ELL 1 Double Output Pentode

This valve was specially designed for car radio receivers and consists of two output pentode units enclosed in a single envelope, each unit having an anode dissipation of 4.5 W. From the point of view of its operation from the car battery, both the heater and the anode current have been kept as low as possible; in consequence, the mutual conductance of each unit individually is not so very high, viz. 1.7 mA/V. The two valve units have been housed in a common bulb for use in balanced circuits, in order that the power supplied to the anode shall be utilized to the best possible advantage; with 3.5% distortion, the output power is 4.5 W.

The two cathodes, screen grids and suppressors are inter-connected within the valve.

Fig. 1
Dimensions in mm.

Fig. 2
Arrangement of electrodes and base connections.

Fig. 3
Anode and screen-grid currents of a single pentode unit of the ELL 1 as a function of the grid bias, at $V_a = V_g = 250$ V.

HEATER RATINGS

Heating: indirect by battery current, rectified A.C. or D.C.; parallel supply.
Heater voltage ........................................ $V_f = 6.3$ V
Heater current ......................................... $I_f = 0.45$ A

CAPACITANCES

Anode-grid system 1 .................................. $C_{aga_1} < 1.3 \mu\text{F}$
Anode-grid system 2 .................................. $C_{aga_1'} < 1.3 \mu\text{F}$

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STATIC RATINGS (PER SYSTEM)

- **Anode voltage**: $V_a = 250 \text{ V}$
- **Screen-grid voltage**: $V_{g2} = 250 \text{ V}$
- **Grid bias**: $V_{g1} = -19.5 \text{ V}$
- **Anode current**: $I_a = 15 \text{ mA}$
- **Screen-grid current**: $I_{g2} = 2.5 \text{ mA}$
- **Mutual conductance**: $S = 1.7 \text{ mA/V}$
- **Internal resistance**: $R_i = 110,000 \text{ ohms}$

OPERATING DATA FOR BALANCED CIRCUIT

- **Anode voltage**: $V_a = 250 \text{ V}$
- **Screen-grid voltage**: $V_{g2} = 250 \text{ V}$
- **Common cathode resistor**: $R_k = 560 \text{ ohms}$
- **Grid bias**: $V_{g1} = -19.5 \text{ V}$
- **Anode current (without signal)**: $I_{a0} = 2 \times 15 \text{ mA}$
- **Anode current at max. modulation**: $I_{a_{\max}} = 2 \times 17 \text{ mA}$
- **Screen current (without signal)**: $I_{g20} = 2 \times 2.5 \text{ mA}$
- **Screen current at max. modulation**: $I_{g2_{\max}} = 2 \times 5 \text{ mA}$
- **Load resistor between anodes**: $R_{aa} = 16,000 \text{ ohms}$
- **Output power**: $W_o = 4.5 \text{ W}$
- **Total distortion**: $d_{\text{tot}} = 3.5 \%$
- **Alternating input voltage per grid**: $V_i = 19 \text{ V}_{\text{eff}}$

MAXIMUM RATINGS

- **Anode voltage in cold condition**: $V_{a0} = \text{max.} 550 \text{ V}$
- **Anode voltage**: $V_a = \text{max.} 250 \text{ V}$
- **Anode dissipation (per system)**: $W_a = \text{max.} 4.5 \text{ W}$
- **Screen-grid voltage in cold condition**: $V_{g20} = \text{max.} 550 \text{ V}$
- **Screen-grid voltage**: $V_{g2} = \text{max.} 275 \text{ V}$
- **Screen dissipation per system ($V_i = 0$)**: $W_{g2} = \text{max.} 0.7 \text{ W}$
- **Screen-grid dissipation per system ($W_o = \text{max.}$)**: $W_{g2} = \text{max.} 1.5 \text{ W}$
- **Cathode current per system**: $I_k = \text{max.} 30 \text{ mA}$
- **Grid voltage at grid current start ($I_{g1} = +0.3 \mu A$)**: $V_{g1} = \text{max.} -1.3 \text{ V}$
- **External resistance between heater and cathode**: $R_{jk} = \text{max.} 5,000 \text{ ohms}$
- **Voltage between heater and cathode**: $V_{jk} = \text{max.} 50 \text{ V}$

The data and characteristics given with respect to this valve refer only to a resistance-free source of voltage; in general, car radios are driven by the car battery by means of a vibrator and the latter, together with the transformer and anti-static circuit, have a fairly high resistance which will somewhat reduce the maximum obtainable output power; the internal resistance, therefore, should be as low as possible. In the case of an internal resistance in the supply unit of, say, 1,600 ohms, with the pre-amplifier valves taking 20 mA, the following values will furnish an output of 4.75 W, with 3 \% distortion:

- **Internal resistance of the anode-feed source**: $R_b = 1,600 \text{ ohms}$
- **Current consumption of amplifying valves**: $I_q = 20 \text{ mA}$
- **Anode voltage**: $V_a = 250 \text{ V}$
- **Screen voltage**: $V_{g2} = 250 \text{ V}$
- **Cathode resistor**: $R_k = 600 \text{ ohms}$
- **Anode current (without signal)**: $I_{a0} = 2 \times 15 \text{ mA}$
- **Anode current at max. modulation**: $I_{a_{\max}} = 2 \times 16.5 \text{ mA}$

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Screen current (without signal) \( I_{gs0} \) = 2 \( \times \) 2.5 mA
Screen current at max. modulation \( I_{gs\text{max}} \) = 2 \( \times \) 4.7 mA
Load resistor between anodes \( R_{oa} \) = 16,000 ohms
Output power \( W_o \) = 4.75 W
Distortion \( d_{10} \) = 3 \%
Alternating input voltage, per grid \( V_i \) = 18 Veff

The output obtainable in respect of other values may be estimated from the above figures.

The maximum anode voltage is 250 V, which on an average car battery voltage of 6.3 V must definitely not be exceeded; actually the use of car batteries may give rise to considerably greater overloads than are usually met with in the case of mains operation, since, when the battery is charging, voltages of 8 to 9 V may occur, with consequent detriment to the life of the valves. With automatic bias, however, over-voltages on the anode and screen grid of 20 \% are permissible. The maximum screen voltage of this valve being 275 V, the voltage drop across the output transformer is allowed for, and there is no necessity for a reduction in anode voltage.

![Fig. 4](image)

Anode current of one pentode unit of the ELL 1 as a function of the anode voltage for different values of grid bias, at \( V_{gs} = 250 \) V.

![Fig. 5](image)

Total distortion \( d_{10} \), alternating grid voltage \( V_i \), total anode current \( I_a \) and total screen current \( I_{gs} \), as functions of the output power of the ELL 1 when used in a balanced output stage with automatic grid bias.