EL 5 Output pentode

This is a high-mutual-conductance, indirectly-heated 9 W output pentode which, owing to its accuracy of construction, is capable of delivering 4.5 W with 10% distortion (i.e., efficiency 50%). The mutual conductance is 9 mA/V and the valve lends itself well to reception incorporating A.F. feed-back; the grid input signal for full modulation is 4.2 V. In balanced output stages it is possible to obtain an output of 8.2 W at $V_a = V_{g2} = 250$ V, in which case the distortion is 3.1% whilst the input signal need only be 6.7 V (per half of the secondary winding of the driver transformer). At a screen potential of 265 V, with 250 V applied to the anode and allowing for a voltage drop of 15 V in the output transformer, an output power of 9 W is developed, with 6.8% distortion, on a grid input of 5.6 V (effective). The special construction of the cathode imparts to this valve its very high mutual conductance with a comparatively low heater power; at the heater voltage of 6.3 V the current is only 0.9 A.

HEATER RATINGS
Heating: indirect. A.C. or D.C. parallel supply.
Heater voltage $V_f = 6.3$ V
Heater current $I_f = 0.9$ A

CAPACITANCES
Anode-to-grid $C_{ag1} = < 0.8 \mu F$

OPERATING DATA: EL 3 employed as single output valve
Anode voltage $V_a = 250$ V
Screen-grid voltage $V_{g2} = 250$ V
Grid bias $V_{g1} = -6$ V
Cathode resistor $R_k = 150$ ohms
Anode current $I_a = 36$ mA
Screen-grid current $I_{g2} = 4$ mA
Mutual conductance $S = 9$ mA/V
Internal resistance $R_i = 50,000$ ohms
Load resistor $R_a = 7,000$ ohms
Output power with 10% distortion $W_o = 4.5$ W
Alternating grid voltage at $W_o = 4.5$ W $V_i = 4.2 \ V_{eff}$
Sensitivity ($W_o = 50$ mW) $V_i = 0.33 \ V_{eff}$
Amplification factor; grid 2 with respect to grid 1 $\mu_{g2g1} = 23$
OPERATING DATA: EL 3 used in balanced output stage (2 valves)
(automatic grid bias)

Anode voltage .......................... \( V_a = 250 \text{ V} \) 250 V
Screen-grid voltage ....................... \( V_{g2} = 250 \text{ V} \) 250 V
Cathode resistor ......................... \( R_k = 140 \text{ ohms} \) 190 ohms
Anode current (without signal) .......... \( I_{a0} = 2 \times 24 \text{ mA} \) 2 \( \times 31 \text{ mA} \)
Anode current at max. modulation ...... \( I_{a,\text{max}} = 2 \times 28.5 \text{ mA} \) 2 \( \times 34 \text{ mA} \)
Screen current (without signal) ........ \( I_{g20} = 2 \times 2.8 \text{ mA} \) 2 \( \times 3.6 \text{ mA} \)
Screen current at max. modulation .... \( I_{g2,\text{max}} = 2 \times 4.6 \text{ mA} \) 2 \( \times 5.8 \text{ mA} \)
Load resistor between anodes .......... \( R_{ea} = 10,000 \text{ ohms} \) 10,000 ohms
Output power ........................... \( W_o = 8.2 \text{ W} \) 9 W
Distortion .............................. \( d_{\text{tot}} = 3.1 \% \) 6.8 \%
Alternating input voltage (per grid) ... \( V_i = 6.7 V_{\text{eff}} \) 5.6 \( V_{\text{eff}} \)

1) separate cathode resistor per valve.

OPERATING DATA: EL 3 employed as triode (Grid 2 connected to anode)

Anode voltage .......................... \( V_a = 250 \text{ V} \)
Grid bias ................................\( V_{g1} = -8.5 \text{ V} \)
Cathode resistor ......................... \( R_k = 425 \text{ ohms} \)
Anode current ........................... \( I_a = 20 \text{ mA} \)
Amplification factor .................... \( \mu = 20 \)
Mutual conductance ...................... \( S = 6.5 \text{ mA/V} \)
Internal resistance ...................... \( R_i = 3,000 \text{ ohms} \)
Load resistor ........................... \( R_a = 7,000 \text{ ohms} \)
Output power with 5 \% distortion ...... \( W_o = 1.1 \text{ W} \)
Alternating grid voltage ............... \( V_i = 5.9 V_{\text{eff}} \)
Sensitivity (\( W_o = 50 \text{ mW} \)) ........ \( V_i = 1.1 V_{\text{eff}} \)

MAXIMUM RATINGS

Anode voltage in cold condition ........ \( V_{an} = \text{max.} 550 \text{ V} \)
Anode voltage .......................... \( V_a = \text{max.} 250 \text{ V} \)
Anode dissipation ....................... \( W_a = \text{max.} 9 \text{ W} \)
Screen-grid voltage in cold condition \( V_{g20} = \text{max.} 550 \text{ V} \)
Screen voltage .......................... \( V_{g2} = \text{max.} 275 \text{ V} \)
Screen dissipation (\( V_i = 0 \)) ........ \( W_{g2} = \text{max.} 1.2 \text{ W} \)
Screen dissipation (\( W_o = \text{max.} \)) \( W_{g2} = \text{max.} 2.5 \text{ W} \)
Cathode current ........................ \( I_k = \text{max.} 55 \text{ mA} \)
Grid voltage at grid current start (\( I_{g1} = 0.3 \mu\text{A} \)) \( V_{g1} = \text{max.} -1.3 \text{ V} \)
External resistance between grid and cathode \( R_{g1} = \text{max.} 1 \Omega \)
External resistance between filament and cathode \( R_{fk} = \text{max.} 5,000 \text{ ohms} \)
Voltage between filament and cathode (D.C. voltage or effective value of alternating voltage) \( V_{fk} = \text{max.} 50 \text{ V} \)
As there is normally a voltage drop across the output transformer, it is necessary to allow for this in determining the supply voltage if the maximum output is to be obtained from the valve. Usually, the screen grid is connected directly to the supply line and, in order to ensure maximum anode voltage (250 V), the screen potential should be slightly higher, this being limited to 275 V maximum (see maximum ratings). Fig. 7 gives a number of useful data as plotted against the screen voltage within a range of 250–275 V and these curves furnish the main operating data with respect to any voltage drop of from 0 to 25 V in the output transformer.

Fig. 8 supplies additional data as a function of the screen voltage for the case where the receiver supply is less than 250 V and the anode potential is less than the screen voltage by 15 V (equal to the voltage drop across the output transformer).

Grid bias may be of the automatic type only (cathode resistor); semi-automatic bias is permissible provided that the cathode current of the EL 3 exceeds 50% of the total current flowing through the biasing resistor. The maximum value for the grid leak, as shown in the maximum ratings, should then be reduced in accordance with the formula: (cathode current of output valve/total current in the resistance) × $R_{gkB}$. Furthermore, the fact must be taken into account that the current of any valves controlled by A.G.C. will affect the bias on the output valve, so that, if A.G.C. is to be employed, the bias may be too low and the anode current therefore too high. In the design of a receiver it is essential to take the high mutual conductance into consideration, as it may otherwise give rise to feed-back and parasitic oscillation. Leads to the valve holders must be as short as possible and a resistor of 1,000 ohms in the control-grid lead is in many cases necessary.

When this valve is to be used in balanced output circuits the following should also be borne in mind. If the standing anode current is more than 25 mA a separate resistor must be used for each valve; differences in the anode currents might be the cause of overloading, due to the fact that one valve carrying a high current would receive too little bias from another with too low a current. It is advisable to watch this point in all cases where the removal of one of the valves would cause damage to another. The data supplied in respect of this valve when used as a triode give a clear idea of its performance as a pre-amplifier in balanced output circuits.

To prevent oscillation it is advisable not to connect the screen directly to the anode but to interpose a resistor of 100 ohms, without any decoupling; for the rest, the same precautions must be taken as for a pentode, such as short leads, etc. The EL 3 coupled as a triode will also give good results when employed as a driver valve in balanced output stages operating with grid current.

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Fig. 4
Anode and screen-grid current as a function of the grid bias at $V_a = V_g = 250$ V.

Fig. 5
Anode and screen-grid current as a function of the anode voltage, with $V_g$ as parameter. EL 3 used as a triode.
Fig. 6
Total distortion, 2nd and 3rd harmonic distortion and alternating grid voltage as a function of the output power. EL 3 used as single-output valve with automatic bias ($V_a = V_t = 250 \text{ V}$).

Fig. 7
Output power with 10 \% distortion... $W_o (10 \%)$ as a function of the screen-grid voltage (in the range 250–275 V), at constant anode voltage ($V_a = 250 \text{ V}$).

Alternating grid voltage... $V_t (10 \%)$
Sensitivity... $V_i (50 \text{ mW})$
Cathode resistor... $R_k$
Anode current... $I_a$
Output power
with 10% distortion... \( W_0(10\%) \)
Alternating grid voltage... \( V_t(10\%) \)
Sensitivity... \( V_e(90\text{ mW}) \)
Cathode resistor... \( R_k \)
Anode current... \( I_a \)

as a function of the
screen-grid voltage
(in the range 200–350 V) and at an
anode voltage of 15 V
less than the screen potential.

Anode current \( I_a \), screen current \( I_{g_b} \), total distortion, 2nd and 3rd harmonic distortion and alternating grid voltage \( V_e \) as functions of the output power \( W_0 \), for 2 EL 3 valves in a balanced circuit, with \( V_{a1} = V_{g2} = 250 \text{ V} \).