10.11.2 Double-triodes

Which idle current, or which internal impedance does an ECC83 have? Such data may be found in the **tables of tube manuals**. These tables, however, are likely to have been compiled 50 or more years ago when manufacturers such as RCA, General Electric, Telefunken, Sylvania, and many others, were still producing tubes. Today, only few manufacturers remain: they each manufacture using several labels. As a consequence, a tube labeled "Valvotron" may well stem from the same Chinese manufacturer as another tube labeled "Tubitronics". Their data may correspond to values found in the tables – or not. As an orientation, these tables and manuals are certainly helpful: they specify mostly average characteristics applicable for typical operating points in the HiFi context … which may not be at fit for guitar amplifiers. More information is given by data sheets featuring characteristic curves, but these may have been subjected to an averaging process (to make them "look better"), or could be a third-generation copy of dubious quality.

The above may be the reason why our freshly unpacked tube does not match the data sheet. Another reason may be the tube itself because, depending on availability, suppliers will often offer similar (but not identical) tubes under the same designation. For example, the packaging may specify "5751 = ECC83 = 7025" although the 5751 has slightly different data compared to the ECC83. We might be reminded of the chocolate Santa the brown body of which, after removing the wrapping, looks suspiciously like an Easter Bunny. It's all marketing driven …

To say that an ECC83 is the same as an E83CC is not quite correct, either, since in fact the E83CC is a **special tube**[⊕] (long-life-tube, long-distance-communication-tube). Such tubes often have gold-plated grids or zirconized electrodes with a highly special cathode build in order to avoid the development of a disruptive intermediate layer. There's magic in the numbers: the 7025 supposedly is a special version of the 12AX7 that in turn is an equivalent to the ECC83. The E83CC is a special version of the latter … but according to the data sheets, it does not correspond to the 7025 but to the 6681 …

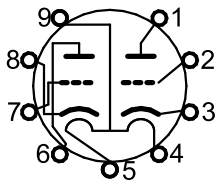
European designation		**ECC 81**	**ECC 82**	**ECC 83**	**-**	**-**
Alternate designation		12AT7 6201[⊕]	12AU7 6189[⊕]	12AX7 7025[⊕]	**5751**[⊕]	**12AY7** 6072[⊕]
Plate voltage	V	250	250	250	250	250
Grid/cathode-voltage	V	-2,0	-8,5	-2,0	-3,0	-4,0
Plate current	mA	10	10,5	1,2	1,1	3,0
Transconductance	mA/V	5,5	2,2	1,6	1,2	1,75
Open-loop gain	-	60	17	100	70	44
Internal plate resistance	kΩ	11	7,7	62,5	58	25
Grid/plate capacitance	pF	1,6	1,5	1,6	1,4	1,3
Max. plate voltage	V	300	300	300	300	300
Max. plate power dissipation	W	2,5	2,75	1,0	1,0	1,5

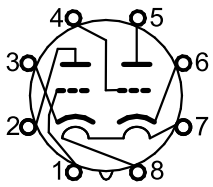
Table: Tube-data (typical standard values). All operational values depend on the corresponding operating point, and are subject to individual scatter. Heater voltage: 6,3 V, heater current: 0,30...0,37A. 9-pin socket.
ECC81 ≈ 6060 ≈ 6201 ≈ 6679 ≈ 7492 ≈ 7728. **ECC82** ≈ 5814 ≈ 6189 ≈ 6680 ≈ 7489 ≈ 7730. **ECC83** ≈ 5721 ≈ 6057 ≈ 6681 ≈ 7025 ≈ 7729.

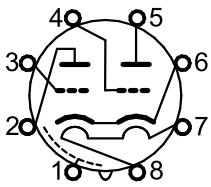
[⊕] This designation is supposed to indicate special tubes, see the tube manuals.

The following table lists old octal tubes that were in service in the amplifiers in pioneering times (up to about the mid-1950's).

Octal tubes		**6 SC7**	**6 SJ7**	**6 SL7**	**6 SN7**	
System(s)		3 + 3	5	3 + 3	3 + 3	
Plate voltage	V	250	250	250	250	
Grid/cathode voltage	V	-2	-3	-2	-8	
Plate current	mA	2	3	2.3	9	
Transconductance	mA/V	1.33	1.65	1.6	2.6	
Open-loop gain	-	70		70	20	
Internal plate resistance	kΩ	53	1 M	44	7.7	
Grid/plate capacitance	pF	2	0.005	2.8	4	
Max. plate voltage	V	250	300	300	300	
Max. plate power dissipation	W		2.5	1	3.5	







Socket connections: left 9-pin socket, mid and right octal socket (seen from below).

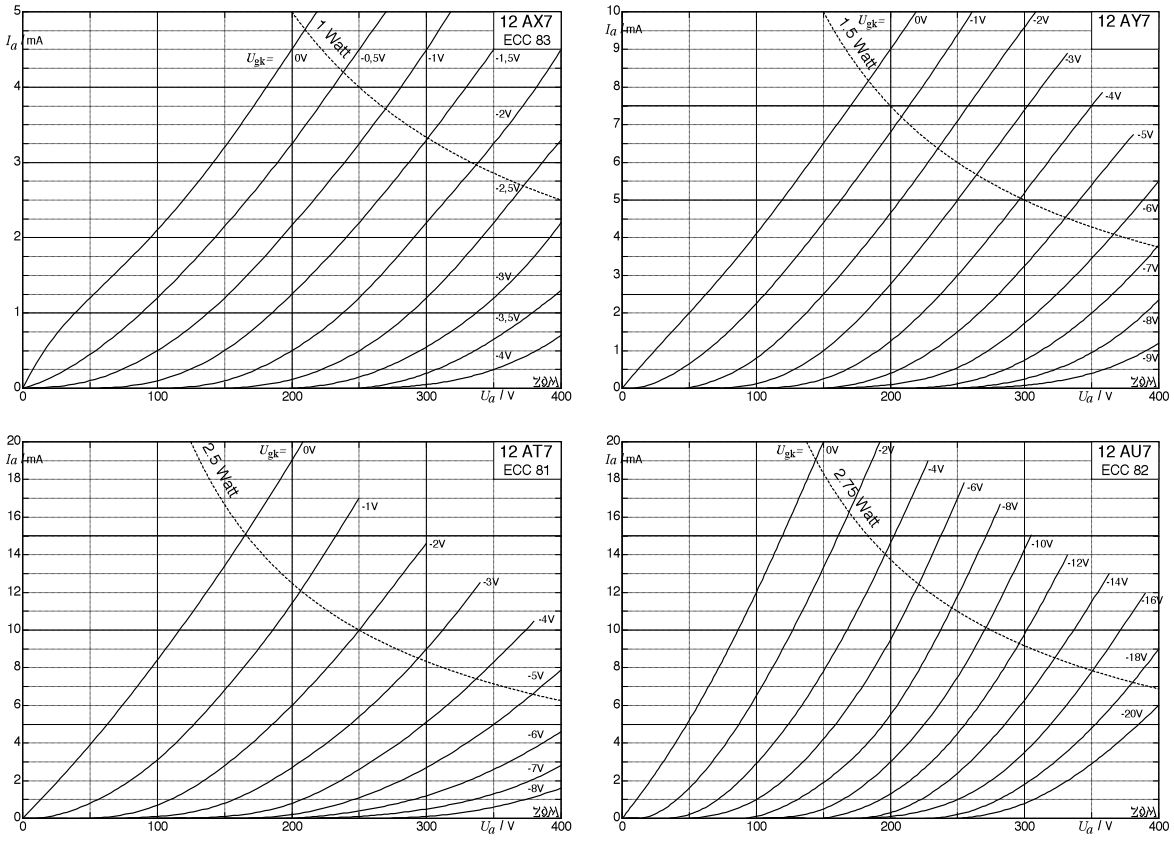


Fig. 10.11.1: Output characteristics of triodes (according to data sheets).

The data books recommend the **ECC83** as preamplifier tube when high amplification is required. The equivalent to the European ECC83 is the US-made **12AX7**, replaced around the beginning of the 1960's by the slightly improved **12AX7A**. The changes related to the maximum load (1,2 W instead of 1,0 W), to the maximum plate voltage (330 V instead of 300 V), and to the typical noise voltage referenced to the input (equivalent noise). For the first time this is limited: (1.8 μV_{eff}, 25 Hz – 10 kHz). The RCA Receiving Tube Manual writes about the equivalent **7025**: *The 7025 is identical with 12AX7A except that it has a controlled equivalent noise and hum characteristic;* the data sheet in addition limits the maximum interference voltage. If less amplification is needed, the recommended tube is the **5751** and for even less gain it is the **12AY7**.

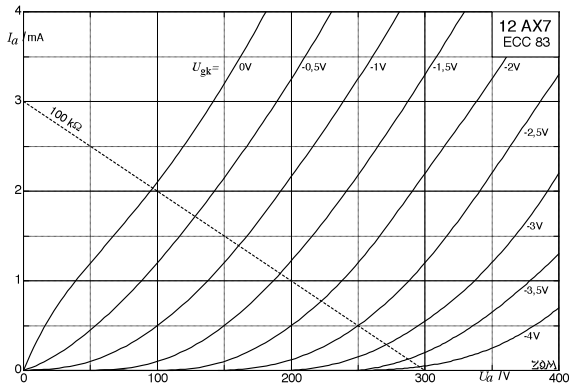
The **ECC81** (**12AT7**) and the **ECC82** (**12AU7**) are specified to 10 mA plate current, and are used not for preamps but for driver- and reverb-circuits. This does not exclude that an ECC81 is operated with a plate current of 1 mA – however in this case we must not expect the low output-impedance specified for 10 mA plate current. The below table lists tube data for the following operating conditions: plate connected to 300 V via 100 kΩ, cathode connected to ground via 1,5 kΩ, cathode resistor bridged with a capacitor; grid at 0 V.

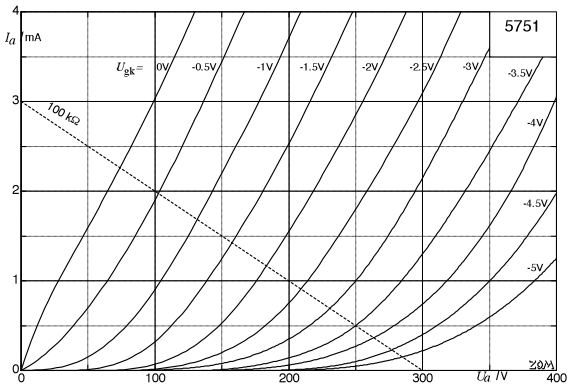
European designation		**ECC 83**	**-**	**ECC 81**	**-**	**ECC 82**
Alternate designation		12AX7	**5751**	12AT7	**12AY7**	12AU7
Plate voltage	V	195	176	140	140	85
Grid/cathode-voltage	V	-1,6	-1.8	-2,4	-2,4	-3,3
Plate current	mA	1,05	1,2	1,6	1,6	2,2
Transconductance	mA/V	1,6	1,4	1.5	1,3	0,8
Open-loop gain	-	100	72	42	41	15
Internal plate resistance	kΩ	70	52	27	30	18

Table: tube data; benchmarks rounded off for small plate current.

The **Barkhausen**-relationship should connect the transconductance S, the open-loop gain μ and the internal resistance R_i (see chapter 10.11.4): $S \cdot R_i = \mu = 1/D$. Checking the tables and data sheets provide by the manufacturers shows that this relationship is often not complied with. Deficient theory is not likely to be the reason; rather, we can surmise that this is due to rounded-off or inaccurate values. The tube parameters given here and in the following are those provided by the manufacturer – they are **not corrected** even though they may give rise to small errors.

In **Fig. 10.11.2** we see the output characteristics of commonly used double triodes. For all diagrams, the ordinate range is 0 – 4 mA to obtain operating conditions typical for preamp applications. For R_a = 100 kΩ, a load characteristic is included as the dashed line; it crosses the abscissa at 300 V (operating voltage). Positive grid voltages will not occur for high-impedance drive-signals (that are typical for guitar amplifiers); therefore the minimum plate voltage is quite high in some cases (e.g. 90V for the ECC83).





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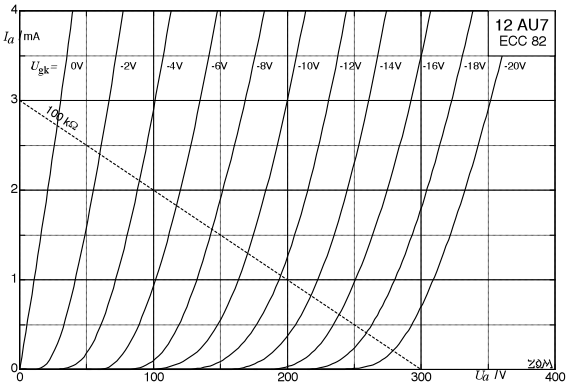

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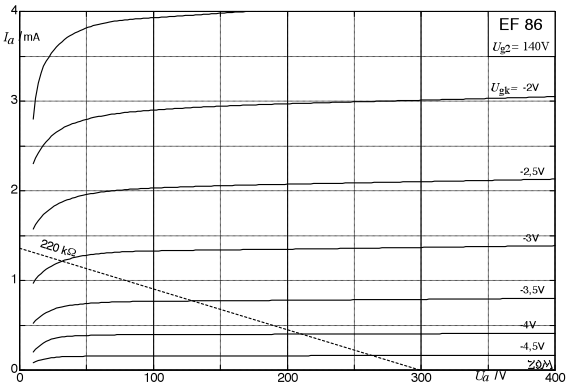
Fig. 10.11.2a: Triode-characteristics for small plate currents (taken from data sheets provided by manufacturers).



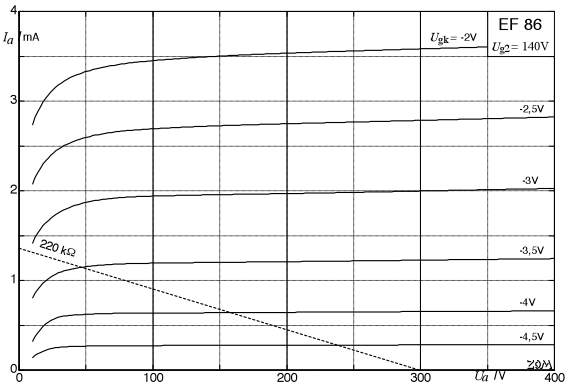


Fig. 10.11.2b: Pentode-characteristics for comparison: left Telefunken, right Svetlana.

