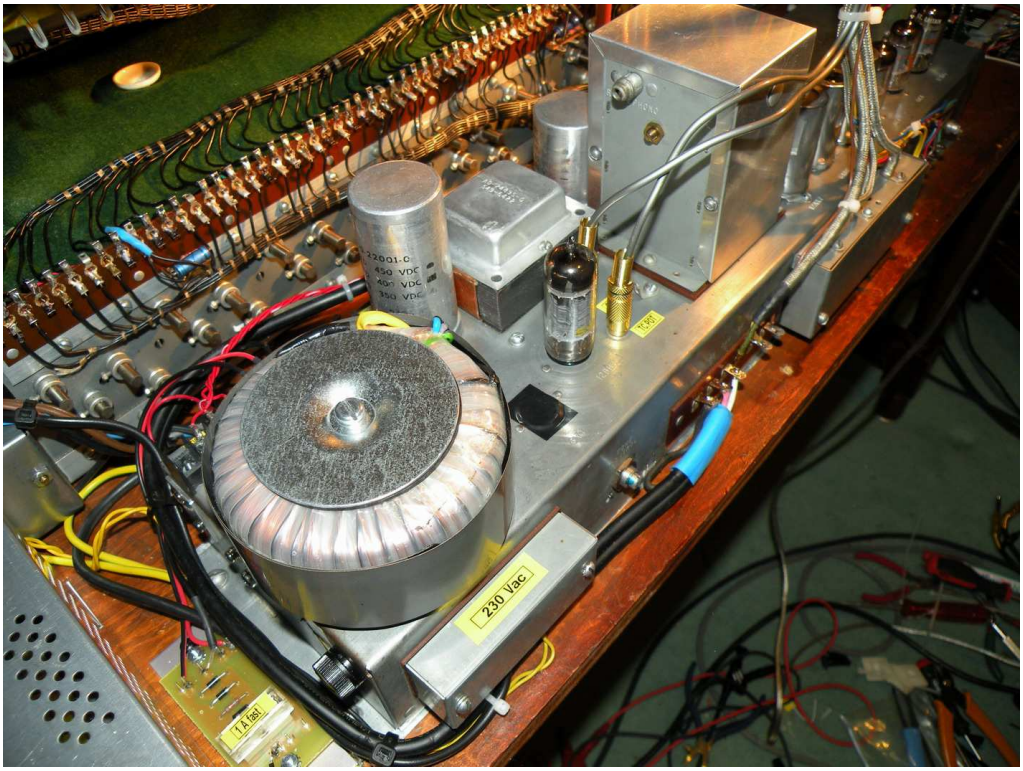
Hammond® B3/C3

HUM & NOISE Reduction

by Dan.Vigin



Binche / Belgium **Oct. 2013**

Hammond B3/C3 - Hum & Noise Reduction.

Purpose of this project.

' Purist or not purist ' , that's the question !

Since the sixties, I had the opportunity to play, restore and repair many Hammond B3 or C3 organs and despite the legendary sound of those instruments that were designed in the fifties or before and with today's technology, there are room for improvements notably at residual Hum & Noise level.

Some may argue on the fact that, it is designed and manufactured so then *'don't touch it, leave it as it is, etc...'.* The instrument should remain intact as it with its typical sound quality and its own shortcomings and imperfections.
Personally, I also concur and respect this statement.

It is easy to understand that the one who is playing on stage in a band or in a noisy environment, even with the volume control of Leslie on position #10, nobody is concerned about residual Hum & Noise level which is on top buried by the level of the organ audio signals during play. For those who don't mind and that are happy so, there is no need to continue reading this chapter.

However, for players which are concerned by getting a 'clean B3 sound' even with swell pedal at full blast position, free from such residual and boring Hum & Noise background disturbances, then this chapter is written for them.

After having worked during twenty years in the Hi-Fi world, needless to explain that excessive residual Hum & Noise level is to me an elementary shortcoming that has to be fought and improved. With today's components it's quite easy to do it.
That was not the case in the early fifties when the B3/C3's were launched on the market.

This Hum & Noise reduction is quite audible and particularly appreciated when in use :

- in recording studios

- in quiet environments such as private home use or home studios

Before going any further, it has to be mentioned that this achievement cannot be done in a couple of hours and require the expertise of a qualified technician.
It is not complicated but some skill is compulsory.

Forewords

We all know the basic principle of Hammond TWG(1). It is not the purpose of this chapter to re-explain the theory behind it but the only thing that to be remembered is that the role of each coil located in front of its matching tone-wheel can be considered as a pick-up coil. While being compartiment shielded by pairs, coils may still pick up magnetic fields from the upper side of TWG.

Any undesirable magnetic fields may be also picked up by the 47 filter transformers located on top of TWG. Those filter transformers are not shielded and any heavy magnetic field pattern may be collected and disrupt and severely increase the residual hum & noise level.

Since TWG's are sensitive to external magnetic fields, the first precaution to be taken is to eliminate them as much as possible.

For instance, when looking to the AO-28 preamp, it's easy to notice that the power transformer is shifted by about 45° off-angle from the chassis. The reason is very simple.

In the fifties, the quality of the steel laminations used in those power transformers was poor. As a result of that, magnetic flux leakage was high and hence inducing the TWG.

It was found by Hammond engineers that by slightly rotating the power transformer, the overall hum was reduced. It's cheaper to do so than to wrap up the whole transformer with expensive mumetal shield material.

This being said, we may easily deduct that eliminating any magnetic field from TWG will reduce the residual overall hum level and it really does !

To achieve that the original power transformer is replaced by a toroidal one so that any external flux leakage will be totally eliminated.

This new toroidal transformer has to be selected for both 115V and 230V operation so that any auto-transformer (mostly needed when US organs are connected to European AC Mains) will be also discarded.

There are other minor modifications to be implemented that will be listed in the next pages.

To be noted that those improvements were implemented on both B3 and C3 organs since more than three years ago and not a single failure was noticed.
The Hum & Noise reduction is quite noticeable.

(1) TWG = Tone Wheel Generator

POWER SUPPLY UNIT (PSU) of AO-28 preamp.

The most important modification will concern the Power Supply Unit of the AO-28 preamp.

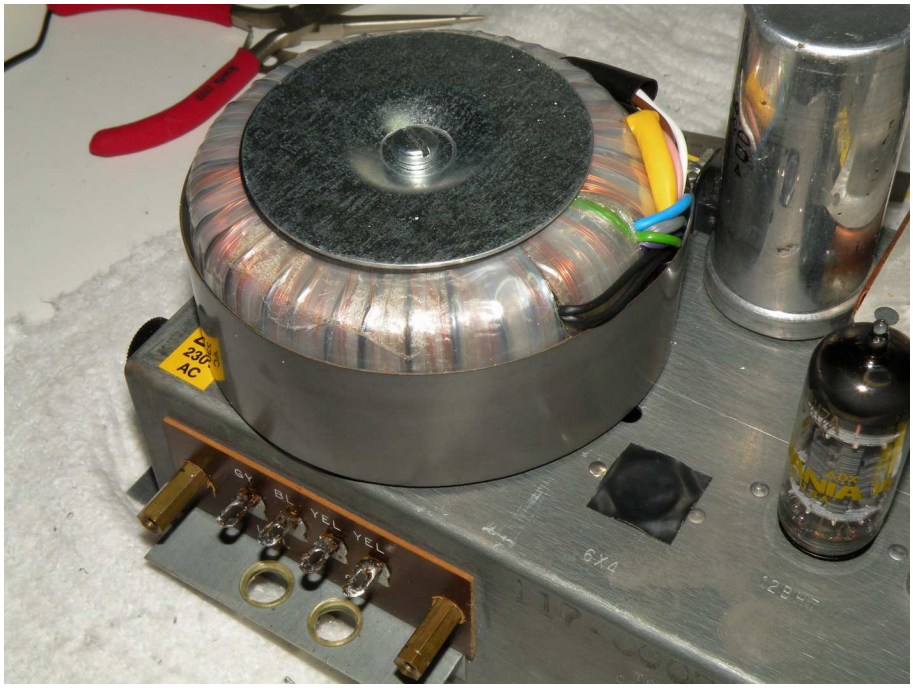
The original power transformer has to be removed and replaced by a toroidal one. In this case, model XA261 made by Amplimo (NL) was selected while equivalent transformers would also do the job. See http://www.amplimo.com/
Datasheet of this toroidal transformer is available in the annexe.
Refer to schematic diagram on next page.

1. Toroidal transformer XA261.

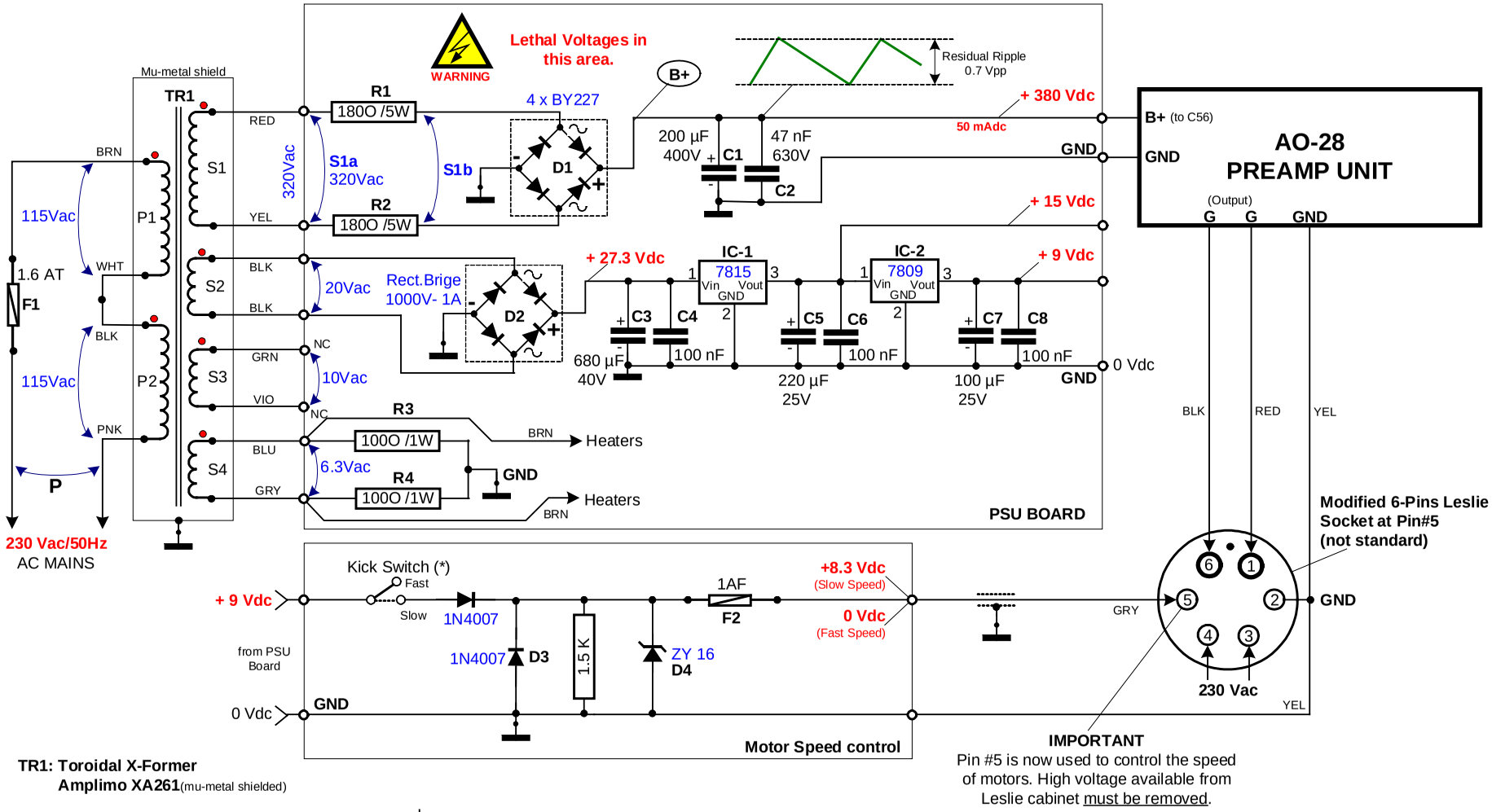
Primary windings : composed of two windings P1 and P2 of 115 Vac each wired in series so that, from now on, the AO-28 preamp is directly connected into 230 Vac i.s.o. being fed by an external auto-transformer (at least for European market).
Since Hammond Co has been always allergic to insert protection fuses in their organs, one 1.6 AT fuse was installed too.
The value of this fuse seems excessive by comparison with the effective current flow absorbed by the AO-28. The reason is that the in-rush current of a toroidal transformer is much higher than a conventional one. This value seems to be the best compromise.

Secondary windings : winding S1 (320 Vac) will provide the high voltage supply, S2 (20 Vac) will be used for low voltages applications and S4 (6.3 V) for heaters. S3 is not used.

The installation of this toroidal transformer is quite easy. Only one hole has to be drilled.



A mumetal shield strip is added around the transformer to be 100 % sure that any magnetic leakage will be eliminated. This shield is grounded.



IMPORTANT
Pin #5 is now used to control the speed of motors. High voltage available from Leslie cabinet must be removed.

TR1: Toroidal X-Former
Amplimo XA261(mu-metal shielded)

Notes:
B+ nominal value recommended by Hammond is +375 Vdc with I= 50 mAdc. Measured 382 Vdc in use on C3 with R1 & R2 rated at 180O.

With 250 Vac (Prim.of TR1), Max value measured was 416 Vdc.

* installed on swell pedal

= organ chassis ground

Tests Results

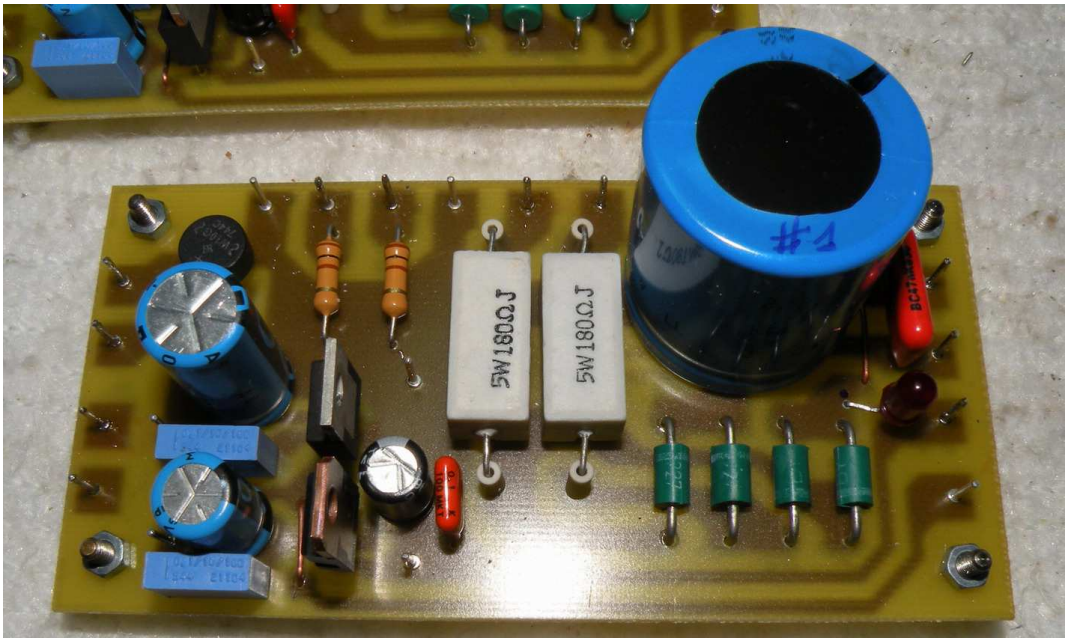
	P	S1a	S1b	B+
Sample #1	220Vac	304Vac	284Vac	360Vdc
	230Vac	322Vac	300Vac	**378Vdc**
	240Vac	342Vac	317Vac	397Vdc
Sample #2	220Vac	311Vac	288Vac	368Vdc
	230Vac	327Vac	303Vac	**382Vdc**
	240Vac	342Vac	317Vac	402Vdc

230V-50Hz PSU for Hammond AO-28 (US made) - Model B3/C3

File: PSU_C3_B3_01.vsd
Issued by: Daniel Vigin
Date: 16/03/2010

2. New AO-28 PSU.

The entire PSU has been redesigned and rebuilt on a dedicated PCB.



High voltage (B+) : the original twin diode tube 6X4 is removed and is replaced by a rectifier bridge composed of 4 x BY227 diodes. However, to compensate the Rs value (also called plate supply resistance) of this rectifier tube, two wirewound resistors of 180 Ω/5W have been inserted in series as shown on the schematic diagram. Based on several trials, after rectifying, this value of 180Ω provides the exact B+ voltage of +380Vdc. The first elco (C56, 40µFon Hammond schematic) is replaced by a new elco of 220 µF/400Vdc installed on PCB, this means more than 5 times higher value.

By doing this way, the residual ripple value will drop to 0.7 Vpp ! It has been always a good engineering practice to shunt elco's with low value capacitors in the range of 100nF.

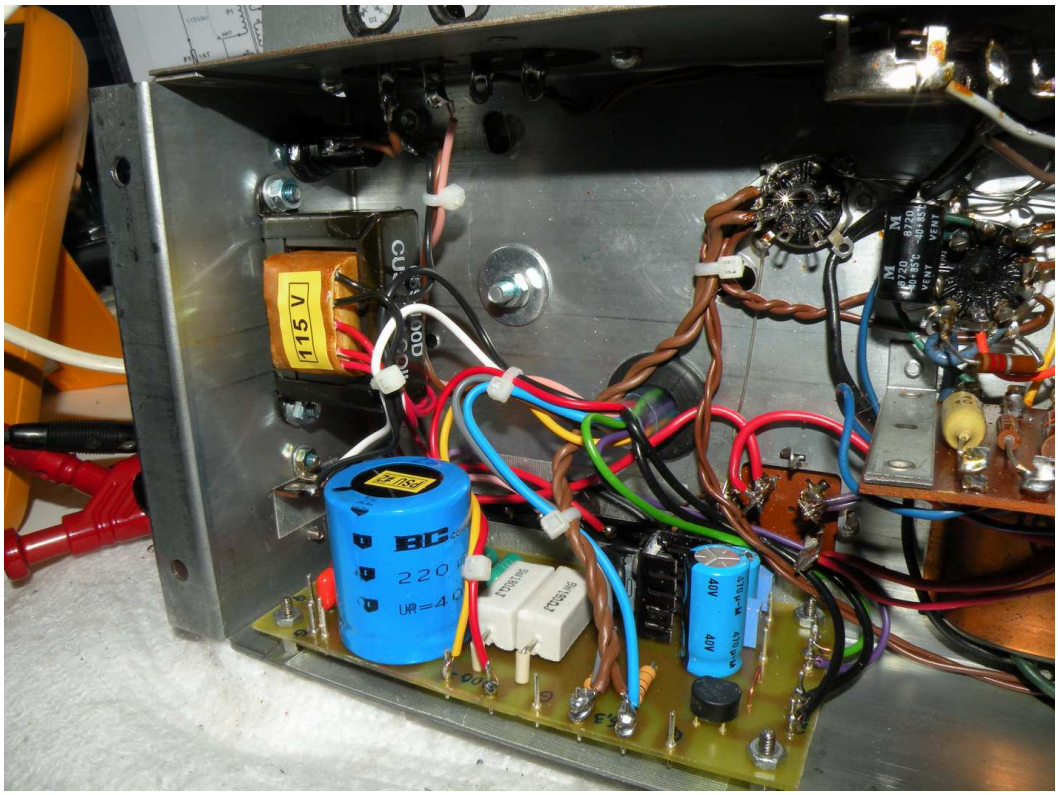
Some may argue on the fact that when switching on, with tube rectifiers because of the time needed by heaters, the voltage at elco's will climb gradually and will extend so the life time of those elco's.
In theory, they are right but in this case, this reasoning is not applicable because :
- professional grade elco's are used and designed to absorb such high current peaks
- two resistors of 180Ω/5W are limiting this in-rush current (remember the 8Ω/5W resistor in Leslie 122 and 143 amplifiers..).
- the internal DC resistance of S1 winding will also limit this peak of in-rush current.

Low voltage applications : the secondary winding S2 is used to provide +15 Vdc and +9Vdc voltages for specific applications.
A basic rectifier bridge (1A – 1000 V) is used followed after filtering by one 15 Vdc regulator 7815 and 9 Vdc regulator 7809. Nothing special, really basic.

Heaters supply S4 : since this toroidal transformer is not equipped with center tap, two resistors of 100Ω/1W are connected to ground in order to 'balance' each terminal of the secondary winding S4.

3. Installation inside AO-28 chassis.

The new PSU circuit (120 x 60mm) is installed on the vertical side of the AO-28 chassis (TWG side). Wiring is extremely simple.
The tube socket of 6X4 tube (V8) has been unwired, only the heaters cabling remains as it (brown wires).

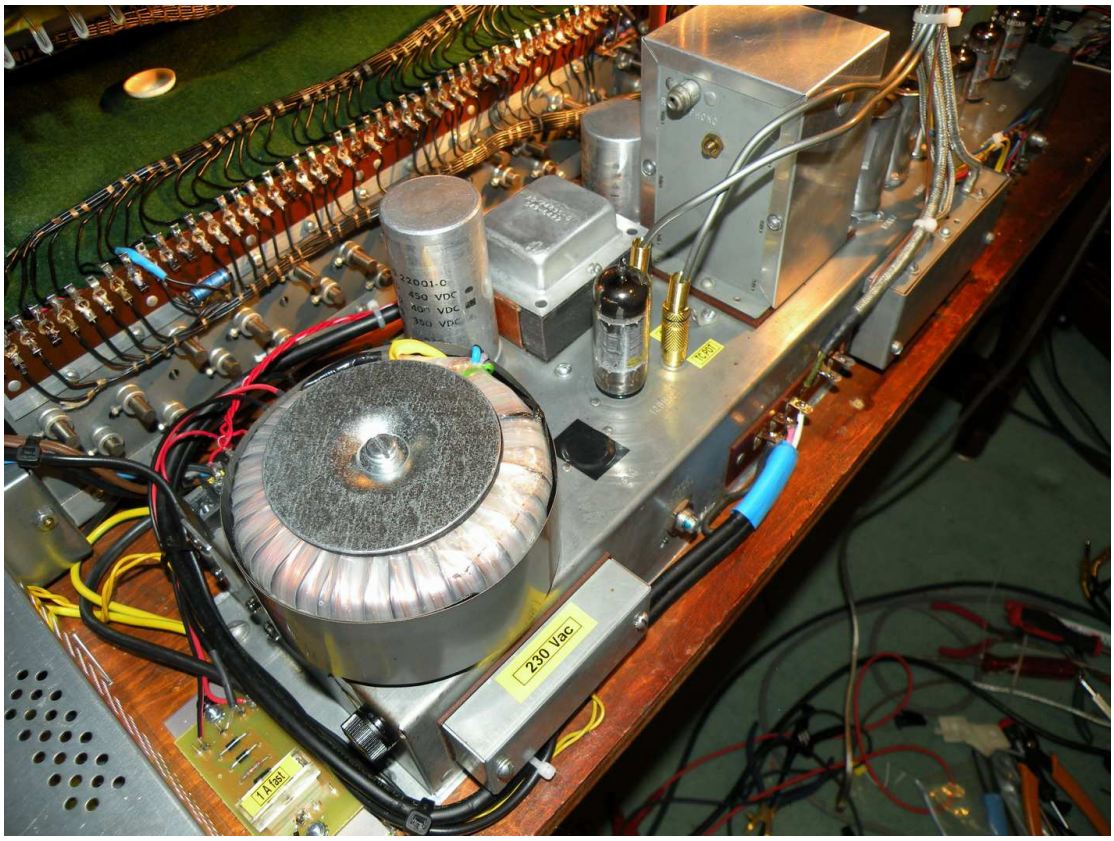


Installation of new PSU board inside the AO-28 chassis.

The small transformer on the left side of the picture is also installed inside the AO-28 chassis. This transformer is part of the Trek II String Bass SB2500A kit and is connected to one primary winding 115Vac of the newly installed toroidal transformer. There is room enough and by doing so any flux leakage will be blocked by the AO-28 metal chassis.

For easiness of voltage measurements and wiring, one 8-terminal connector is mounted on the AO-28 chassis (TWG side).

How it looks inside the B3/C3 when completed.



When watching this picture there are some more remarks that merit some attention.

- Fuse-holder is nearby the toroidal transformer (easy access).

- Links between the output transformer T3 (G–Bn–G) and Leslie 6-pins socket are also shielded, see twin black cable (no so easy on B3's).

- The 9-pin adapter into the 12BH7 (to Trek II – Reverb RV-1C) tube has been removed and replaced professional CINCH plugs and sockets.

- An additional small PCB is installed for the motor speed control on the bottom left hand side of the picture. See next chapter 'Leslie Motor Speed control'.

- Rectifier tube 6X4 has been removed and socket covered.

The whole AO-28 Preamp Unit is now fed directly with 230 Vac (EUR) and the auto-transformer 230V/115V has been removed from the organ (less magnetic field).

Conclusions.

Initially, on trial purpose, this new PSU was firstly implemented on my Hammond C3. The Hum & Noise reduction was so noticeable and effective, in the range of – 6dB to – 8dB unweighted even with swell pedal at full blast, that I have decided to duplicate it on my B3 as well. Both organs are identically wired so.

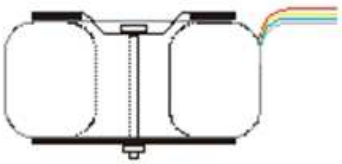
All musician friends having played on those two organs have recognized this appreciable Hum & Noise reduction.

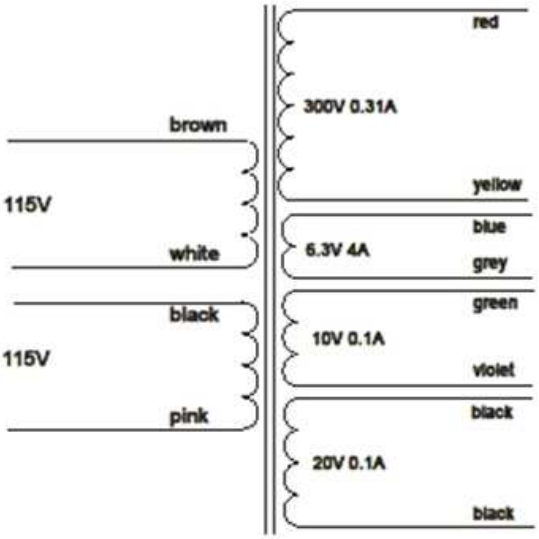
To be also noted that those modifications were done more than three years ago and not a single problem did occur at PSU level.

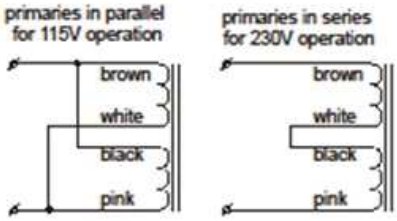
Trust having been of some help with these information.

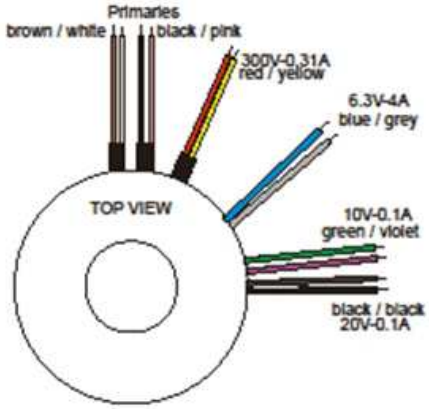
Dan. Vigin

Toroidal transformer type XA261









Diameter	98mm
Height	48mm
Weight	1.4kg

Height and weight are measured without mounting materials
All leads are approx.200mm long

Supplied mounting materials:
1 metal washer Ø7cm
2 neoprene washers Ø7cm
1 bolt M5x55 with nut

manufactured and tested according to EN61558.

Time lag fuses to be used.
Primary:
For 115V mains : 1.2A 5x20mm IEC127 high I^2t-value
For 230V mains: 0.63A 5x20mm IEC127 high I^2t-value.

Secondary: additional protection is required for each secondary winding

Type number	primary	secondaries voltage	current
XA261	2x 115V	300V	310mA
		6.3V	4A
		10V	100mA
		20V	100mA

All voltages are under full ohmic load.
Regulation : 8%

50Hz / 60Hz

CE 115V / 230V RoHS

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HB | June 2004

XA261

toroidal power transformer for valve-amplifiers