MAINTENANCE HANDBOOK

FOR

HF SSB LINEAR AMPLIFIER
TYPE 7010

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AMENDMENT RECORD

Enter below the amendment title and date of entry, and the name of the person entering the amendment.

Amend No.	Amendment Title	Date Entered	By
1	300W PEP Version only	-	-
2	1KW PEP Pulse Transmitter Type 7010G only	-	-
3	Incorporated	Issue 2	
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1. GENERAL INFORMATION

1.1 Introduction

The type 7010 LINEAR AMPLIFIER is intended for use as a base HF SSB/AM transmitter, driven by a type 7021 HF SSB/AM EXCITER, housed in the same cabinet. Output powers of 1 KW PEP or 500W PEP versions are available (others to special order). The transmitters are either single channel or multi-channel (up to six), the single channel being manually tuned. The multi-channel transmitters are automatically servo-tuned on channel change. Both version are pre-wired for remote control.

When placed into service the run-up procedure is fully automatic eliminating operator errors in sequencing. The transmitter is completely protected against any antenna condition ranging from absolute short circuit to completely open circuit and attempted operation of the transmitter under such conditions cannot cause damage. In addition to full metering of essential parameters at the front panel,a continous SWR indication is provided.

The cabinet rear door contains an air filter to ensure a dust free flow to the PA valve cooling system. The system is protected against air flow failure.

The linear amplifier is mounted on slides and may be extended from the cabinet for servicing. It is still operational in this position. Gate safety switching has been eliminated by careful construction.
Adequate warning labels are affixed to panels under which lethal voltages are accessable.

The type 7010 may carry "CODAN" or "EILCO" brand names. It is type approved by the APO.

1.2 CAUTION - MODE Switch

The mode transmitted (A3H or A3J) is selected by a switch at the rear of the Exciter.

This switch must be returned to the correct position after tests or measurements have been performed.

1.3 Specification

The specification figures are for a 7010 Linear Amplifier driven by a 7021 Exciter. All figures refer to the 1KW version. Where 500W figures differ they are shown in brackets.

Frequency Range	2 - 12MHz (2 - 15MHz)
No. of Channels	6 maximum in multichannel version
Operating Modes	A3J normally upper sideband but lower sideband available A3H (compatable AM)
Frequency Stability	5 parts in 10^7 over the temperature range 0-60°C
Power Output	A3J 1000W PEP 2tone test (500W) A3H 250W nominal (125W)
RF output inpedance	50 ohms nominal. The transmitter can be loaded into any impedance producing a VSWR of less than 2:1
Harmonic Emissions	At least 45 dB below PEP
Spurious Emissions	Spurious Emissions (not harmonics) separated from the carrier by more than 20 kHz : 50 dB below PEP
Carrier Suppression	At least 50 dB below PEP
Unwanted Sideband	At least 43 dB below PEP
Intermodulation Products	At least 40 dB below PEP
Hum and noise	At least 50 dB below PEP
Audio input level	The onset of compression may be adjusted for input signals between -20 dBm and +10 dBm into 600 ohms.
Audio input impedance	10 k ohm balanced.
ALC Range	An increase of 30 dB in input level above the compression level will produce less than 1dB increase in power output.
AF frequency response	± 3dB 300 - 2800 Hz.

1.3 Cont'd

Controls	Power on/off HT on/off Function:- Normal/Off/Local/Tune Local control:- Standby/Transmit CHANNEL select Mode A3H/A3J at rear.
Metering Separate meters for	a) Cathode Current (Switched each tube & total) b) Tune (Switched PA grid & anode) c) Load d) Switched. Screen current (each tube) Major HT. voltage Minor HT. voltage Grid Bias voltage Load SWR Servo balance.
Protection	Overload trips are provided for. Low air pressure Low grid bias High plate current High SWR
Power requirements	220-260 v 50 Hz single phase. Other voltages and frequencies to order.
Power consumption	2000 V A (1300VA) 2 tone test. 500 V A standby
Environmental	Ambient Temperature C 0 to 30 30 to 60 Relative humidity 95% from 95% at 30°C to 50% at 60°C Atmospheric Pressure 700 milibars (7500' or 2500 metres) above sea level
Dimensions (cabinet)	$20\frac{1}{2}$"W x 23"D x 56"H 52cmW x 58.4cmD x 142.2cmH (19" standard panels).
Weight	
Finish Colours	Colours to BS381C:1964 Panels Sky No 210 in semigloss stoved enamel Cabinet Mid bronze green No 223 in armorhide vinyl Lettering Black.

LINEAR AMPLIFIER TYPE 7010

3. BRIEF DESCRIPTION

3.1 General

The LINEAR AMPLIFIER TYPE 7010 is in three main sections :-

(a) AMPLIFIER (and integral power units). (para 5.3 to 5.9)

(b) HIGH VOLTAGE SUPPLY (paras 5.3 to 5.9)

(c) POWER CONTROL UNIT. (para 5.1.2 and 5.2)

The AMPLIFIER occupies the top section of the cabinet and the other two units the bottom section.

An HF SSB EXCITER Type 7021 housed directly under the AMPLIFIER is an essential part of the complete transmitter.

3.2 Mechanical

The AMPLIFIER and EXCITER can be extended out from the cabinet on extending runners for servicing and adjustments. No gate switches are provided as access to lethal voltages can only be obtained by removing sub-panels which are clearly labelled. Provision is made for the fitting of a gate switch if locally required (see para 5.12).

The HIGH VOLTAGE SUPPLY is firmly bolted to the cabinet floor and should not be removed with the AMPLIFIER in the extended position.

The POWER CONTROL UNIT can be removed from the cabinet independant of the High Voltage Supply.

A centrifugal type air blower is fitted to the rear of the AMPLIFIER which provides cooling for the PA Valves. A pressure operated AIR FLOW SWITCH is fitted and if the air flow fails or reduces for any reason the unit is disabled.

3.3 Supplies

The HIGH VOLTAGE SUPPLY is designed to provide approximately +1800V DC for the PA Valve anodes, provision is made for monitoring the voltage and current supplied by the unit.

The POWER CONTROL UNIT provides a + 24V DC supply for relay operation and by a series of interlocks ensures correct operation of all the AMPLIFIER supplies. The unit houses the main circuit breaker and all fuses, the indicator neons for each supply and fault indicator lamps.

The AMPLIFIER houses the remainder of the supplies, namely the MINOR HT SUPPLY (regulated +350V DC and +300V DC), BIAS (-50 to -100 VDC) and FILAMENTS (6.1 and 6.3V AC).

3.4 Signal circuits

The DRIVER STAGE is a single valve Class A amplifier driven by the 100mW RF output from the exciter unit. The output is developed across the combined driver anode/PA grid tuned circuit. On multi-channel amplifiers the inductance tap and tuning capacitor is pre-selected to suit the channel frequency by relays switched by the diode matrix which is controlled by the exciter. The stage is manually tuned, assisted by a phase comparator circuit and tune indicator meter.

The PA STAGE uses four air-cooled valves in parallel operated in Class AB1. The cathode and screen currents of each valve are separately monitored and each screen voltage can be adjusted to "balance" the four cathode currents.

The PA TANK circuit on single channel amplifiers is manually tuned and loaded. On multi-channel amplifiers the tank inductor tap and additional loading capacitors are pre-selected to suit the channel frequencies by relays switched by the diode matrix. The tuning and loading capacitors are motor driven, servo operated from signals derived from a tuning phase comparator and a load comparator. Coarse control of the servo amplifiers is from relay selected SERVO PRESET potentiometers to ensure that the phase comparator does not accidently tune to a harmonic of the channel frequency.

Feedback from the PA anode to DRIVER cathode maintains linearity and stability of the amplifier. A separate ALC voltage is fed back to the exciter unit to limit the PA dissipation during'TUNE'and controls the PEP of the amplifier during normal operation.

An SWR detector is connected between the PA tank circuit and the output Socket. Signals from this circuit are fed to an SWR bridge circuit (on the LOAD, ALC & DET PCB) which drives the SWR meter and operates a SWR TRIP circuit should the load cause a high SWR reading. The SWR TRIP circuit will shut down the transmitter in the event of a fault.

The SERVO-AMPLIFIER system is described separately in para 4.

4. BRIEF DESCRIPTION - SERVO AMP ASSY

4.1 Reference BLOCK DIAGRAM D03-00079

4.2 SIGNAL CONDITIONS

(1) MAJOR HT MONITOR is a +12V level, present only when the Major HT SUPPLY is on.

(2) INITIATE CHANNEL CHANGE, normally this input is at +12V but becomes GND for a short duration when a channel change is initiated.

(3) TUNE COMMAND SIGNAL, normally this output is +12V but becomes GND for the duration of the TUNING and LOADING process. (LP1 normally illuminated, goes out during tuning).

4.3 NORMAL OPERATION

MAJOR HT MONITOR (+12V) and INITIATE CHANNEL CHANGE (+12V), via OR GATE 1 will hold the DETECTOR AMP output at ground.

OR GATE 2, has no inputs (MOTION DETECTORS no output) thus the ENABLE GATE has no input and the following AND GATE has only one input (MAJOR HT MONITOR).

The TUNE COMMAND GATE therefore gives +12V output inhibiting the SERVOS via OR GATES 3 and 4 and associated INHIBIT GATES, which prevent operation of the FINE SIGNAL AMPS.

Should the MAJOR HT MONITOR cease (GND) the input is removed from the AND GATE preventing operation of the TUNE COMMAND GATE even if an INITIATE CHANNEL CHANGE pulse is received.

4.4 CHANNEL CHANGE

The INITIATE CHANNEL CHANGE pulse (GND) via OR GATE 1 will cause the DETECTOR AMP output to be +12V and via OR GATE 2 and ENABLE GATE will give the second input to the AND GATE which now enables the TUNE COMMAND GATE which gives the TUNE COMMAND SIGNAL (GND). (LP1 goes out).

The TUNE COMMAND SIGNAL is fed to the EXCITER which generates the 'TUNE' SIGNAL for the LINEAR AMPLIFIER input. It is also passed to OR GATES 3 and 4 and when the INITIATE CHANNEL CHANGE pulse ceases (the DETECTOR AMP output +12V is holding the INHIBIT GATES) the FINE SIGNAL AMPS can operate. The TIME DELAY will maintain the TUNE COMMAND SIGNAL until the MOTION DETECTORS provide an output, either one of which will continue to maintain the TUNE COMMAND SIGNAL (and reset the TIMER), via OR GATE 2.

4.5 SERVO OPERATION

4.5.1 TUNE

The SERVO PRESET and FOLLOW POT (on the TUNE MOTOR) are arranged to give an identical output when the LINEAR AMPLIFIER is correctly tuned.

When the channel change was initiated a different SERVO PRESET was relay selected to suit the channel frequency and the TUNE COARSE AMP will now receive a differential input. This will be amplified, limited by the LEVEL GATE and fed via the FINE SIGNAL AMP and SERVO AMP to drive the TUNE MOTOR (in the correct direction) to turn the TUNING CAPACITOR towards resonance. The FOLLOW POT is ganged to the TUNING CAPACITOR and the TUNE COARSE AMP differential input will reduce to zero as resonance is reached. This is indicated on the SERVO BALANCE meter, used for initially setting the SERVO PRESETS, and periodic checks. This circuit ensures that the PA TANK CIRCUIT is not accidently tuned to a harmonic of the channel frequency.

When resonance is almost reached the output from the TUNE PHASE COMPARATOR (see para 5.4.3) will take command of the FINE SIGNAL AMP to give more precise tuning signals to the SERVO AMP.

4.5.2 LOAD

A coarse amplifier is not required, loading is achieved in the same manner as above, signals from the LOAD COMPARATOR, servo controlling the loading capacitors.

The TUNING and LOADING process is interdependant but when the LINEAR AMP is correctly tuned and loaded to the new channel frequency, both MOTION DETECTORS will cease to give an output. OR GATE 2 now has no inputs and cannot operate the ENABLE GATE and one input from the AND GATE is removed. The TUNE COMMAND GATE will be held by the TIMER for a short period (1.5 secs) and then shut off the TUNE COMMAND SIGNAL (revert to +12V output), the EXCITER (& LIN AMP) will now revert to normal operation, LP1 will light.

5. TECHNICAL DESCRIPTION

5.1 POWER SUPPLY (Ref. DWG. C04-00103)

The supplies are divided into three main sections :-

(a) HIGH VOLTAGE SUPPLY which provides +1800V DC
(b) POWER CONTROL UNIT which provides +24V DC for relay operation in the AMPLIFIER and controls all the supplies.
(c) FILS,BIAS and MINOR HT supplies which are integral with the amplifier and described in para. 5.3.

5.1.1 HIGH VOLTAGE SUPPLY (Ref DWG C04-00103)

The AC supply for the high voltage transformer (T1) is fed via a 10A 250V circuit breaker (CB1), contact A1, contacts C1, C2 and C3 in parallel and SW1. When energised the MAJOR HT neon (LP1) connected across T1 primary will be illuminated. Voltage taps are provided on T1 primary and a tap selection table is provided on DWG C04-00103.

The secondary of T1 is bridge rectified by D1 to D24, a VDR (Voltage dependant resistor) R1 to R24 is placed across each diode to ensure equal voltage distribution and protect the diodes from transients. Filtering is effected by L1 and C3A to C7B (in series parallel). R25 to R29 across the capacitors ensure equal voltage distribution and C1 tunes L1 to the ripple frequency. R31 and R32 are the bleed and divider network, arranged to give approximately +12V at their junction and this is fed via TS1/K as the MAJOR HT MONITOR voltage. (This is used for metering and in the BIAS REGULATOR and SERVO AMPLIFIER circuits as a control). The negative return current through R30 produces a negative voltage (proportional to current) which is fed via TS1 /J to the HT OVERCURRENT detector circuit.

5.1.2 POWER CONTROL UNIT

The operational sequence is described in para 5.2

(A) Relay Supply

The AC supply for the relay supply transformer T2 is fed via CB1 and F1 and when energised will illuminate the AUXILLARY neon LP2. The primary of T2 is voltage tapped and the taps are also arranged to provide a corrected voltage for the FAN active supply when operated at 40 Hz.

The secondary of T2 is fed via ~~F3~~ F2 to supply two rectifier systems:-

(i) 24V Supply

D1 to D4 form a bridge rectifier and produce the +24V smoothed relay supply. It is fed via SK1/8 to the AMPLIFIER and via the interlock link and SK1/2 to contact E1

5.1.2 (ii) Fault Indicator Supply

D2, D4, D5 and D6 form a bridge rectifier to provide an unsmoothed supply of approx 15V which is used to operate the fault indicator lamps and relays. The RELAY SUPPLY lamp LP5 is illuminated from this supply.

(B) TIMER CIRCUIT

With the E1 contact closed (normal) the +24V supply is extended to the TIMER and the B, C and D relays.

In the normal sequence of operations (see para 5.2) D10 will be grounded via SK1/10 and TR2 will be cut-off its base being grounded via R6. The anode of D9 will also be grounded via R3. Current through R5, Z1 Z2 and D10 will establish a zenered voltage (+13.3V) at the junction of R5 and Z1. C2 and C3 connected to this point can only charge via R4 (D9 held back biased) so initially the gate of TR1 is held positive. TR1 is a P-channel deplection type FET and therefore non-conducting. When C2 and C3 have charged sufficiently via R4 (approx 60 seconds) TR1 will conduct. TR1 current through R6 will cause TR2 to conduct and operate the D relay. D2 contact will now complete the path for the C relay to operate.

In effect this circuit delays the application of the MAJOR HT supply for 60 secs, and allows the PA valve cathodes time to reach operating temperature.

In the event of a BIAS failure :-

(a) The ground is removed from SK1/10, and
(b) E1 contact opens the +24V supply, (this shuts off the MAJOR HT supply).

C2 and C3 will discharge via D9 (now forward biased) and R2, thus ensuring a further 60 seconds delay when the BIAS is restored.

However R3 causes a short delay in discharging C2 and C3, and this permits a momentary break in the AC supply (such as when resetting other fault indicators) avoiding the 60 second delay.

(C) MISCELLANEOUS

The AC supply for the FILS BIAS and MINOR HT supplies in the AMPLIFIER is fed through this unit via CB1, A1, B2 and F2 to SK1/17 and when energised will illuminate neon LP4.

NB. The EXCITER is activated independantly and not controlled by this unit.

(D) START DELAY

The Major HT transformer is energised via a current limiting resistor for approximately 50 mSec before the full AC supply is applied, thus reducing current transients to a tolerable level, see para 5.2.1

5.2 POWER CONTROL UNIT - OPERATION SEQUENCE

With the AC supply connected to the cabinet the EXCITER may be operated independantly of the remainder of the equipment.

5.2.1 STARTING SEQUENCE

Circuit Breaker CB1 switched ON :-

(a) AC MAINS neon LP3 illuminated

(b) AUXILLARY neon LP2 illuminated, if F1 intact.

(c) RELAY SUPPLY lamp LP5 illuminated, if F3 intact.

(d) +24V relay supply available to the AMPLIFIER and the B, C and D relays via E1.

Further action can only take place if the EXCITER, AMPLIFIER and the loom are correctly installed.

(1) If the EXCITER function switch is at NORMAL, the operator at the remote position must now operate the POWER ON switch to provide an earth at SK1/5.

(2) If the EXCITER function switch is at LOCAL, the earth at SK1/5 is automatically provided.

SK1/5 now grounded :-

(a) Relay $\frac{A}{3}$ will operate.

(b) A2 contact provides latching of the $\frac{A}{3}$ relay via SK1/6 and the EXCITER function switch or remote POWER OFF switch.

(c) A3 contact completes the AC fan active circuit via SK1/16

(d) A1 contact prepares the FILS, BIAS & MINOR HT and MAJOR HT active lines.

The AIR FAN now operating will close the AIR FLOW switch and earth SK1/4.

SK1/4 now grounded :-

(a) Relay $\frac{B}{3}$ will operate

(b) B1 contact prepares the $\frac{C}{3}$ relay path as far as D2 contact

5.2.1 Cont.

(c) B3 contact prepares the E/2 relay path as far as D1 contact.

(d) B2 contact completes the FILS., BIAS & MINOR HT active line via F2, SK1/17 and illuminates LP4.

The AMPLIFIER is now powered except for MAJOR HT. The BIAS FAIL relay A/1 in that unit operates providing an earth at SK1/10 and removing the earth from SK1/11. SK1/10 grounded starts the TIMER for D/2 relay and SK1/11 opens the E/2 relay path (until BIAS FAIL occurs).

After 60 seconds delay the TIMER operates D/2 relay via TR2.

(a) D1 contact prepares the E/2 relay path, (which will now operate in the event of a BIAS FAIL grounding SK1/11).

(b) D2 contact completes the C/3 relay path and grounds SK1/3. This lights the TX AVAILABLE lamp at the remote console. (If applicable)

C/3 relay operates via the charging current of 3C1.

(a) Contacts C1 and C2 complete the AC supply to T1 via 3R4 and SW1. SW1 is normally closed, its use generally being limited to isolation of MAJOR HT during adjustments. 3R4 limits the high current transient which may cause CB1 to trip out as T1 core energises.

(b) Contact C2 permits 3C2 to charge via 3R3. After a delay of 50mS J/3 operates.

(c) Contacts J1 and J3 close and bypass 3R4. This allows full AC supply to T1, the current transient now being within acceptable limits.

(d) Contact J2 closes and bypasses 3C1, and also holds C/3 relay via 3R1.

The MAJOR HT is now available, the Major HT Indicator LP1 illuminated, and the AMPLIFIER fully powered. The MAJOR HT supply will be switched off when C/3 relay is released due to either POWER "OFF" being selected on any one of the fault relay contacts opening (B1, D2, G1 or F1). Contact C2 will cause 3C2 to discharge via 3R3 and release J/3 relay. Contact J2 prevents re-operation of C/3 relay without the start delay afforded by J/3. 3R1 will discharge 3C1 rapidly to permit a restart sequence.

Should the $\frac{J}{3}$ relay be inadvertantly be unplugged and a POWER "ON" start made, $\frac{C}{3}$ will operate but will abort within 2 seconds as 3C1 $\frac{J}{}$ceases charging. No further action is possible until $\frac{J}{3}$ is replaced.

5.2.2. BIAS FAIL

Should the BIAS supply fail the BIAS FAIL RELAY will release grounding SK1/11 and opening SK1/10. SK1/10 open will release the $\frac{D}{2}$ and $\frac{C}{3}$ relays SK1/11 grounded will operate $\frac{E}{2}$ relay and illuminate LP6.

(a) E1 contact will release the supply from the $\frac{B}{3}$ relay and also the $\frac{C}{3}$, $\frac{D}{2}$ relay and the TIMER. This removes all the supply to the AMPLIFIER except the FAN active.

(b) E2 contact provides self latching of the $\frac{E}{2}$ relay.

This circuit cannot be restored until the BIAS supply is restored to ground SK1/10.

5.2.3 HT OVERCURRENT

The MAJOR HT negative return via R30 developes a voltage proportional to the current and is arranged to operate the $\frac{H}{2}$ relay if excessive. R1a and R1b are provided to adjust the current sensitivity.

$\frac{H}{2}$ relay operates :-

(a) H1 contact will operate the $\frac{G}{2}$ relay and light LP7 indicating an HT OVERCURRENT.

$\frac{G}{2}$ relay operates :-

(a) G1 contact releases $\frac{C}{3}$ relay (MAJOR HT off).

(b) G2 contact provides self-latching of the $\frac{G}{2}$ relay.

$\frac{C}{3}$ relay released : opens the AC supply to T1 and the MAJOR HT is switched off, this releases the $\frac{H}{2}$ relay (no self latching) but $\frac{G}{2}$ remains operated(self-latching).

The circuit may be restored by momentarily breaking the MAIN AC supply (at CB1) which releases the $\frac{G}{2}$ relay.

5.2.4 HIGH SWR

The SWR measuring circuit will provide a ground at SK1/1 in the event of an aerial fault. This will operate the $\frac{F}{2}$ relay and illuminate LP8.

(a) F1 contact releases $\frac{C}{3}$ relay (MAJOR HT off).

(b) F2 contact provides self latching of $\frac{F}{2}$ relay.

When the aerial fault is rectified the $\frac{F}{2}$ relay may be released by momentarily breaking the AC supply at CB1.

5.2.5 AIR FLOW SWITCH

Failure or partial failure of the air supply will remove the ground from SK1/4 and release $\frac{B}{3}$ relay.

(a) B1 contact releases $\frac{C}{3}$ relay (MAJOR HT off)

(b) B2 contact open circuits the FILS, BIAS & MINOR HT supply.

(c) B3 contact open the $\frac{E}{2}$ relay path, preventing its operation as the BIAS supply fails which would give a false indication.

NB : No AIR FLOW FAIL lamp is provided, but this is self-evident.

5.2.6 RELAY SUPPLY

A short circuit or overload of the relay supply will blow the F2 fuse and extinguish the RELAY SUPPLY lamp LP5.

5.2.7 AUXILIARY SUPPLY

A short circuit or overload of the FAN Supply or T2, will blow the F1 fuse and extinguish LP2.

5.2.8 FILS BIAS & MINOR HT

A short circuit or overload of this circuit will blow the F3 fuse and extinguish LP4.

5.2.9 AC MAINS SUPPLY

An overload of the MAJOR HT supply or any other circuit protected by fuses will trip the circuit breaker CB1 and extinguish LP3.

5.2.10 REMOTE INDICATION

Release of the $\frac{C}{3}$ relay by any of the above eventualities will extinguish the TX AVAILABLE lamp on the operators console. Normal procedure would be for the operator to operate the POWER ON switch to reset the fault indicators and relays if the failure was temorary or intermittent. Repeated attempts to reset will not damage the equipment but if unsuccessful the POWER CONTROL PANEL should be consulted for indication of the fault and subsequent rectification NB : The TX AVAILABLE lamp will not light for at least 60 seconds if the $\frac{D}{2}$ relay was released by a BIAS failure.

5.3 AMPLIFIER SUPPLIES Ref DWG B04-00102 (1 Kw) B 04-00313 (500 W)

5.3.1. FILS, BIAS and MINOR HT Primary Supply

The AC mains are connected to the appropriate voltage tap on the primary of T4, the active fed via PL1/23 and the neutral fed via PL1/24.

5.3.2 FILAMENTS

(A) The 6.3V secondary of T4 is connected only to V5 the DRIVER AMP valve filaments.

(B) The 6.1V secondary of T4 is connected to V1 to V4 the PA VALVES filaments.

5.3.3. BIAS REGULATOR

The 90V secondary of T4 is rectified by 5D1 to 5D4 and filtered by 5C1, the positive rail being grounded. The negative supply via 5R2 is zenered by 5Z1 to set the negative supply to 5TR1 and 5TR2 at -12V, from this rail 5R10, 5D6 and 5Z3 zener the base of 5TR2 at approx - 6.8V. When the PTT is operated an earth is applied to PL1/12. The path 5R1, 5Z2 is effectively open circuit because the voltage across 5R1 and 5Z2 is less than the conduction voltage of 5Z2.

The potential divider 5R7, RV6 (BIAS SET), 5R6 and 5R5 set the base of 5TR1 at a voltage dependant on the bias voltage. As the negative rail (BIAS) tends to go negative this will be reflected across 5R6 and 5R5 to reduce the conduction of 5TR1 and 5TR2 will conduct. The volt drop across 5R9 will turn on 5TR4. 5R16, 5R17 and 5R18 potential divider hold 5TR5 and 5TR6 in a conducting state, the current controlled by 5TR4. Conduction through this SHUNT circuit will reduce the bias voltage by increasing the volt drop across 5R3. The BIAS is set by RV6 to approx - 55V.

When the PTT is released (i.e. no ground on PL1/12) the positive voltage via IR69 (from PL1/8), 5R1, 5R2 and 5D5 will cause the ratio of the voltage divider chain feeding 5TR1 base to change, and allow the BIAS voltage to reach a higher value (approx - 70 V). This will reduce (but not cut off) the standing current in the PA valves.

5.3.4 MAJOR HT MONITOR

When PL1/21 is positive indicating that the MAJOR HT is available the base of 5TR3 is held at approx +0.6V via 5R11 and 5D7. 5TR3 is therefore cut-off having no effect on 5TR4.

If the MAJOR HT fails or is switched off, 5R12 and 5R11 potential divider will cause 5TR3 to conduct and ground the base of 5TR4 which will cut off. This open circuits the SHUNT chain and full BIAS (- 90 V) is available to cut off the PA Valves.

5.3.5 BIAS FAIL

Normally the BIAS is at -55V (or higher) and the bias voltage via 5R21 and 5Z4 will zener the emitter of 5TR7 at -6.8V. The potential divider 5R20, 5RV1 (SET TRIP), and 5R19 set the base of 5TR7 such that 5TR7 is conducting and relay $\frac{A}{1}$ is operated 5R4 and 5Z5 zener the collector of 5TR7 at -51V so that the voltage rating of 5TR7 is not exceeded.

If the BIAS falls below the safe level the voltage on the base of 5TR7 will rise, cut off 5TR7 and release the $\frac{A}{1}$ relay.

The A1 contact will remove the ground from PL1/19 (BIAS AVAILABLE) and ground PL1/20 (BIAS FAIL).

(This action operates the $\frac{E}{2}$ relay in the POWER CONTROL UNIT, closing down all supplies except the FAN active, see para 5.2.2).

5.3.6 MINOR HT REGULATOR

The 300V secondary of T4 is rectified by 6D1 to 6D4, filtered by IC48; IR70 is the capacitor bleed resistor.

The 12-0-12V secondary of T4 is rectified by 6D5 and 6D6 and filtered by 6C1. The negative rail of this supply is connected to the +350V rail.

6TR1 is an IC precision voltage regulator powered by the floating supply and produces a reference voltage (7.15V nominal between V ref and V-. 6R4 and 6R5 divide this reference voltage such that half is supplied to the INVERTING input (pin 4.) Vref is also connected to the potential divider 6R7, 6RV1, 6R1, 6R2 and 6R3 the latter grounded. The regulator controls the +350V rail so that the current flowing in the divider chain produces a voltage drop of half V ref between V ref and the slider of 6RV1 which is connected to the NON-INVERTING input (pin 5).

The output voltage at Vz (pin 9) is passed via 6R10 and 6R11 divider to the base of the external pass transistor 6TR3 and thus controls the conduction of 6TR3 (and 6TR2 in series). 6R14 and 6R15 divider controls the base of 6TR4 such that the Volt drops across 6TR3 and 6TR2 are equalised.

The voltage divider 6R9 and 6R8 will set the voltage at CL (pin 2) at approx. - 2.7V (w.r.t. Cs) and the internal current limiter is held off. 6R12 is effectively connected between C_L and C_S and when 6TR3 current through 6R12 reaches 130mA the volt drop across it will be approx 3.4V sufficient to overcome the - 2.7V delay and the 0.6V base drive required to operate the internal current limit transistor, which conducts. The output from Vz is thus reduced.

If the supply is short circuited, the output current is limited to 25 mA, since no voltage is developed across 6R9. This fold- back action action reduces the dissipation in 6TR2 and 6TR3 to a safe value under fault conditions. If under any fault condition (e.g. flashover of a PA valve) the screen voltage should rise above the unregulated screen supply voltage, 6D9 will conduct to provide a low impedance path to IC48. 6Z1 to 6Z4 are across the screen set potentiometers 1RV1 to 1RV4 maintaining a zenered 50V drop across them and supplying + 300V to the driver stage.

The current drawn from the +300V supply is greater than the maximum negative screen current of the PA Valves.

5.4 DRIVER STAGE Ref DWG B04-00102 (1 Kw) BO4-00313 (500W)

5.4.1 Valve Conditions

The DRIVER Valve V5 is a very high slope (45mA/V) pentode type E55L. In consequence to maintain a constant plate current a positive voltage is applied to the grid through divider R2, R3, and a suitable cathode resistor is used.

R10 and C1 form a filter for the driver stage from the +300V stabilised rail (Va = approx 210V).

R3 and R9 form a voltage divider for the screen supply and this is de-coupled to the cathode by C7, (Vg2 = approx 100V).

5.4.2 Signal conditions

The RF signal input from the EXCITER unit at approx. 100 mW (50 ohm) is applied via SK1 to the primary of T1 a wide-band RF transformer. The signal from the secondary of T1 feeds the floating input circuit, R4 is a parasitic stopper and R1 peaked by L1 set the input impedance to 50 ohms.

The amplified output is coupled via C10 to the PA grid tuned circuit L6 and C19 (for other channels the appropiate L6 tap and tuning capacitor are relay selected). C19B is selected in value such that C19A is at approx. mid-travel when the circuit is at resonance. R31 is a damping resistor across the tuned circuit and if required R23 to R28 may be added across C14A to C19A to suit channel requirements for additional damping.

The driver stage is tuned manually (pre-set) and indication of resonance is afforded by a phase comparator, which compares the phase of the grid to cathode input signal and the phase of the output signal. This is the most sensitive means of tuning to resonance and the comparator gives a zero meter reading when the input and output are 180° out of phase.

5.4.3 PHASE COMPARATOR

A balanced push-pull voltage is obtained across R13, R14 in phase with the current through T2 primary. Since the current in the inductive branch of a parallel tuned circuit is 90° out of phase with the voltage across the tuned circuit the voltages across R13, R14 will be 90° out of phase with the anode voltage of V5. The grid to cathode voltage of V5 is added to the junction of R13, R14 and the vecter sum is rectified by D1, D2. When the anode circuit is correctly tuned the rectified output from D1 and D2 will be equal and M1 when switched to the GRID position will show zero. Detuning the grid circuit will cause unequal outputs from D1 and D2 and hence indicate on M1.

5.4.4 NEUTRALIZING

Because feedback from the PA anodes to the driver stage cathode is used a simple neutralizing circuit cannot be used.

A balanced bridge circuit is arranged such that C4 is used to neutralize the valve anode to grid capacity and C2 is used to neutralize the feed back circuit. The two capacitors are inter-dependant. The adjustment procedure is described in para 7.6.

5.5 PA STAGE

5.5.1 Valve Conditions

The PA valves V1 to V4 are ceramic based air cooled tetrodes type 4CX250B. They are operated in Class AB1, the most linear mode consistant with adequate efficiency, improved by feedback to the previous stage and ALC fed back to the EXCITER stages. Forced air cooling is provided as soon as the heater voltage is applied, an air fail circuit is fitted and the anode supply is inhibited until the cathodes reach operating temperature (60 secs delay).

The MAJOR HT (+1800V) is fed via L11 and L10 decoupled by C31 to the anodes in parallel. The screens are fed from the MINOR HT stabilised supply (+350V) via the individual screen set potentiometers VR1 to VR4.

The screen currents may be independantly monitored and each screen is independantly decoupled by C24 to C27. The signal grid BIAS is fed from the BIAS REGULATOR via R30 (decoupled by C22), R29, L9 and L6. Each grid has a parasitic stopper fitted. The PA valves have four cathode connections and a 10 ohm resistor is connected between each and ground. The effective 2.5 ohms at each cathode enables individual cathode currents to be monitored. The voltage developed when the PA is off resonance is also used to operate an ALC overide circuit, this is described in para. 5.8.4 (TUNE ALC).

5.5.2 Signal Conditions

The signal across the GRID tuned circuit (L6, C19) is amplified and fed via C28, C29 and C30 to the PA TANK circuit. A small voltage is fed via C32, C35 to the phase comparator circuit. (see para. 5.4.3) The correct tap on L12 is relay selected and C36 and C 37 are the TUNING capacitors. C38 and C39 are the LOADING capacitors and at lower frequencies C40 to C46 may be added by relay contacts M1 and N1 when the diode matrix is pre-conditioned. L13 is a protective inductor providing a short circuit to DC in the event of a failure of C28 to C30 dielectric (no effect on RF). The output signal is fed via the primary of 7T1 to the output socket SK2.

5.5.3 Load Comparator

Since the voltage gain of a circuit is dependant upon load resistance a comparator circuit can be used to determine when the stage is properly loaded. It is designed so that a pre-determined ratio between a negatively rectified grid voltage and a positively recified anode voltage produce zero error output when the stage is correctly loaded.

Grid voltage indication is derived from 2C1 and 2C2 capacitive divider rectified by 2D1, filtered by 2R1 and 2C4 producing a proportional negative voltage at 2VR1. Anode voltage indication is derived from IC33 and 2C7 capacitive divider coupled via 2C6, rectified by 2 D2, filtered by 2R3 and 2C5 producing a proportional positive voltage at 2 VR1. The slider of 2VR1 is set to give zero indication on the centre zero meter M2 (LOAD INDICATOR) when the stage is correctly loaded.

The error voltage is also used on automatic transmitters to operate the SERVO LOADING SYSTEM.

The TUNE ALC circuit see (para 5.8.4) limits the PA cathode current to 400 mA when TUNING and LOADING.

5.5.4 NEUTRALIZING

Neutralizing is effected by C20 and C23. Adjustment of this circuit is described in paras. 7.7.3 for Multi-Channel, 7.8.3 for single channel, transmitters.

5.5.5 Feedback

Overall feedback from the PA anode to the driver stage cathode is via C11, C6 divider.

5.6 SWR DETECTOR. (Sub-Assembly) 08-00145

This circuit is used to generate two voltages proportional to the forward and reflected powers of the transmission line connected to the load (aerial). To achieve this 7T1 secondary load is divided into two equal parts 7R1 and 7R2, the centre of which is connected to the voltage sampling divider 7C1, 7C2, and 7C3. This will provide sum and difference voltages at the ends of the transformer secondary which are rectified by 7D1 and 7D2. 7D1 rectifies the FORWARD component and 7D2 rectifies the REFLECTED component (filtered by 7C4 and 7C5 respectively).

The use of a toroidal current transformer for 7T1 and a low value load resistor across the secondary renders the detector virtually independant of frequency.

7C2 is adjusted until the indicated SWR is minimum under matched conditions. Forward bias for the diodes 7D1 and 7D2 is provided from the SWR BRIDGE circuit via L1 (see para. 5.8.5)

5.7 DIODE MATRIX (Sub-Assembly) 08-00146

A ground appropriate to the channel selected will be extended from the EXCITER via PL1 pins 1 to 6. The appropriate diode cathode (D7 to D12) will be grounded and thus operate the channel select relays. Relays A,B,D,F,H and K select the appropriate tap on L6 (Grid) and tuning capacitor (C14 to C19). Relays C,E,G,J and L select the appropriate tap on L12. (PA TANK) the lowest channel tap is pre-set. Relays M and N may be selected for pre-determined channels by the addition of diodes D13 to D24 which will add in the additional load capacitors C40 to C46. Diodes D1 to D6 are the catching diodes across the channel relays. This sub-assy also carries R1 a 330 ohm resistive load for the indicator lamp LP1.

5.8 LOAD, ALC and DETECTOR sub-assembly 08-00147

5.8.1 Power Supply

The 10V-0-10V secondary to T4 is applied to pins 18,31 and 20 respectively. This is bridge rectified by 2D5 to 2D8 and filtered by 2C14 and 2C15 to provide a +12.5V-0-12.5V supply.

5.8.2 Load Comparator

Part of this sub-assembly but has been described in para 5.5.3

5.8.3 ALC

Part of the PA TANK circuit voltage is tapped from 1C34 and 2C13 capacitive divider, rectified by 2D4 and filtered by 2C12 and fed via 2VR2 to PL1/17. This ALC voltage is fed back to the EXCITER stages. During normal operation 2D3 is back biased 2TR1 output being negative. (see next para).

5.8.4 TUNE ALC

During normal operation the EXCITER TUNE COMMAND is positive and applied to the INVERTING input of 2TR1 via 2R5 and 2R7 ensures the output of 2TR1 is negative to back-bias 2D3.

During TUNE the EXCITER TUNE COMMAND is ground holding the INVERTING input of 2TR1 at ground. The NON-INVERTING input is positive fed via 2R6 with a voltage dependant upon PA cathode current. The resultant output from 2TR1 is positive and proportional to PA cathode current is passed via 2D3 to the ALC line over-riding normal ALC voltages. The circuit is adjusted to limit the PA cathode current to 400 mA during TUNE.

5.8.5 SWR BRIDGE

The +12.5V aupply is dropped by 2R10 and zenered by 2Z1 to +6.2V. The -12.5V supply is dropped by 2R37 and zenered by 2Z2 to -6.2V. The voltage divider 2R14, 2D10 provides 0.6V forward bias for the SWR detector diodes 7D1, 7D2 and the logarithmic diodes 2D11, 2D12 (i.e. 0.3V per diode) which improves the low level efficiency of the rectifier diodes and provides a low standing current for the logarithmic diodes. The rectified output voltages from the forward and reflected power rectifiers are fed to the logarithmic diodes through series resistors so that the current in these diodes is proportional to the forward and reflected powers and hence the voltages appearing across the logarithmic diodes are proportional to the logarithm of the forward and reflected powers. (The voltage across a forward biased silicon diode is proportional to the logarithm of the current passing through it).

2TR4 to 2TR9 firm a high input impedance differential amplifier to indicate the difference between the voltages on 2D11, 2D12 on meter M4 which is calibrated directly in SWR. (It can be shown that SWR is directly related to the ratio of forward and reflected power i.e. the difference between the logarithms of the forward and reflected power). 2RV3 sets the balance of the amplifier with no power output from the transmitter and 2R22 is adjusted to give the correct amplifier gain. (It should be noted that 1:1 SWR gives 0 reflected power and hence theoretically infinite deflection of the meter so that the meter may read over full scale when the transmitter is loaded into a 50 ohm resistor).

5.8.6 SWR TRIP

The SWR TRIP is operated when the reflected power rises above that produced by full power into a load with a VSWR of greater than 2:1. Operation directly from the SWR indicator is not practicable as the circuit would trip on RF pick-up by the transmitter aerial from an adjacent transmitter when the transmitter was delivering no power to the aerial (PTT no speech A3J).

The output voltage from the reflected power rectifier is applied to the base of TR10, the emitter of which is biased to +3V by 2R31, 2R33. When the reflected power rises above the trip level TR10 will conduct 2TR11 will conduct and latch 2TR10 on via 2D9 and cause 2TR12 to conduct grounding PL1/14. This ground (SWR TRIP) is passed to the POWER CONTROL UNIT and will cause the power supply to be removed and the HIGH SWR fault indicator to light.

5.9 CONTROL LOGIC Part of Sub-assembly 08-00148 (SERVO AMP PCB)

Refer to the Section 4 BRIEF DESCRIPTION for the overall operation of the circuit before the technical description.

5.9.1 Command Detector Amplifier

Normal

The INITIATE CHANNEL CHANGE and MAJOR HT MONITOR inputs are normally both +12V and the OR gate diodes 4D9 and 4D10 are back-biased. 4TR24 base is held positive via 4R59 and thus conducting to bias off 4TR25 and hence 4TR26, providing no output from this stage.

Operate

Either input becomes ground and therefore the cathode of 4D9 or 4D10 will be grounded to cut off 4TR24 causing 4TR25 and 4TR26 to conduct and produce +12V output across 4R64.

If this was initiated by the MAJOR HT MONITOR failing the output via 4D11 and 4D12 is used to inhibit the SERVO AMPS but a TUNE COMMAND SIGNAL cannot be generated, due to the lack of supply voltage to 4TR31.

If the output was initiated by the INITIATE CHANNEL CHANGE signal (GND) the TUNE COMMAND SIGNAL will be generated and maintained by a TIMER until the INITIATE CHANNEL CHANGE pulse is removed and the output via 4D11 and 4D12 ceasing releases the INHIBIT GATES at the SERVO AMPS.

5.9.2 TUNE COMMAND GATE and associated ENABLE GATE

Normal

The +12V supplied by MAJOR HT MONITOR is grounded by 4TR31 whose base is held positive via 4R71 and 4D18. The base of 4TR29 is grounded cutting off 4TR29 and +12V is fed via 4R69 to the TUNE COMMAND rail.

This is fed direct to PL1/11 and the EXCITER to inhibit the TUNE signal and also to the TUNE ALC inhibit circuit. It is also fed via 4D13 and 4D14 the OR GATES inhibiting the SERVO AMPS.

MAJOR HT MON fails

The TUNE COMMAND signal remains positive there being no +12V via 4R73 to operate the base of 4TR29.

5.9.3 INITIATE CHANNEL CHANGE

The +12V output from the COMMAND DETECTOR amplifier is fed via 4D17 (OR GATE), 4R68 and 4Z3 to the base of 4TR30 (ENABLE GATE) 4TR30 will conduct and drop the anode of 4D18 to -12.5V rail and cut off 4TR31 (AND GATE). 4TR31 cut off permits +12V via 4R73 to the base of 4TR29 which will conduct and ground the TUNE COMMAND rail.

The TUNE COMMAND signal (Gnd) :-

(a) is passed via PL1/11 to the EXCITER which will now produce the TUNE signal to the AMPLIFIER input.

(b) removes the OR GATE inputs via 4D13 and 4D14.

(When the INITIATE CHANNEL CHANGE pulse ceases the OR GATES will have no inputs and the INHIBIT GATES no longer hold the SERVO AMPS which will start to tune the LINEAR AMPLIFIER). The MOTION DETECTORS now provide an input via 4D15 and 4D16 the OR GATE and thus maintain the TUNE COMMAND signal.

5.9.4 TIMER (TUNE COMMAND)

During the period between cessation of the INITIATE CHANNEL CHANGE pulse and an output being received from the MOTION DETECTORS the TUNE COMMAND GATE is held operating by 4C11 which is charging via 4R71 (approx $1\frac{1}{2}$ secs delay).

5.9.5 SIGNAL LAMP

Whenever the TUNE COMMAND SIGNAL is present only a TUNE input is available from the EXCITER.

When the TUNE COMMAND signal ceases the programme input is available from the EXCITER and this is indicated by LP1.

Normally 4TR28 is held conducting by the positive voltage via 4R69 and 4R67 and the resultant volt drop across 4R69 turns on 4TR27 illuminating LP1. During TUNE, 4TR28 is held off by the TUNE COMMAND signal (gnd) which cuts off 4TR27 extinguishing LP1. The supply for LP1 is extended via 2R1 from the +24V rail on the DIODE MATRIX sub-assembly.

5.9.6 COMPLETION OF TUNE

The TUNE and LOAD motors have tuned and loaded the LINEAR AMPLIFIER the MOTION DETECTORS will give no output and the OR GATE (D15-D17) will have no input. 4TR30 will cut off and the negative of 4C11 is now connected via 4R71 to the +12.5 V rail (instead of -12.5V). The positive end of 4C11 is a 0v via 4TR27 and 4C11 discharges via 4R71 until the base of 4TR31 is sufficiently positive for 4TR31 to conduct ($1\frac{1}{2}$ secs delay). 4TR31 conducting grounds 4TR29 which will now cut off and the TUNE COMMAND rail reverts to +12V.

5.10 SERVO AMPLIFIER (TUNE)

5.10.1 Coarse Amplifier

When the LINEAR AMPLIFIER is correctly tuned the FOLLOW POT 1RV5 connected to the tuning capacitor shaft and the appropriate SERVO POT (3RV1 to 3RV6) both give the same output; and there is no voltage differential at the input to 4TR1. When a channel change occurs a different SERVO PRESET is brought into circuit by the channel select relays. There will then exist a voltage differential between the FOLLOW POT connected to the NON-INVERTING input and the selected SERVO POT connected to the INVERTING input of 4TR1. The difference will be amplified in 4TR1 to give an output (appropriate to the direction of motion required) via 4D1 and 4D3 if positive or via 4D2 and 4D4 if negative. This will be passed via 4R10, limited by 4D5 and 4D6, to the NON-INVERTING input of 4TR3. The amplified signal will over-ride any output from the TUNE phase comparator circuits being fed via 4R11.

When (as will be shown) the TUNE motor has driven the tuning capacitor to almost the correct position for resonance the FOLLOW POT and SERVO POT differential and hence the coarse AMP output will diminish below the output from the phase comparator.

The phase comparator output will now take control of the FINE amplifier (4TR3) for more precise tuning.

5.10.2 SERVO BALANCE INDICATOR.

The output of the COARSE AMP is fed via 4R8 to the multimeter circuit and enables initial setting up and subsequent checks to be made on the SERVO PRESET adjustment. The purpose of the SERVO-PRESETS and COARSE AMP is to ensure that the tuning capacitor is driven to the correct position to tune the frequency by the phase comparator as the latter can give an output at a harmonic frequency.

5.10.3 FINE AMPLIFIER

The signal (derived from COARSE AMP or phase comparator) is amplified by 4TR3 and fed via 4R16 to the SERVO AMPLIFIER. If the FINE AMP output is positive 4TR4 will conduct (vice versa, 4TR5) The resultant volt drop across 4R18 will cause 4TR8 to conduct sending a positive output to the TUNE MOTOR (M5). 4TR8 conducting causes 4TR6 to conduct turning 4TR8 full on ensuring a good start to M5 and full speed. (The motors are not proportionally controlled). When the tuning capacitor has correctly tuned the circuit to resonance, the phase comparator output will be zero and the SERVO system will stop.

The reverse direction is accomplished by 4TR5, 4TR9 and 4TR7 giving a negative output to M5.

5.10.4 FINE AMP INHIBIT GATE

4TR2 connected to the INVERTING input of 4TR3 is a P-channel depletion type FET. Normally the TUNE COMMAND rail at +12V holds 4TR2 cut off and full feedback from the SERVO AMP via 4R17 reduces the gain of 3TR3 to less than unity and its output is inhibited. During TUNE, the TUNE COMMAND signal grounds the gate of 4TR2 which conducts and 4R15 reduces the feed-back (via 4R17) allowing 4TR3 to amplify and operate the SERVO AMP.

5.11 SERVO AMPLIFIER (LOAD)

The LOAD SERVO system is a duplicate of the TUNE SERVO system, except that no COARSE AMP is fitted or required. The load comparator operates directly into the FINE AMPLIFIER (Comprises 4TR14 to 4TR23.)

5.12 GATE SWITCH FACILITY Ref DWG C04-00103

Reference to the drawing will show a link fitted between SK1/8 and SK1/2, this bridges the +24V supply to contact E1. This link may be removed and a GATE SWITCH (closed when safe) may be connected to bridge SK1/8 and SK1/2.

7.11 Notes on adjustment and operation

These notes should be read in conjunction with "Section 7 Test & Alignment" to provide a greater insight to the operation of the automatic tuning system.

1. Automatic Tuning

The automatic tuning and loading facility provides signals to drive two electric motors one driving the anode tank tuning capacitor, the other driving the loading capacitor (output capacitor of the pi-tank).

The signal for the control of the anode tuning is derived from a phase comparator which compares the phase of the RF voltage on the grid of the PA stage with the phase of the RF voltage in the anode circuit. Correct tuning is achieved when the load presented to the anode of the tubes is resistive, i.e. when the anode voltage is precisely 180° out of phase with the voltage on the grid. When this is true, the output voltage from the phase comparator is zero, the anode tuning meter reads zero and the motor driving the anode tuning capacitor ceases to rotate. Because the phase comparator output can be positive or negative, (depending on whether the phase of the voltage in the anode circuit lags or leads that of the grid circuit) the motor driving the anode tuning capacitor can be caused to rotate clockwise or anticlockwise as is required to drive the system to the null point.

The phase comparator will also provide an output if the anode tank is tuned to a harmonic of the operating frequency (if this should exist within the tuning range of the capacitor). To prevent the capture of this false tuning point an additional arrangement is provided. This consists of a mechanically driven potentiometer which provides a voltage related to the actual position of the tuning capacitor. Another potentiometer (SET COARSE SERVO) is set such that the voltage from its moving arm is the same as that from the potentiometer on the tuning capacitor when the correct point is reached. The output from each potentiometer is fed to the differential inputs of an integrated circuit amplifier arranged such that the output of the amplifier falls to zero when the correct tuning is achieved.

The signal from the phase comparator is mixed with the signal from the coarse position amplifier and fed to the main amplifier driving the servo motor. The signal from the coarse position control is fed via diodes, the forward voltage drop of which must be overcome before the voltage alters the voltage from the phase comparator. In this way, a "dead band" is established in which the setting of the coarse servo pot is unimportant and the capacitor positioning is arranged by the phase comparator alone. In order to ensure that the SET COARSE SERVO pot is correctly set, the output of the coarse amplifier can be read on the meter when the switch is in the SERVO BAL position.