EL 2 Output pentode

The EL 2 is an indirectly-heated, 8 W output pentode for use in car-radio receivers; the low heater-power consumption makes this valve very suitable for this purpose. With an anode and screen potential of 250 V, the mutual conductance is 2.8 mA/V at the working point. The cathode attains its full working temperature in a very short time, namely 18 seconds. The control-grid connection is at the top of the envelope.

HEATER RATINGS
Heating: Indirect by battery current; series or parallel supply.
Heater voltage ............... \( V_f = 6.3 \) V
Heater current ............... \( I_f = 0.2 \) A

CAPACITANCES
Anode to grid 1 ............... \( C_{ag1} < 0.6 \) \( \mu \)F

Fig. 1
Dimensions in mm.

Fig. 2
Arrangement of electrodes and base connections.

Fig. 3
Anode and screen current as functions of the grid bias for equal anode and screen voltages of 200 V and 250 V.
OPERATING DATA: EL 2 used as Class A output valve (single valve)

Anode voltage ....................................... \( V_a = 200 \text{ V} \) 250 V
Screen-grid voltage .................................. \( V_{gs} = 200 \text{ V} \) 250 V
Cathode resistor ...................................... \( R_k = 480 \text{ ohms} \) 485 ohms
Grid bias .............................................. \( V_{g1} = -14 \text{ V} \) -18 V
Anode current ........................................ \( I_a = 25 \text{ mA} \) 32 mA
Screen-grid current .................................. \( I_{gs} = 4 \text{ mA} \) 5 mA
Mutual conductance .................................. \( S = 3 \text{ mA/V} \) 2.8 mA/V
Internal resistance .................................. \( R_i = 70,000 \text{ ohms} \) 70,000 ohms
Load resistor ........................................... \( R_a = 8,000 \text{ ohms} \) 8,000 ohms
Output with 10 \% distortion .......................... \( W_o = 2.3 \text{ W} \) 3.6 W
Alternating grid voltage with 10 \% distortion ......................... \( V_i = 8.5 \text{ V}_{\text{eff}} \) 10 \text{ V}_{\text{eff}}
Alternating grid voltage for 50 mW output .................. \( V_i = 1 \text{ V}_{\text{eff}} \) 0.9 \text{ V}_{\text{eff}}

OPERATING DATA: EL 2 used as output valve in balanced circuit (2 valves)

Anode voltage ........................................ \( V_a = 200 \text{ V} \) 250 V
Screen-grid voltage .................................. \( V_{gs} = 200 \text{ V} \) 250 V
Common cathode resistor ............................. \( R_k = 320 \text{ ohms} \) 305 ohms
Anode current (without signal) ....................... \( I_{a0} = 2 \times 21 \text{ mA} \) 2 \times 27.5 mA
Anode current at full modulation ...................... \( I_{a_{\text{max}}} = 2 \times 24.5 \text{ mA} \) 2 \times 32.5 mA
Screen current (without signal) ....................... \( I_{g20} = 3.5 \text{ mA} \) 2 \times 4.5 mA
Screen current at full modulation ..................... \( I_{g2_{\text{max}}} = 2 \times 6 \text{ mA} \) 2 \times 8 mA
Load resistor between the two anodes ................. \( R_{an} = 8,000 \text{ ohms} \) 8,000 ohms
Output power ......................................... \( W_{o_{\text{max}}} = 5 \text{ W} \) 8 W
Total distortion at full modulation ................... \( d_{\text{tot}} = 1.5 \% \) 1.4 \%
Alternating grid voltage at full modulation .......... \( V_i = 14 \text{ V}_{\text{eff}} \) 17 \text{ V}_{\text{eff}}

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**Fig. 4**
Anode current as a function of the anode voltage with \( V_{g1} \) as parameter, at \( V_{g2} = 250 \text{ V} \).
EL 2

Fig. 5
EL 2 used as triode. Anode current as a function of the grid bias at $Y_a = 200$ and 250 V.

Fig. 6
EL 2 used as triode. Anode current as a function of the anode voltage for different values of grid bias.

Fig. 7
Various data as function of anode and screen voltage of the EL 2.
OPERATING DATA: EL 2 used as triode (grid 2 connected to anode)

Anode and screen-grid voltage \( V_a = 250 \text{ V} \)

Grid bias \( V_{g1} = -27 \text{ V} \)

Anode current \( I_a = 15 \text{ mA} \)

Mutual conductance \( S = 1.7 \text{ mA/V} \)

Internal resistance \( R_i = 4,100 \text{ ohms} \)

Amplification factor \( \mu = 7 \)

MAXIMUM RATINGs

Anode voltage in cold condition \( V_{ma} = \text{max.} 550 \text{ V} \)

Anode voltage \( V_a = \text{max.} 250 \text{ V} \)

Anode dissipation \( W_a = \text{max.} 8 \text{ W} \)

Screen-grid voltage in cold condition \( V_{g2o} = \text{max.} 550 \text{ V} \)

Screen-grid voltage \( V_{g2} = \text{max.} 250 \text{ V} \)

Screen-grid dissipation \( W_{g2} = \text{max.} 1.6 \text{ W} \)

Cathode current \( I_k = \text{max.} 45 \text{ mA} \)

Grid voltage at grid current start (\( V_{g1} = +0.3 \mu A \) \( V_{g1} = \text{max.} -1.3 \text{ V} \)

Resistance between grid and cathode with automatic bias \( R_{g1k} = \text{max.} 1 \text{ M ohm} \)

Resistance between grid and cathode with fixed bias \( R_{g1k} = \text{max.} 0.6 \text{ M ohm} \)

Resistance between filament and cathode \( R_{fk} = \text{max.} 5,000 \text{ ohm} \)

Voltage between filament and cathode (direct voltage or effective value of alternating voltage) \( V_{fk} = \text{max.} 50 \text{ V} \)

This valve can be used in a single or balanced output stage in car radio sets. For 12 V batteries the heaters of two of these valves can be connected in series, or, alternatively, one EL 2 may be placed in series with another valve in the same series, for example the EBC 3 or EF 6. The cathode must be decoupled with respect to the earth line through a capacitor of at least 2 \( \mu F \), but an even higher capacitor of 25 or 50 \( \mu F \) is better. When used in balanced output circuits (two
valves), the bias should preferably be automatic and the EBC 3 or EL 2, connected as triode, may be employed as driver. Bearing in mind the cost of the driver transformer and the required reproduction of low audiofrequencies, the designer will find a transformation ratio of $1:(2+2)$ quite suitable, but if the EL 2 is used, connected as a triode, the ratio may be somewhat higher.

Tables I and II furnish particulars of the EL 2 for the single output valve, allowing for the voltage drop across the output transformer; the values for output power refer to the effective power at the output side of the valve and in this case the transformer losses should be deducted.

![Circuit diagram of the EL 2 as employed for the measurements the results of which are given in Table I.](image1)

**Fig. 10**

**Table I.** Loading resistance

$I_a = I_{rprim} + n^4 R_{sec} + n^2 R_L = R_{tr} + n^2 R_L$.

**Output power**

$P_o = i_a^2 (R_{prim} + n^2 R_{sec} + n^2 R_L) = i_a^2 (R_{tr} + n^2 R_L) = i_a^2 I_a$.

**Direct voltage on the anode** $V_a = V_b - I_a R_{prim}$.

**Power loss in output transformer**

$i_a^2 (R_{prim} + n^2 R_{sec}) = i_a^2 R_{tr} = P_o / E_a$.

![Circuit diagram of the EL 2 as used for the measurements the results of which are given in Table II. For the symbols and formulae employed see text, Fig. 10](image2)

**Fig. 11**
TABLE I

EL 2. Output power and alternating voltage across grid leak as a function of the voltage drop across the output transformer, at an anode voltage of 250 V.

\[ I_a = 32 \, \text{mA} \]

<table>
<thead>
<tr>
<th>Anode voltage (V)</th>
<th>Supply voltage (Vb)</th>
<th>Screen resistance (Rg) (ohm)</th>
<th>Voltage drop in output transformer (Vtr) (V)</th>
<th>With 10% distortion</th>
<th>At 5% distortion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Anode load resistance (Rt) (ohm)</td>
<td>Alternating grid voltage (Vtr) Veff</td>
<td>Output power (Wt)</td>
</tr>
<tr>
<td>250</td>
<td>250</td>
<td>0</td>
<td>0</td>
<td>8,000</td>
<td>9.4</td>
</tr>
<tr>
<td>250</td>
<td>260</td>
<td>1,600</td>
<td>10</td>
<td>8,000</td>
<td>9.4</td>
</tr>
<tr>
<td>250</td>
<td>270</td>
<td>3,300</td>
<td>20</td>
<td>8,000</td>
<td>9.3</td>
</tr>
<tr>
<td>250</td>
<td>280</td>
<td>4,800</td>
<td>30</td>
<td>8,000</td>
<td>9.0</td>
</tr>
<tr>
<td>250</td>
<td>300</td>
<td>8,400</td>
<td>50</td>
<td>8,000</td>
<td>8.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Power loss in output transformer</th>
<th>Wt/Wo 100%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TABLE II

EL 2. Output power and peak alternating grid voltage as a function of the voltage drop across the output transformer at 250 V supply and screen voltages.

\[ I_a = 32 \, \text{mA} \]

<table>
<thead>
<tr>
<th>Anode voltage (V)</th>
<th>Supply voltage (Vb)</th>
<th>Screen voltage (Vg)</th>
<th>Voltage drop in output transformer (Vtr) (V)</th>
<th>With 10% distortion</th>
<th>At 5% distortion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Anode load resistance (Rt) (ohm)</td>
<td>Alternating grid voltage (Vtr) Veff</td>
<td>Output power (Wt)</td>
</tr>
<tr>
<td>250</td>
<td>250</td>
<td>250</td>
<td>0</td>
<td>8,000</td>
<td>9.4</td>
</tr>
<tr>
<td>250</td>
<td>250</td>
<td>250</td>
<td>10</td>
<td>7,500</td>
<td>9.6</td>
</tr>
<tr>
<td>250</td>
<td>250</td>
<td>250</td>
<td>20</td>
<td>7,000</td>
<td>9.6</td>
</tr>
<tr>
<td>250</td>
<td>250</td>
<td>250</td>
<td>30</td>
<td>7,000</td>
<td>9.5</td>
</tr>
<tr>
<td>250</td>
<td>250</td>
<td>250</td>
<td>50</td>
<td>6,000</td>
<td>9.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Power loss in output transformer</th>
<th>Wt/Wo 100%</th>
</tr>
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</table>

Note: In calculating the power loss due to the resistance of the output transformer windings, it was assumed that the losses in primary and secondary windings were equal.