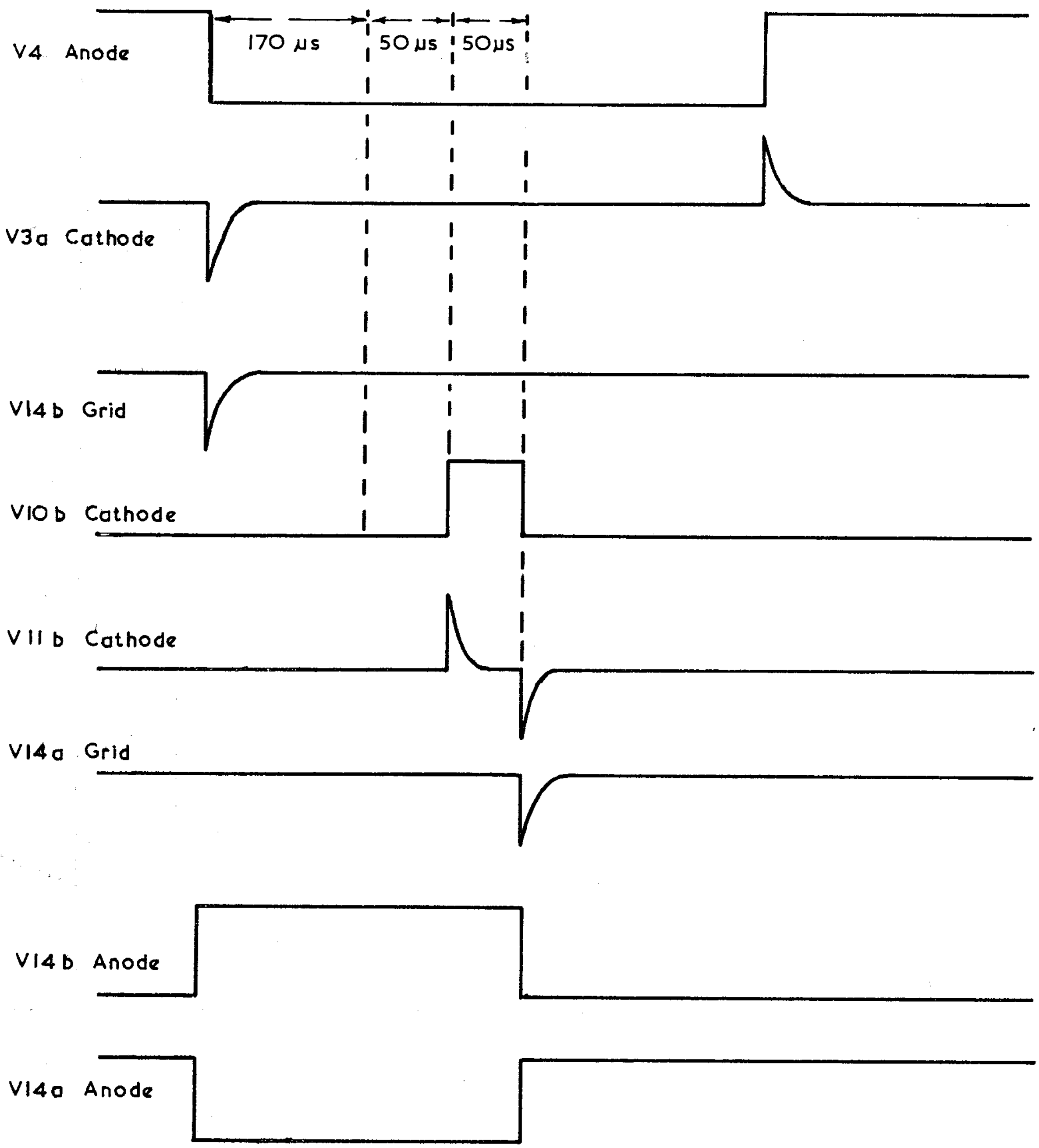


Fig 35 DELAY ADDING STAGE A - WAVEFORMS

The output waveforms from V16 are fed via the gating distribution unit to the deflection amplifiers for switching intertrace and radar scan deflection waveforms to the deflection coils.

The positive waveform from V16b is also fed to V17.

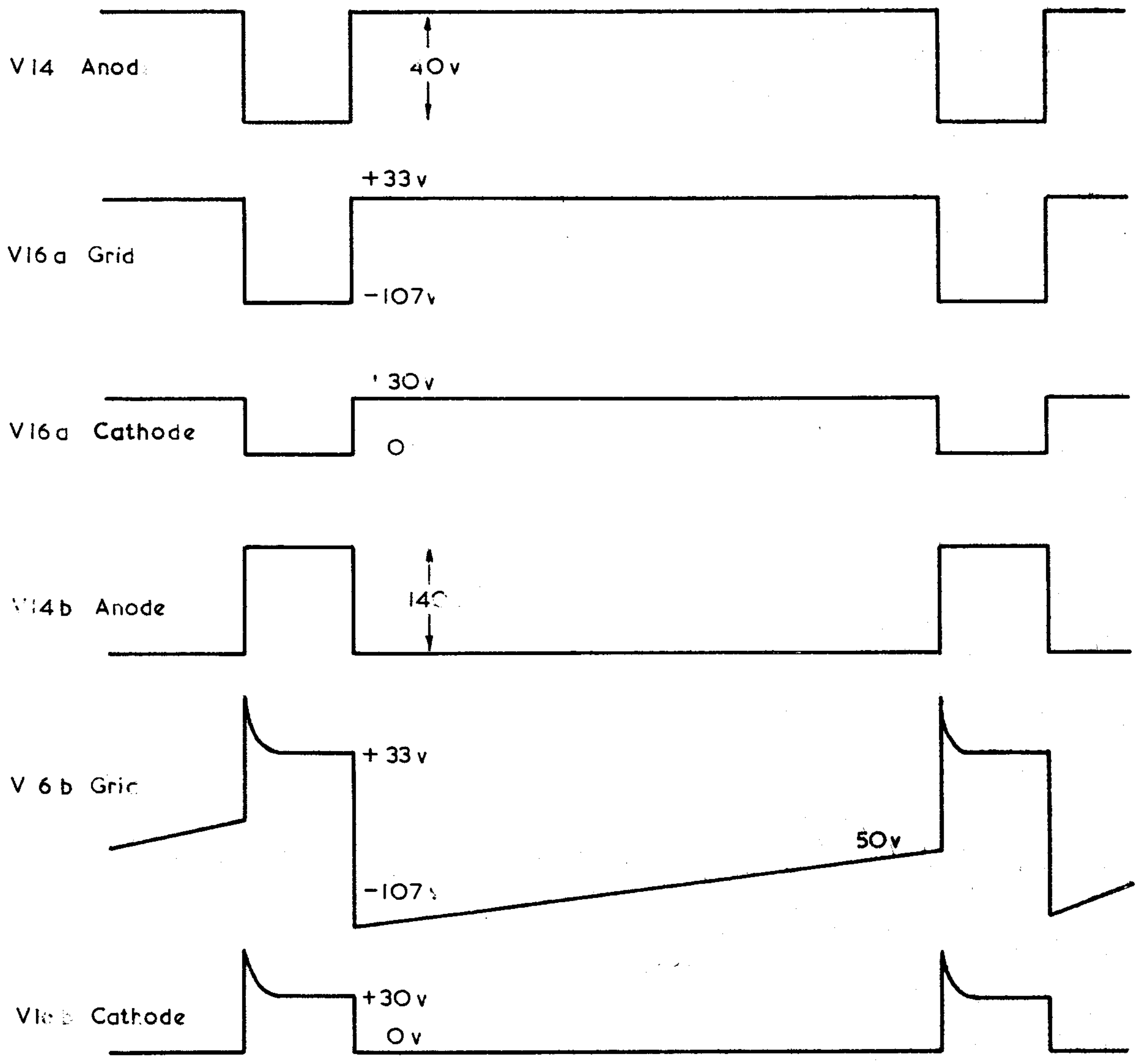


Fig 36 DELAY ADDING STAGE A - WAVEFORMS

12. <u>Azication Generator Drive Pulse.</u> V17. This is a see-saw amplifier with an approximate gain of

$$\frac{R117}{R115} = \frac{470\ k\Omega}{820\ k\Omega} \qquad \frac{3}{5}$$

The output is therefore a negative going pulse, 270 µsecs wide approximately 20V in amplitude. It is fed to rack assembly 302 to trigger the sawtooth generator which provides the waveforms for interface deflection

13. Delay Adding Stage B. This stage adds the outputs from the two 50 μsecs delay stages to form a 100 μsecs pulse to be used as the intertrace bright up.

14. Bi-stable Flip-Flop. V18 and V19 (Refer Fig 37) In the static condition either V19a or V19b will be conducting; assume V19a conductin. V6a cathode waveform is differentiated and applie to V18b cathode. Only the negative pip will cause this valve to conduct and cause V19a to cut off and V19b to conduct. V10b cathode waveform is differentiated and applied to V18a cathode. Only the negative pip will cause the valve to conduct and cause V19b to cut-off and V19a to conduct.

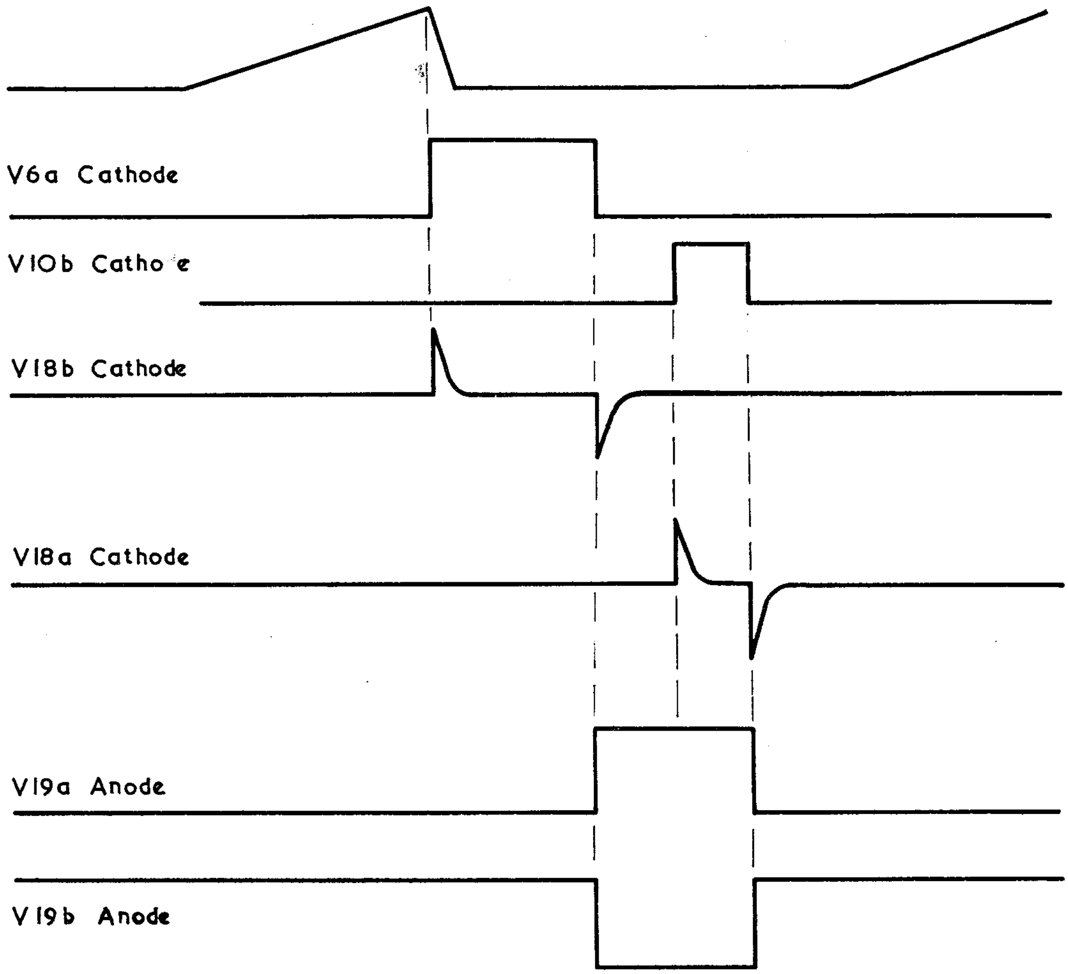


Fig 37 DELAY ADDING STAGE B - WAVEFORMS

V19a anode waveform will be a positive going pulse, 100 μsecs wide occurring 170 μsecs after the end of every other 500 p.r.f. timebase waveform or, a 100 μsecs pulse occurring 250 μsecs after each 250 p.r.f. timebase.

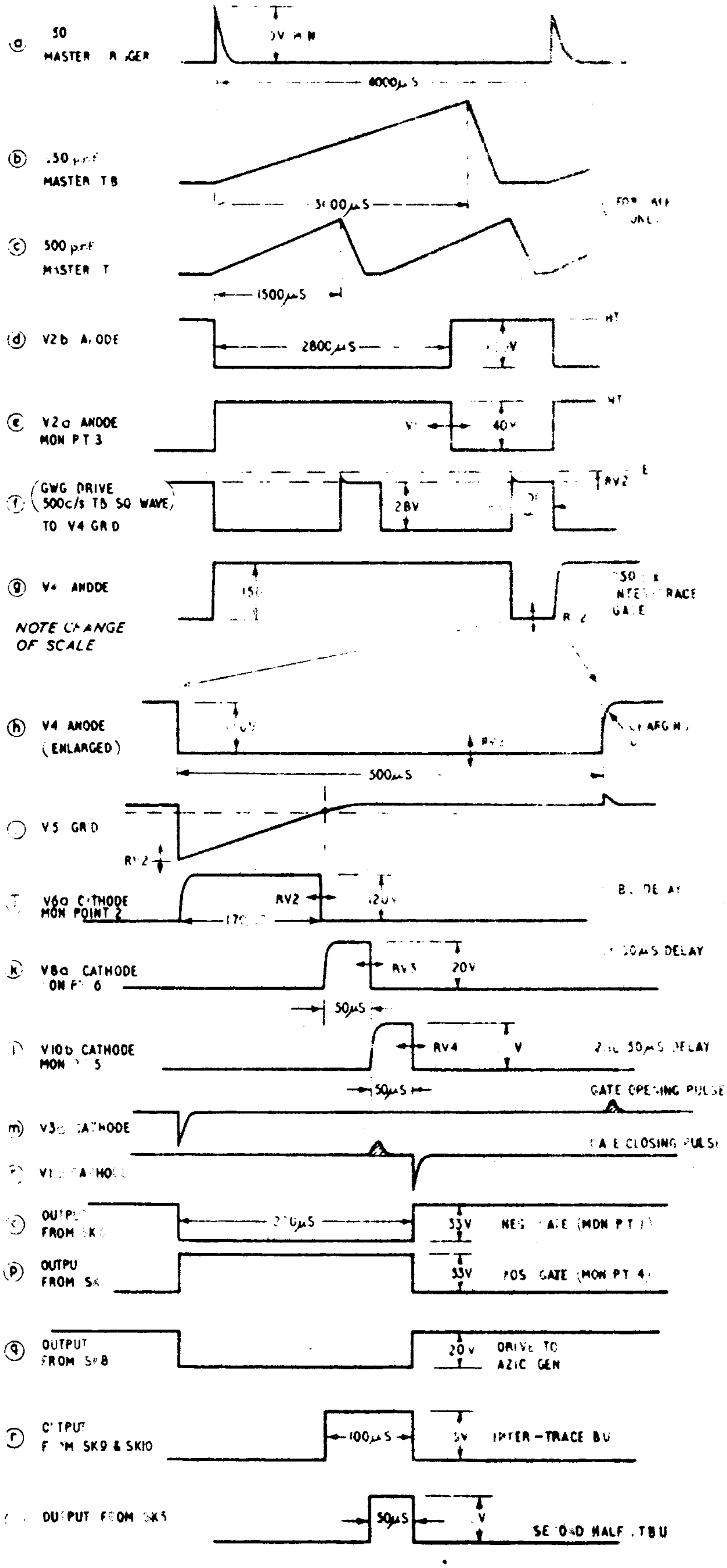


Fig 38 WAVEFORM GENERATOR (GATING) TYPE 101 - WAVEFORMS

15. Intertrace Bright-up Output. (Refer Fig 38) V20A and V21 form a low impedance output stage designed to produce an output waveform with extremely steep sides and constant amplitude.

a. Static Conditions. V20A conducting, its anode connected via R134 to +300V and its cathode to a negative potential. V20A anode voltage will be approx -25V (which is V21 grid potential) and V21 is cut off.

b. Action. The 100 μsecs pulse from V19A lifts V20A cathode potential. V20A cuts off, its anode potential will rise. V21 cuts on. Feedback from anode to grid (C38 and R137) ensure that when V21 conducts it passes a cathode current of 50 mA, producing a 5 volt pulse at the cathode.C40. A 1 μFd capacitor reservoir capacitor prevents a heavy drain on the h.t. supply when V21 conducts. C39, a 0.001 μFd capacitor speeds up the positive going edge of the waveform by holding up the anode potential at the instant the valve conducts. The circuit action of V11A, V12A and V20B, V22 is similar to the operation of V20A, V21.

16. Gating Distribution Unit. (Refer Fig 39) This unit provides six low impedance outputs for the positive gating waveform and six for the negative gating waveform. Each output is capable of supplying up to seven p.p.i. consoles.

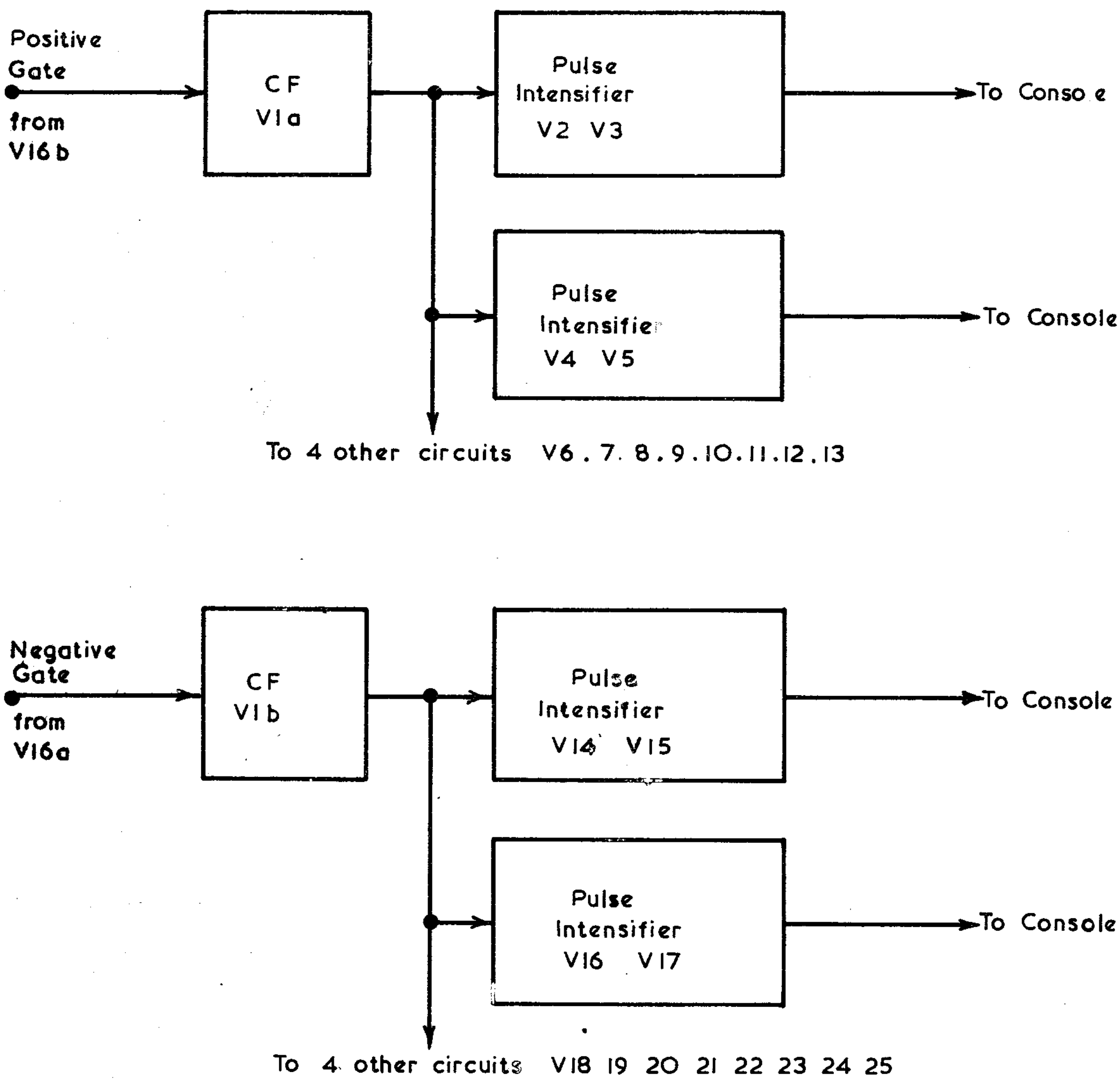


Fig 39 GATING DISTRIBUTION UNIT - BLOCK DIAGRAM

17. V1A is a cathode follower feeding the positive gate waveform to six identical pulse intensifier circuits. V1B is a cathode follower feeding the negative gate waveform to six identical pulse intensifier circuits. V1A and V1B have different grid potentials in order to handle the input waveform.

18. Cathode Follower V2. (Refer Figs 40, 41 and 42) Stray capacitance across the cathode load becomes high, causing the negative edge of the waveform to be exponential. On the positive going edge, the valve is conducting heavily and stray capacitances charge very quickly giving steep edge. V3 is included in the circuit to improve the negative edge by discharging the stray capacitances very quickly.

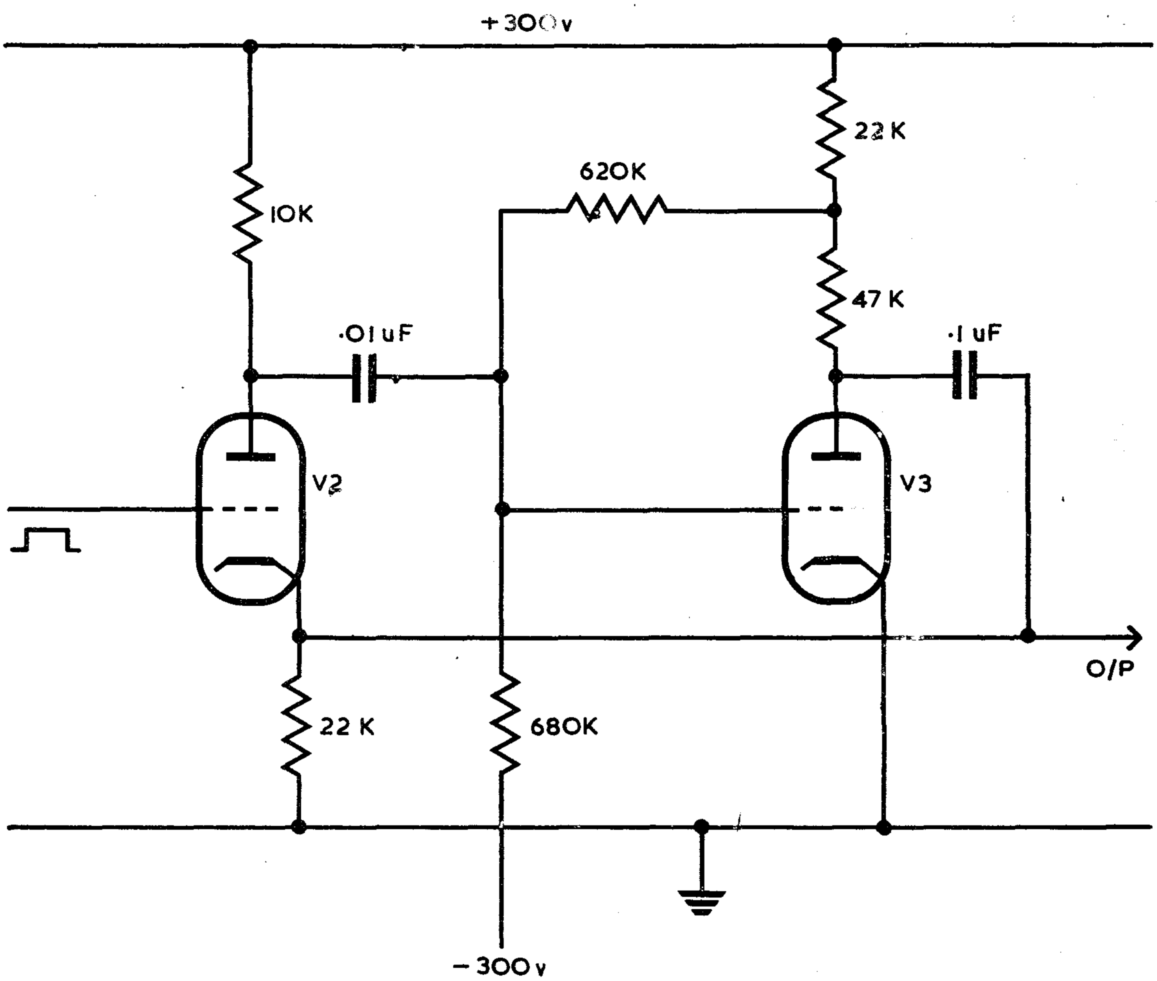


Fig 40

19. V2 and V3 normally conducting.

Input waveform causes V2 grid potential to rise. V2 anode voltage falls causing V3 anode volts to rise. This rise is fed back to V2 cathode, helping to lift V2 cathode potential. V3 will cut off.

The equivalent circuit will be.

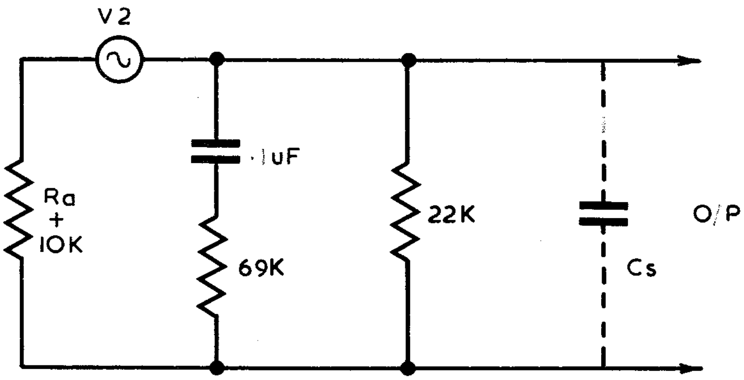


Fig 41

20. On the negative edge V2 anode volts rise and V3 conducts. V3 will therefore be in parallel with the stray capacities and help to discharge them quickly.

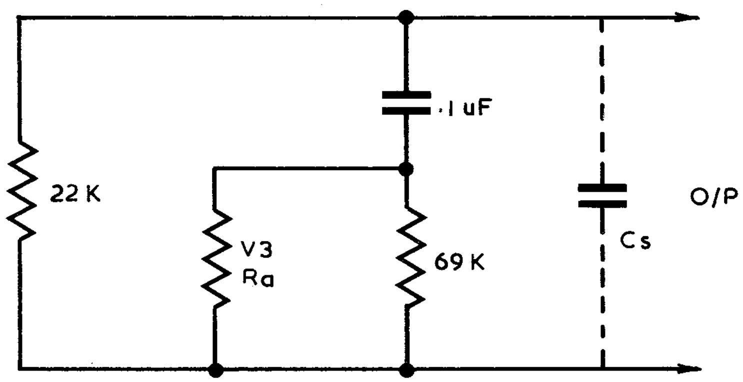


Fig 42

1. Purpose. (Refer Fig 44) Accepts the intertrace bright up pulses from the gating waveform generator T101 and distributes them to azicating consoles and also re-routes all azication information to a standby console when the main console fails.

2. This rack assembly contains:

a. Two Distribution Units (ITBU) (Refer Fig 43) One main, one standby. Each unit provides eight low impedance outputs, six of them fed to the consoles, one for the STOP LOOK console and one to workshops for test purposes.

b. Panel Switching T876. Changes over the distribution units.

c. Relay Unit (Azication Changeover). Switches all azication information from the main to standby console.

NOTE. Azication deflection waveforms do NOT pass through this unit but are fed direct to both consoles.

d. Power Unit 903. Supplies h.t. and l.t. to the distribution units.

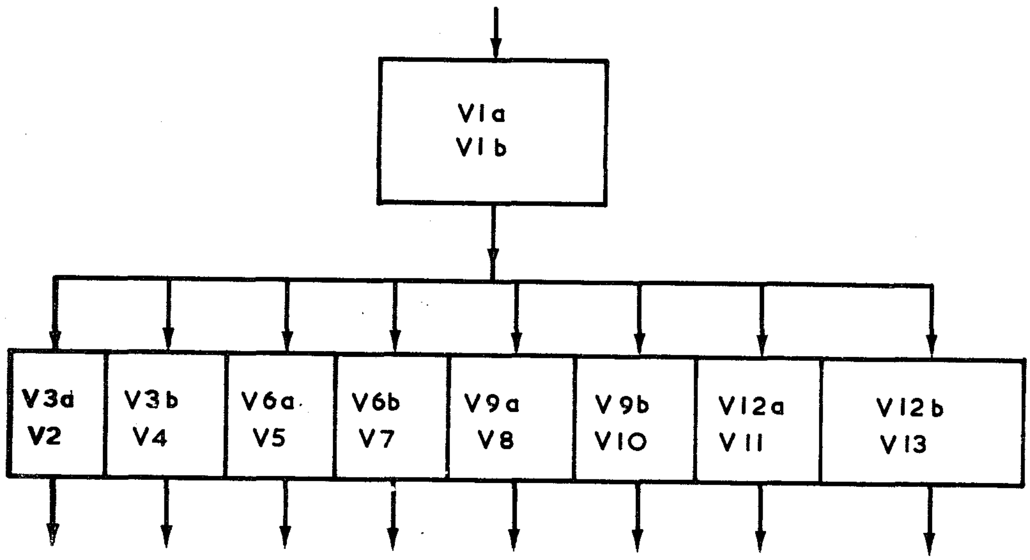


Fig 43 DISTRIBUTION UNIT ITBU

3. The input waveform is the 100 μsecs pulse 5V in amplitude from the ITBU output stage in the WGF T101. It is fed to the low impedance input at V1A cathode and a positive pulse produced at V1A anode. The amplitude of this pulse is made independent of input amplitude by feedback from anode to grid. The output of V1A fed to the cathode follower V1B which feeds the pulse, now about 30V in amplitude, to the eight output stages.

Feedback from V1B to the input of V1A by C2 stabilises the output.

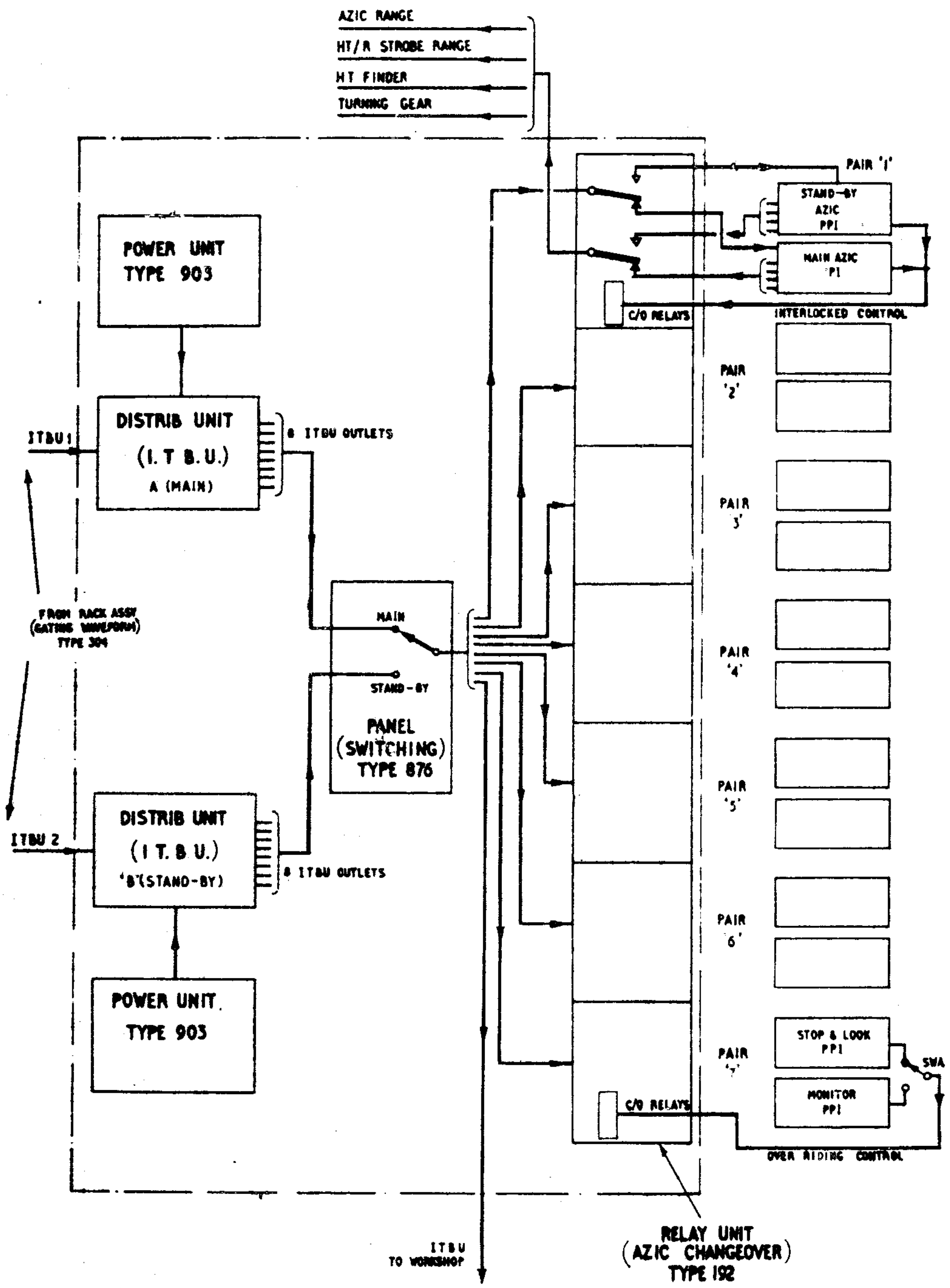


Fig 44 RACK ASSEMBLY TYPE 306 - SIMPLIFIED BLOCK DIAGRAM

4. Output Stage. (Refer Fig 45) V3A is normally conducting its anode voltage will be approximately -25V. V2 will be cut off.

The input to V3A cathode causes V3A to cut off. V3A anode potential will rise until V2 conducts. Feedback from anode to grid via 160 kΩ and .0068 μFd capacitor is designed to make V2 pass 70 mA when it conducts giving a 5V pulse at the cathode. The 70Ω potentiometer on control panel 859 (STROBER MARKER) is the cathode load of V2.

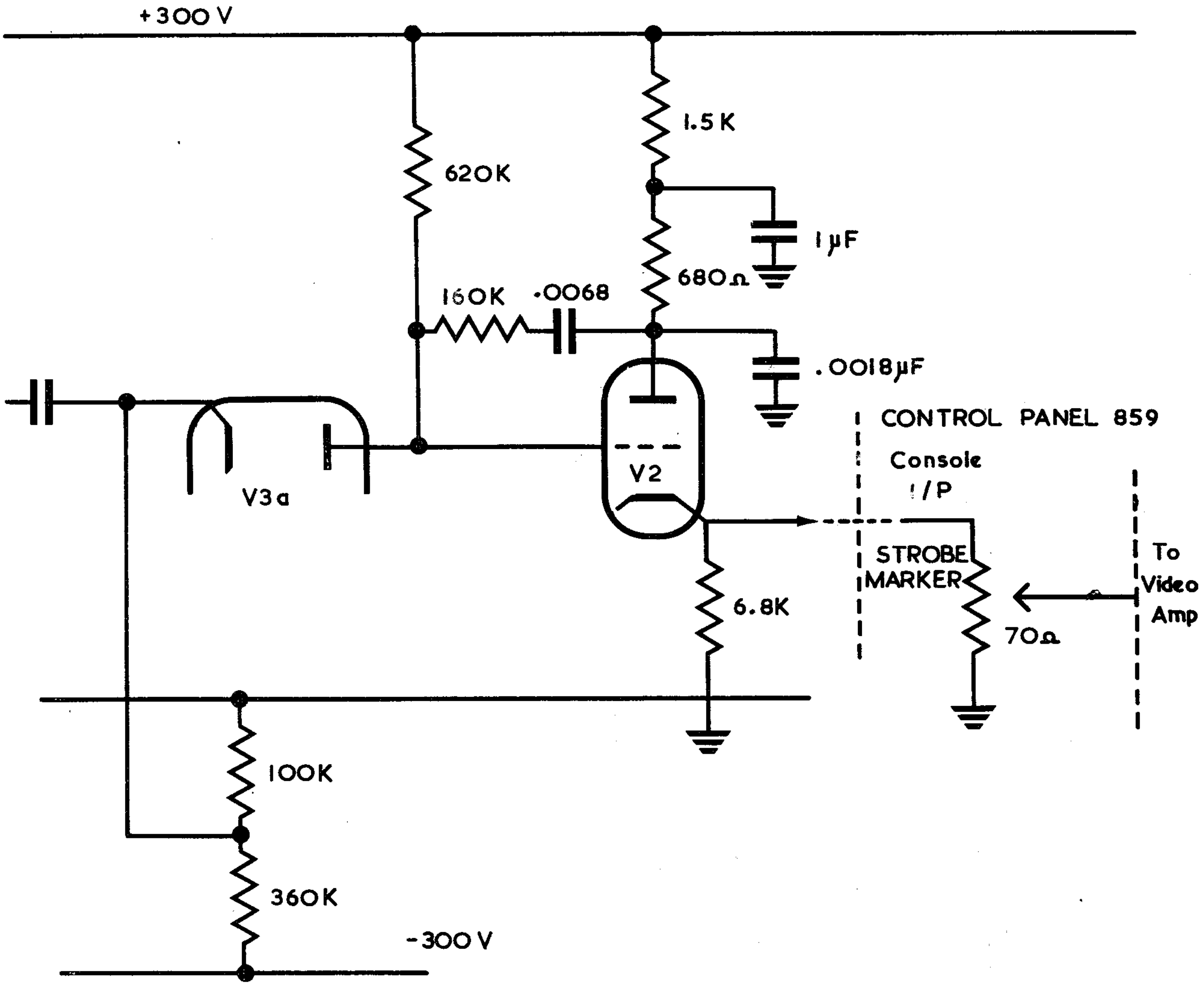


Fig 45 OUTPUT STAGE V3A, V2

5. The 1 µFd capacitor acts as a reservoir to prevent a heavy drain on the h.t. supply when V2 conducts. The .0018 µFd capacitor speeds up the leading edge of the waveform by holding up to the anode voltage at the instant V2 conducts.

6. The 5V pulse developed across the 70Ω potentiometer is fed to the video amplifier, mixed with signals, radar bright up etc and fed to the c.r.t. grid. It will brighten up the last 100 µsecs of the intertrace deflection waveform producing the intertrace marker on the c.r.t. face.

7. Panel Switching T876. (Refer Fig 46) For switching from main to standby distribution unit.

There are eight banks of switches, one bank for each output. The dummy load is connected to the output not being used.

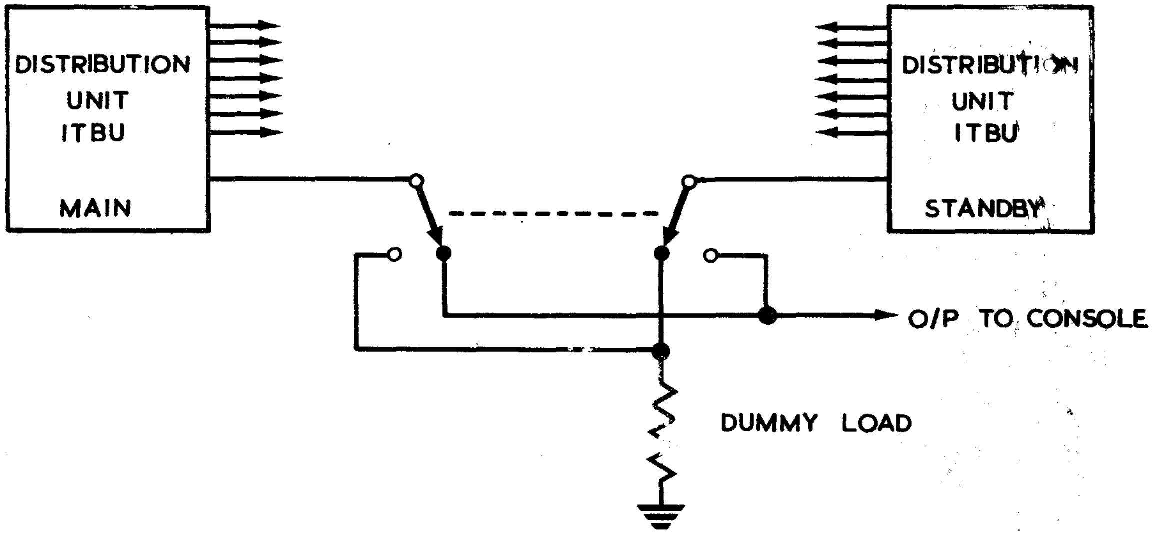


Fig 46

8. Relay Unit (Azication Changeover) T192. (Refer Figs 47, 49) This unit carries seven banks of four relays which effect the changeover of azication facilities between main and standby consoles.

Banks 1 to 6 operate with normal MAIN/STANDBY consoles.

Bank 7 applies to the STOP AND LOOK/MONITOR consoles. Interlock action ensures that the standby console cannot switch on azication facilities while the main console is operational.

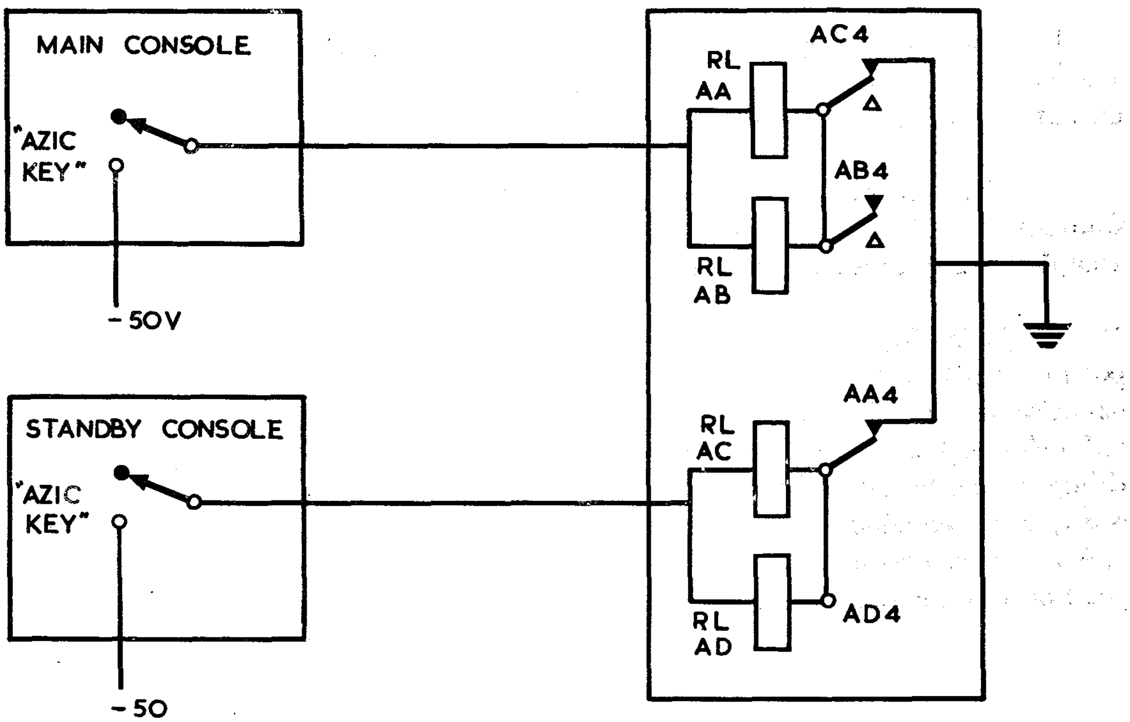


Fig 47 BANKS 1 TO 6

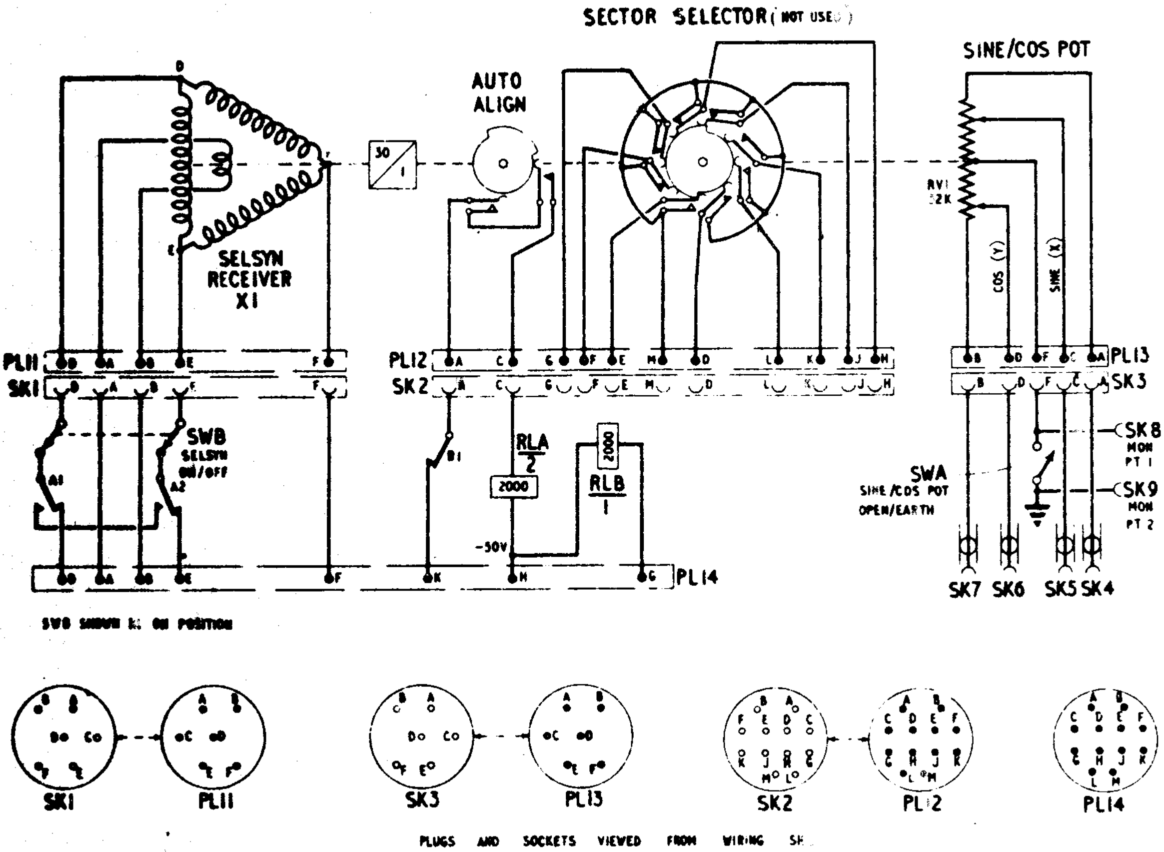


Fig 48 RESOLVER UNIT (AZICATION) - CIRCUIT

9. The relay of the main console (AA) has a normally closed contact (AA4) in series with the relay associated with the standby console (AC).

When switching on AZIC KEY of main console, RLAA energises opening AA4 so that RL's AC and AD cannot energise. Should the main console become unserviceable the azication facilities must be switched off before they can be applied to the standby console.

When switching off AZIC KEY of main console, RL's AA and AB de-energise. Contact AA4 closes. Switching on AZIC KEY of the standby console. RL's AC and AD energise, contact AC4 opens preventing RL's AA and AB from energising.

10. (Refer Fig 49). Interlock action is as for banks 1 to 6 but an over-riding switch is put in circuit so that azication facilities can be fed to the monitor p.p.i. when the occasion arises. The azication facilities would normally be fed to the stop and look console. RL' GA and GB would be energised and contact GA4 will be open. By switching the over-riding switch to the MONITOR position, RL's GC and GD will be energised, CC4 will open, de-energising RL's GA and GB which switch the azicating facilities to the monitor p.p.i. It must be noted that the over-riding switch must be put back to STOP/LOOK position when normal operation is resumed.

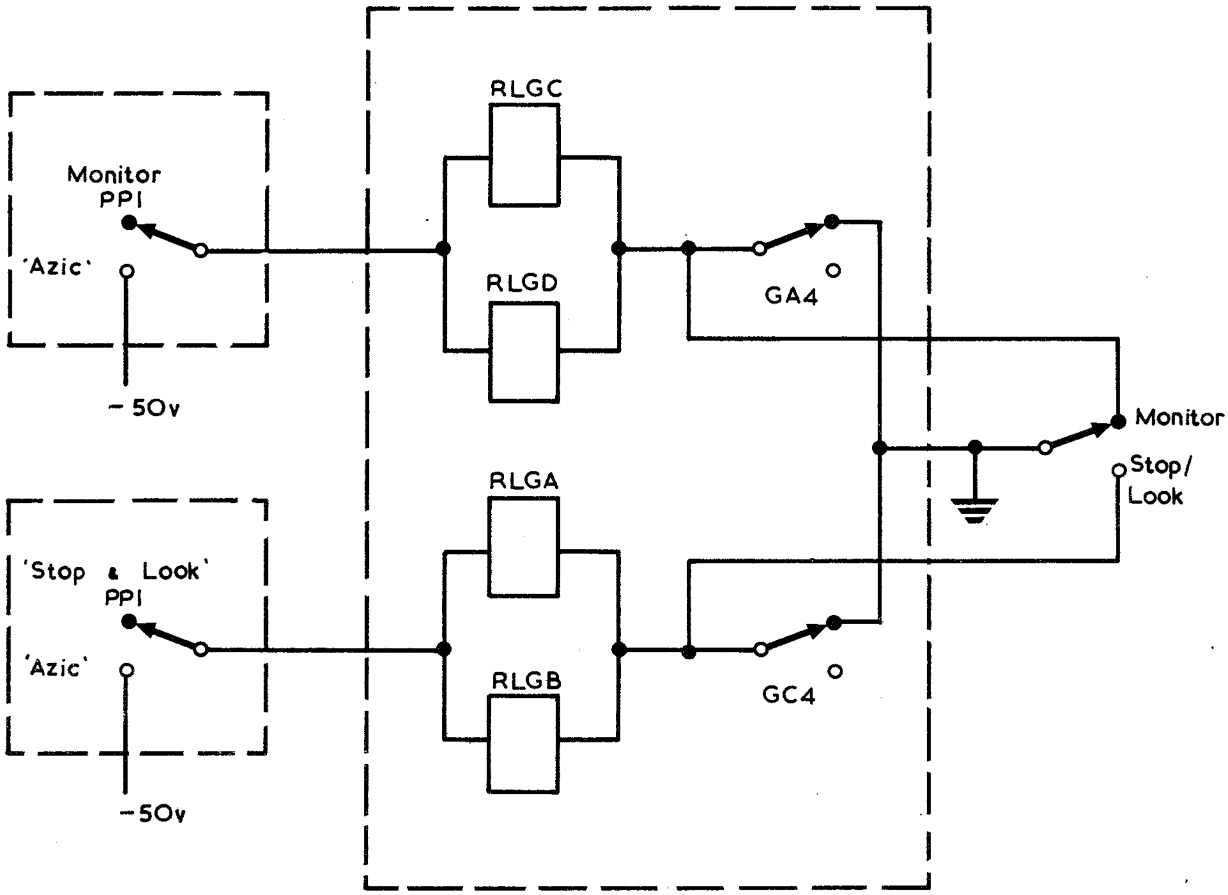


Fig 49 RELAY BANK 7 - INTERLOCK

11. Azication Changeover. (Refer Fig 50) The following action takes place when AZIC KEY on the main console is pressed.

a.

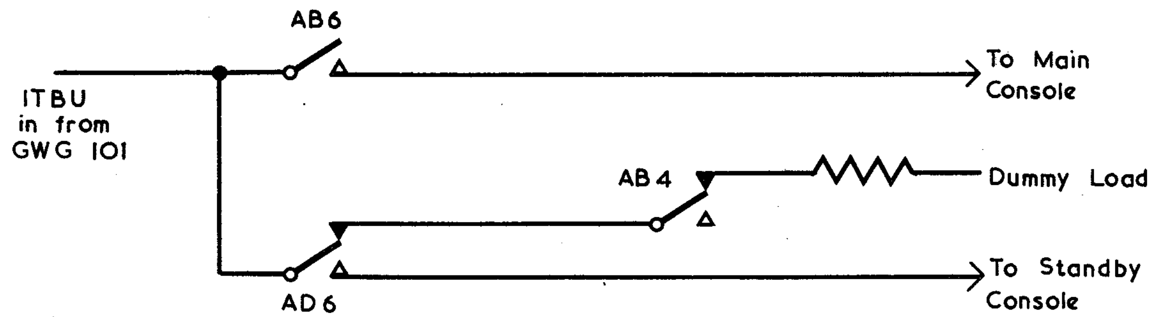


Fig 50a

Relay AB energises. Contact AB6 feeds ITBU to main console.
Contact AB4 disconnects the dummy load.
Relay AD remains de-energised.

b

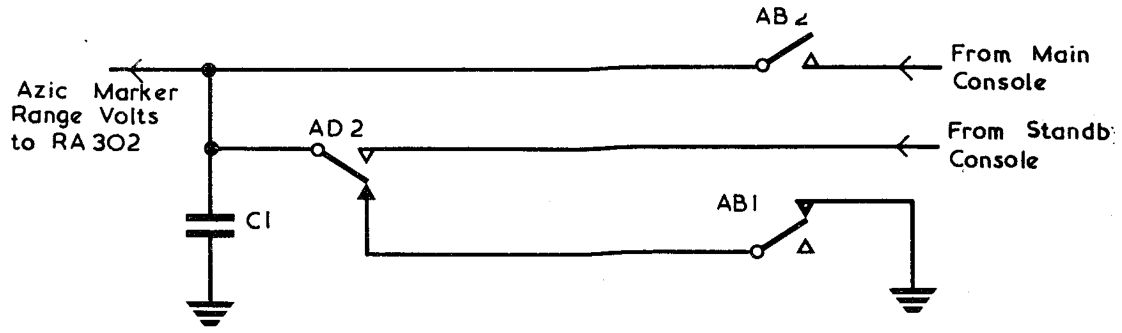


Fig 50b

Relay AB energises

Relay AD de-energised.

Contact AB2 feeds volts to RA302.
Contact AB1 disconnects line from earth.
C1 (.5μF) decouples the suppl .

c.

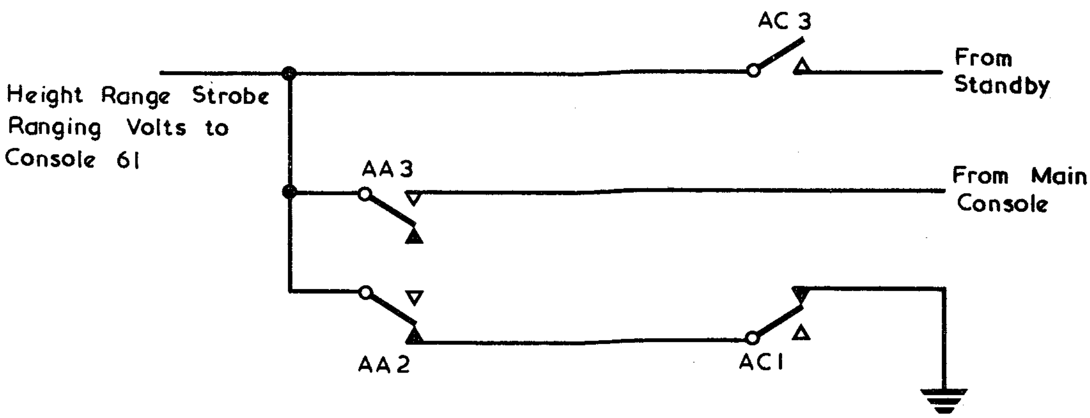


Fig 50c

Relay AA energises.

Relay AC de-energised.

Contact AA3 closes feeding volts to console 61.
Contact AA2 opens, disconnecting ear h connection.

d.

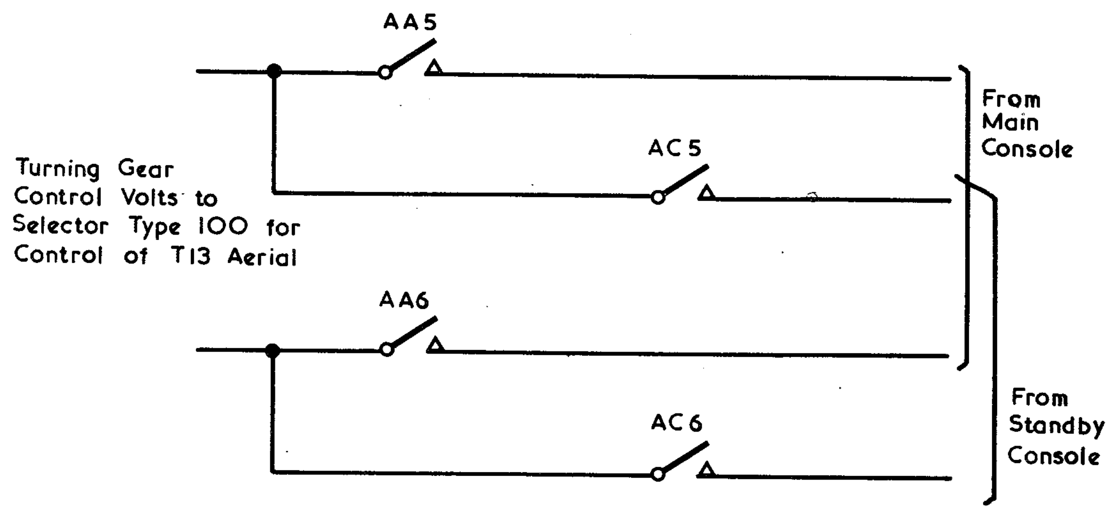


Fig 50d

Relay AA energises.

Contacts AA5, AA6 close connecting the turning gear control to the T13 aerial turning gear.

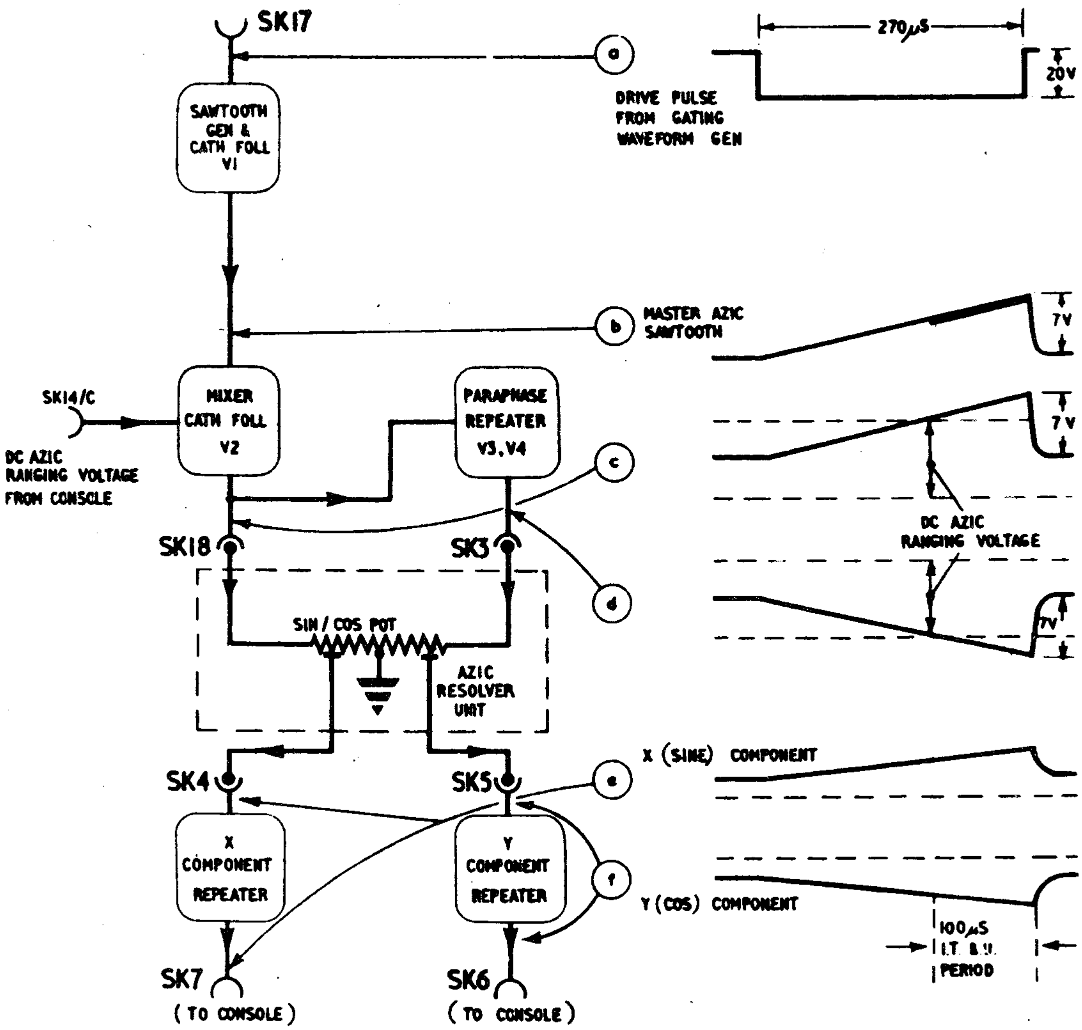


Fig 51 WFG AZIC 100 - BLOCK DIAGRAM AND WAVEFORMS

1 Purpose. Produces sawtooth waveform and resolves it into the X and Y componen s fo· the azication marker. These two waveforms are fed to the deflection amplifiers to prod ce the short ·'ne or AZICATION MARKER which indicates to the PPI operator the exact bearing on which the height f'nding T13 aerial, under his control, is nodding One rack assembly contains four entirely separate azication resolver units, each with its associated waveform generator and power unit. One resolver is linked with one height finding (T13) aerial.

2. The complete group of associated units linked to one head contains the following units:

a Waveform Generator (Azication) T100. Produces the sawtooth waveform and also feeds the resolved components to the azication console and its standby.
NOTE. The ITBU is only fed to one.

b. Resolver Unit (Azication). Resolves the sawtooth from the WFG 100 into the ·ine and cosine components.

c. Power Unit T905. Supplies h.t. and l. t. to the WFG T100.

One complete group is used with the master search head, and produces a continually rotating azication marker in synchronism with this head. This marker is displayed on the monitor p.p.i. console and is used when re-synchronising rotation of a slave head to master, especially, after a period of stop and look operation. The LOCAL/REMOTE switch on the distribution panel permits the resolver to be switched off from the monitor when not actually in use, thus preventing the heavy wear on the SIN/COS potentiometer which would result from prolonged continuous rotation.

3. Resolver Un t Azication. (Refer Fig 52.) This unit contains the sine/cosine potentiometer res lver, sel yn drive and auto-align. Resolver units 1, 2 and 3 in the rack are connected by selsyn i k to he T13 height finding aerials, Resolver unit No 4 is connected by selsyn link to the master search head. (Type 7 or T80)

The selsyn is of the slave iype and rotates with th T13 head. The rotor is driven at a speed 30 times the aerial speed, allowing transmissions of greater torq - nd more accurate following. A 30.1 reduction gear reduce the speed of sector selector cams, auto align cams and resolver wiper o the correct aerial speed.

4 Auto-align Resolvers 1 to 3. The auto lign system works in the same manner as hat used with the p.p.i and T14 aerial but the connection re slightly different. As there is no intermediary control unit for T13 (ie nothing corresponding with control unit 619 used with the T14 head), an extra relay (relay B) is on the azication resolver rack. This c rresponds to relay C in the control unit 619 in T14 auto-align system.

5 Auto-Align Resolver No 4. (Refer Fig 53) When used w.h the master search head (normally Type 7) the auto-align system differs slightly, because control unit 618 in head control rack governs the Type 7 rotation and contains an auto-align relay, making RLB in the resolver unit redundant. Connections a e m de via the distribution panel 878 at the bottom of the rack.

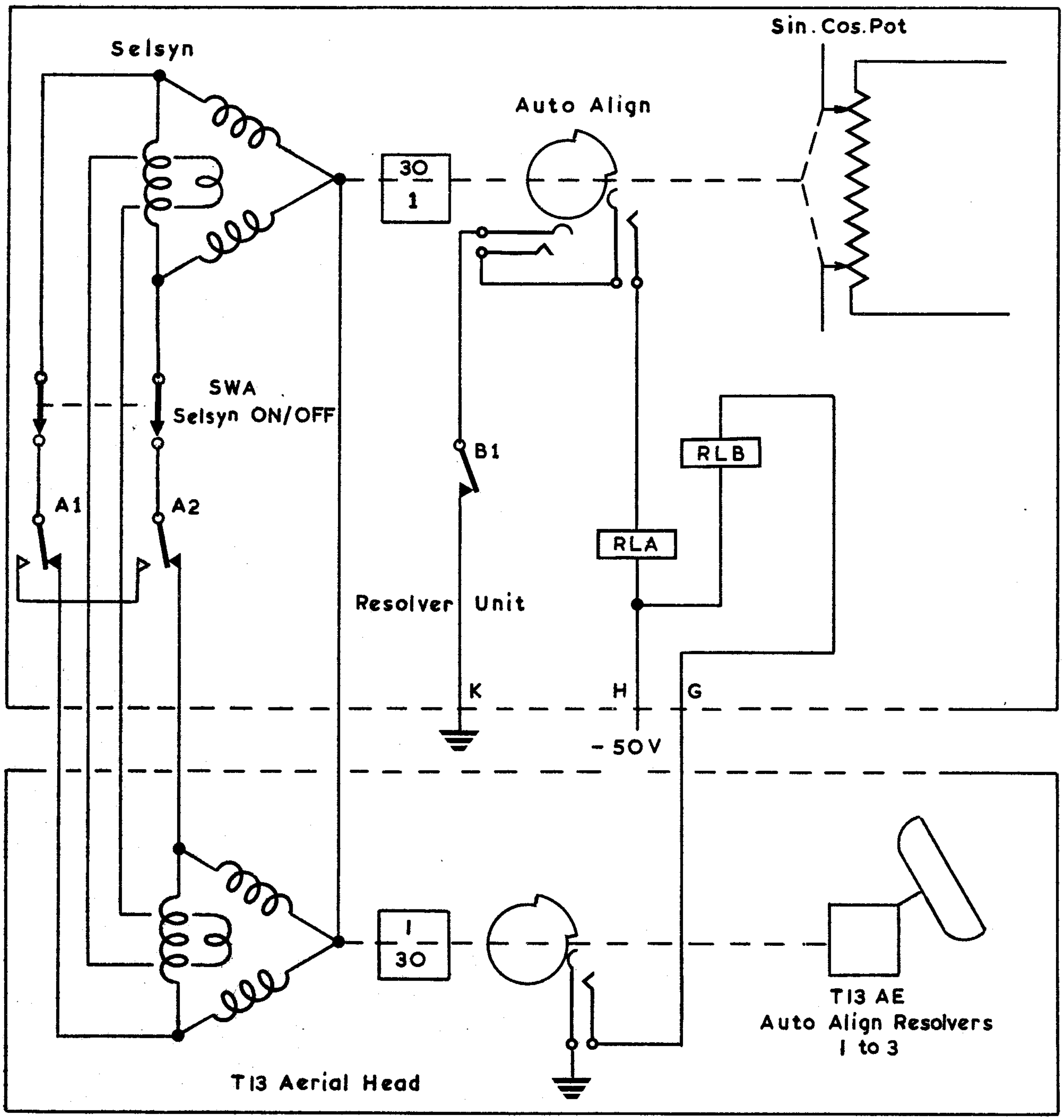


Fig 52 AUTO ALIGN RESOLVERS 1 TO 3

6. The auto-align lead is open during the 8° closure in the Type 7 head and earthed during the remaining 352° due to the operation of the relay in control unit 618. The selsyn drive can be disconnected by LOCAL-REMOTE switch. When on REMOTE, relay A is operated from the monitor p.p.i.

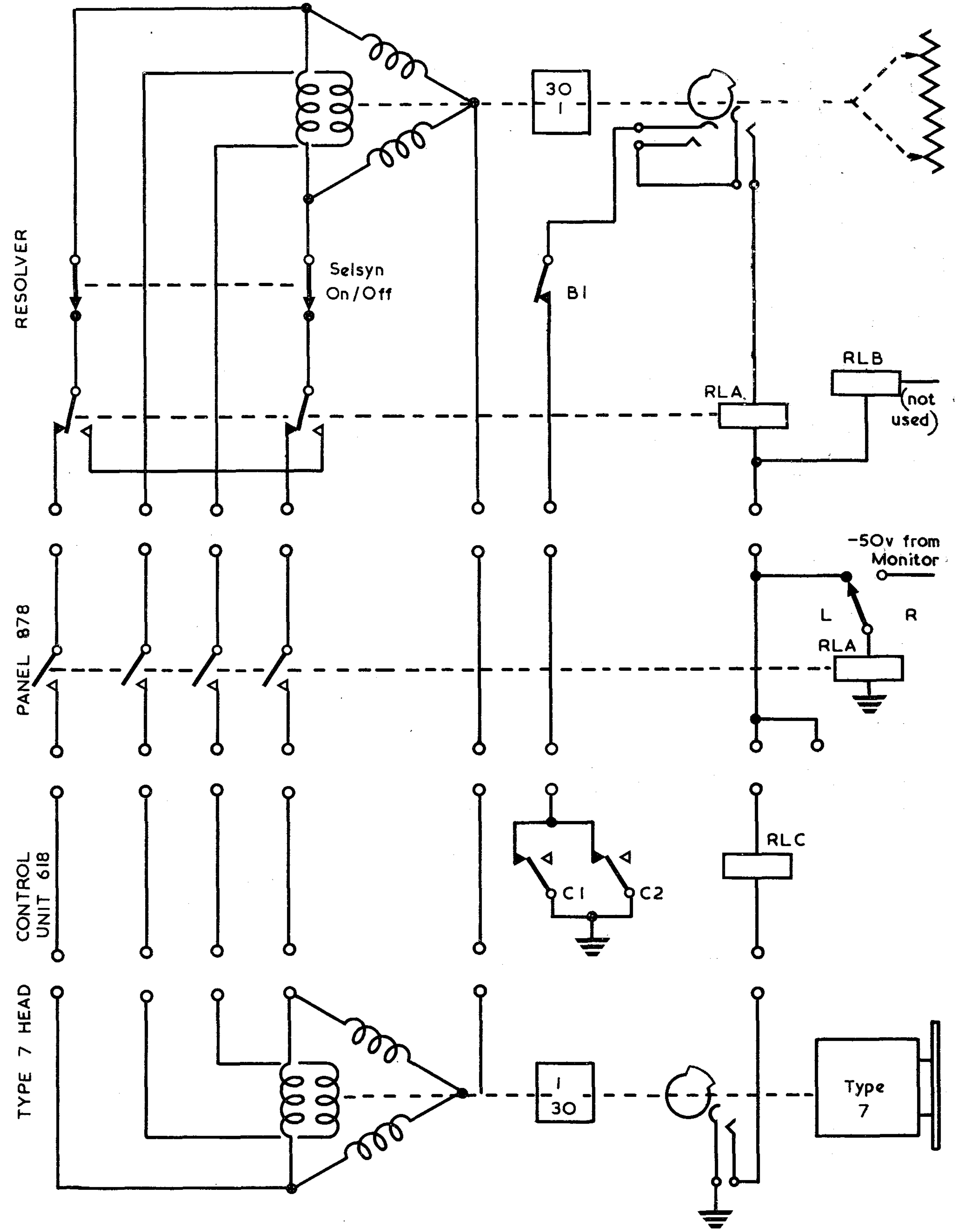


Fig 53 AUTO ALIGN RESOLVER NO 4

7. The input is a negative going square wave, 20V in amplitude and 270 μsecs wide. It is applied to V1, which is normally conducting, causing it to cut off. The anode voltage rises on a CR of .01 μFd and 1 MΩ which is a rise of 7 volts in 270 μsecs. The output waveform, a sawtooth 7 volts in amplitude 270 μsecs wide, is fed to the cathode follower V1B.

8. V1B feeds this azication sawtooth to the mixer cathode follower V2. The waveform will settle with its base line only a fraction of a volt below the potential to which the 1 MΩ grid resistor is taken, ie the d.c. ranging voltage less a small correction (for the V2 grid cathode potential and for the initial unbrightened part of the sawtooth). The combination of sawtooth and d.c. ranging voltage is fed to one of the sine-cosine potentiometers and to a paraphase amplifier from V2 cathode.

9. V3 and V4. Paraphase Amplifier. A see-saw amplifier with unit gain. Gain is adjusted by RV3. The output is fed to the other side of the sine-cosine potentiometer.

10. Switching at V2 Cathode. Part of the setting up procedure:

a. SW.B to TEST. SW.A to E. The input to the paraphase amplifier is earthed and the DC SET controls are adjusted for 0V at V4A cathode.

b. SW.A to +25V. Adjust RV3 so that the meter, connected between the centre of sine-cosine potentiometer, reads 0V. The paraphase amplifier output will be -25V and its gain unity.

11. X and Y Component Repeaters. Identical circuits which feed the resolver components to the deflection amplifiers. The circuit is a repeater amplifier with the feedback line made variable so that the gain can be adjusted to unity.

1. Produces the h.t. supplies for the console 64. One rack assembly can supply the h.t. for six consoles. It contains the following units:

a. Rectifier Unit T100. This provides +420V unstabilised at approximately 6 amps and supplies the regulator circuits in the console (which develop +250V) the c.r.t. circuit and the stabiliser unit T100 in rack assembly T305.

b. Stabiliser Unit T100. This unit provides six separate outputs at +250V 600 mA stabilised, and supplies the push-pull stage in the deflection amplifiers and acts as a comparison voltage in the trip circuits of the consoles stabilising circuits.

c. Rectifier Unit T101. Provides +570V at 600 mA to supply the stabiliser circuits in the consoles which provide +400V stabilised and the focus coil stabiliser circuit.

d. Rectifier Unit T102. This unit supplies -470V at 1.5 amps which supplies current for the regulator circuits, which provide a -300V stabiliser.

e. Relay Unit T184. This unit is responsible for ensuring the bulk power supply is not switched on until the first console is switched on, delaying the application of the mains to the h.t. transformer until one minute after the valve heaters are on and also for switching the h.t. voltages to the console.

f. Transformer Assembly T3300. This transformer is supplied with three-phase mains supply to its delta wound primary and supplies the three phase rectifier units with six phase voltages at appropriate voltage and current levels from its three double star secondary windings.

2. 6 Ø Tran:former. (Ref r F'g 54) Primary wind ng is delta wound a d suppl ed to it is 400V 3 Ø 50 Hz v a relay un't T184. There are three secondary windings, each winding consists of two entire'y separate thr e phase w ndings 180° out of ph se w th each other. The three secondar es supply the ee rect'f er units, all of wh ch are ident'cal in operation.

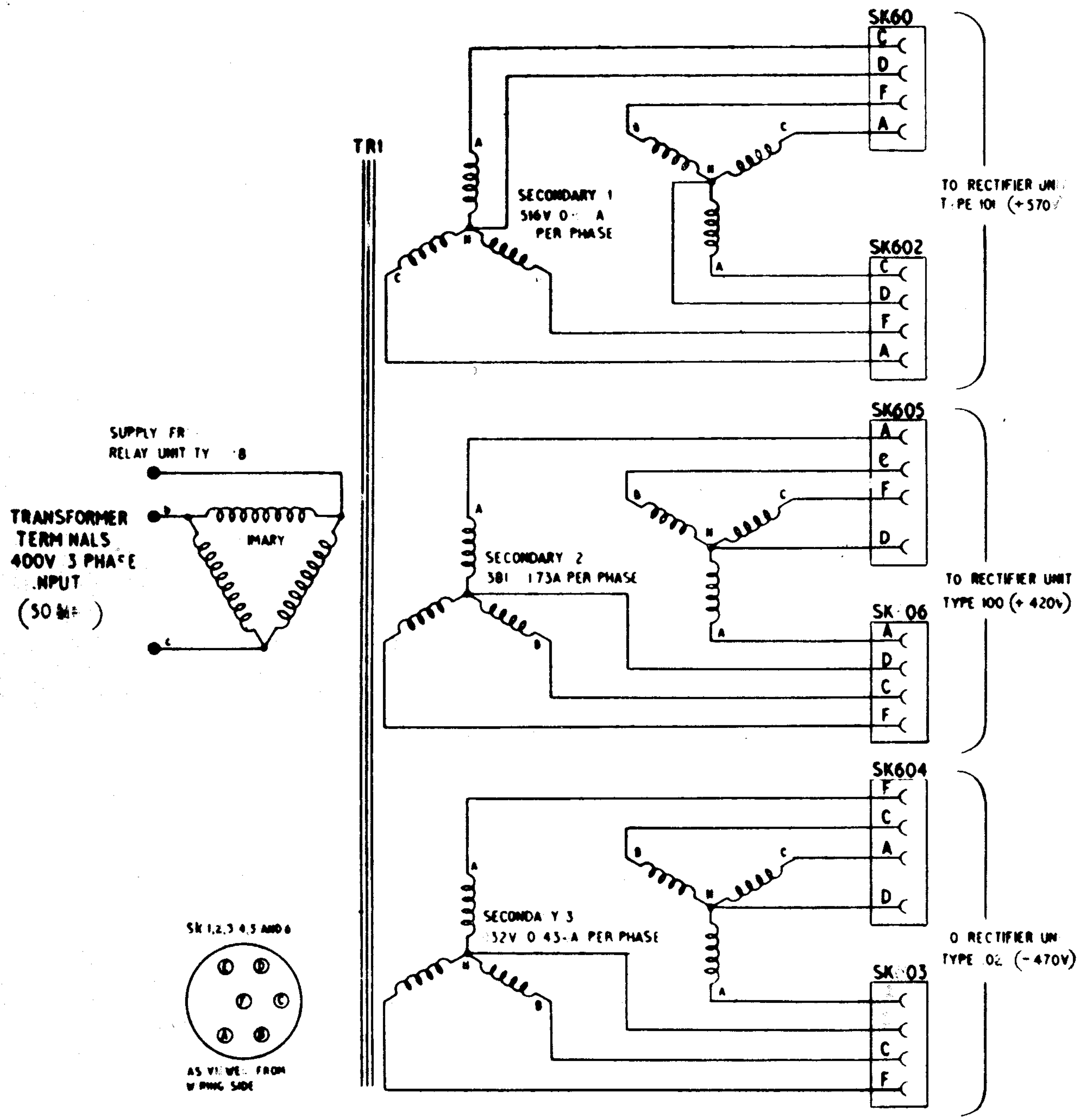


Fig 54 TRANSFORMER ASSEMBLY - CIRCUIT

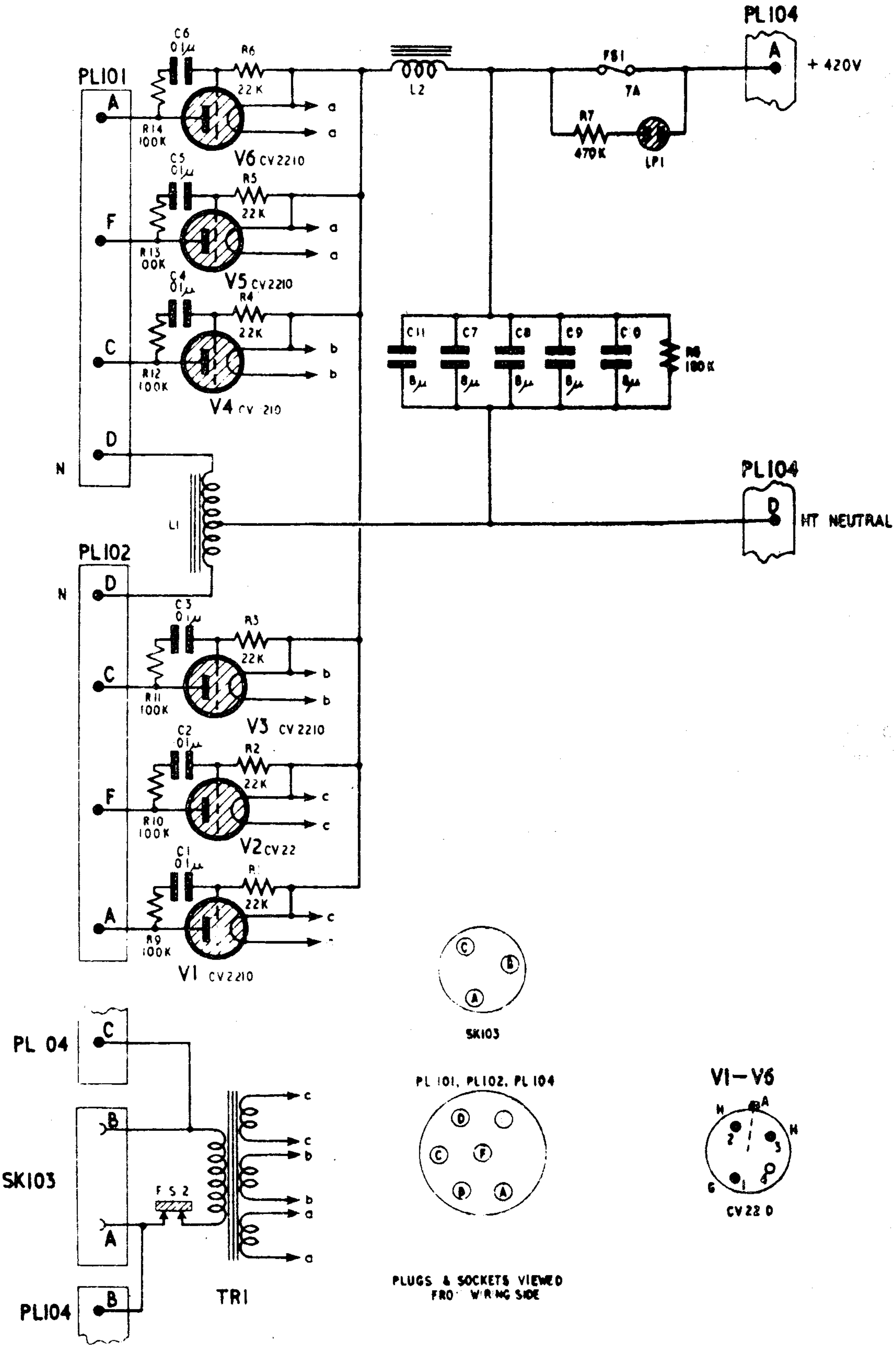


Fig 55 RECTIFIER UNIT (+420V) TYPE 100 - CIRCUIT

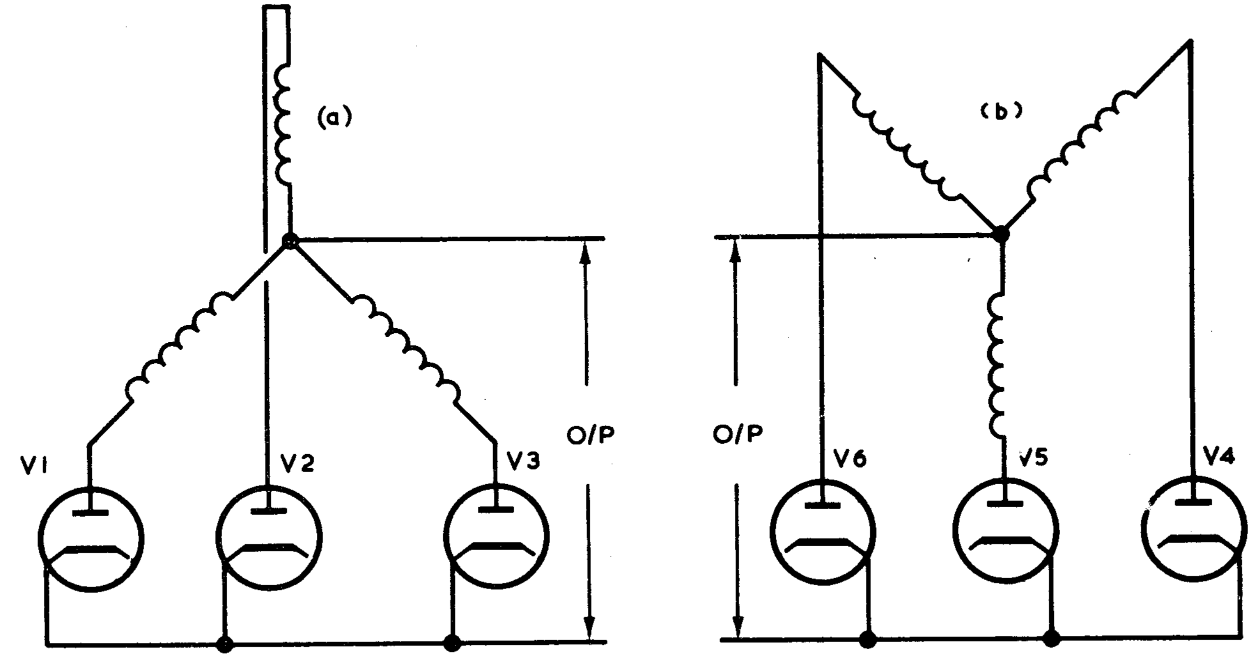


Fig 56 6 PHASE RECTIFICATION

3. <u>6 Ø Rectification.</u> (Refer Fig 57) The two secondary windings forming one main secondary feed six rectifying valves. They can be considered as being two separate three phase rectifiers, the outputs of which will be connected in parallel. In order that all windings shall be equally loaded, the balance choke is connected between the two neutrals.

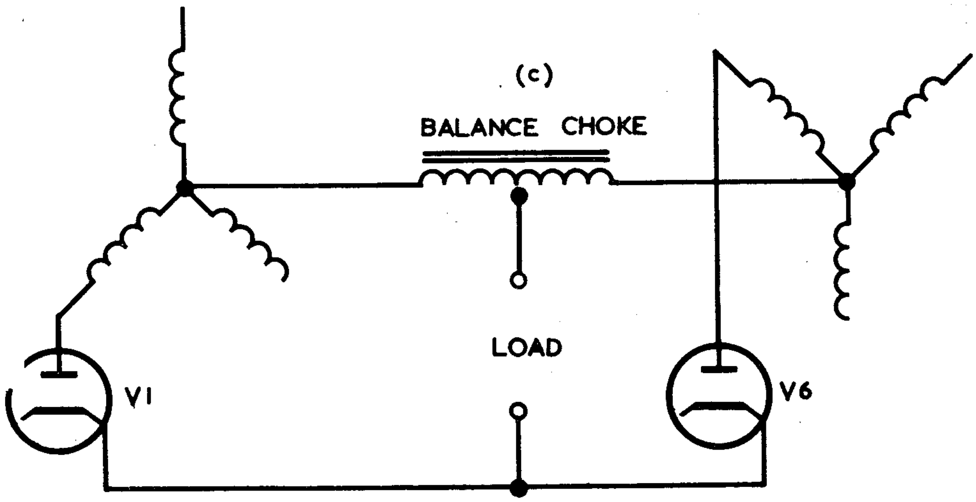


Fig 57

As the magnetic fields set up by d.c. in both halves of the choke are in opposite directions, they cancel. This removes all possibility of core saturation and the choke is of small dimensions.

4. Rectifier Unit T100. Uses six Xenon filled thyratron rectifiers as the power unit must be capable of 6 amps, continuous current. The anodes of these rectifiers are provided with a.c. from the 6 Ø transformer secondary. The grid of the thyratron is connected to a phase shifting net-work, so that it is already positive when the anode swings positive and so does not restrict the firing time of the valve. The output from the cathodes is fed to a choke input filter smoothing circuit.

5. Rectifier Unit T101. Produces +570V at 600 mA.

The circuit is similar to the rectifier unit 100 but uses soft diode rectifiers because the output current required is much less.

6. Rectifier Unit T102. This circuit produces -470V and is similar to rectifier unit T101 circuit. Smoothing is in the h.t. negative lead from the rectifiers.

7. Stabiliser Unit T100. Consists of six separate and similar circuits which are provided with +420V from rectifier unit T100 and which provide +250V stabilised to the consoles 64 at the instant the associated console is switched on. Complete compensation of changes in the applied +420V is effected by tapping the screen of the control valve into a voltage divider across the input and using this supply for the anode supply of the control valve. Otherwise normal series regulation gives correct compensation, the output being referred to the station -500V reference supply. The two series valves pass about half the h.t. current, the rest is bypassed through a 620Ω 100W shunt resistor (which has very little effect on regulation because of low impedance output circuit).

8. Relay Unit T184. Contains switches for the rack and relay circuits. These switches have the following functions:

a. Prevent the rack being switched on until at least one of the consoles supplied by the rack has been switched on.

b. Delays the application of h.t. to all valves in the rack and the console until one minute after the heaters have been switched on.

c. To prevent h.t. from being fed out to a console until the h.t. line to that console has been completed.

9. Switching 'ON' the BPS.

a. SW.C on RU184 must be closed.

b. Heaters are switched 'ON' on one of six consoles. This feeds -50V to one of sockets 513/A to F. SK513/P is earthed. RLB and RL.L energise. L/1 opens, holding off RL.K. B/1, B/2 close, feeding mains to heater transformers and to time delay RL.C.

c. After one minute C/1 closes, energising RL.M. M/1 changes over, energising RL.A. A/1, A/2, A/3 close, feeding 400V 30 Ø mains to transformer T.3300. RL.L (slow to break) now closes L/1, energising RL.K. K/1, K/2, K/3 close, shorting the 47 ohms anti-surge resistors.

d. As long as one or more of the six consoles served has heaters switched 'ON' the BPS will remain 'ON'

10. Switching on Console 64.

a. Closing the CONSOLE ON/OFF switch energises RL.A. Contacts A1 and A2 close, switching 230V to T1 which supplies 6.3V to the heater element of relay B.

b. Transformer T1, together with transformers T2 and T3 also supply the heater voltages to all valves in the console.

c. Providing the TEST/NORMAL switches on stabiliser 51 and WFG T80 are in the NORMAL position the heater element to RL.B is supplied with 6.3V.

d. After half minute RL.B operates. B1 closes completing the circuit to RL.C.

(1) Contact C1 closes holding RL.C energised independent of contact B1.
(2) Contact C2 opens, breaking supply to RL.B heater which cools down and contact B1 opens.

e. Close HT ON switch and press HT RESET.

f. Providing the trip relays on stabiliser 51 and WFG T80 are de-energised (contacts closed) then RL.D energises and D1 closes holding in RL.D.

g. -50V will now be fed to the h.t. relay in RU184 via console ON/OFF switch, Contact C1, Contact D1 and the HT ON switch.

h. The h.t. relay energises closing its three contacts which switch the h.t. voltages out of the console.

11. TEST/NORMAL switches and HT Trip Circuits. (Refer Figs 58,59) These circuits are in the stabiliser T51 and WFG T80. The circuits compare the stabilised voltages in these units with the +250V of the STAB T100 in bulk power supply. If the voltages are incorrect, the trip relays operate, opening their contacts, breaking the earth return to RL.D. RL.D de-energises, contact D1 opens, de-energising the h.t. relay in RU184 which switches off the h.t. supplies to the console. The TEST/NORMAL switches are used for setting up the voltages in the console.

12. In all cases when the voltages are correct the relays will be de-energised. If one voltage changes there will be a voltage across the associated relay causing it to energise and switching off the console. The TEST/NORMAL switches break the circuit so that, when adjusting voltages, the relays are out of circuit and the trip circuitry is inoperative.

13. Stabilising Unit (Voltage) T51. This unit is supplied with +570V, +420V and -470V d.c. from the bulk power supply. It contains three stabiliser circuits and produces +400V +250 and -300V for use in the deflection amplifiers and e.h.t. unit.

14. +400V and +250V Stabilisers. Normal series stabilisers working on the same principle as the stabilisers in other power units in the racks.

15. -300V Stabiliser. The positive output of the -470V input is earthed in the bulk power supply (RU184) as well as in this stabiliser unit so that a series regulator cannot be used. Instead a shunt regulator is used.

a. The tetrode V1 is the shunt regulator with its cathode load in series with the negative h.t. supply. Any change of current due to load variation or input supply change will affect V1 in such a manner as to keep the cathode at a constant potential.

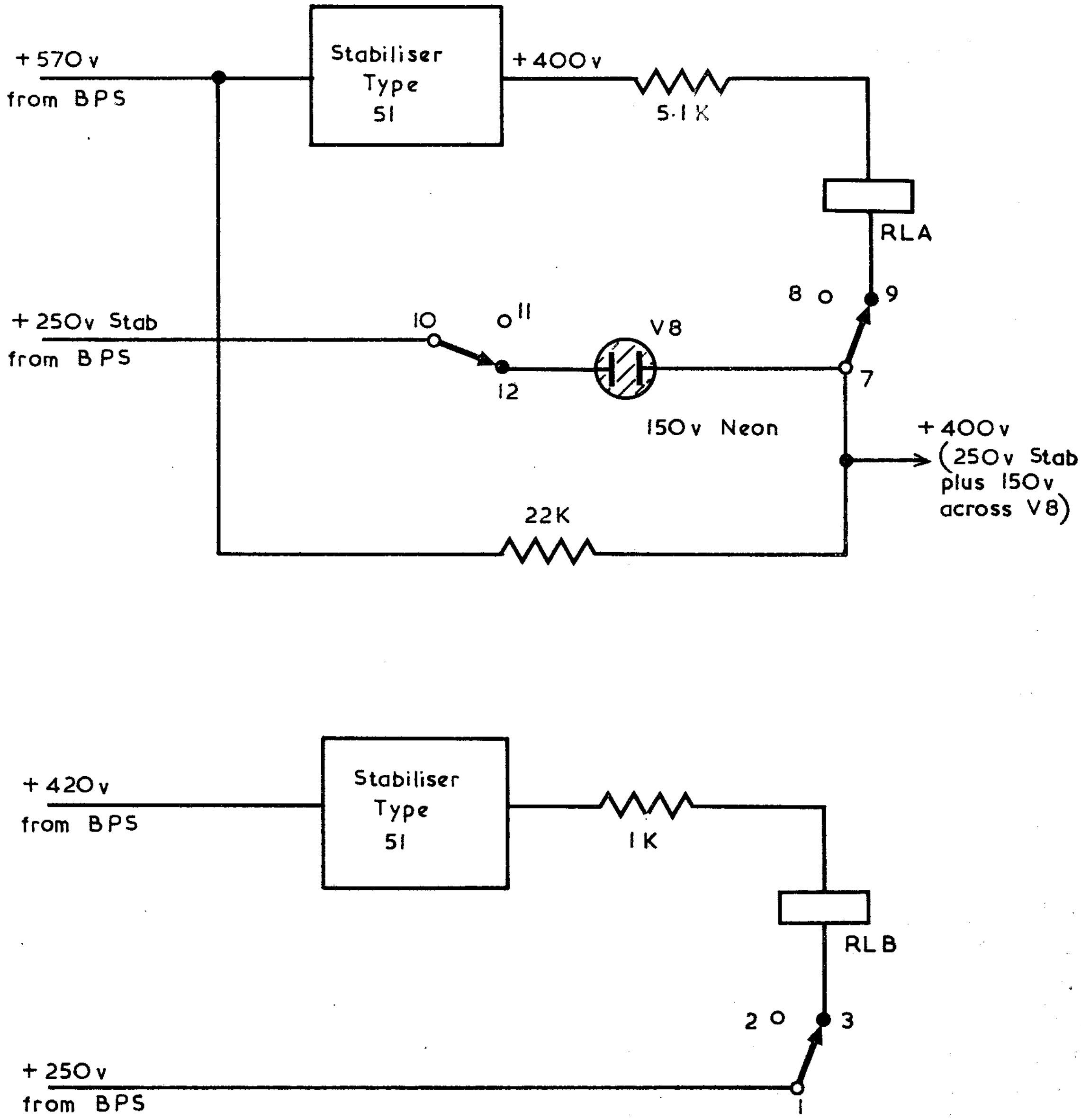


Fig 58 TRIP CIRCUIT (STAB 51)

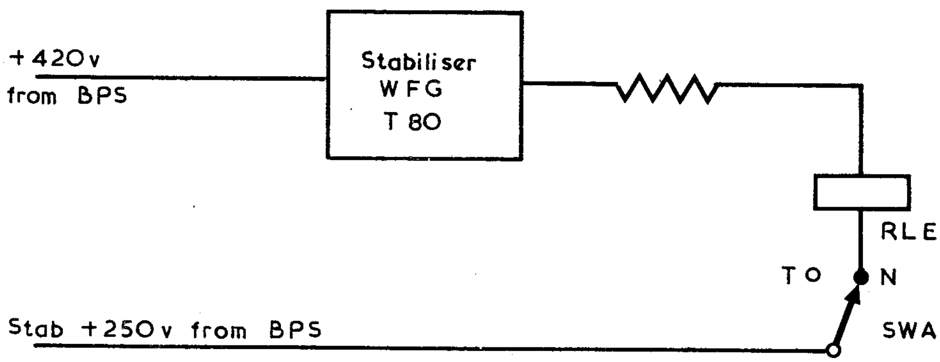


Fig 59 TRIP CIRCUIT (WFG80)

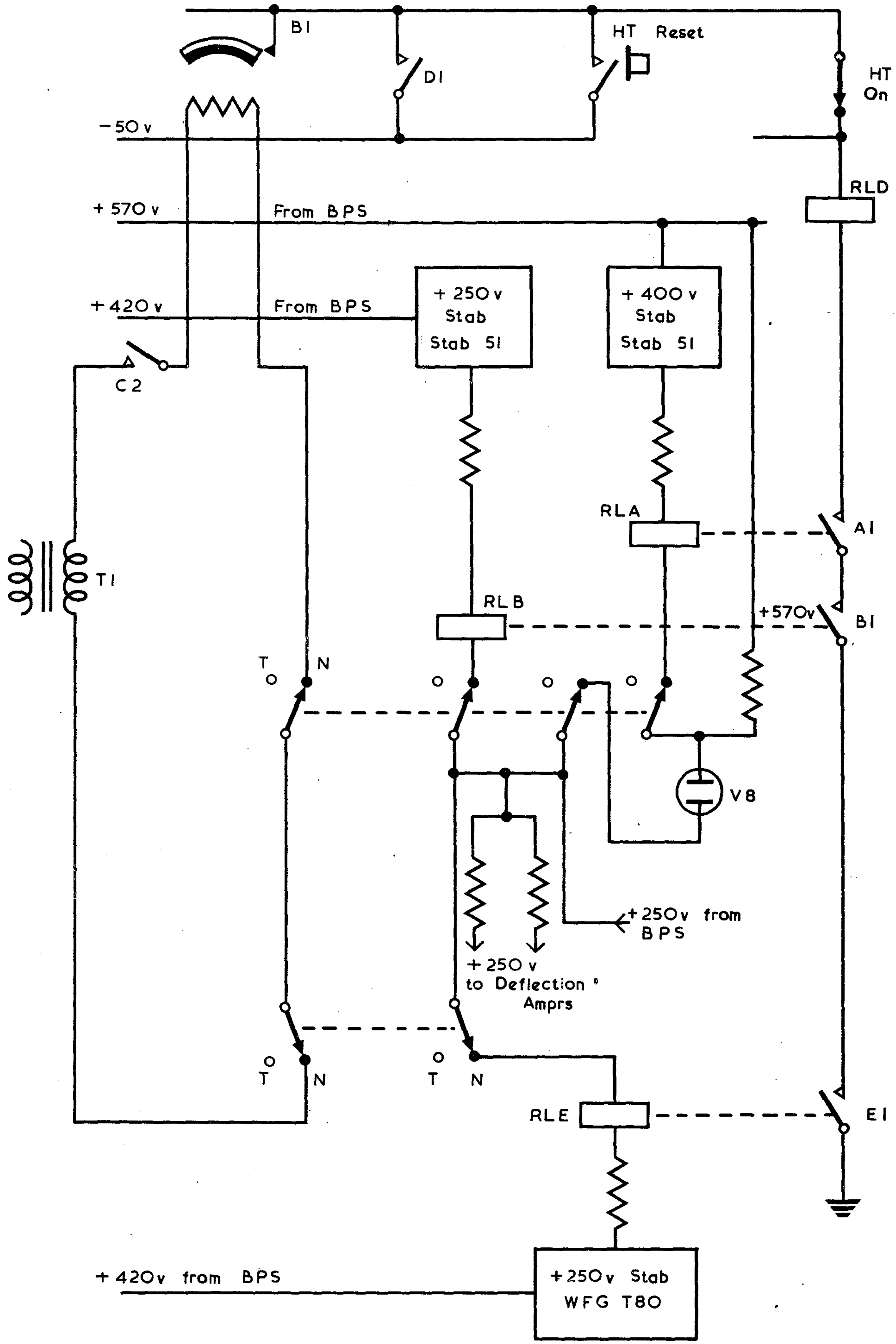


Fig 60 TRIP CIRCUIT AND CONSOLE SWITCHING COMBINED

15 b. Assume load current decreases. The -300V will tend to go more negative. V4b cathode goes negative in respect to its grid, causing its anode voltage to fall. This is fed via V4a to V1 grid causing an increase in current through V1 which increases the voltage drop across its cathode load, bringing the cathode potential back to -300V.

c. Any change of -470V is fed via the 1MΩ resistor R25 to V4a grid.

d. The -300V stabilised output acts as the reference voltage for the positive stabilisers.

16. Waveform Generator Type 80. (Power Supply) There are two voltage stabilisers in this unit providing +250V stabilised and -300V stabilised. These supplies are used in the waveform generator T80, blanking unit T26, the video amplifiers and the off-centre voltage network.

The stabiliser circuits are identical with those in the voltage stabiliser Type 51.

As the load current for the negative supply is different to that in the STAB 51, the cathode load of the regulator valve is increased to 2.2k.

17. EHT Unit. Supplies +15V at 100 µamps which is regulated and maintained ripple free. It is fed to the final anode of the c.r.t. where accuracy of supply is essential to maintain correct deflection sensitivity and keep the screen free from ripple pattern. The circuit consists of a multivibrator driven switching valve which cuts on and off the current through a ringing coil. The output from the coil is fed to a voltage doubler rectifier circuit.

18. V1A and B form an assymmetrical multivibrator with a 3:1 mark space ratio and a repetition frequency of 6.5kHz. The anode waveform of V1B is 200V in amplitude, positive going during the shorter period. The common 47kΩ anode resistor limits the anode voltage of the non-conducting valve.

19. V2 a buffer and shaper isolates the multivibrator from the switching valve and also gives the correct shape waveform to compensate for the coupling between V2 and V3.

The trailing edge to V2 grid cuts off the valve and the anode voltage rises to that at the junction of R13,R14. C5 charges and the anode voltage gradually rises giving a sloping top to the output waveform until V2 is cut on again. This waveform is fed through a medium CR to V3 grid. This coupling is a medium CR so that fast fluctuations from the regulator valve will affect V3 grid.

20. The slope on V2 anode waveform is lost in the coupling to the grid of the switching valve, V3. V3 is cut on and off by its grid waveform. DC conditions in V3, (and thus the current flowing when V3 cuts on) are set by:

a. V4, the regulator valve anode voltage. Changes at V4 anode are fed direct to V3 grid.

b. EHT SET control which fixes the steady level at V4 anode.

c. V9 cathode voltage. This only affects V3 when V4 fails.

21. Ringing Choke. (Refer Figs , 61) When V3 cuts off the coil in its anode circuit rings at 20 kHz, point E going +5kV. Due to auto-transformer action point F is +75kV. As V3 anode and point E swing negative the grid goes positive again and screen current flows. When the anode goes positive, anode current flows and damps the ringing circuit.

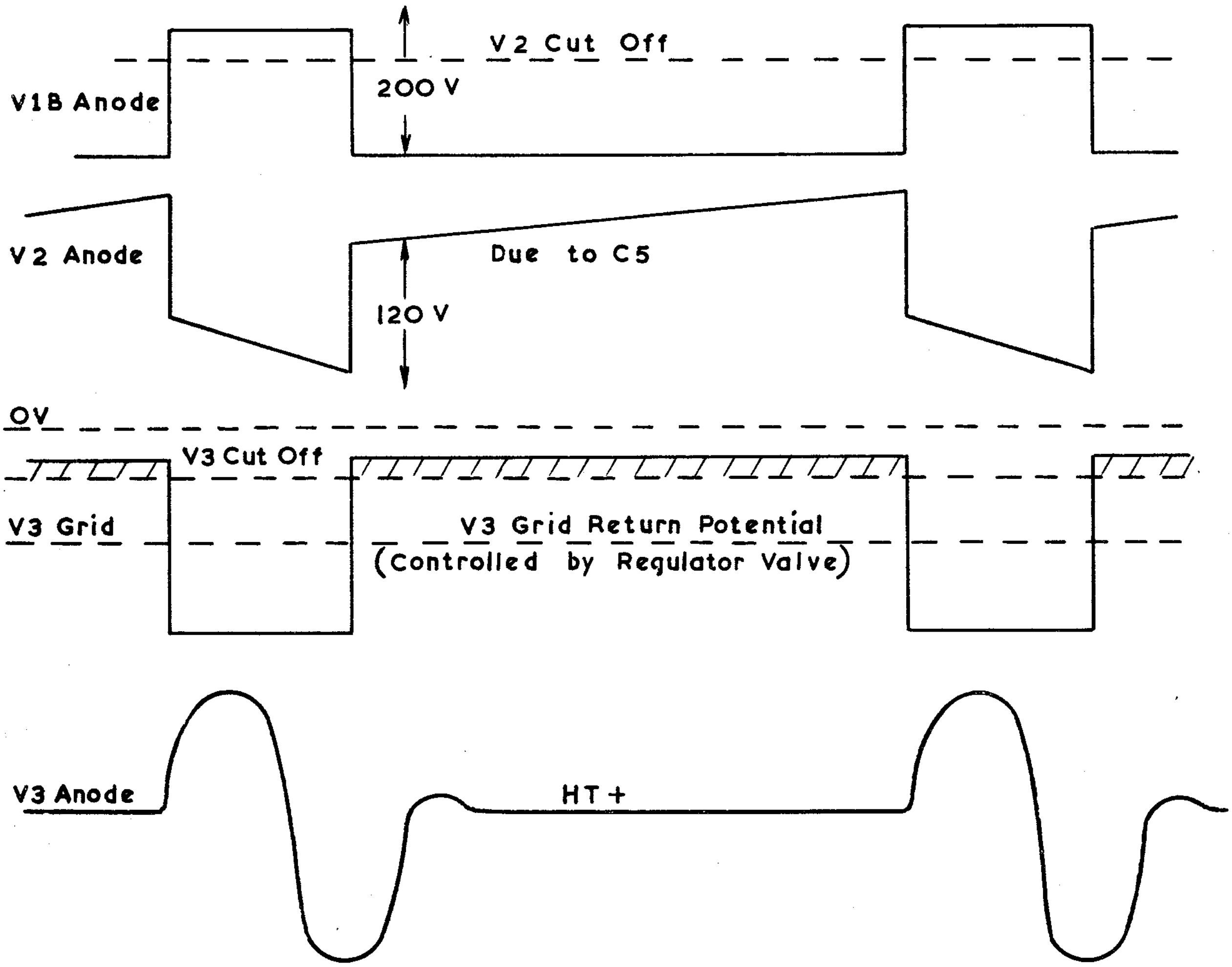


Fig 61 RINGING CHOKE CIRCUIT WAVEFORMS

22. EHT Rectifier Doubler. The 7.5 kV ringing at F occurs at a p.r.f. of 6.5 kHz and charges C12 via V6 to a mean level of 7.5 kV. ie during negative half cycles. During the positive half cycles this charge remains in C12, since V6 will be cut off. Thus when point F is at +7.5 kV the anode of V7 is +15 kV. (7.5 kV from auto transformer plus 7.5 kV in C12). The reservoir capacitors C20/C21 will charge to +15 kV. Smoothing is obtained by R43, C22/C23.

23. Regulator V4. The +15 kV output is connected to the -500V reference voltage via 26 x 100MΩ resistors. A tapping is made to V4 grid so that any variation of eht output will affect V4 anode current. V4 anode is connected via R26 to V3 grid.

24. Assume +15 kV increases, V4 grid volts rise causing a fall in anode voltage. This makes V3 grid potential go more negative so that when V3 is conducting the maximum anode current it passes will be reduced with a consequent reduction of amplitude of ringing and therefore of e.h.t.

25. Ripple voltages in the output +15 kV are minimised as follows:

a. Any ripple at the positive plates of C22, C23 is offset by an an phase ripple at the appropriate level being tapped from the subsidiary winding of the transformer.

b. 300 Hz ripple is developed across C11 and injected to V4 grid via C10.

c. 6.5 kHz ripple is bypassed by C9 and C10 to prevent driving V4 into grid current.

d. The capacitor C8 gives negative feedback around the V4 amplifier loop to maintain circuit stability.

26. Safety Diodes. V8 and V9 prevent excessive e.h.t. should V4 fail. If V4 fails its anode voltage rises causing V3 grid to rise to approximately zero volts which will give an e.h.t. of nearly 30 kV. To prevent V3 grid from rising too much, a limiting action by V8 and V9 occurs.

27. When the circuit is working correctly and producing 15 kV, a voltage is produced across the winding A-C. This voltage is rectified by V8 causing about 130V across F73. The cathode of V8 is held at +140V by R74, R75, which results in V9 cathode being +10V in respect to earth. V9 anode is at a negative potential so V9 is non-conducting.

28. Should V4 fail, the voltage at the anode of V9 and the voltage at V3 grid will rise towards earth or zero potential. V3 output to the safety circuit increases and the additional voltage developed across R73 makes V9 cathode negative w.r.t. earth. Thus the valve conducts to hold V3 grid at this potential and limit e.h.t. to approximately 20 kV.

1. Console 64, the fixed coil p.p.i. display present information from the search heads together with additional information between traces. The number of consoles depends on the stype of station.

2. There are four main types of console 64.

a. Plotting Console (least facilities).

b. Interception Console (more complex R/T facilities and has H/R strobe key to brighten trace on A scope).

c. Azication Console (has control of turning gear of T13 and carries azication mark facilities).

d. Combined Console (has facilities of (b) and (c)).

3. The basic console 64 contains the following units:

a. Stabiliser Unit T51.

b. EHT Unit.

c. Deflection Amplifier (sine) RHT 313.

d. Deflection Amplifier (cosine) LHT 314.

e. Blanking Unit.

f. Waveform Generator Type 80.

g. Video Amplifier Type 312.

The different types of console have different types of control desks.

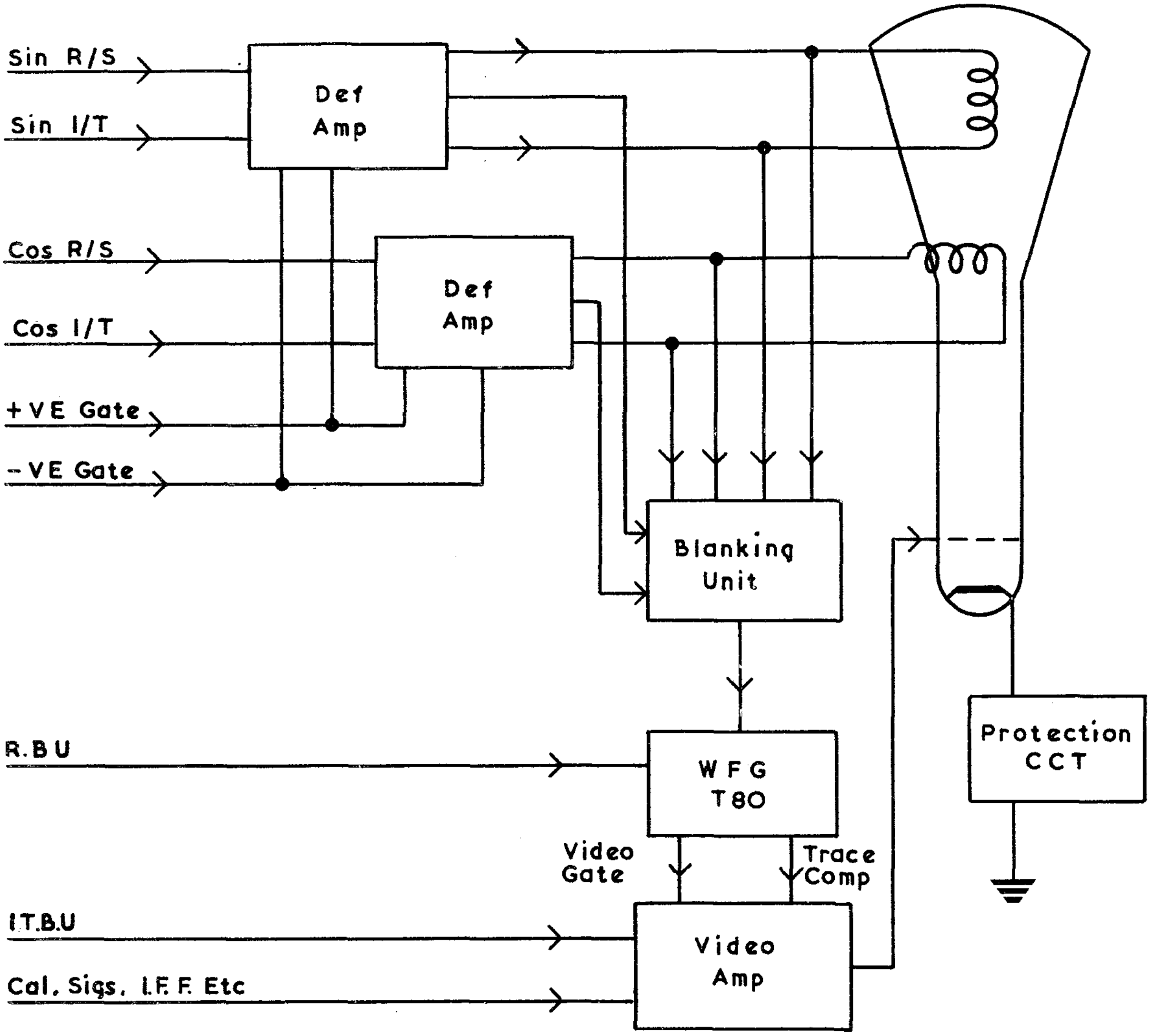


Fig 62 BLOCK DIAGRAM OF CONSOLE SIGNAL CIRCUIT

4. Console Signal Circuit. (Refer Fig 62) This circuit incorporates the following units:

a. Deflection Amplifiers. Combine radar scan and intertrace deflection waveforms and causes them to feed linear current waveforms through the timebase coils.

b. Blanking Unit. Produces a blanking waveform which drives the c.r.t. grid negative when the timebase fails or spot goes beyond visible screen area.

c. Waveform Generator T80. Combines radar bright-up with the blanking waveform.

d. Video Amplifiers. Combine all waveforms which are to be fed to the grid.

e. Protection Circuit. Cuts off c.r.t. when h.t. fails or console is switched off.

5. Deflection Amplifiers. There are two deflection amplifiers in each console.

X deflection amplifier. R.H.313
Y deflection amplifier. L.H.314.

Both have identical circuits. The functions of each is to feed a current waveform into the deflection coils for the timebase and to feed a current waveform into the coils during the intertrace period for the azication marker.

6. Trace Expansion. This is the method employed to alter the range of the timebase. It enables particular parts of the display to be examined in greater detail. The following tables give the off-centring facilities available, for various tube radii representations at 250 Hz and 500 Hz respectively.

Tube radius (nautical miles)	Off-centre (nautical miles)
160	+80
120	+120
80	+160
40	+200

Tube radius (nautical miles)	Off-centre facilities
120	Nil
80	40
40	80

7. Off Centring. Enables the whole picture to be shifted so as to bring any particular region of interest to the centre of the tube. When, due to off-centring, a particular point is brought to the tube centre this point is fixed for all degrees of expansion, ie the picture expands about the centre of the tube and not from the trace origin.

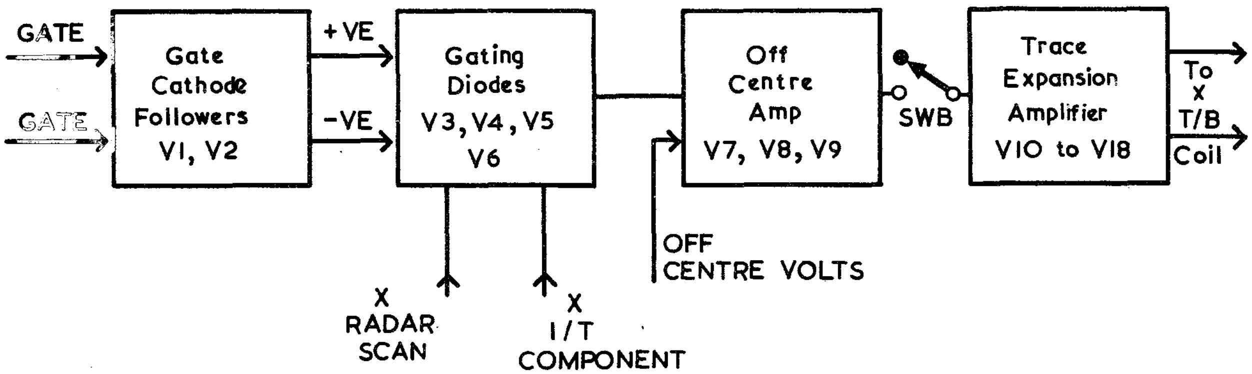


Fig 63 BLOCK DIAGRAM OF DEFLECTION AMP RH T313

8. Gate Cathode Followers V1, V2. (Refer Figs 63,64) The gating waveforms from the distribution unit (gating) in RA 304 are fed to V1a and V1b respectively. The d.c. levels are indeterminate and have to be accurately set before being applied to the gating diodes so are d.c. restored by V2 to the correct level.

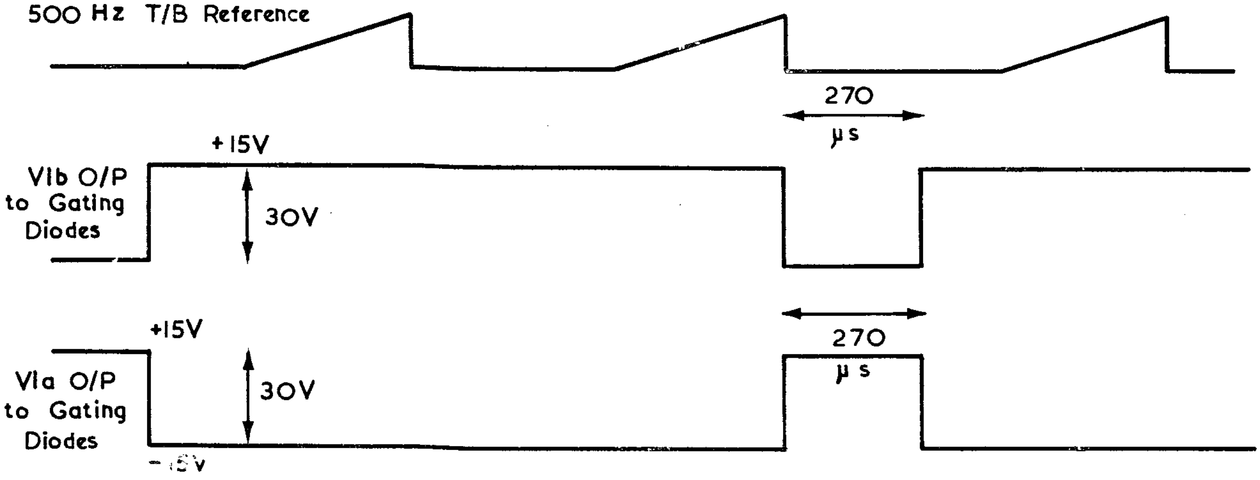


Fig 64 GATE CATHODE FOLLOWER WAVEFORMS

9. Gating Diodes. V3, V4, V5 and V6. This circuit admits the timebase component to the off-centre amplifier during the trace period plus last part of intertrace period, and the intertrace component during the gated period, ie end of timebase to 270 µsecs later.

10. (Refer Fig 65) During the timebase period the circuit operates as follows:

a. V4b cathode at +15V, Anode to $+\frac{1}{2}$V approx. ∴ V4b is cut off.

b. V4a anode at -15V, cathode to $+\frac{1}{2}$V approx. ∴ V4a is cut off.

c. V5b anode at +15V, cathode to $+\frac{1}{2}$V approx. ∴ V5b is conducting and its cathode potential rises to +15V.

d. V5a anode to $+\frac{1}{2}$V, cathode to -15V. ∴ V5a is conducting and its anode potential falls to -15V.

e. V6a cathode +15V (held by V6b) while its anode is at zero volts (V7 grid potential). ∴ V6a will be cut off.

f. V6b cathode at 0V (V6a anode potential) V6b anode at -15V (held by V5a), ∴ V6b will be cut off.

g. Any input from the intertrace arm will no reach V7 grid as V6 and V4 are cut off. Positive going inputs from the radar scan arm will be fed V7 grid via V3a, and negative going inputs via V3b.

11. During the intertrace period the circuit action is the same but potentials reverse due to the gating waveform voltages changing.

a. The negative gate potential falls from +15V to -15V and the positive gate potential rises from -15V to +15V. Therefore V4a and V4b are conducting and V3a, V3b, V5a and V5b are cut off.

b. Positive going intertrace inputs pass through V6b to V7 grid and negative going inputs through V6a to V7 grid.

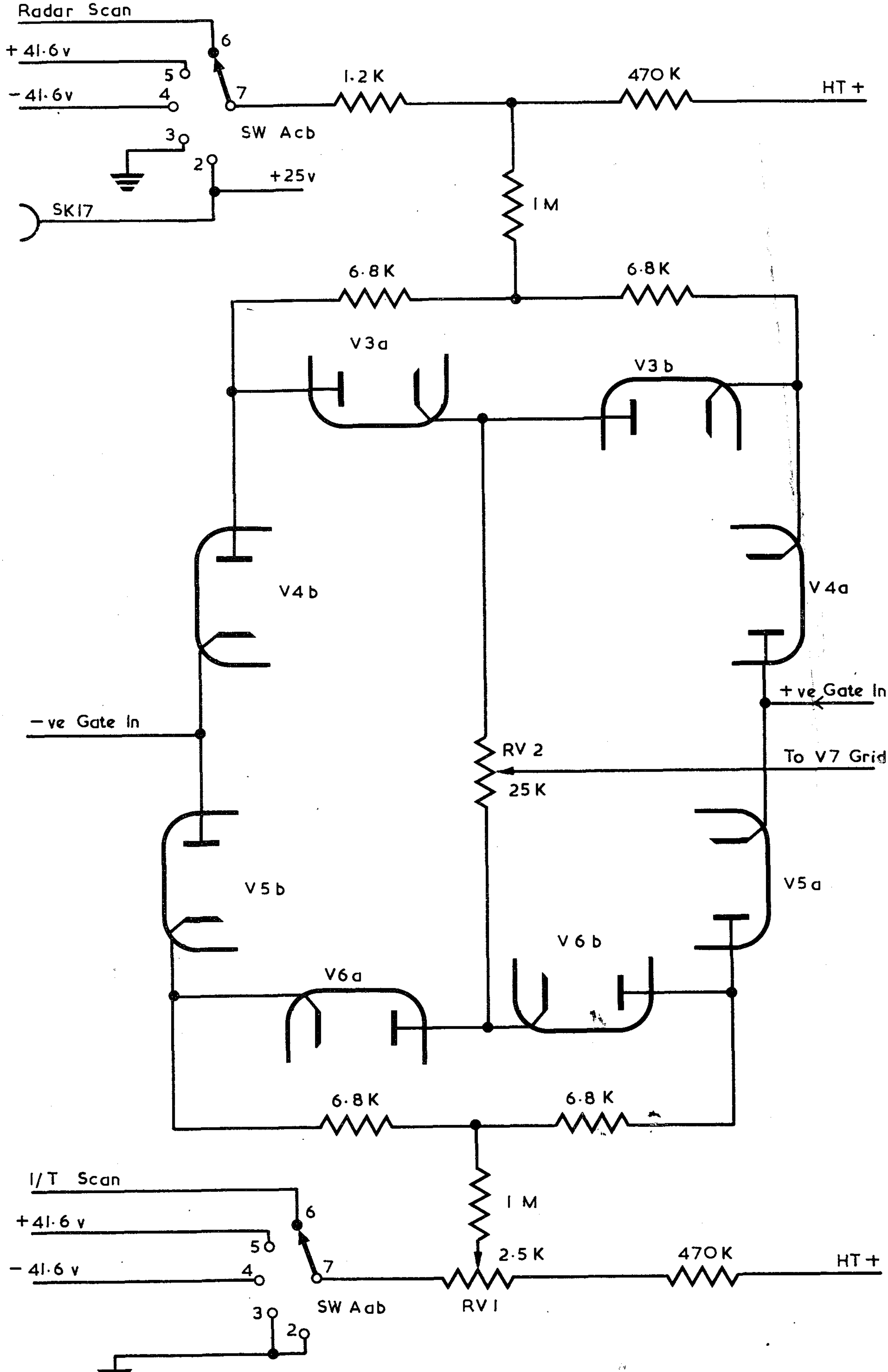


Fig 65 GATING DIODE CIRCUIT

12. Small variations in diode characteristics will produce a difference of d.c. levels at the output. The scan and intertrace origins will not be at the same point. RV1 is adjusted to correct this. (Two spots would be seen on c.r.t. face and RV1 is adjusted until they co-incide).

13. Off centre Amplifier. (Refer Fig 66) This circuit superimposes the off-centre voltage on to the radar scan and intertrace components and applies the resultant, without amplification, to the trace expansion amplifiers.

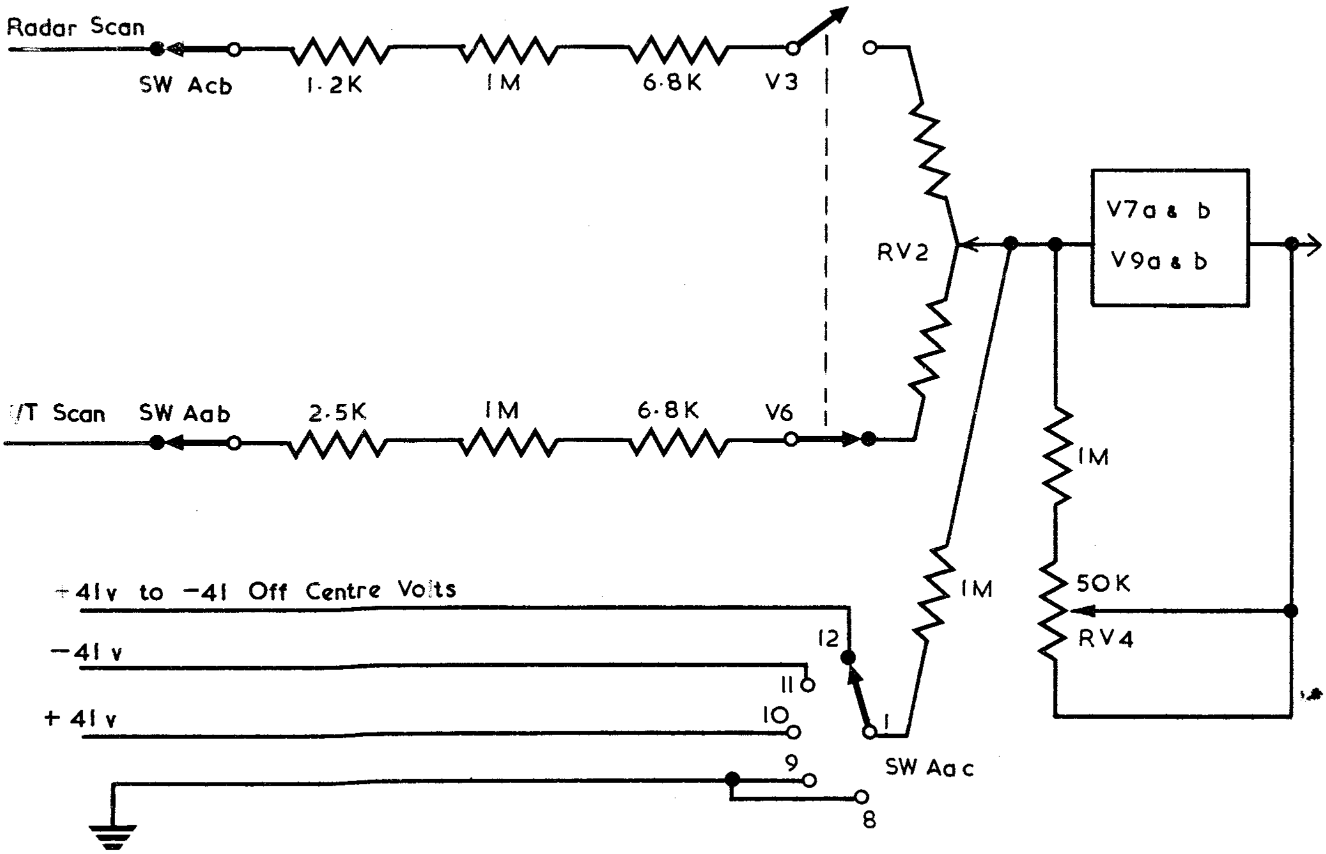


Fig 66 OFF CENTRE CIRCUIT

14. The gating diode circuit forms a resistor input arm to a see-saw amplifier V7, V9. Feedback through RV4 and 1MΩ gives an overall gain of approximately unity. RV4 is adjusted so that the gain of the X deflection amplifier is exactly the same as the Y deflection amplifier.

15. RV2 is adjusted so that both input arms have the same resistance and therefore the gain for radar scan and intertraze will be the same.

16. The off-centre voltage consists of a steady d.c. potential, variable between +41V and -41V representing a shift of up to 200 nautical miles each way. Altering this voltage will alter d.c. levels throughout the amplifier so that the scan and intertrace components start from this potential.

17. With the amplifier input at zero, the junction of the 1.2 kΩ and 8.2 kΩ resistors (V9b cathode) will be at zero and V9b cathode at +7.5V. This is necessary because d.c. conditions in the trace expansion amplifiers demand a level of +7.5V at V11b grid for a centred spot.

18. Because the input to the amplifier can be large, (ie maximum off centre volts plus maximum sawtooth) the third valve of the amplifier can be cut off (V9a (313)) resulting in loss of negative feedback. V7 grid would become highly positive or negative causing all the gating diodes to conduct and short circuit the radar scan and intertrace arms. To prevent this limiting diodes V8a and V8b are in circuit.

19. V8a is normally cut off. With a negative going input V9b cathode voltage rises. V8a anode voltage rises and when it reaches 0V approx. V8a conducts. The feedback line of the amplifier is now on 18 kΩ resistor in parallel with the normal feedback line which will reduce the gain of the amplifier and limit the input waveform. Positive going inputs cause V9b cathode to go negative, V8b conducts reducing the overall gain. Limiting action in this amplifier occurs after trace expansion limiters and blanking have operated.

20. Trace Expansion Amplifiers. These are used to produce deflection coil current waveforms which are a linear reproduction of the input voltage waveforms. V11, 12 and V14 form a see-saw amplifier with the input arm made variable to give different values of gain for different trace expansions.

SWITCH 1.	RLC closed. Overall gain 2. 80 nautical mile range.
SWITCH 2.	RLB closed. Overall gain 1. 160 nautical mile range.
SWITCH 3.	RLA closed. Overall gain 2/3rds. 240 nautical mile range.
SWITCH 4.	All relays open. Overall gain 1/2. 320 nautical mile range.

NOTE. ALL RANGES GIVEN FOR CRT DIAMETERS.

21. V11a and V11b form a cathode coupled in-phase amplifier which is coupled to an amplifier V12. V12 feeds the output valve V14 which has a timebase coil in its anode circuit. With no input to the amplifier and the spot in the centre of the tube, V14 passes 130 mA causing a cathode potential of 28.6V. RV3 is adjusted to this and it makes V11b grid at +7.5V.

22. As feedback is taken from V14 cathode, there must be a sawtooth waveform across the cathode resistor. A sawtooth current exists in the resistor and the valve, but the anode current is not a sawtooth due to the effect of the screen (which reduces anode current at the start of the waveform and gives a slow start to the timebase). To offset this, the voltage waveform is modified by correction capacitors across the input arm resistors.

23. To obtain push-pull deflection, the amplifier V17a, V17b, V18 and V15 is used. This is a see-saw amplifier with unity gain, its input coming from V14 cathode. The input arm resistor 100 kΩ (R106) and the feedback resistor 100 kΩ (R113). RV5 sets the d.c. conditions of the amplifier, ie V15 cathode at 28.6V with centred spot.

24. The diode limiters V10a and V10b prevent either V14 or V15 from cutting off - or passing excessive current (See Fig 67). If V14 cuts off due to excessive input, the feedback loop is broken causing a considerable rise of voltage at V11b grid. V17a grid is driven negative causing V15 to pass excessive current. V10a limits the positive rise and V10b the fall of

voltage at V11b grid. Limiting action takes place when the cathode of V14 or V15 reaches +2V on its negative going excursion. At this point the spot would be well past the edge of the screen and octagonal blanking would be operating so that no distortion is visible.

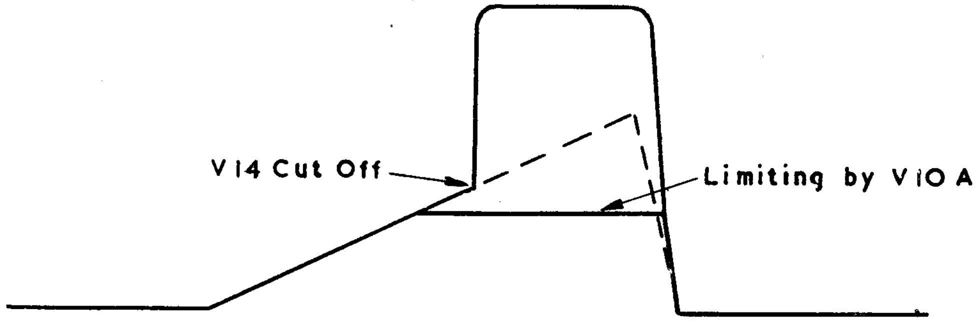


Fig 67. SK14 V11a ANODE WAVEFORM. SHOWING EFFECT OF LIMITER

25. Trace Expansion when Off-centred. (Refer Fig 68) Because the deflection waveform and the off-centre voltage are both fed to the deflection amplifiers when the trace is off-centred the off-centre voltage is amplified as well. Thus the trace will expand about the tube centre and not from trace origin.

26. Test Switch Positions. (Refer Fig 69) Portion 1 is used to equalise the gain of X and Y amplifiers. Positions 2, 3 and 4 are used for correct alignment of trace and intertrace information and are adjusted on each amplifier separately.

Action. The action of the circuit is as follows:

a. Position 2. Inputs circuits earthed. This enables the relative d.c. origin levels on scan and intertrace sides to be set by RV1. Two spots will be seen on c.r.t. screen. RV1 is adjusted until they coincide.

b. Position 3. 41V represents a deflection of 200 nautical miles. It is applied to scan and intertrace so as to permit the relative gain of the amplifier on these two channels to be exactly equalised by RV2. This ensures correct alignment of intertrace markers and radar picture for negative deflections. As this test is carried out on maximum trace deflection and since -41V deflects the spot beyond the edge of the tube, an opposing +41V is applied to the off-centre amplifier to bring the spots back to c.r.t. centre. Adjust RV2 until both spots coincide.

c. Position 4. As for Position 3 but +41V fed to input arms and -41V to the off-centre amplifier, providing a similar adjustment but for positive deflections.

The adjustments in Positions 3 and 4 must be done successively to obtain coincidence in both positions.

d. Position 1. Off-centre and intertrace arms earthed.

Radar scan input is +25V. Adjust RV4 for equal gain of both amplifiers. The +25V, fed by flying lead to the Y amplifier, ensures the same input for both amplifiers.

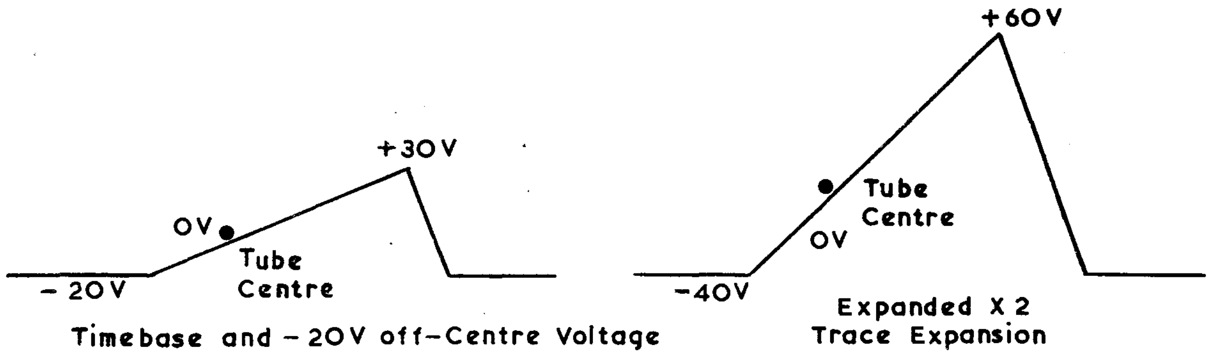


Fig 68 TRACE EXPANSION

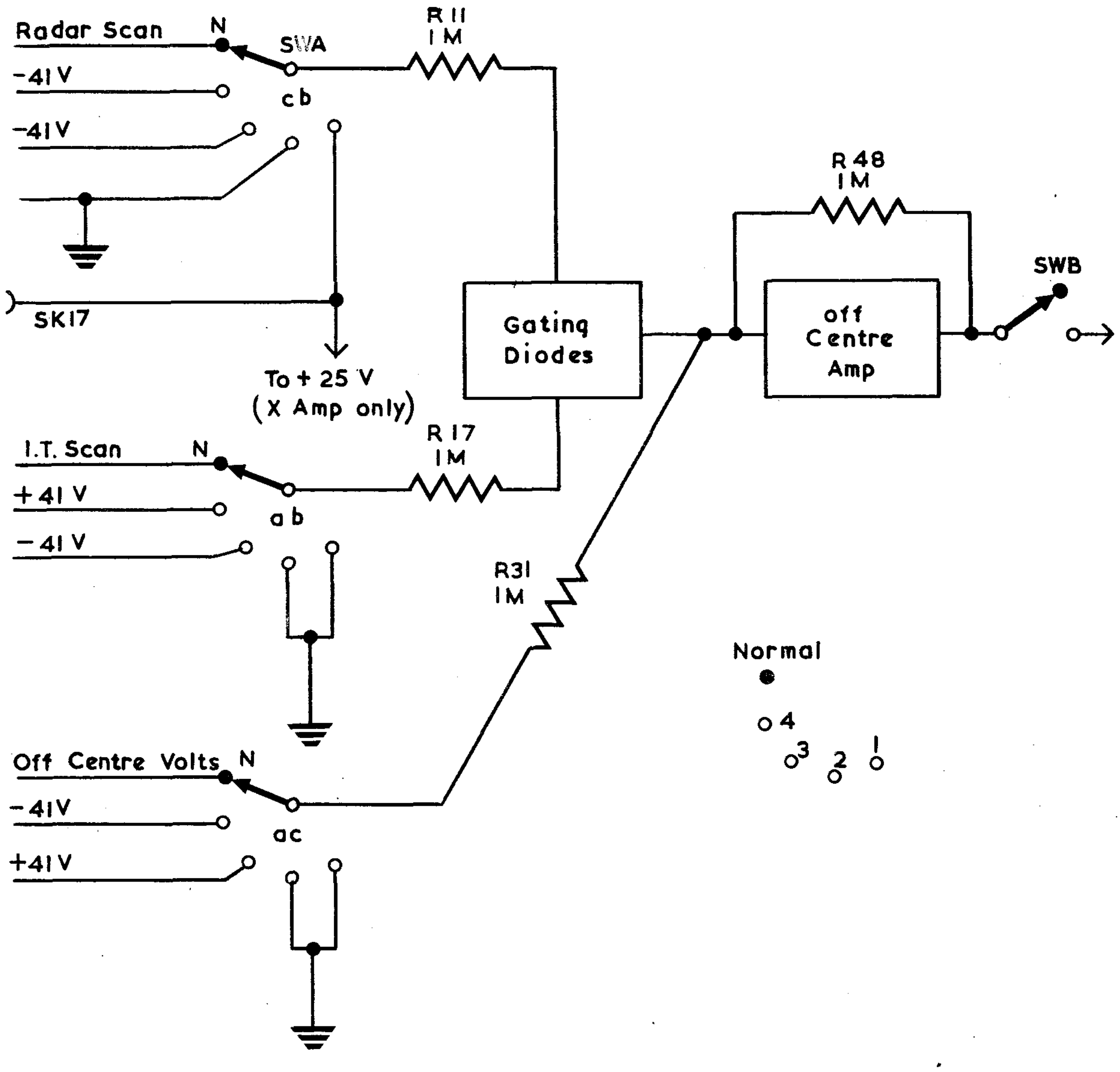


Fig 69. DEFLECTION AMPLIFIER SETTING UP CIRCUITS

Blanking Unit T26. Produces a blanking waveform which will blank off the c.r.t. when:

a. X and/or Y scan components fail.

b. The spot is deflected beyond the edge of the screen due to off-centring or trace expansion.

The focus coil stabilised supply also comes from this unit.

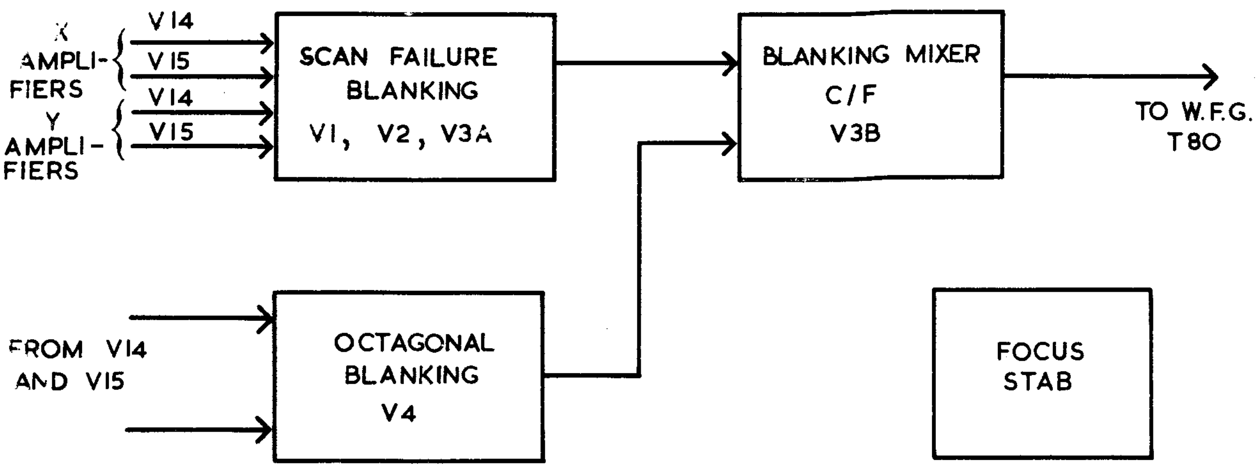


Fig 70. CRT BLANKING UNIT. BLOCK DIAGRAM

28. Scan Failure Blanking. The operation depends on the existence of a rate of change of current through the X and Y deflection coils. When both rates of change, or when one ceases to appear and the other falls below a certain value, then blanking is effected.

29. Operation. (Refer Fig 71) The voltage waveform across a deflection coil is a pedestal waveform which is varying in amplitude sinusoidally. The waveforms are applied to diodes, the anodes of which are at approx -2V. Only the negative going waveforms will have any effect on V3a.

30. Assume V14 (X amp) has negative going voltage waveforms at its anode. This is applied via a medium CR to V2a cathode, making V2a cathode approx -6V. V2a conducts, its anode voltage drops to -6V causing V1a, V1b and V2b to cut off, V3a grid falls to -6V and V3a cuts off. V3b cathode voltage is at +3.5V approx. From diagrams in Figure 71 it can be seen that at any one particular time there is a negative going waveform from the deflection amplifiers causing one of the diodes to conduct (the others will cut off) and V3a grid will be held at a negative potential causing V3a to be cut off. Thus V3b cathode will be held at +3.5V.

If the input from the deflection amplifiers fails then V3a conducts and V3b cathode falls to -60V. This fall of voltage is fed via the WGF T80 and video amplifiers to the grid of the c.r.t. causing cut off.

31. Octagonal Blanking. Whilst V4 is cut off it does not affect V3b and blanking output is controlled by scan failure circuit. If, however, V4 is brought into conduction, V3b grid potential falls, over-riding the other input. The object then of V4 input is to apply voltages, derived from the X and Y amplifiers, of correct amplitude, phase and timing to effect octagonal blanking.

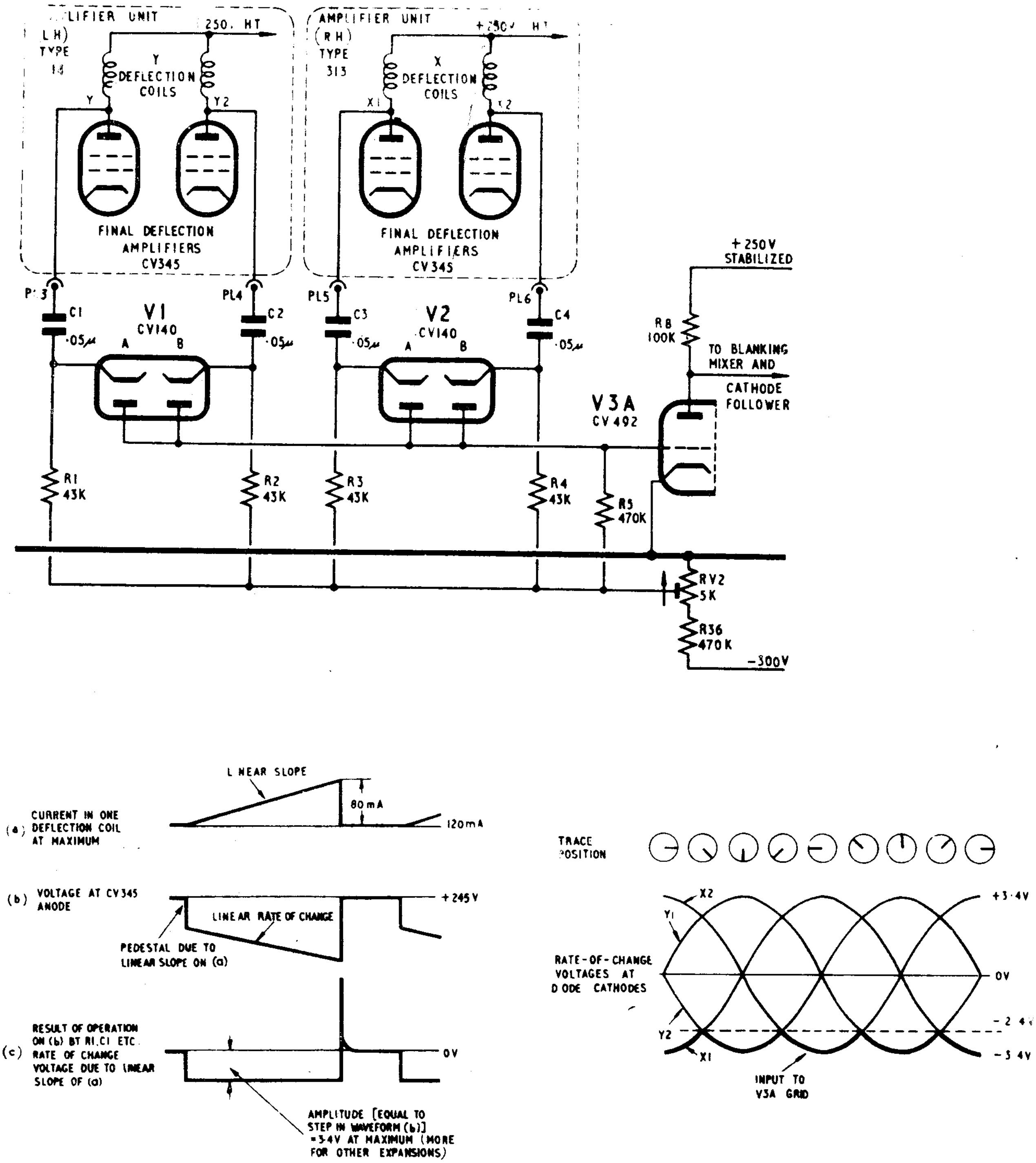


Fig 71.   SCAN FAILURE BLANKING

32.   V14 and V15 cathodes in X and Y amplifiers have a voltage waveform equal to the current waveform in the anode circuit. Therefore the cathode potential is a measure of spot displacement. With no deflection (spot in the centre of the tube) the cathodes of V14 and V15 are at 28.6V. With deflection, the voltage vary sinusoidally between +2V and +55V, limited to these valves by the limiters in the trace expansion amplifiers. It takes 17V to deflect the spot to the edge of the tube.

33. Assume trace points due East, then Y deflection is zero and X deflection maximum. V14 cathode (X amp) falls from +28.6V towards +2V. V13 will start to conduct when V14 cathode at +25V. (V4 cathode and V13 cathode at +25V). V4 cathode potential starts to fall and when V14 cathode is at +11V the spot is at the edge of the tube and V4 must be made to conduct. Its cathode is now at 19.1V so the grid potential is adjusted so that it is brought into conduction and blanking is effected.

34. Move the trace through 180°. V15 cathode falls to +2V, V16 conducts, effecting blanking when V15 cathode is below +11V. Exactly the same will apply to the Y amps. When the X and Y amplifier cathodes are connected via diodes to V4 cathode, square blanking apparently occurs.

35. Assume trace points North-East. (Refer Fig 72) One X and one Y deflection waveform must have the same amplitude and therefore the cathode potentials are equal.

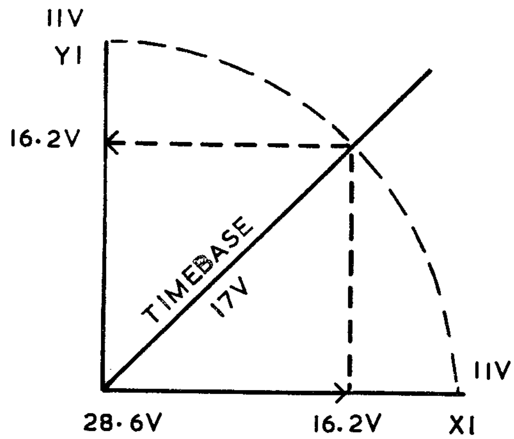


Fig 72

X1 cathode must have fallen by

$$\frac{1}{\sqrt{2}} \times 17 = 12.4\text{volts.}$$

$\therefore$ X1 and Y1 aathodes are
28.6 - 12.4 = 16.2 volts

In this case V13 in both amplifiers will be conducting and V4 cathode potential is +19.3V so that the cathodes of V14 and V15 only have to fall slightly for V4 to conduct and blanking occurs.

Thus two blanking conditions are:

a. Square blanking when trace is vertical or horizontal.

b. Square blanking when trace is NE, SW, SE and SW.

These two conditions will add together making octagonal blanking (See Fig 74)

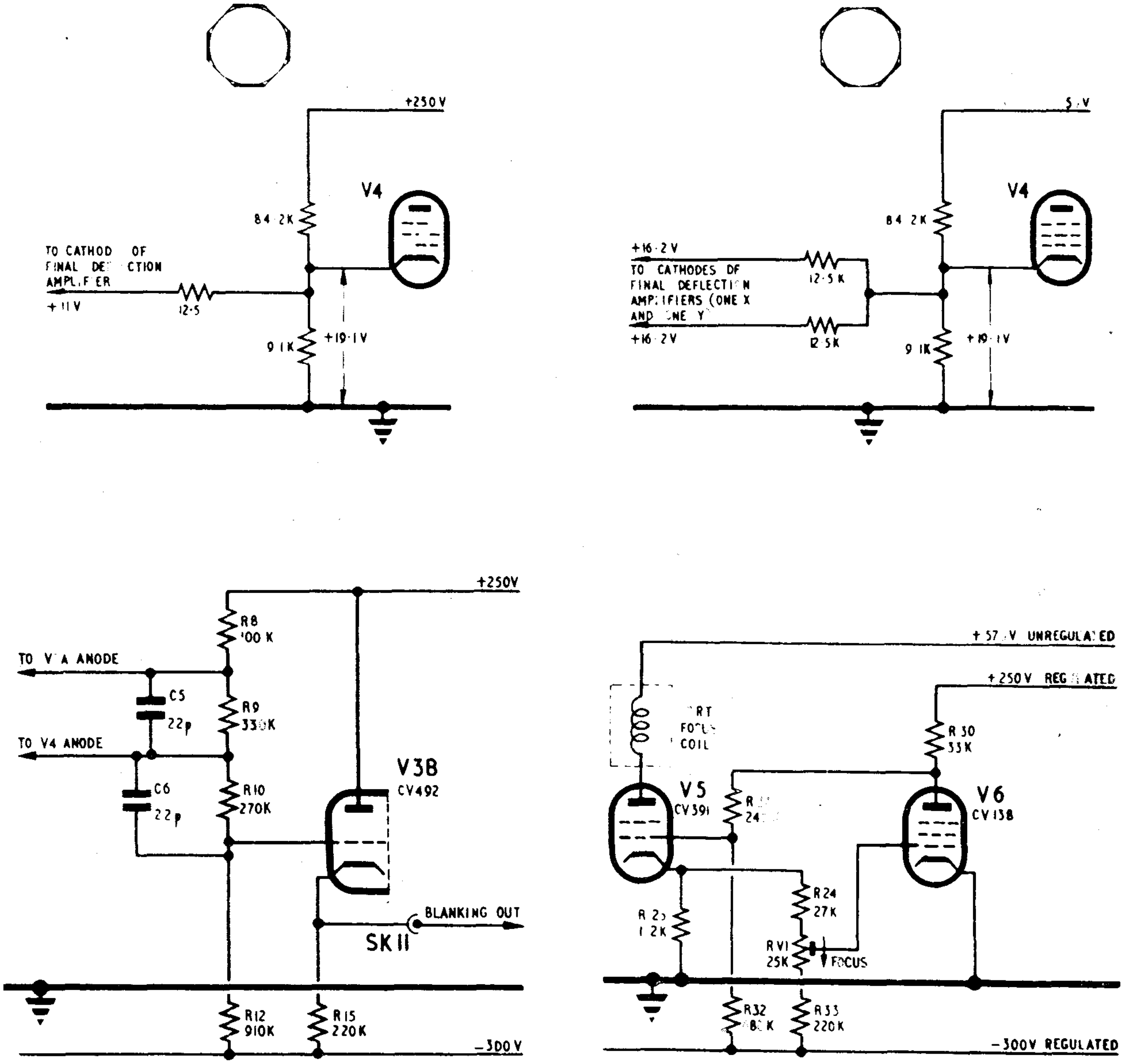


Fig 73 OCTAGONAL BLANKING NETWORKS

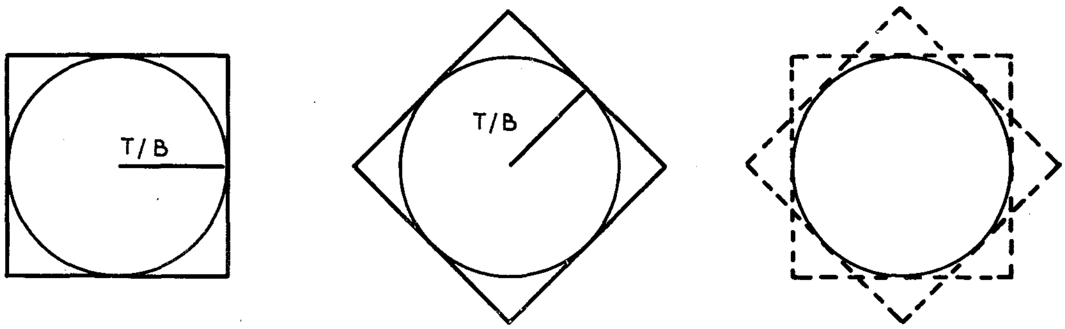


Fig 74 BLANKING DIAGRAMS

36. Waveform Generator Type 80. (Refer Figs 75-78) This unit combines the radar bright up and blanking waveforms to produce the video gate and to produce a trace compensating waveform.

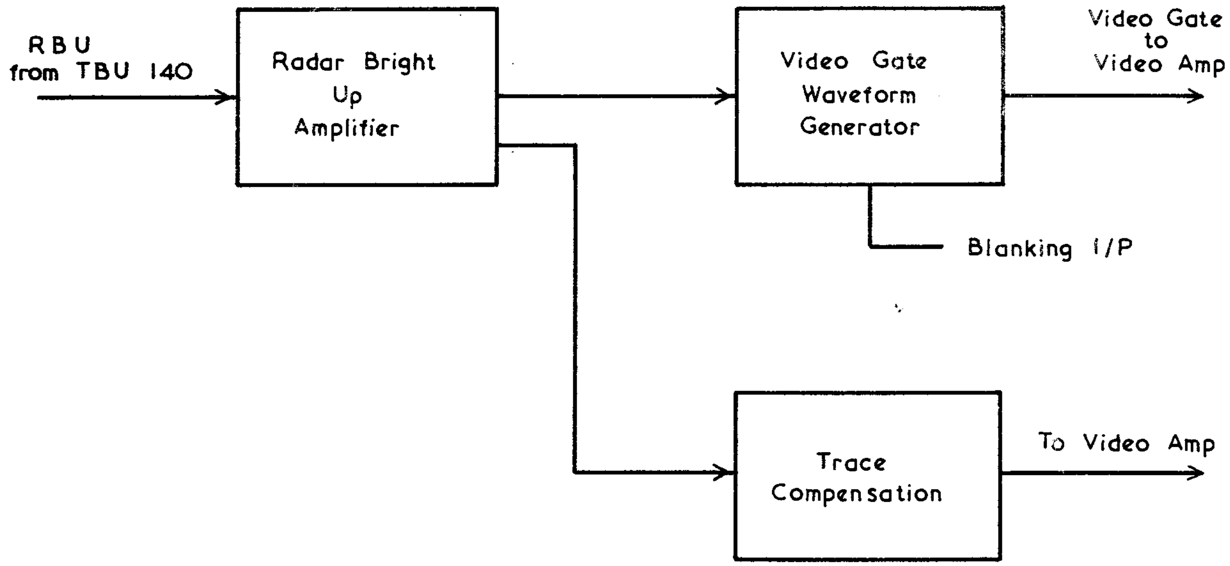


Fig 75 WAVEFORM GENERATOR TYPE 80

37. Radar Bright up Amplifier. (Refer Fig 76) Amplifies the radar bright up from TBU 140 via HSU and/or SELECTOR 33 and applies two versions of it, with correct polarities, amplitudes and d.c. levels to the video gate waveform generator and to the trace compensating waveform generator.

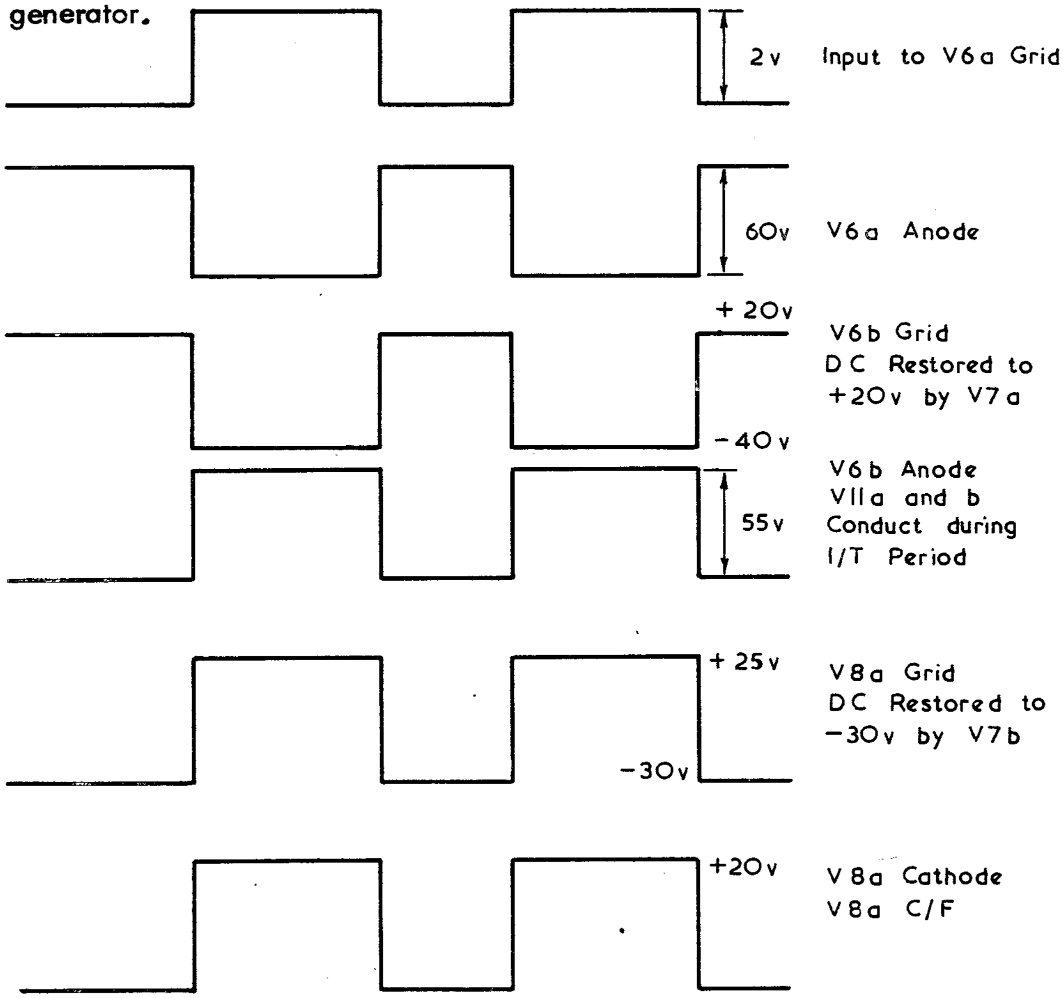


Fig 76 RADAR BRIGHT-UP AMP WAVEFORMS

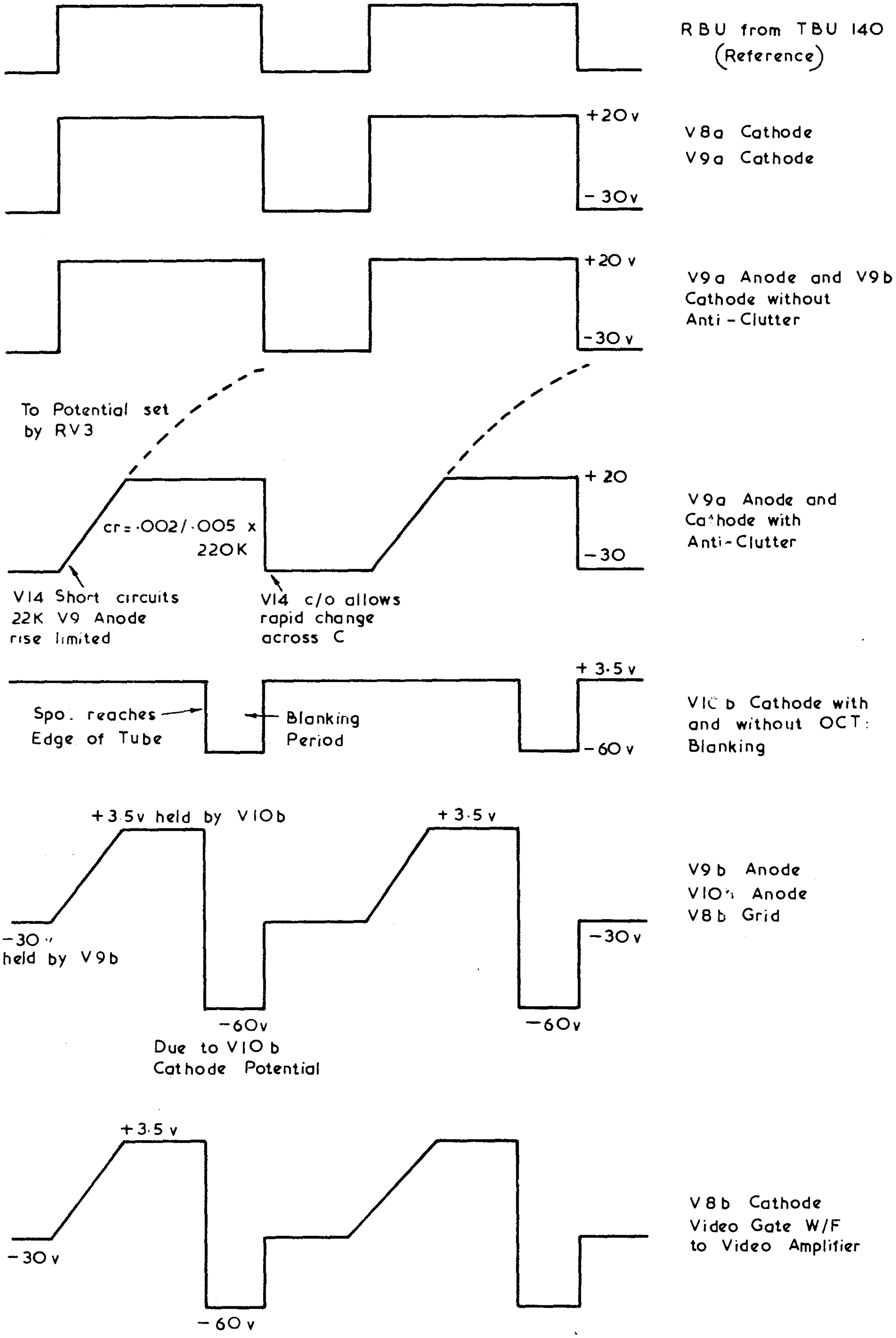


Fig 77 VIDEO GATING WAVEFORM GENERATOR

38. Trace Compensation. Produces a sawtooth of voltage which, when applied to the grid of the c.r.t., gradually increases the brightness of spot as it moves towards the c.r.t. edge, thus ensuring an even brightness over the whole screen area.

39. Action. During the intertrace period V6b is conducting, V11a and V11b are conducting. V11b holds V11a cathode and V10a grid at approximately earth potential.

a. During the timebase period, V6b, V11a and V11b are cut off. V10a grid will fall towards the potential set by RV4 on a time constant of C15/C19 x MΩ (C15/C19 being switched by TRACE EXPANSION switch). V13 will be conducting holding one side of the capacitors at earth potential.

b. At the end of the timebase period V6b, V11a and V11b conduct. V10a grid returns instantaneously to earth potential as V13 cuts off and the change of voltage appears across R65 (see Fig 78). The output from V10a cathode is a negative going sawtooth waveform, the width of the timebase and is fed to the final stage of the video amplifiers.

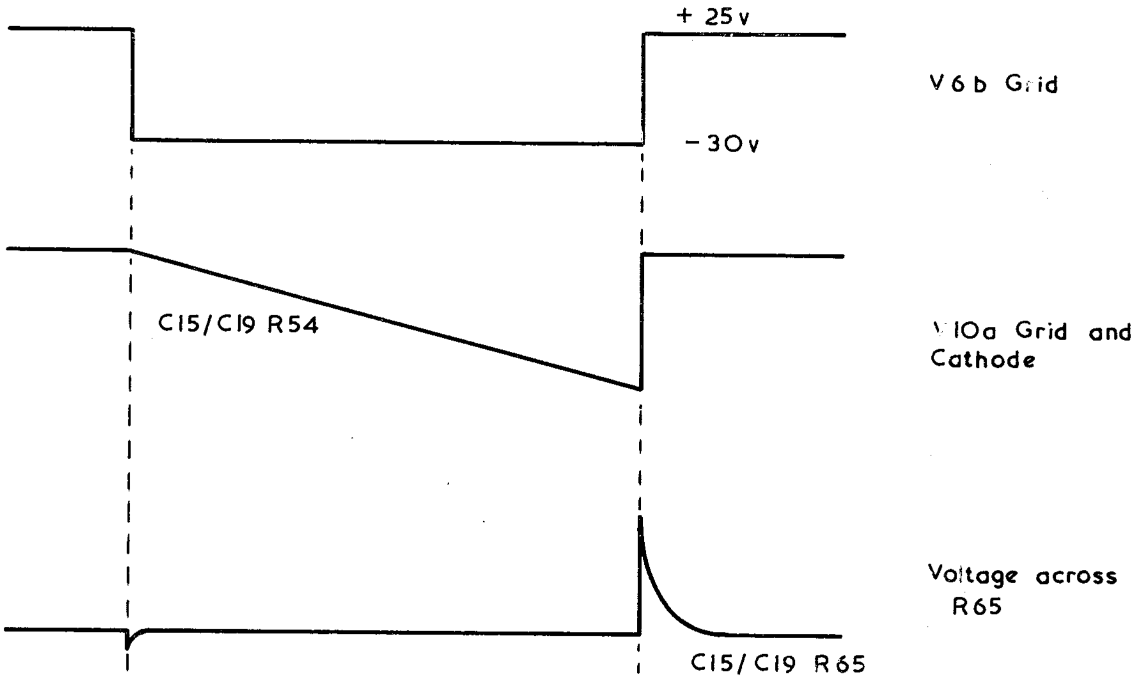


Fig 78 TRACE COMPENSATION WAVEFORMS

40. Video Amplifier. This unit accepts all video inputs, ie radar, video map, range rings, IFF, range strobe and ITBU. It amplifies and limits them, mixes them at the appropriate levels and finally applies them to the grid of the c.r.t. The trace compensation waveform from the WFG T80 is also fed to the circuit.

a. Signals and noise are prevented from reaching the c.r.t. grid during the intertrace and blanking period by the video gate from the WFG T80.

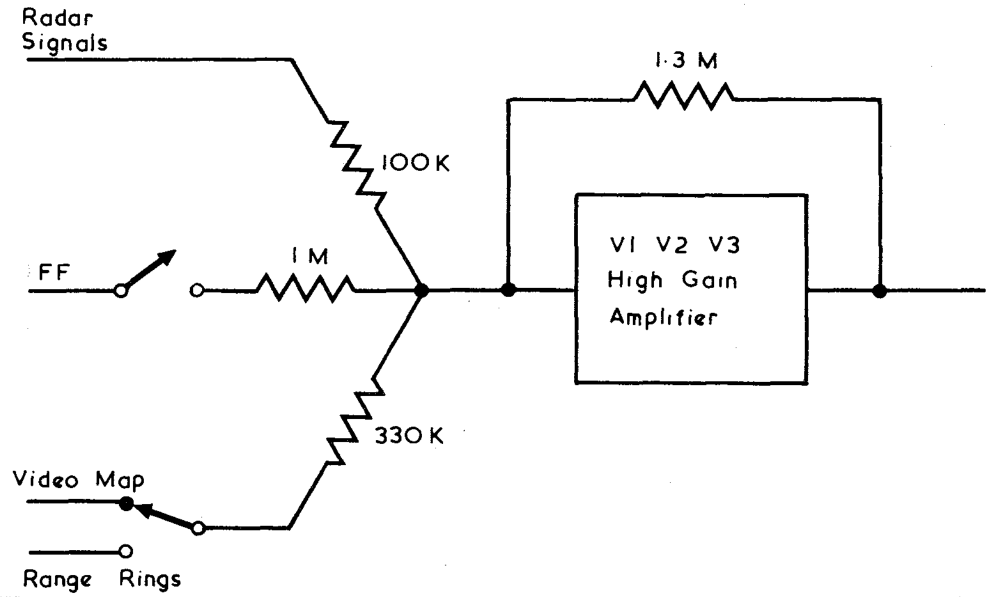


Fig 79 MIXING AMPLIFIER

41. <u>Initial Mixing Amplifier.</u> (Refer Fig 79) V1, V2 and V3 form a see-saw amplifie .

Gain for radar signals	=	13
Gain for IFF	=	1.3
Gain for video map	=	4

These different gains are necessary because the inputs are of different amplitudes and the amplifier must make all the amplitudes equal without distorting the waveforms. As the signals are limited to just above noise level so that all signals have the same brightness, the noise is amplified to approximately the same amplitude as calibration and IFF. Signals will be of greater amplitude.

The amplifier is designed to deal with the narrow rather than for low impedance output and distortion correction. Therefore V1 is a pentode with a low value anode load and V2 a cathode follower feeding the grounded grid triode, V3. Everything has been designed to reduce the effects of stray capacities and yet keep gain high and phasing correct. RV1 and RV2 set the d.c. conditions of the circuit. Capacitors across the see-saw arm resistors improve the pulse shape. (h.f. compensation)

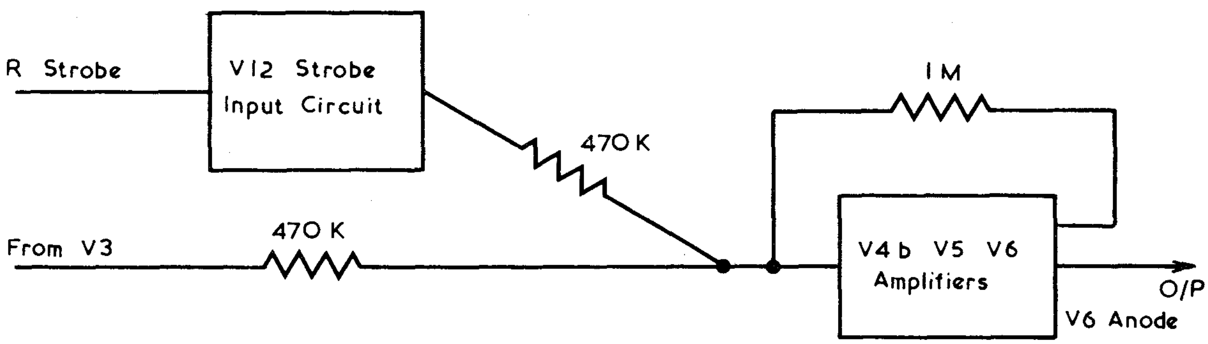


Fig 80 GATING AND LIMITING AMPLIFIER BLOCK DIAGRAM

42. Gating and Limiting Amplifier. (Refer Fig 80) V5 and V6 form a see-saw amplifier for combining the range strobe and the output from V3.

RV3 and RV7 set the d.c. conditions of the circuit.

The strobe input circuit keeps all input capacitors in a discharged condition despite any large signal input. V12 prevents any positive spike on the input waveform fram causing V6 to cut off.

43. Intertrace Period. V5 is conducting. V4b cathode at -30V, held by the video gate waveform. V4b conducts holding V6 grid at -30V. V6 is cut off, preventing signals etc, from reaching the grid of the c.r.t.

44. Timebase Period. V4b cathode rises to +3.5V. V6 grid rises to a potential decided by RV7 and V5. (approx -2V) V6 conducts allowing signals and noise to pass to the c.r.t. grid. The negative input to V5 causes V6 grid potential to rise. Should these inputs cause V6 grid to reach +3.5V then V4b conducts, holding the grid at +3.5V. ie limiting the rise of V6 grid. All signals above a certain amplitude (just above noise level) will be limited. When blanking occurs V4b cathode falls to -60V. V6 grid potential will be -60V, held by V4b. V6 cuts off preventing signals appearing at the output.

During the intertrace time V4b cathode rises to -30V but V4b remains cut off. RV8 varies the current through V6 and thus the amplitude of the output.

45. Dimming Circuit. (Relay F). Refer to R.A. T301 Note, para 8.

46. Final Mixing Amplifier. (Refer Fig 81) For combining the output from V6, the ITBU and trace compensation waveform and feeding the resultant to the c.r.t. grid.

47. ITBU Amplifier V11. A see-saw amplifier with a gain of approx 4. The output is therefore a negative going pulse, 20V in amplitude, 100 μsecs wide.

48. V8, V9. A see-saw amplifier mixing signals etc from V 6 anode, trace compensation from WFG T80 and the ITBU from V11. Signals and trace compensation are d.c. restored to V8 grid potential by V7. The ITBU pulse is of very short duration and need not be d.c. restored. The amplifier gain is adjusted for various gains depending on the input. The output waveform, a combination of radar signals, strobe, video gate, ITBU, and trace compensation is d.c. restored by V10b to the c.r.t. grid potential (see Fig 82(h)).

49. CRT Protection Circuit. Prevents "blooming" and screen burn if the +250V or -300V fails when the console is switched off. The circuit consists of V13a, V10a and V10b. V13a is normally conducting, its anode at earth, held there by V10a, therefore the c.r.t. cathode is at earth potential.

a. If +250V h.t. fails, V13a grid is driven negative; V13a anode potential rises, V10a cuts off and the c.r.t. cathode will be at a positive potential, cutting off the c.r.t.

b. If -300V fails, V13a cathode rises in potential due to C.40, V13a grid remaining constant due to the capacitor C41 to -500V. V13a rises and the c.r.t. is cut off. This action is also assisted by V13b, the rise of -300V to 0V causing it to conduct which lifts its cathode potential to a positive value.

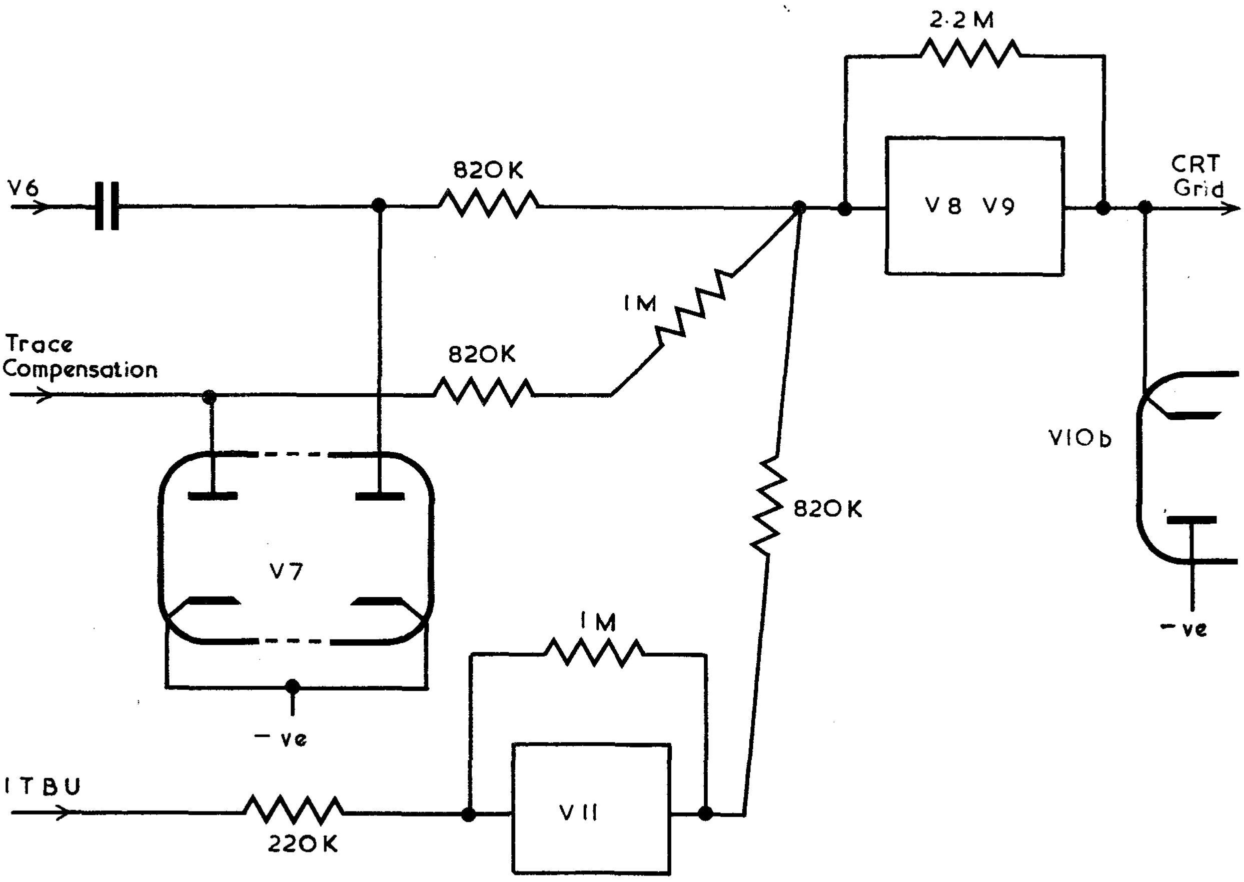


Fig 81 FINAL MIXING AMPLIFIER

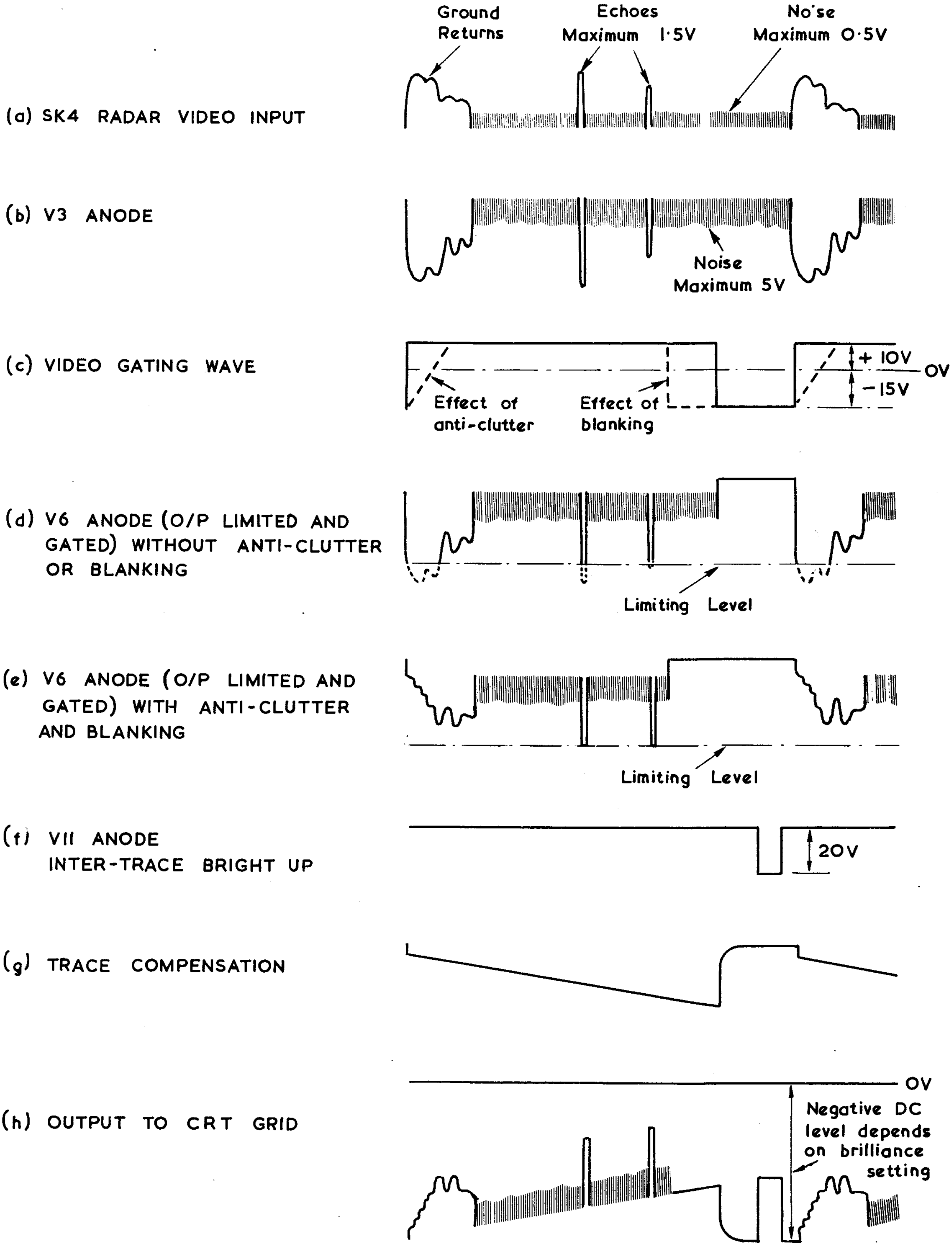


Fig 82 WAVEFORMS IND UNIT

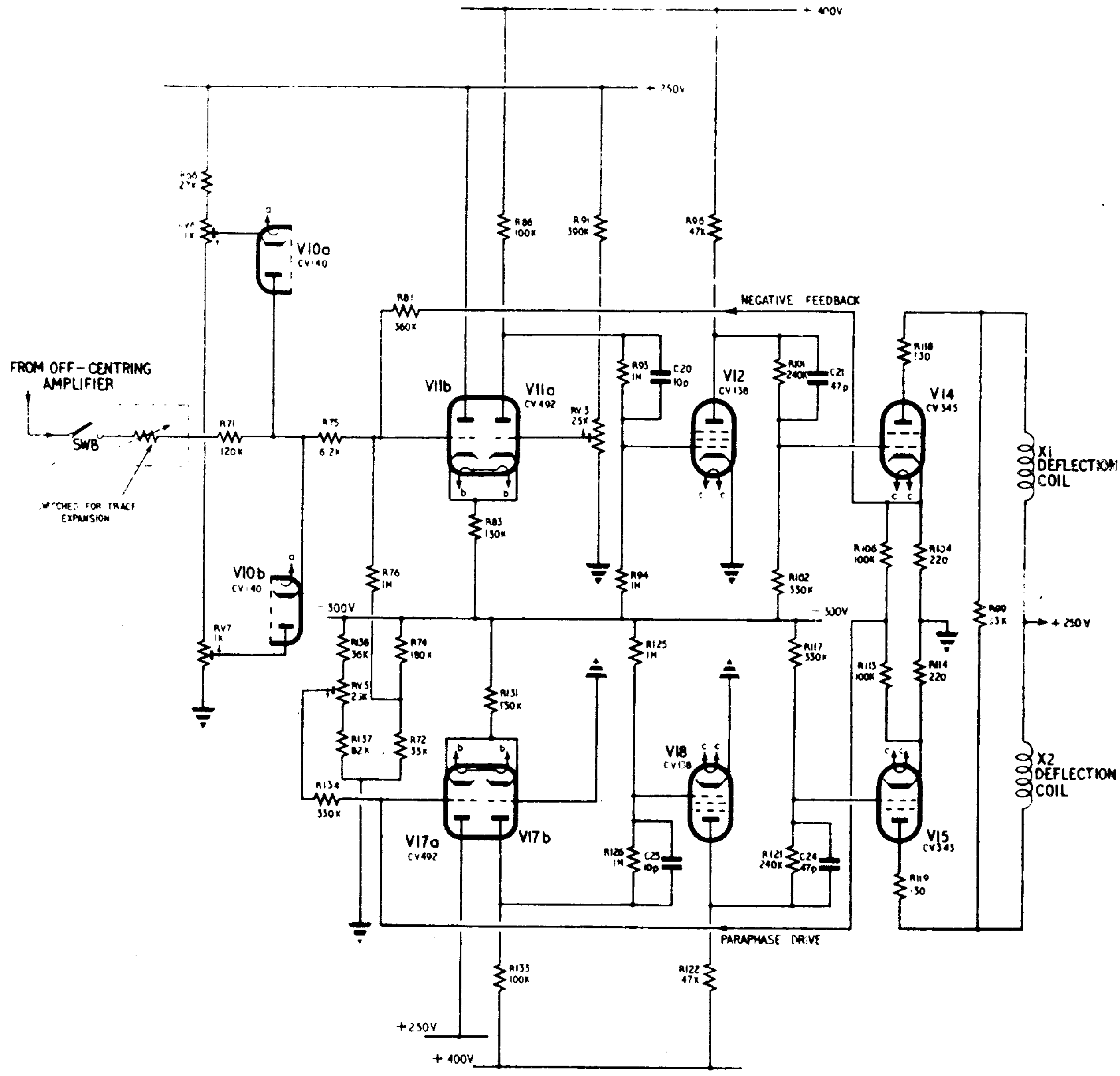


Fig 83 TRACE EXPANSION AMPLIFIER (SIMPLIFIED)