DU USER GUIDE

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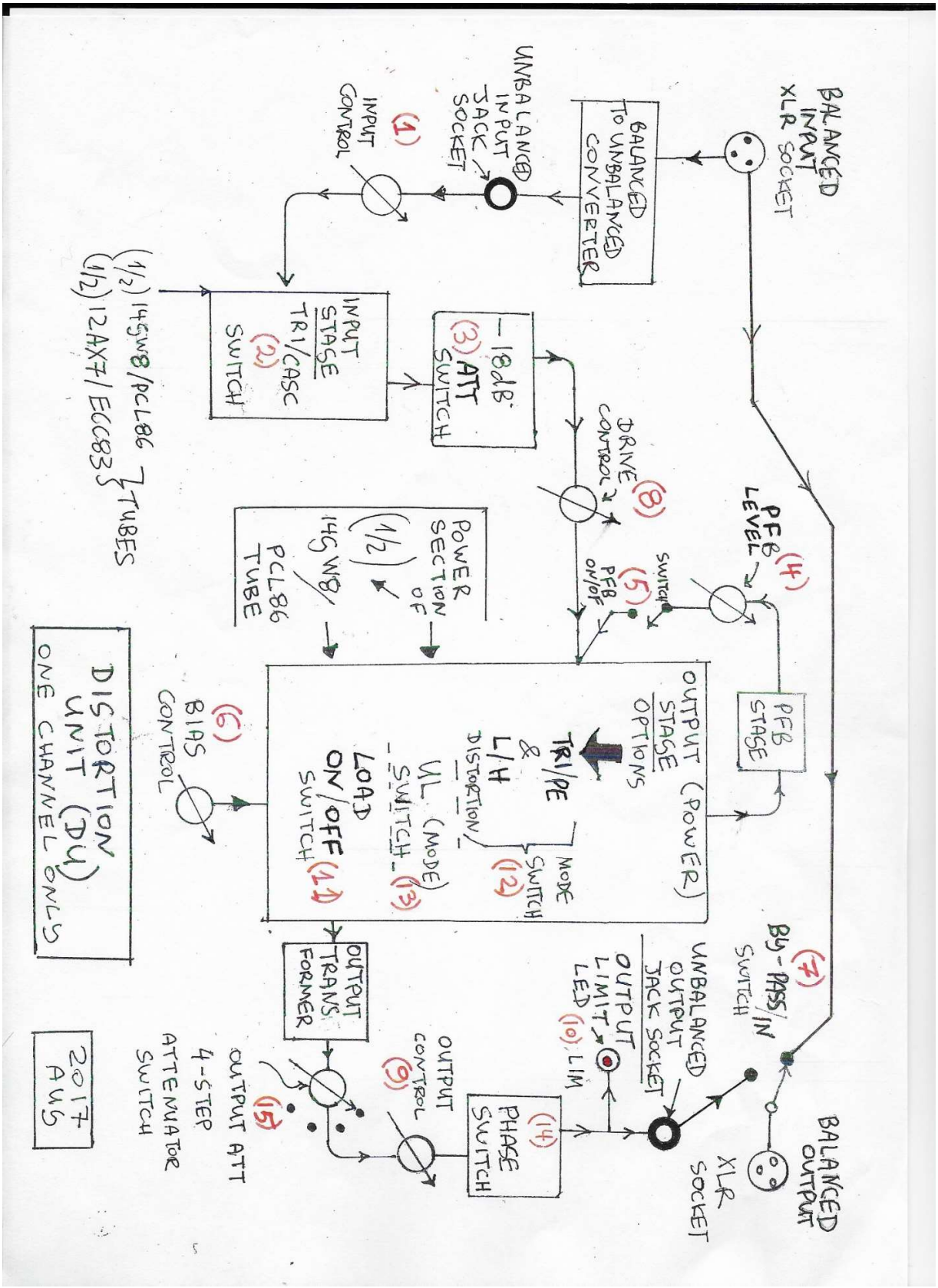
Table of Contents

DESCRIPTION & FEATURES 5
Input and output stages 5
Distortion 'tone' in relation to frequency 6
Differences between triode and pentode sound 6
Off Load' mode operation 7
Positive feedback (PFB) 7
FRONT PANEL CONTROLS AND SWITCHES 9
OPERATING CONTROLS FROM LEFT TO RIGHT AND THEIR FUNCTION 9
PREPARATION BEFORE SWITCHING ON 13
(1) PLACEMENT 13
(2) GROUND LIFT SWITCH 13
(3) STAND-BY SWITCH 14
FIRST TIME SWITCHING ON 14
(4) The output attenuation switch 15
(5) Inputs, outputs & BY-PASS rotary switch (6) 15
PRECAUTIONS 16
BIAS CONTROL AND HOW IT AFFECTS DISTORTION AND CLIPPING IN THE OUTPUT STAGE 17
HOW TO USE THE BIAS CONTROL (6) IN TRIODE ULTRA-LINEAR AND PENTODE MODES 18
SWITCHING ON 20
TESTING THE UNIT AND OPERATING GUIDELINES 21
CASCODE versus TRIODE 22
TECHNICAL NOTES 30
SAFETY 30
GROUND LOOPS 30
GROUND LIFTING 30
BALANCED AND UNBALANCED LINES 31
TUBE ISSUES 32
NOISE, MICROPHONY & AGE 32
MICROPHONY TEST 32
EMISSION LOSS 33
IONIZATION 34

HOW OFTEN AND WHEN IS IT NECESSARY TO REPLACE TUBES 34
FUSES 35


BALANCED INPUT XLR SOCKET
UNBALANCED INPUT JACK SOCKET
BALANCED TO UNBALANCED CONVERTER
INPUT CONTROL (1)
(1/2) 145W8/PCL86
(1/2) 12AX7/ECC83 TUBES
INPUT STAGE TRI/CASC (2) SWITCH
-18dB (3) ATT SWITCH
DRIVE CONTROL (8)
PFB LEVEL (4)
PFB ON/OFF (5) SWITCH
POWER SECTION OF (1/2) 145W8/PCL86 TUBE
OUTPUT (POWER) STAGE OPTIONS
TRI/PE & L/H DISTORTION/UL (MODE) SWITCH (12)
MODE SWITCH (13)
LOAD ON/OFF SWITCH (11)
BIAS CONTROL (6)
PFB STAGE
BY-PASS/IN SWITCH (7)
OUTPUT LIMIT LED (10) LIM
UNBALANCED OUTPUT JACK SOCKET
BALANCED OUTPUT XLR SOCKET
PHASE SWITCH (14)
OUTPUT CONTROL (9)
OUTPUT TRANS. FORMER
OUTPUT ATT 4-STEP ATTENUATOR SWITCH (15)
DISTORTION UNIT (DU) ONE CHANNEL ONLY
2017 AUG

DESCRIPTION & FEATURES

The signal that enters this Distortion Unit **(DU)** can be adjusted to produce a wide variety of clean, mildly or excessively distorted sounds. This is an analogue sound processor and **familiarity** of the unit and **experimentation by the user** are essential in creating a particular 'tone signature'.

Input and output stages

The unit has **balanced** and **unbalanced inputs and outputs** but **only one input or output can be used at a time.**

The DU consists of an input stage and an output stage. The signal level that enters the input stage is set by the **input gain control**, and the output signal level is set by an **output control plus an attenuator.** Vacuum tubes are used all throughout the signal chain, except the input balanced to unbalanced converter and the positive feedback stage. The balanced **(XLR)** input can accept a signal of an amplitude of **6.4VRMS (18dBu) maximum,** and this signal level must not be exceeded.

The DU has been designed to accept standard **studio input signal levels of between 0.775VRMS (OdBu) to 1.228VRMS (+4dBu),** and its **input impedance is 50k.** It can also accept lower level signals but if high distortion levels are desired the INPUT control and other level controls must be set higher than usual. The **input** impedance of the equipment that the **DU is connected too** must not be less than **2K.**

The **input** stage can operate in two modes **triode or cascode.** Cascode is *a* low noise pentode made out of two triodes *(=CASCaded triODE).*

The output **of the input stage** can be **attenuated if necessary** before it is fed to the **drive control.** This enables a **finer adjustment** of the signal that enters the output stage and makes it easier to **blend** the tone created by the **two stages** for mild coloration purposes instead of hard distortion.

The signal from the drive control is fed to the output stage which is a Single Ended (SE) mini power amp using the power section of the PCL86/14GW8 triode/pentode tube and can be set to work in **triode, ultralinear and pentode** low **or high distortion** modes.

One of the factors that affect the output **distortion** is how **high** the **drive** control is set, and the **output of the unit must always be reduced each time the drive control is set high for more distortion.** The output stage is centred around a **high quality 1492s SOWTER output transformer.**

The output stage also has a **bias control** that sets the amount of **DC** current that flows through the PCL86/14GW8 power tube and output transformer under idle (no signal) conditions. This gives great flexibility in **altering the shape of the output waveform, its symmetry and the way that it clips,** see relevant section. **Clipping** occurs when the signal's maximum output is **constricted** by an amplifier's circuitry.

Distortion 'tone' in relation to frequency

***** The distortion of a signal composed out of **two or more different frequencies** sounds **harsher** than the harmonic distortion of **single notes (frequencies)** and it is called **Inter-Modulation (IM)** distortion.

*****Any type of distortion in the **low single** frequencies sounds **smoother** and **"warmer"** than distortion in the mid frequencies.

***** Mild Intermodulation (**IM)** distortion of **low** frequency notes can also sometimes generate **'warmth'**.

***** Harmonic distortion in high frequencies (above a few kHz) in single frequency signals is difficult to detect due to **the** range of the human hearing. However, **IM** distortion caused by high frequency signals is **detectable.**

***** The **output transformer** and the way it interacts with the power tube also generates distortion especially in the **low** frequencies.

Differences between triode and pentode sound.

At low input signals **triode** mode produces predominantly **second harmonic distortion** which is more musical. Drive and gain controls must be set low to drive the DU softly to **avoid clipping** if this kind of sound coloration is desired. As the drive level is turned up, more distortion will be generated, first low even, then low odd (like third) and a smaller amount of higher orders both even and odd, until eventually clipping **occurs.**

In **pentode** mode distortion **starts earlier**, as far as the drive level is concerned. Pentode output will produce more **third** and **higher order odd** harmonic distortion products, in addition to second and higher even products. By overdriving the power stage in higher drive settings and with gain switched high, harsh edgy sound and a boost in the high mids and treble occurs.

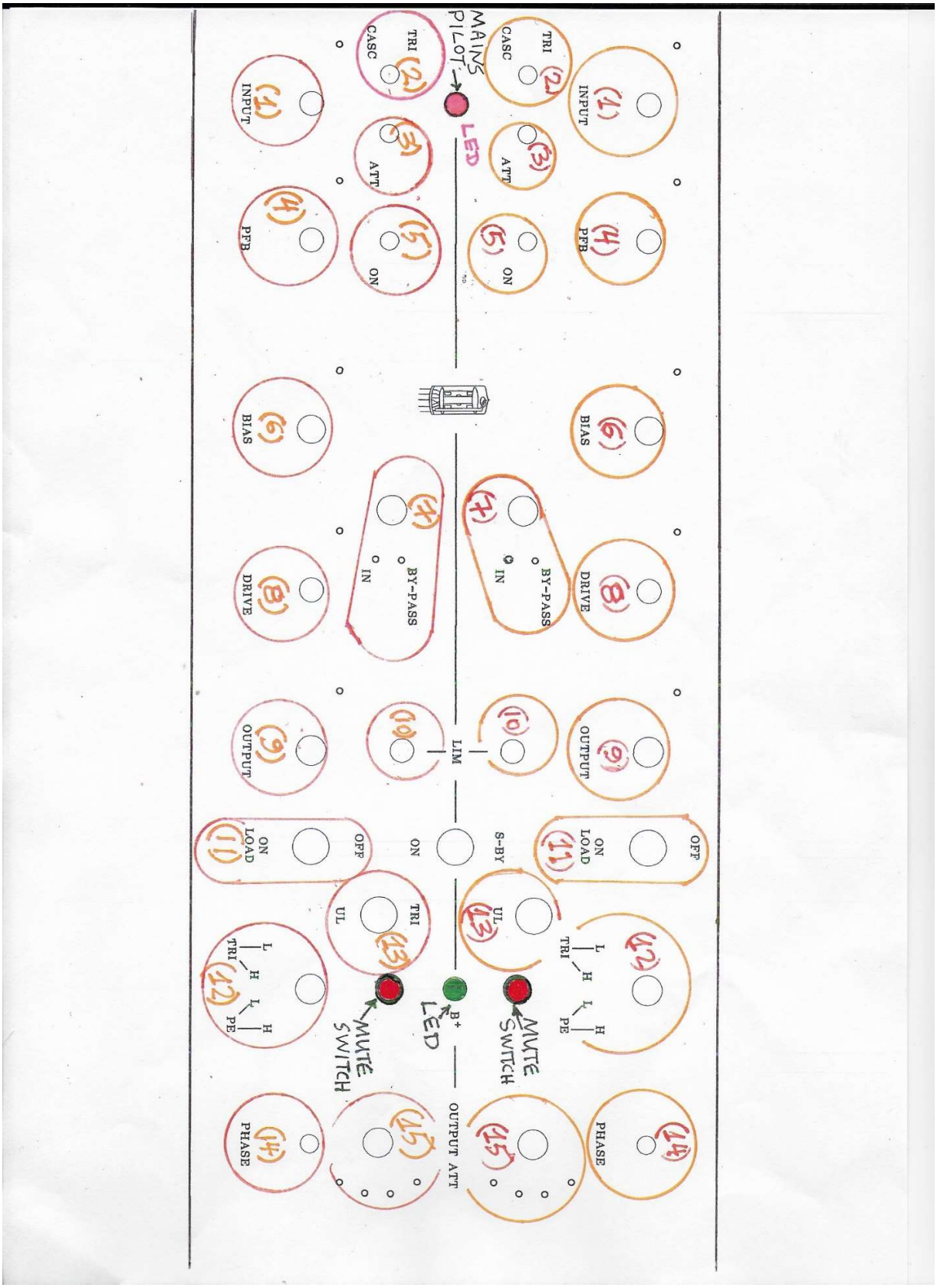
In **ultra-linear** mode the tube operates somewhere in the middle between triode and pentode. This mode was widely used in 50's and 60's hifi's, the sound is a bit more like in triode mode but with more volume and a bit more distortion (odd harmonic too) especially in the low and high frequencies.

Off Load' mode operation

In **'off load'** mode the load that is connected to the output of the DU is removed (reduced to zero) and this alters the characteristics of the amplified sound wave, introducing high distortion that is **extreme, harsh and shrill.** This mode can be switched **on** or **off.**

Positive feedback (PFB)

This feature is also used for an **extreme** type of distortion where the DU output amplifier can become **unstable** and in high PFB settings oscillate**.** This is because the output signal re-enters the input of the output stage in such a manner (phase) so that it increases the amplification. This mode can be controlled and switched **on** or **off.**


MAINS PILOT
LED
INPUT
TRI
CASC
ATT
ON
PFB
BIAS
DRIVE
BY-PASS
IN
LIM
OUTPUT
OFF
ON
LOAD
S-BY
UL
TRI
L
H
PE
PHASE
OUTPUT ATT
MUTE SWITCH
B+
LED

FRONT PANEL CONTROLS AND SWITCHES

(1) In the middle of the front panel (from top to bottom) and about two thirds of the distance from left to right there is a **large** toggle **switch** labeled as **S-BY/ON.** When this switch pressed down **(ON** position) it connects the **high (B+) voltage** lines from the internal power supply to the audio circuits of the unit.

(a) The **S-BY** switch must be pressed down **(ON) approximately one minute** after you have turned **on the mains.** The **mains on/ off switch is at the back,** situated next to the IEC mains input socket. This **delay** is necessary to ensure that no high voltage is applied to the circuits **until the tubes have reached their operating temperature.**

(b) This switch must also be used to **disconnect the high voltage** from the **tubes** every time you **use the (12) TRI L/H, PE L/H and the (13) UL mode switches,** as discussed later.

(2) The **red** LED on the far left of the logo (on the center- line that separates the top and bottom channels) which will light up as soon as the mains switch at the back is pressed **on,** and it indicates that the **mains has entered the unit and the tube filaments are lighting up.**

(3) The **green B+** LED on the same center-line on the right of the S-BY/ON switch that **lights up** when the **(B+) high voltage** is connected to the audio circuits and the **unit is ready to operate.**

OPERATING CONTROLS FROM LEFT TO RIGHT AND THEIR FUNCTION

THE BOTTOM CHANNEL IS THE MIRROR IMAGE OF THE TOP CHANNEL

(1) INPUT: this control adjusts the amount of signal that enters the input stage of the unit and it is directly wired across the **unbalanced (jack) input which is also the output of the balanced to unbalanced converter** stage. The position of this control enables the unit to accept a high range of input signal levels.

The more you turn up the INPUT control the more harmonic and intermodulation distortion is generated by the input stage.

This control has **no** effect on the amount of signal that **enters** the **(XLR) balanced input converter** stage, but it adjusts the **level coming out of the XLR input converter**, and thus the signal that enters the DU input stage.

The **balanced to unbalanced converter does not amplify the signal, it has a gain of 0dB**

(2) TRI/CASC: this switch selects the input stage operating mode. In the up position is **triode (TRI)** in the down position is **cascode (CASC)** mode.

(3) **ATT:** an attenuation switch that when pressed down the signal level coming **out of the input stage is reduced by approximately 18 dBs.**

(4) **PFB:** is the Positive Feedback control that adjusts the amount of in-phase signal that can re-enter the input of the power stage and can be used to generate extreme distortion and/or oscillation.

(5) **PFB ON:** a switch that when pressed **down** the **PFB** effect comes **on**, when pressed **up is off.**

(6) **BIAS:** this control sets the amount of DC current that flows through the PCL86/14GW8 power tube section. The higher this control is set the higher this DC current is.

(7) **BY-PASS/IN:** a two way rotary switch with a pointed knob; when this knob points to **IN**, and to do that you must turn the switch clockwise the **XLR output socket is connected to the output of the unit so you get the DU processed sound.** As far as the **balanced XLR inputs and outputs are concerned this is a true BY-PASS** switch, but it **only** affects the balanced **(XLR) i**nput/outputs.

(8) **DRIVE:** it controls the signal level that enters the output power stage, and how **hard the output tube and transformer are being driven.**

(9) **OUTPUT:** it adjusts the amount of signal that comes out of the unit and it works in conjunction with the (15) **OUTPUT ATT** (output attenuator) rotary switch situated at the right end of the front panel.

(10) **LIM LED:** it is situated right **under the OUTPUT** control on the **top channel** and right **on top of the OUTPUT** control on the **bottom channel.**

This is the **output limiter LED** that lights up when the **output signal coming out of the unit** has reached its **maximum** level of **6.7VRMS ,18.8dBu** (approx.) and a hard clipping action takes place at the output to stop any further signal increase in order to protect the equipment that the unit is connected to.

(11) **LOAD ON/OFF:** a large toggle switch; **OFF LOAD** (switch set in the **UP** position) is an **extreme** harsh and shrill **distortion effect** when the output stage works in pentode **(PE)** mode, especially in the high distortion setting.

In triode and ultra-linear modes the effect is more subtle and not as strong.

(12) **TRI L/ H,PE L/H:** a 4 step rotary switch that selects the mode that the output stage operates.

From left to right:

step 1: **TRI L**= **TR**Iode **L**ow distortion, the signal level in **TRI/L is higher than in TRI/H mode.,**

step 2: **TRI H**=**TRI**ode **H**igh distortion, or to be more precise 'higher' distortion, because triode mode offers mild coloration (more than serious distortion) and the difference in tone between TRI L and TRI H is not huge anyway.

step 3: **PE L**= **PE**ntode **L**ow distortion

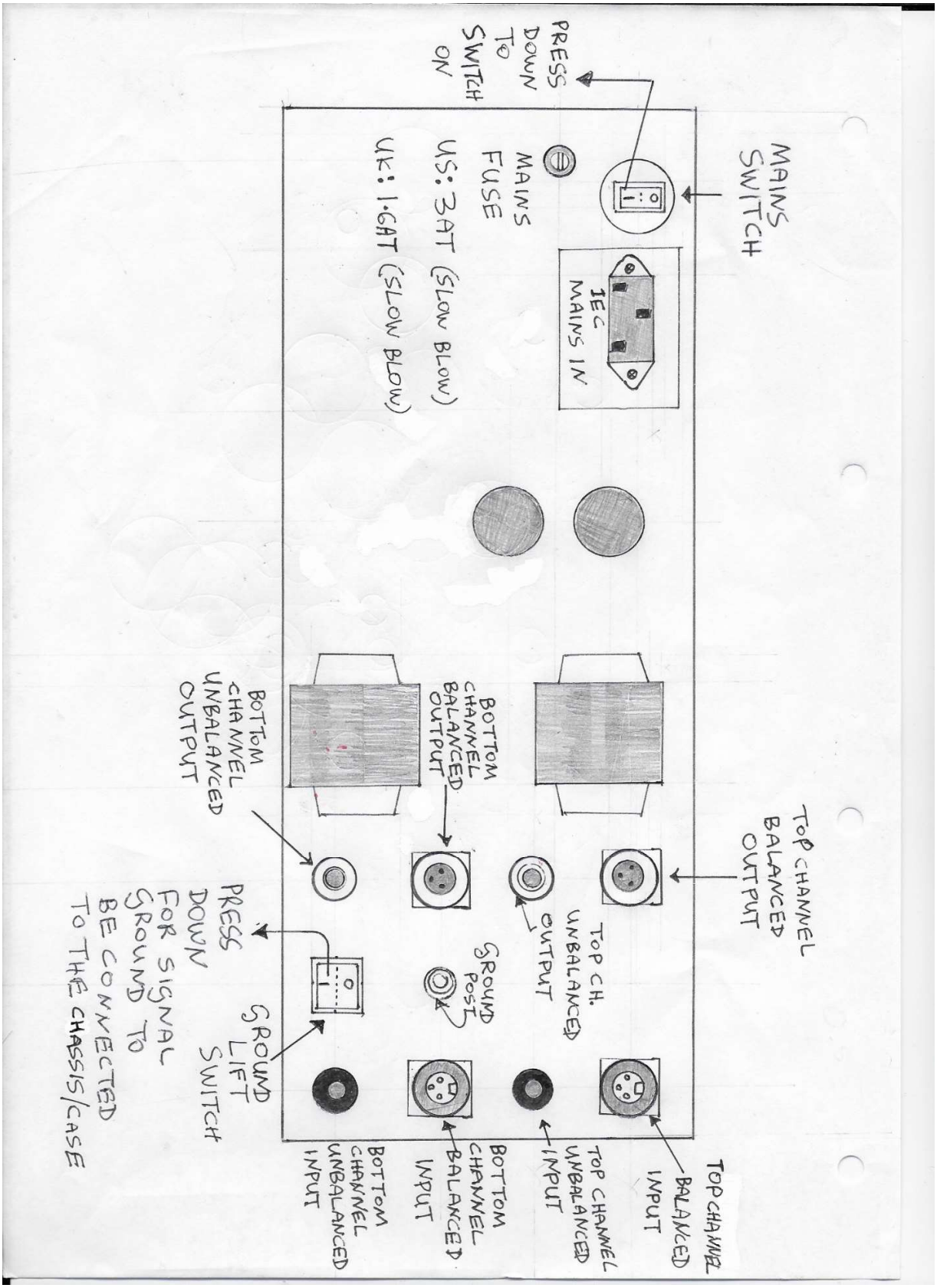
step 4: **PE H**= **PE**ntode **H**igh distortion, and this mode has been especially designed for **high distortion**, and the **signal level in PE/H is higher than in PE/L**

(13) UL: a large toggle switch that selects between triode and ultra-linear mode, situated on the left of the **MUTE** switch.

(14) PHASE: a miniature toggle switch, it reverses the phase of the output signal.

(15) OUTPUT ATT this is a four-step rotary attenuator switch to extend the range of the **OUTPUT (9)** control due to the fact that there can be a **considerable variation of signal level that the unit can generate.**

Assuming that when this control is set in the **fourth dot** clockwise the output attenuation is **odb** then in the third dot clockwise it is **-3dB**, the second -6dB, first **-12dB**


MAINS SWITCH
PRESS DOWN TO SWITCH ON
MAINS FUSE
US: 3AT (SLOW BLOW)
UK: 1·6AT (SLOW BLOW)
IEC MAINS IN
TOP CHANNEL BALANCED OUTPUT
TOP CH. UNBALANCED OUTPUT
BOTTOM CHANNEL BALANCED OUTPUT
BOTTOM CHANNEL UNBALANCED OUTPUT
GROUND POST
GROUND LIFT SWITCH
PRESS DOWN FOR SIGNAL GROUND TO BE CONNECTED TO THE CHASSIS/CASE
TOP CHANNEL BALANCED INPUT
TOP CHANNEL UNBALANCED INPUT
BOTTOM CHANNEL BALANCED INPUT
BOTTOM CHANNEL UNBALANCED INPUT

PREPARATION BEFORE SWITCHING ON

Remove the protective plate which is screwed in front of the frontplate. The 10mm wrench for the nuts is supplied but you will also need a flat screwdriver.

Carefully unscrew the top cover, make sure that all the tubes are firmly placed in their sockets. The best way to do that is by holding them **softly** from the **top tip** and giving them a **very gentle** push downwards to check that the pins are inserted all the way into the sockets. Also, if you **softly** hold the tubes from the **top tip** and **very gently** move them from side to side a slight play (approx. 1/8" in the tip area) is normal.

(1) PLACEMENT

***** The location of the distortion unit **(DU)** is important.

***** Its location/mounting must allow **adequate air circulation** from below, the sides and above it to disperse the heat that the tubes/semiconductors generate.

Avoid hot locations such as near **radiators** or other heating units.

IF THE UNIT IS MOUNTED ON A RACK:

(a) If mounted on a **rack** ensure that the unit below it **does not get hot.**

(b) Even if the unit **below** the DU runs **cool**, there must still be a distance of at least a **2U** (3 1/2) inches, 90mm) of empty air space between the DU and the unit **below.** If the unit below gets **warm** this gap must be increased by least **4U** (7 inches 18 ohm).

(c) Leave a **4U** distance of empty air space between the DU and the unit that is on **top** of it.

(d) both sides of the whole rack must be open to allow air passage.

(e) Also, if the unit is mounted on a **rack** it will need **extra support** from below due to its **weight.** A sturdy rack **shelf is** suitable the 1" feet will allow air to enter from below.

Keep the top **clear** of items such as papers or anything that could **block air passage** and cause **overheating.**

PLACE THE UNIT AWAY FROM SOURCES OF INTERFERENCE

(2) GROUND LIFT SWITCH

If this switch is used **incorrectly** the unit will become susceptible to **interference, noise and hum.**

Ensure that this switch which is situated in the rear panel is in the **on** position which is with the **(I) pressed down.** This is to ensure that the metal case is connected to the negative signal ground of the

unit's electronic circuits so that it (the metal case) works as a **shield against external interference** but also prevents **internal instability and oscillation.**

In most studios and especially if the balanced (XLR) inputs and outputs are used it may never be necessary to operate this ground switch, so there is a piece **of tape to keep it in the ON position at all times.**

If you need to operate this switch (see **notes on ground lifting & loops**) just pull the tape off.

It is important to remember that unless the case is shielded (connected to the signal ground) by other means if the GROUND LIFT SWITCH in is the off position the unit will be noisy.

(3) STAND-BY SWITCH

Ensure that the front panels stand-by switch **(S-BY)** is **off,** (the **up** position). This is because the high voltage must not be applied to the tubes and the circuits until the tubes have warmed up.

FIRST TIME SWITCHING ON

If you switch on for the **first time** and **until you get used to the unit:**

(1) Set all controls for **zero output** and the **switches** for a **low level output.**

(a) Turn all controls and **especially the OUTPUT (9)** control fully anticlockwise, press the input attenuation switch **ATT (3)** down (to reduce the drive to the output stage) and set the **TRI/CASC** switch**(2)** in triode (TRI,**up**).

(b) Set the positive feedback PFB switch **(5)** off **(up**).

(c) Set the **OFF/ON LOAD** switch **(11)** in the **ON LOAD** position (**down**).

(d) Set the triode/pentode **TRI/PE** switch **(12)** in triode **(TRI, L)**

(e) Set the **UL** switch **(13)** in triode **(TRI)** mode **(up)**.

(f) Set the phase switch **(14) up** for the output limit indicators **LIM LED'S (10)** to light up if the maximum output signal limit has been reached.

(2) Insert an **audio signal at the input and test one channel at a time**

Connect an audio signal to the input of the first channel to be tested. The input can accept a wide range of **line level** signal amplitudes, and offers ample gain adjustments.

However, for the following **first tests** I would recommend to use a source with an **average output of approximately 0.775Vrms/ 0dBu.**

***** The input of the unit can also accept old type domestic devices with an average line output level of **0.3162VRMS/-7.8dBu.** In this case the input gain settings must be higher than the ones I recommend in the following paragraphs.

However, If the signal at the input is below the **-7.8dBu** level, the unit may not to be able to distort as much.

***** For input signal levels **higher** than the **odBu** level the INPUT control **(1)** may need to be set lower for a clean sound.

(3) Connect the output of the unit to the **LINE input of a mixer, a monitor amplifier or any device that accepts studio line level signals.** The **input impedance** of this device must **not be less than 2K.** A simple monitor amplifier is the best choice for the first introductory tests.

(4) The output attenuation switch

If you are switching on for the first time, it is **well advised to introduce this extra output attenuation** by setting this switch **(15)** fully anticlockwise in the first dot, in both channels.

The price to pay when this attenuation is applied is that for some **clean low distortion settings the output volume may be low** but it is a price worth paying until you get to know how to control the output level of the unit and how to reduce this output when it is necessary. This will be the case for instance when you are overdriving the input stages or the output stages especially in **pentode (PE)** and **OFF LOAD** mode to create serious distortion.

The setting of this switch also depends on the sensitivity of the equipment that you drive and you may end up setting it in one position permanently once you get to know the unit.

(5) Inputs, outputs & BY-PASS rotary switch (6)

***** Do not use the XLR (balanced) and JACK (unbalanced) inputs simultaneously.

***** Do not use the XLR (balanced) and JACK (unbalanced) outputs simultaneously.

***** In the **BY-PASS** (top) position the **signal does not go through the unit at all, and the controls have no effect** so you will only get the original signal that you put in. This is because in the **BY-PASS** mode the **XLR output is directly connected to the XLR input.**

***** If you are using this switch please make sure that you **do not change any settings** while you are on **BY-PASS** mode because there is **big difference in output signal levels between different settings.**

* The BY-PASS switch **only works for the balanced (XLR) inputs and outputs.** If you happen to use the jack inputs or outputs or both and you set this switch on BY-PASS the **signal will disappear.**

*** Please make sure to set it in the (IN) position at all times when either (jack) unbalanced input or output or both are used per channel.**

***** Until you **familiarize** yourself with the unit and the **various different output signal levels please keep** this switch on the **(IN)** position to **avoid any errors.**

PRECAUTIONS

PLEASE DO NOT LEAVE THE UNIT SWITCHED ON WHEN NOT IN USE

(1) Each time:

(a) you increase the input gain settings

(b) change from triode to ultra linear or pentode,

(c) operate in OFF LOAD mode

(d) operate in positive feedback (PFB) mode

Ensure that you decrease the OUTPUT (9) or the stepped attenuator OUTPUT ATT (15) controls so that the output of the unit remains as constant as possible.

This is because when you overdrive the input or the output stages or you switch into a mode that produces more distortion, it is not just the shape of the signal (and thus the sound) that changes but also the **amplitude of this signal**.

For example the units output in **pentode** high distortion mode **(PE,H)** can **be four times higher (+12dB)** than at the output at triode high distortion mode (TRI, H).

If you operate in **OFF LOAD** and **PFB** simultaneously the output signal can reach **very high levels** indeed. The output of the unit is internally limited by an overload clipping circuit (see (3) below). However, a high enough signal such as a loud buzzing noise caused by a faulty input lead may damage an amp or speakers if the input gain levels as well as the **OUTPUT (9)** and **/or ATT (15)** controls are set too high.

It is therefore best to **start quietly** and gradually turn the levels up so that you can **keep control** of the units overall output level.

Careful use of the **OUTPUT** control (9) plus the **(15) OUTPUT ATT** (attenuator) rotary switch is very important and necessary.

For instance when you operate in pentode high distortion **(PE/H)** mode and you overdrive the output stage the output signal amplitude can reach very high values. You can set the **OUTPUT**

ATT (15) fully anticlockwise (first step) and use the **OUTPUT(9)** control to fine tune the level coming out of the unit.

However, if the output of the unit is not high enough you can first turn the **OUTPUT** (9) control down to zero then turn the **OUTPUT ATT** (15) switch one step clockwise (to attenuate less) and finally use the **OUTPUT** (9) control to re-adjust.

Always turn the OUTPUT (9) **control down to zero whenever you change anything and then gradually turn it up again.**

(2) If you are switching on for the **first time** and **until you get to know** the unit:

(a) Introduce extra output attenuation by setting the **OUTPUT ATT** (15) switch **fully anticlockwise** (in the first dot) in both channels. You can always set this control higher later if the output volume is low as you get to know the unit.

(b) Always turn the **OUTPUT (9)** control down to **zero** first and then turn it up to the required output level.

(3) Ensure that output overload **LED LIM** (10) is always off, as soon as it **lights up** that means that **the maximum output limit has been reached**.

For this LED to work the PHASE (14) switch must be set in the up position.

The restriction in the amplitude of the output signal is achieved by a clipping circuit. This clipping is **very hard**, it does not sound good so as soon as this LED lights up please **turn down the** (9) **OUTPUT control.**

(4) Always set the S-BY/ON switch on S-BY (up) before you use the TRI/PE (12) **and/or UL** (13) **switches and after you have used them press S-BY/ON down again (ON).**

This procedure is explained in the '**THE OPERATING GUIDELINES**' section.

BIAS CONTROL AND HOW IT AFFECTS DISTORTION AND CLIPPING IN THE OUTPUT STAGE

The output stage has a **bias** control that sets the amount of **DC** current that flows through the power tube and output transformer under idle (no signal) conditions. The **lower** this **bias** control is set the **higher** the **even harmonic distortion generated by the output stage will be.**

When the power (output) stage is driven hard:

(1) One part (say for instance the top half) of the waveform clips because *the output signal in the power tube is entering its* ***cut off*** *region and* this is called **cut off clipping.** This happens in all three triode**, ultra linear and pentode** modes of operation.

*** Cut off clipping is soft and builds up gradually.**

(2) The other part (say for instance the bottom half) of the waveform clips because of:

(a) In **triode** mode :
*An electrode at the **input** of this tube called the **grid** starts drawing **current*** and this is called **grid clipping.**

***Grid clipping** in most control settings starts **abruptly** and is **hard.**

(b) In **pentode** mode:

(i) the **same grid current effect** that occurs in triode mode

(ii) the output signal in the power tube is entering its **saturation region.**

By the way, saturation *clipping also takes place in triodes but not in the output amplifier circuit of this DU.*

***In most control settings in **pentode** mode **saturation** clipping is **gradual** and it **coincides** with **grid clipping** . As a result this creates a softer clipping in this part of the cycle despite the harshness of the grid current effect unless the tube operates in high bias currents where grid clipping takes place before saturation.

*** At certain settings in **pentode** mode you can create a **symmetrical** output waveform where both parts of the signal 's cycle clip **softly**

(3) In **ultra-linear** mode the tube behaves like in triode mode (as far as clipping is concerned) unless it operates in very low bias currents.

HOW TO USE THE BIAS CONTROL (6) IN TRIODE ULTRA-LINEAR AND PENTODE MODES

(1) When the power stage is **not driven hard**

(a) At **low BIAS** settings

(i) The power output tube generates the highest amount of even harmonic distortion in all three triode **(TRI)** ultra-linear **(UL)** and pentode **(PE)** modes

This type of distortion sounds ”warm" and musical and increases gradually at a rate proportional to the signal level.

The **least** amount of distortion is generated in **TRI,L** mode.

(ii) The output stage distorts more at frequencies below **100Hz** and especially around **30...40Hz** and this produces a **"crunchy" bass sound.**

This is due to the fact that the output transformer primary inductive reactance decreases and interacts more with the tube at low bias currents.

(b) At **high BIAS** settings

(i) In triode **(TRI)** and ultra-linear **(UL)** modes the power tube will generate **less** distortion even in the low frequencies.

(ii) Triode low distortion mode **(TRI, L)** when the **BIAS** (6) is set to **10** is the mode for the **cleanest sound** possible, **provided** the drive signal is kept low enough not to cause **grid clipping** (see **(c)** and **(d)** below).

(iii) In pentode mode the power tube produces not just even but also a fair amount of odd "rougher" harmonic distortion.

(2) When the power stage is driven **hard**

(a) At **low BIAS** settings:

(i) In Triode Low distortion mode (**TRI L** on the MODE switch) and when the **BIAS** (6) is set to **zero,** both grid clipping and cut off clipping occur at the same signal level, so that the output waveform **distorts symmetrically.** As soon as the **BIAS** (6) is set **above zero, hard grid clipping appears first** resulting in an **asymmetrically** distorted waveform.

(ii) In all other modes **TRI** (**H**) **UL and PE** (**H**=high or **L**=low distortion) soft **cut off clipping** takes place **first** also resulting in an **asymmetric** waveform, rich in **even** harmonic distortion.

(iii) In pentode mode for hard **grid clipping** to occur the signal must be increased even further, well after **cut off clipping** has taken place.

So at low **BIAS** settings and with careful use of the **DRIVE** (8) control (so that the signal entering the power tube does not get too high) it is possible to operate the DU **so that grid clipping does not occur.**

(v) There is more **interaction** between the **output transformer** and the **power tube** and that generates a very characteristic distortion in the **low** frequencies, in all modes of operation, but especially in **pentode (PE)** mode.

(b) At BIAS settings 3...7

(i) The waveform can be adjusted to take any shape in all modes except in triode low distortion **(TRI L).**

(ii) In pentode **(PE)** low **(L)** or high **(H)** distortion modes **grid clipping** often coincides with the tube entering its **saturation** region and it is nearly as **soft and gradual** as the **cut off clipping** in the opposite half of the cycle.

By experimenting with both the **BIAS** (6) and **DRIVE** (8) controls you can generate a **symmetrical waveform** that is clipped softly on both top and bottom half cycles.

In pentode high distortion mode **(PE,)H** with the **BIAS** (6) set to around **5** the waveform clips **symmetrically** and **softly** in both half cycles.

(iii) The **interaction** between the **output transformer and tube** is **not as high,** but the stage still generates **low frequency distortion** (but not as much as when the **BIAS 6** is set low) especially in **pentode high distortion mode (PE,H)**

(c) At maximum **BIAS (=10)**

(i) In **triode** and **ultra-linear** modes when the signal reaches a certain level **grid clipping** will occur **first** which sounds **harsh,** and that happens well **before cut off clipping.**

The transition from **a clean (TRI or UL)** sound to **grid clipping distortion** is very **abrupt,** as already mentioned in **(1).**

So to keep the **sound clean** you must set the **DRIVE (8)** control much **lower** and/or set the input stage attenuator **(ATT, 3)** switch in the **down** position . The unit's output under these conditions may be **low**, so the **OUTPUT control (9)** or the **OUTPUT ATT** switch**(15)** may have to be set **higher**.

(ii) In **pentode**, and especially in high distortion mode (switch **12** set at **PE,H**) *tube saturation and the grid current effect interact with one another* and as a result **grid clipping is not as hard as in triode and ultra-linear modes.**

(iii) **Low** frequency distortion is the highest in **pentode** high distortion mode **(PE,H).**

SWITCHING ON

***** Ensure that the **S-By** switch in the front panel is **off,** in the up position.*****

*****Connect the unit to the **mains.**

*****Switch on the unit by pressing (**down)** the mains switch at the **back,** located next to the **mains IEC input.**

*****The **red LED** on the far left of the front panel will light up.

*****Ensure that the **BY-PASS** switch **(7)** is in the **IN** (**clock-wise**) in both top and bottom channels*****

*****Ensure that the **OFF/ON LOAD switch (11)** is in the **ON LOAD (down)** position in **top** and **bottom** channels.

Also, in many applications the **PFB** mode will not be used, it is an extra feature for an **extreme kind of sound.**

*I would recommend **not to use the PFB mode at first** until you get to know the unit well enough, so* for the initial tests keep the **PFB switch (5) up (off).***

- After approximately 40 seconds press the S-BY (down, ON) to operate. The green B+ LED on the left of the front panel will light up.
- Ensure that the **PHASE** switch **(14)** is in the **up** for the output limit indicators **LIM LED'S (10)** to light up if the maximum output signal limit has been reached**. ***

***** See notes about **FIRST TIME SWITCHING ON (1 a...f)**

TESTING THE UNIT AND OPERATING GUIDELINES

- **Test one channel at a time**, go through all the tests on the top channel and then do the same tests on the bottom one.

- Start with single low frequency signals, then mid to high frequency signals, then drum loops and beats and finally complex signals made out of different frequencies.

- For the first tests use the DU in **clean mode** (low tube distortion amplifier) and **gradually move into higher distortion modes** of operation. To do this you must set the **DRIVE** (8) and perhaps **INPUT**(1) controls low to drive the DU softly and to avoid clipping. How high the INPUT (1) control must be set depends on the amplitude of the input signal.

(1) With an input signal of approximately **odBu (0.775V rms)** and for a clean sound set:

Input control, **INPUT** (1) **= 7**

Switch, **TRI/CASC** (2) **= TRI (up)**

Switch, **ATT** (3) **= ON (down)**

DRIVE(8) **=5**

OUTPUT ATT (15) **= fourth dot clockwise**

(2) For as little distortion as possible, or just mild coloration, you must:

(a) operate in **triode low distortion** mode with rotary switch (12) set in **TRI L.**

(b) The **higher the BIAS** (6) control is set the **lower** the distortion will be **until grid clipping occurs** which contains a large amount of high order harmonics and sounds very harsh. The **transition** from clean sound to grid clipping distortion is **very abrupt.** Therefore, to keep this clean 'tone' coloration, be aware of this grid current effect, and turn the **DRIVE** (8) control **down as soon as it appears.**

If you want to reduce the grid current distortion in the output stage, **reduce** the bias setting by a **small amount** and/or change to **TRI H (=triode higher distortion, mode switch** 12) to avoid grid clipping at the expense of a slight increase of even harmonic distortion.

Please **disconnect the high voltage (B+) from the unit before you operate TRI/PE mode switch,** see further down in this section.

For the first time set the **BIAS** (6) **to 8 and then try different settings.**

(3) By gradually turning up the **OUTPUT** (9) control you should be able to hear the signal from the speakers.

(4) Try **cascode** operation:

(a) Set the **INPUT** (1) control to **zero first**

(b) Set the **TRI/CASC** (2) switch in **CASC (down** position). To avoid any clicking noises while you operate (2) you can press the **MUTE** switch.

(c) Turn up the **INPUT** (1) control **again**. You will have to set it in **a lower position** now because in **cascode mode the input stage produces more gain as well as distortion**.

(d) If you wish to generate **more input stage distortion in cascode** mode keep on turning up the

INPUT (1) control while simultaneously turning down the **DRIVE** (8) control in order to maintain : (i) a constant signal drive to the output stage so that its distortion levels do not change (ii) a constant output level.

An important point to emphasize (as it has already been mentioned) is that when the input stage works **in cascode mode it also produces more gain (it amplifies more)** so the signal level increases by approximately by **6dBs.**

CASCODE versus TRIODE

In the up position which is **triode (TRI)** mode and at low **INPUT** (1) control settings, the input stage will produce a relatively clean sound but with "musical" low order (mainly second) even harmonic distortion the amount being directly proportional to the signal level set by the INPUT (1) control.

In the down position, i.e. **the cascode (CASC) mode**, the input stage will produce **more distortion,** of the **odd harmonic** type as well as even (harmonic distortion), the amount of which depends again on how high you set the INPUT (1) control.

Subjectively speaking this will result into a **"dirtier and harsher sound"** for signals that are made from **two or more different frequencies** due the higher amount of **intermodulation distortion** (for signals that are made out of two or more **different frequencies**).

In single frequency signals the difference in distortion between triode and cascode is a lot more subtle.

On very **low** INPUT(1) control settings (for less intermodulation distortion), **mild sound coloration** is also possible in cascode mode if a fair amount of third harmonic distortion (on top of the second) is preferred.

(5) Overdriving the output stage :

(a) **Set DRIVE** (8) and **OUTPUT** (9) controls to zero first

(b) Set the output attenuation switch **ATT (15)** to its lowest position, the first dot.

(c) Switch back to triode in the input stage by setting switch (2) in the **TRI** position **(up)**

(d) Set the **INPUT** (1) control to **5** and remove the input stage attenuation by setting the **ATT** (3) switch in the **up** position.

(e) For a **symmetrical** over-driven output signal **in triode low distortion** mode (switch **12** still set in **TRI L**, switch **13** still set in **TRI, up**) set the **BIAS** control (6) to **zero**.

(f) Re-set the **OUTPUT** (9) to **5** and gradually turn up **the DRIVE** (8) all the way up from **0 to 10** to hear the over-driven signal. If the output is too high turn the **OUTPUT** (9) down control a bit, if it is low move the **ATT** (3) one dot clockwise.

(e) Turn down the **DRIVE** (8) control to a lower setting (perhaps **3**) just before the output stages distortion is about to start and start turning up the **BIAS** (6) control to hear the **grid clipping distortion.** You will notice that the higher (6) is set the higher this distortion is.

TRY OUTPUT STAGE OPERATING MODES TRI H and PE (L&H),

BUT FIRST

To avoid premature tube failure please make sure that before you use the TRI/PE (12) switch:

- **Disconnect the high voltage (B+) from the unit by setting the S-BY switch in the UP position (labelled as S-BY on the front plate).**
- **Use the TRI/PE mode switch (12) to choose between triode or pentode, low or high distortion (L or H).**
- **Reconnect the high voltage by setting the S-BY switch ON (down position).**

You can use the momentary **RED MUTE** switch if you wish to silence the clicking sounds generated which is situated under the mode switch at the top channel and on top of it (the mode switch) at the bottom channel.

(6) Switch on to triode higher distortion (**TRI H,** mode switch **12**) using the procedure above

(a) For clean sound set the controls at the same levels as in **(1)**

(b) Try different **BIAS** control settings.

(c) Set **DRIVE (8)** control to zero (momentarily) and the output attenuation switch **ATT (15)** to its lowest position (max, attenuation) which is the first dot clockwise. Set the **BIAS (6)** control to zero, the **ATT** switch **(3)** in the up position and turn up the **DRIVE (8)** control to **overdrive** the output stage.

Cut off clipping which is **softer** takes place first at such **low bias** current and the output waveform is very asymmetric rich in even harmonic distortion.

(d) Try different **BIAS (6)** control settings, at around **5** the waveform clips symmetrically and at settings **higher than 5 harder grid clipping occurs first.**

(e) Repeat **(a),(b) (c) &(d)** using a **single low frequency** signal to generate **bass distortion** first and then try signals made out of a combination of **different frequencies** to generate **intermodulation distortion.**

THE INPUT ATTENUATION SWITCH **ATT (3)** IN RELATION TO THE **DRIVE (8)** CONTROL

The input attenuation switch **ATT (3)** can be used in conjunction with the **DRIVE (8)** control to **blend** the **distortions/colourations** generated by both **input** and power **output** stages without seriously overdriving the power stage, especially if the input stage is set in **cascode** mode.

Use the **DRIVE (8) control together** with the **ATT (3)** switch to enable a finer adjustment when:

***** The input stage is already over-driven (say in cascode mode which also produces more gain)

***** When trying to avoid **hard grid clipping** whilst using the **BIAS (6)** control.

(7) Cascode mode (input stage)

Set the input attenuation switch **(3)** in **ATT (down)** and switch the input stage into **cascode** mode using the procedure outlined in (4) so that the output stage is not over-driven

(8) Set the **input** stage back into **triode (TRI)** mode (**TRI/CASC** switch 2 up) and switch the **output** stage into **pentode** low distortion mode (**PE L**, mode switch **12**).

BUT FIRST

In order to avoid premature tube failure please make sure that before you use the TRI/PE (12) switch :

- **Disconnect the high voltage (B+) from the unit by setting the S-BY switch in the UP position (labelled as S-BY on the front plate).**
- **Use the TRI/PE mode switch (12) to choose between triode or pentode, low or high distortion (L or H).**
- **Reconnect the high voltage by setting the S-BY switch ON (down position).**

You can use the momentary RED MUTE switch if you wish to silence the clicking sounds generated which is situated under the mode switch at the top channel and on top of it (the mode switch) at the bottom channel.

Also, the output level will always be higher in pentode mode so always turn the OUTPUT (9) control down a bit when you switch from triode (TRI) to pentode (PE).

Alternatively, you can use the **OUTPUT ATT (15)** switch by turning it one dot anticlockwise.

(a) For a **relatively clean sound** (operation in pentode generates more distortion than triode mode) set the controls at the same levels as in **(1)** and the **BIAS (6)** control to **10,** but try different settings too.

(**b)** Set the **BIAS (6)** control to **8** for **symmetrical clipping, and temporarily turn OUTPUT (9)** control to **zero**

(c) Set the the **ATT** switch **(3)** in the up position and turn up the **DRIVE (8)** control to overdrive the output stage.

Ensure that the **output level remains constant** by using the **OUTPUT (9)** and/or the **OUTPUT ATT (15)** switch.

As it already been mentioned:

*****One part (say for instance the top half) of the waveform clips softly *and* this is called **cut off clipping.** This happens in **triode, ultra linear and pentode** modes of operation.

***** In **pentode** mode however and in most settings the other part (bottom half) of the waveform clips because of **saturation** and **grid current** effect combined.

*** Saturation** clipping is **soft** and it dominates in pentode mode so that **both** parts of the signals **cycle clip softly** unless the tube operates in high bias currents

(d) Try **different BIAS (6)** settings to create various different waveform shapes.

(e) Repeat **(a),(b) (c) &(d)** using a **single low frequency** signal to generate **bass distortion** first and then try signals made out of a combination of **different frequencies** to generate **intermodulation distortion.**

(9) Test the input stage in **cascode** mode combined with output stage in **Pentode** mode; remember in cascode mode the input stage produces more **gain,** so use the same procedure as in **(8)** pentode low distortion mode

(10) Pentode high distortion mode (**PE**, mode switch **12**)

***** Set the input stage back into triode mode: **TRI/CASC (2)** switch in **TRI (up)**

***** This mode not only generates **high distortion**, it also produces a **high signal level** at the **output** of the unit. Until you are familiar with the unit, turn the **OUTPUT (9)** control down to zero and set the **OUTPUT ATT (15)** switch fully anticlockwise (**first dot**).

***** Set mode switch **12** to **PE H**

BUT FIRST

In order to avoid premature tube failure please make sure that before you use the TRI/PE (12) switch :

- **Disconnect the high voltage (B+) from the unit by setting the S-BY switch in the UP position (labelled as S-BY on the front plate).**
- **Use the TRI/PE mode switch (12) to choose between triode or pentode, low or high distortion (L or H).**
- **Reconnect the high voltage by setting the S-BY switch ON (down position).**

You can use the momentary **RED MUTE** switch if you wish to silence the clicking sounds generated which is situated under the mode switch at the top channel and on top of it (the mode switch) at the bottom channel.

(a) For a **relatively clean sound** (operation in pentode **PE H** generates high distortion levels) set:

Input control, **INPUT (1) = 7**

Switch, **ATT (3) = ON (down)**

DRIVE(8) = 3

BIAS (6) = 7

(b) Gradually turn up the **OUTPUT (9)** at a setting that the unit produces the same level of output as in the previous tests.

(c) Try different **BIAS (6)** control settings, in **PE H** mode there is considerable difference in sound at different bias levels even if the distortion is low.

(d) Turn up the **DRIVE (8)** control to overdrive the output stage, Ensure that the **output level remains constant** by using the **OUTPUT (9)** and/or the **OUTPUT ATT (15)** switch.

(e) Try different **BIAS (6)** control settings, in **PE H** mode the shape of the output wave form varies considerably at different bias settings

(f) Repeat **(a),(b),(c),(d)&(e)** using a **single low frequency** signal to generate **bass distortion** first and then try signals made out of a combination of **different frequencies** to generate **intermodulation distortion.**

(g) For **extreme overdrive,** it works better with single frequency signals:

(i) Temporarily turn **OUTPUT (9)** control to **zero** and set the the **ATT** switch **(3)** in the up position

(ii) Turn up the **DRIVE (8)** control to overdrive the output stage.

(iii) Ensure that the **output level remains constant** by using the **OUTPUT (9)** and/or the **OUTPUT ATT (15)** switch.

(11) Ultra-Linear (UL) mode

To operate in **UL** mode you must first set the rotary mode select switch (12) to triode **(TRI L or H)** and then press the **UL** (13) switch in the **down** position.

BUT FIRST

***In order to avoid premature tube failure please make sure that before you use rotary mode (12) and/or (13) toggle switches:**

- **Disconnect the high voltage (B+) from the unit by setting the S-BY switch in the UP position (labelled as S-BY on the front plate).**
- **If the TRI/PE mode switch (12) is set in PE (L or H) mode set it into triode low or high distortion (L or H) mode.**
- **Use the UL (13) switch to choose between triode or ultralinear, UL is in the down position.**

Reconnect the high voltage by setting the S-BY switch ON (down position)

* You can use the momentary **RED MUTE** switch if you wish to silence the clicking sounds generated.

Note that the output level will always be higher in ultra-linear mode so always turn the OUTPUT (9) control down a bit when you switch from triode (TRI) to ultra-linear (UL).

The **UL** (13) switch works in conjunction with the **TRI/PE rotary switch** (12) **and it only works when TRI/PE switch is set on TRI (L or H). It has no effect in pentode mode (PE,L/H)**

***when the **UL** (13) switch is pressed **down** and the **TRI/PE** (12) switch is on **L**= **UL** mode **L**ow distortion

***when the **UL** (13) switch is pressed **down** and the **TRI/PE** (12) switch is on **H**=**UL** mode **H**igher distortion

(a) You can repeat the same procedures and tests as the ones discussed in sections (1)...(7) for triode mode operation.

(b) The differences in sound between ultra-linear **(UL)** and triode **TRI** or **UL** high and low distortion **(L** or **H)** are subtle.

(c) If you set the unit for clean sound, the way in which cut off clipping and grid clipping occur is very similar to triode mode and (again) it depends on where you set the **BIAS** (6) control.

(d) In the mid and high frequencies, the difference in tone between **triode and ultra-linear is subtle.** However, in **low frequencies** (below 80Hz and especially around 30...40 Hz) the output stage generates **more distortion in UL mode than in triode.** This distortion sets up gradually in these low frequencies, and increases as the frequencies get lower, similar to pentode low distortion mode **(PE, L/H)**.

(12) The **OFF LOAD** mode (**switch 11**)

This mode not only generates the **highest amount of distortion,** it also produces the **highest signal level** at the **output** of the unit.

Until you are familiar with the unit before you start experimenting in **OFF LOAD,** turn the **OUTPUT** (9) control down to zero and set the **OUTPUT ATT** (15) switch fully anticlockwise **(first dot)**

Also, for the first tests it easier to use single low to low mid frequency signals.

(a) Set the **DRIVE** (8) control to **zero** (**momentarily**), the input attenuation switch **ATT** (3) in the **up** position (no input attenuation) and set the **INPUT** (1) control to **7**.

(b) The **BIAS** (6) control must be set **as low as possible, preferably to zero** when you operate in **OFF LOAD** mode until you get used to it. The effect also works at high **BIAS** (6) settings, but the signal tends to **disappear (in PE** mode) unless the **DRIVE** (8) control is turned up **really high**, so it takes a bit of practice to get it right.

(c) Set the mode switch (12) to pentode low distortion **(PE,L)** first following the same procedure as in **(8) pentode low** distortion mode.

(d) Set the **ON/OFF LOAD** (11) switch in the **up** position.

(e) Set the **OUTPUT**(9) control to **3** (approx.) and gradually turn up the **DRIVE** (8) control. If you need to reduce the effect you can also set the **INPUT** (1) control to a lower setting.

(13) The Positive Feed-Back (PFB) mode (switch 5, control 4)

The first thing to do in order to understand the **PFB** function is to test it in **self oscillating** mode so:

(a) Turn the **INPUT** (1) control down to zero to "**kill**" the input signal **momentarily**.

(b) Momentarily again, turn the **OUTPUT** (9) control down to **zero**, press the input attenuation switch **ATT** (3) **down** (for input attenuation), set the **BIAS** (6) to **8**, the **DRIVE** (8) to **5,** the **OFF/ON LOAD** (11) switch to **ON LOAD (down),** the mode (12) switch to **PE L** (using the **S-BY on/off** procedure) and the **OUTPUT ATT** (15) to minimum **(first dot).**

(c) Ensure that the **PFB** (4) control is set to zero and then press down **(on)** the **PFB** (5) **ON/OFF** switch.

(d) Turn up the **OUTPUT** (9) to a low setting **(1...3)** and gradually turn up the **PFB** (4) control until the DU starts **oscillating,** it will start oscillating in high **PFB** settings **7...10.**

If you turn the **DRIVE** (8) down (to a lower setting) the oscillation will start at lowers **PFB** (4) settings

(d) Now turn the **PFB** (4) down to zero (**momentarily**), re-set the **INPUT** (1) control to **7** and repeat **(d)** to **mix** the **oscillation** with the **input** signal.

(e) If you now vary the **DRIVE** (8) control while the **PFB** (4) is set to **7...8** you will be able to mix the two signals, and using the **PFB**(5) switch you can switch the effect **on** and **off.**

The **PFB** (4) control is a **logarithmic potentiometer** so that at low settings **(0...4)** makes it possible to increase the in-phase signal **gradually.**

The way to use this control is to turn it up until oscillation starts and then back it off a bit.

The **PFB** mode is very unpredictable and it does **not depend on the PFB control setting alone.** For instance, when the output stage is operating in triode mode the **PFB** (4) control must be set higher to trigger oscillation than when the output stage is operating in pentode mode.

Also, the **PFB trigger level** plus the amount of the **PFB effect** is just as much affected by the setting of the **DRIVE** (8) **control** as it is affected by the **PFB** (4) control.

In triode and UL mode in most situations for the **PFB** to be triggered the **DRIVE** (8) control must be turned to a **lower setting than 5**.

(14) You can now combine all the different modes of operation of the unit.

An interesting effect to investigate is how the **PFB** (4)**, BIAS** (6) **DRIVE** (8) controls interact in both **OFF** and **ON LOAD** modes (switch **11**).

TECHNICAL NOTES

SAFETY

The **chassis** and **metal case** of every electrical appliance must always be securely and permanently **connected to the mains ground.**

This is the **middle pin of the IEC** mains input socket, and the connection between the chassis/metal case and mains ground is the **safety earth bond.**

This bond (connection) provides a very low resistance path to earth, so that if a live wire comes into contact with the exposed metal work the resulting live to earth current will **blow the mains fuse and avoid an accident.**

THE SAFETY EARTH BOND MUST NEVER BE BROKEN TO AVOID DANGER OF ELECTROCUTION

Always use a three conductor IEC mains cord and make sure that it is in perfectly good condition.
Also ensure that the mains outlet ground connection (in the room/studio where this cord is plugged) is regularly checked by a qualified electrician.

GROUND LOOPS

If two or more units are connected through unbalanced audio leads and these units are safety earthed, **ground loops** will be developed **between** the electrical safety grounds (**earth bonds**) and the signal grounds of the **interconnecting cables.**
This is because part of the signal (the signal ground) takes two routes:

a) Through the audio leads
b) Through the negative power supply lines (since it is connected to them) the metal chassis & case of each unit or its power supply, safety ground connection (earth bond) and eventually mains earth wiring.
This could result in **hum that sounds more like buzzing**, especially if some units are powered from different sockets far apart, and at least one unit contains a noisy power supply.

GROUND LIFTING

If this problem occurs, it is possible to brake the loop by **disconnecting the units case from the signal ground**.

First turn the units **output level control to zero,** remove the tape and press the **ground lift switch** in the opposite direction. Then you can **gradually turn up the output level control to test if the hum has gone.**

It is very important to turn the output control to zero first, because the are many reasons why hum appears when two units are connected to one another, badly shielded interconnecting cables to name one. If a ground loop is not the reason of the hum **operating the ground lift switch for the wrong reasons could increase the hum/noise to a much higher level.**

If a ground loop is the reason, then **ground lifting can eliminate** (or at least reduce) the **hum**.

*If **both units** are **safety earthed** and only **one** has the **signal ground connected to its chassis/case** the other one is still shielded for noise. This is because **both cases are still connected to the signal ground through the mains safety ground wiring.***

The situation becomes more complicated of course if more than two units are connected together because more than one ground loop may exist, and as I already mentioned there may be other reasons for the hum too.

One way to **eliminate hum** is to use the **balanced input and outputs,** *because no part of the signal is going through any ground connection outside the unit. That means that the various unit metal cases are not connected together through the interconnected cables.*

BALANCED AND UNBALANCED LINES

A **balanced line** is made out of two wires, one wire caries a signal which is out of phase with respect to the signal in the other wire, so you need both wires to get the full signal, thus **both wires are live. The ground is not part of the signal and this results in eliminating ground loops, a great advantage.**

Also, because the input of the equipment that these two wires are going to only accepts out of phase signals, it **rejects *in-phase signals like* noise, hum and interference.** *This is because the input of the receiving device is only sensitive to the signal difference between the two wires and not to something that is added to both wires in equal amounts during propagation.*

An **unbalanced line** consists of only one live wire electrically referenced to ground and the **ground is also part of the signal.** This can create **ground loops** and since only one wire is carrying the signal (with respect to ground) the input of the receiving device **does not reject noise/interference.**

Now one thing worth mentioning here is that hum/noise and interference picked up from the surroundings is not an issue at the output *because the output impedance of the unit is low and the signal is relatively high. It can only be a problem at the input because the impedance is higher*

TUBE ISSUES

NOISE, MICROPHONY & AGE

Tube **noise** often manifests itself as **excessive hiss and intermittent crackling noises a condition that gets worse with time,** but this type of noise (unlike microphony) is **not** caused by vibration. Excessive hiss is often caused by emission loss due to **age.**

Microphony is a noise that manifests itself as:

(a) the equipment makes noises when it is **moved** around, sometimes these noises can be loud.

(b) Ringing and whistling noises similar to mic/PA audio feedback which may start or stop at random.

A tube is a mechanical device and its various ***component parts*** *are welded to one another and can become* ***loose*** *with time.*

Ringing *is due to mechanical resonance.*

Often in very noisy tubes you get a combination of these noises like for instance a **gradual build-up of** rumble which may develop into a **loud crackling** sound which may stop or get worse if the equipment moves or receives a gentle knock.

All tubes generate noises, some do it more than others and **tubes** become **noisy with age.**

Some tubes however are noisy even if they are **new. N**ew **O**ld **S**tock **(NOS) tubes** can be **microphonic even** though **perfect in all other aspects.**

Age makes minor noise problems worse, and **thermal cycling** (the equipment is switched on and off) can deteriorate the adhesion of the mechanical elements. However, you must never **leave the equipment on when not in use because a lot more damage can be done this way and it is not safe when you leave it on for long periods of time and you are not around.**

MICROPHONY TEST

Please keep the volume low and then turn it up gradually when you perform this test:

Tap the suspected tube very gently and listen for noises. A slight knocking is to be expected but a loud bang/crackle is not acceptable. Also, if the tube starts 'ringing' when it is taped, or it was 'ringing' before and after taping it temporarily stopped- it is microphonic.

Pre-amp tubes such as the 12AX7, have been designed and manufactured for low noise/microphony operation. At the factory the ones branded for 'low noise' are specifically selected through testing after the manufacturing process. Some factories for instance may select 100 out of a batch of 1000

after 'burning in' and testing, and a further selection of 10...20 out of the 100 batch may then be chosen as very low noise types.

I always buy low noise tubes and then through testing here in the workshop I further select 1...2 out of 5 for extra low noise operation to use in noise sensitive circuits.

The nearer a tube is to the input of a pre-amp/processor, the louder its noise will be. In an output stage even a noisy tube may appear to be quiet.

If the first tube of the input stage is noisy, its noise will be amplified by the rest of the system. If this tube is also in an input stage that accepts very low level signals (like for instance the output of a microphone) the noise level will be higher. If a tube of the same type that happens to be less noisy exists somewhere else in the unit, further away from the input in the signal chain, and it is swapped with the first one, the noise may be substantially reduced.

The **first tube** in the **DU** is the **small signal triode** section of the **PCL86/14GW8** triode/pentode tube which is electrically the same as a **12AX7.** Now, because the unit is designed to accept studio line level signals (0dBu, 0.775Vrms) if it becomes noisy its **noise will be low** in low DRIVE (8) level settings and especially if the input attenuation is on with **ATT (3) switch down in the ATT** position. If the noise increases when the attenuation is off (ATT switch **up**), then the triode section of this tube has become noisy.

The 12AX7 (part of the 14GW8) generated noise will disappear as soon as you set the DRIVE (8) control to zero, if it does not that means that the problem lies in the **pentode** section of the **14GW8**.

When you operate the input stage in **cascode** the **smaller** twin **12AX7** triode tube which is **shared between both channels**, so it will affect them both, but **only in cascode** mode if it becomes noisy.

EMISSION LOSS

As a tube **ages, it gradually loses its ability to produce the same level of audio signal that it was capable of in the beginning of its working life.** *This is due to gradual fall in transconductance (***gm***), a parameter that quantifies the ability of the cathode to emit electrons.* In simple terms *the emissive material coating on the cathode erodes with age, fewer electrons are emitted and* the **signal level drops.**

There are other reasons for a drop in gm due to age such as air leakage, and/or electrical leakage between components inside the tube.

Emission loss (due to ageing or whatever reason) can cause a tube to generate more and more **hiss with time**, which may appear intermittent at first but then it becomes continuous.

Noise, microphony and leakage problems, can sometimes (but rarely) exist in new tubes especially if they are bought from places where they are not 'burned in' and tested properly.

Another problem which may not necessarily be due to age, but it is a fault that usually appears with age is **crackling noises which can either be continuous or intermittent without any vibration.** *This is due to the irregular arrival of electrons at the plate of a tube.*

IONIZATION

Ionization is a serious problem *as well as* ***gas currents and electrical leakage between different tube elements*** *which cause it.* These problems can develop with age but can also happen to new tubes especially if they operate **too close to their maximum ratings.** They are not common in pre-amp tubes but they occur in power tubes and can **damage other circuit components too,** because ionization can cause **internal** and **external arching plus high current surges.**

Ionization can occur in medium power tubes like the PCL86/14GW8 in the OUTPUT STAGE, if such medium power amplifier circuit is not designed and built with safe and reliable operation in mind. To avoid premature failure of any kind when I design and build any circuit I make sure that all tubes are operating conservatively well **below their maximum ratings.**

As I already mentioned **newly bought tubes can occasionally be faulty too or become faulty after a few hours of operation** if they are not 'burned in' and tested correctly. **Such tubes can damage other components inside the main and/or the power supply unit.**

New tubes can also **be damaged during transport if they are not packed properly.**

Please buy tubes from reputable sources. I keep spare new tubes for all units I have designed and built, they have been fully tested in my workshop.

For best reliability and longevity, the unit must:

1) Only be switched on when it is being used.

2) Switch on the power supply first, wait 40 seconds then press the stand-by switch (S-BY) to operate.

3) Always go to stand-by (OFF, that is UP) each time you use triode/pentode (12) and triode /ultra linear (13) switches and vice versa and then press the S-BY switch down again to operate.

4) Allow plenty of ventilation around the unit.

HOW OFTEN AND WHEN IS IT NECESSARY TO REPLACE TUBES

There is no definite rule or answer. It I depends on how often, how many hours per day the equipment is being used, the tube itself and what it does.

The two **PCL86/14GW8 output tubes must be replaced more often** due to their higher power dissipation.

As a rough guide :

If you operate the unit say for instance 5 hours a day for a whole year, the PCL86/14GW8s may need replacing every 12...18 months whilst the rest every 2...3 years, unless they become noisy.

FUSES

Fuse choice is based on estimates and some of the fuses in the power supply unit have slightly low ratings on purpose to ensure that they blow if something goes wrong and protect the circuits that they are connected to.

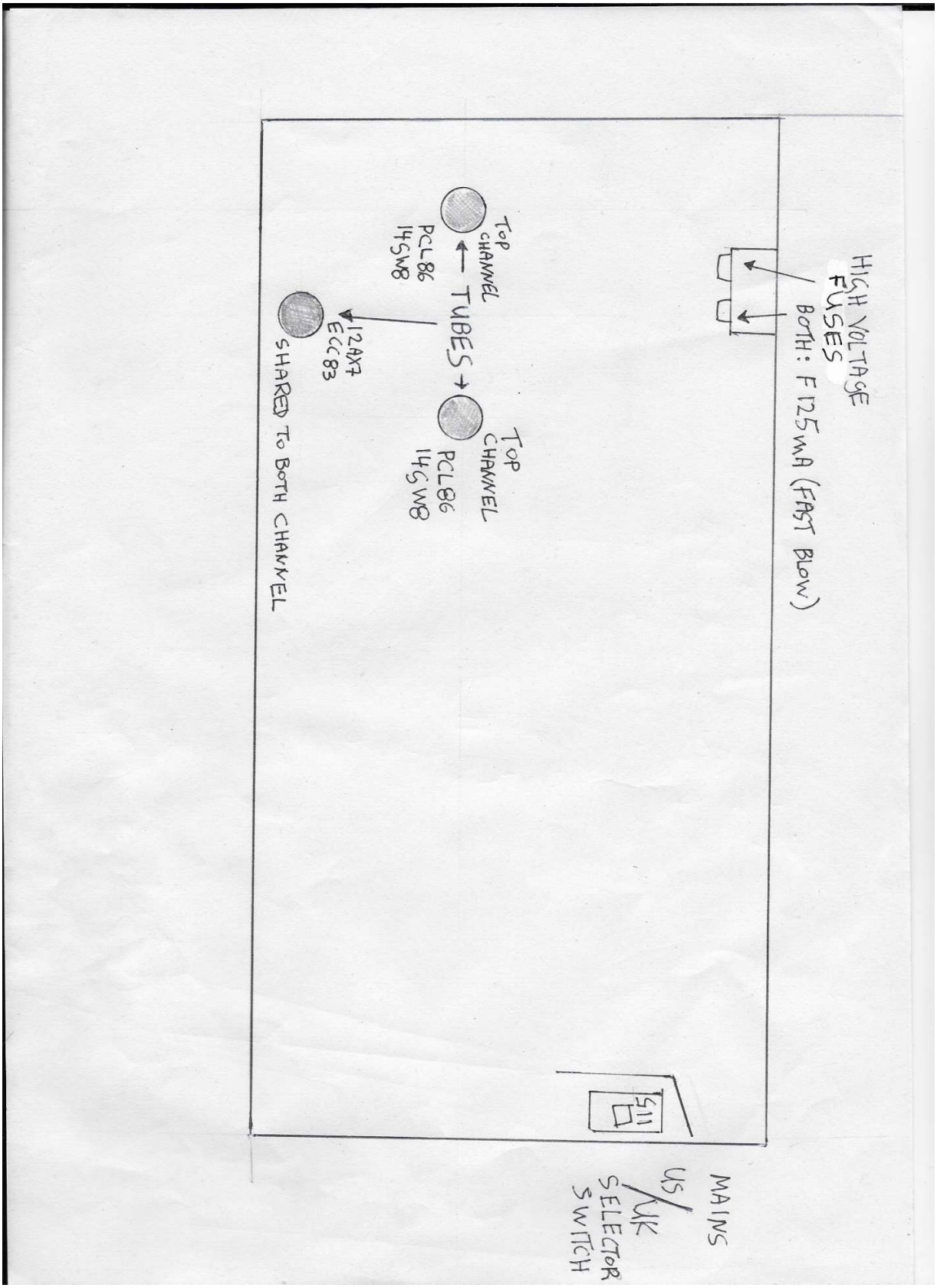
Occasionally, a fuse may fail like any other component (it is a thin piece of wire after all) in which case it must be replaced with the same type and value. A fuse that is faulty must not be colored black, if it is then the fuse is blown, in which case the reason why it is blown must be investigated before it is replaced in order to avoid further damage.

Every fuse inside the unit has an LED in its vicinity which is lit during operation to indicate that the fuse is not blown/failed. If an LED is off and you want to replace its fuse please:

(1) Unplug the power supply from the mains

(2) Wait approx. two minutes for the power supply capacitors to be discharged

(3) Carefully replace the fuse.


HIGH VOLTAGE FUSES
BOTH: F 125mA (FAST Blow)
TOP CHANNEL
PCL86 145W8
TUBES
TOP CHANNEL
PCL86 145W8
12AX7 ECC83
SHARED TO BOTH CHANNEL
MAINS
US/UK SELECTOR SWITCH