EL 3 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.
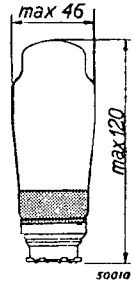

Fig. 1
Dimensions in mm

Fig. 2
Arrangement of electrodes and base connections.

HEATER RATINGS

Heating: indirect, A.C. or D.C. parallel supply.

Heater voltage . . . . $V_f = 6.3$ V
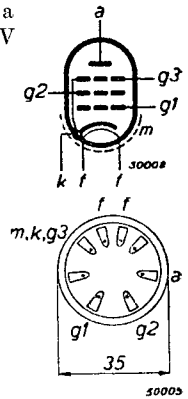
Heater current . . . . $I_f = 0.9$ A

CAPACITANCES

Anode-to-grid . . . . $C_{ag1} = < 0.8\ \mu\mu$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. .	μ_{g2g1}	= 23

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OPERATING DATA: EL 3 used in balanced output stage (2 valves)
(automatic grid bias)

Anode voltage	V_a	$= 250$ V	250 V
Screen-grid voltage	V_{g2}	$= 250$ V	250 V
Cathode resistor	R_k	$= 140$ ohms	190 ohms [1])
Anode current (without signal)	I_{ao}	$= 2 \times 24$ mA	2×31 mA
Anode current at max. modulation	$I_{a\,max}$	$= 2 \times 28.5$ mA	2×34 mA
Screen current (without signal)	I_{g20}	$= 2 \times 2.8$ mA	2×3.6 mA
Screen current at max. modulation	$I_{g2\,max}$	$= 2 \times 4.6$ mA	2×5.8 mA
Load resistor between anodes	R_{aa}	$= 10,000$ ohms	10,000 ohms
Output power	W_o	$= 8.2$ W	9 W
Distortion	d_{tot}	$= 3.1$ %	6.8 %
Alternating input voltage (per grid)	V_i	$= 6.7$ V_{eff}	5.6 V_{eff}

[1]) separate cathode resistor per valve.

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

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

MAXIMUM RATINGS

Anode voltage in cold condition	V_{ao}	$=$ max. 550 V
Anode voltage	V_a	$=$ max. 250 V
Anode dissipation	W_a	$=$ max. 9 W
Screen-grid voltage in cold condition	V_{g20}	$=$ max. 550 V
Screen voltage	V_{g2}	$=$ max. 275 V
Screen dissipation ($V_i = 0$)	W_{g2}	$=$ max. 1.2 W
Screen dissipation ($W_o =$ max.)	W_{g2}	$=$ max. 2.5 W
Cathode current	I_k	$=$ max. 55 mA
Grid voltage at grid current start ($I_{g1} = + 0.3$ μA)	V_{g1}	$=$ max. -1.3 V
External resistance between grid and cathode	R_{g1k}	$=$ max. 1 M ohm
External resistance between filament and cathode	R_{fk}	$=$ max. 5,000 ohms
Voltage between filament and cathode (D.C. voltage or effective value of alternating voltage)	V_{fk}	$=$ max. 50 V

Ia(mA)

Wa = 9W

Vg2 = 250 V

Ra = 7000 Ω.

Vg1 = 0 V

-1V
-2V
-3V
-4V
-5V
-6V
-7V
-8V
-9V
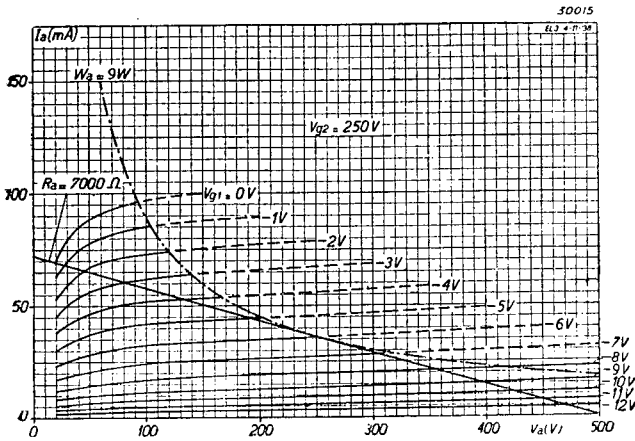-10V
-11V
-12V

Va(V)

50015

Fig. 3
Anode current as a function of the anode voltage at different values
of grid bias, at $V_{g_2} = 250$ 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_{g1k}. 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.
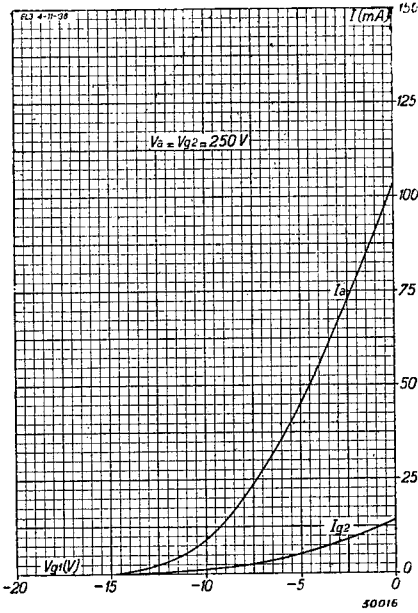
Fig. 4
Anode and screen-grid current as a function of
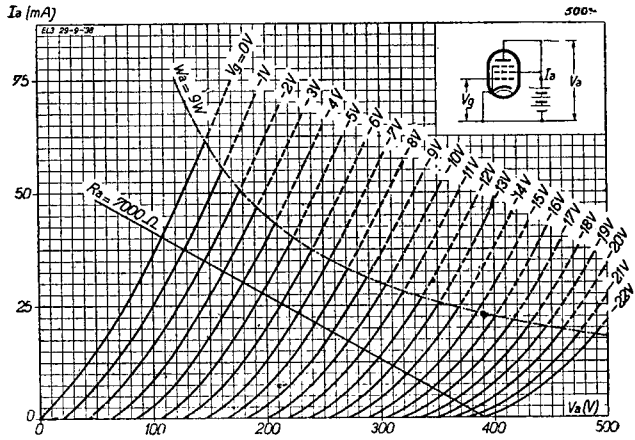the grid bias at $Va = Vg_2 = 250$ V.

Fig. 5
Anode and screen-grid current as a function of the anode voltage,
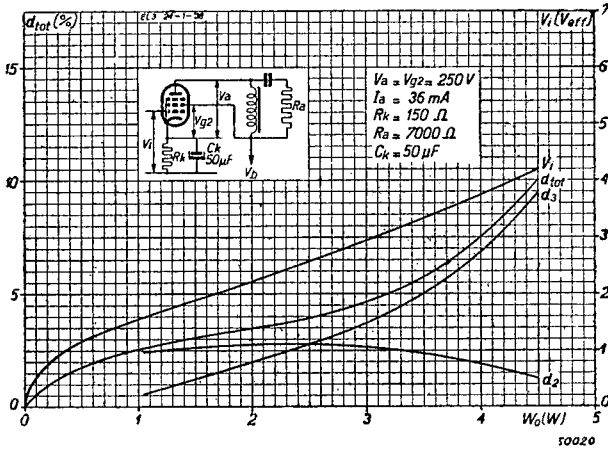with Vg as parameter. EL 3 used as a triode.

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 ($V_a = V_{g_2} = 250$ V).
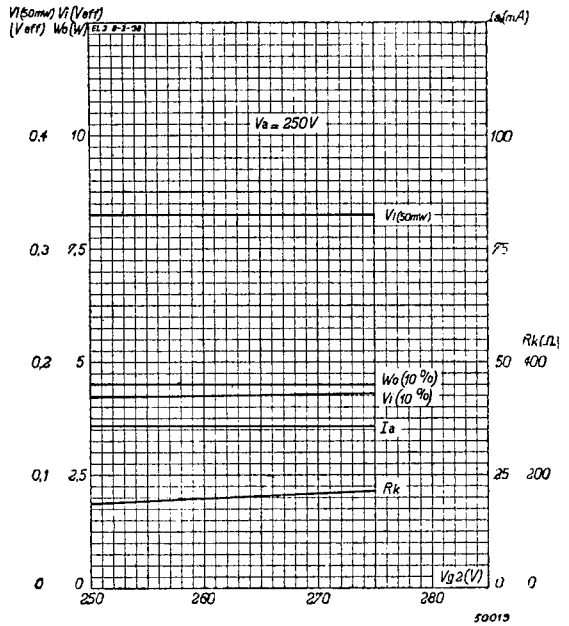

Fig. 7

Output power
with 10 % distortion. . . Wo (10 %)
Alternating grid voltage . . Vi (10 %)
Sensitivity . . . . Vi (50 mW)
Cathode resistor . . . . . . Rk
Anode current. . . . . . . Ia

as a function of the screen-grid voltage (in the range 250–275 V), at constant anode voltage ($Va = 250$ V)

Fig. 8
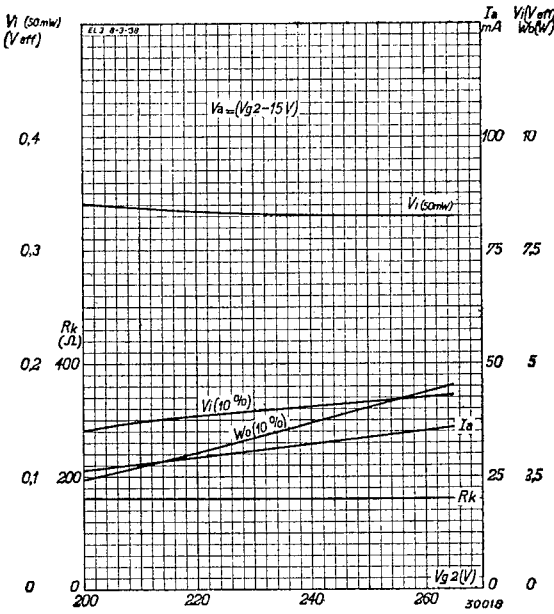
Output power
  with 10 % distortion . . . Wo (10 %)
Alternating grid voltage . . Vi (10 %)
Sensitivity . . . . Vi (50 mW)
Cathode resistor . . . . . . Rk
Anode current . . . . Ia

} as a function of the
screen-grid   voltage
(in the range
200–265 V) and at an
anode voltage of 15 V
less than the screen
potential.
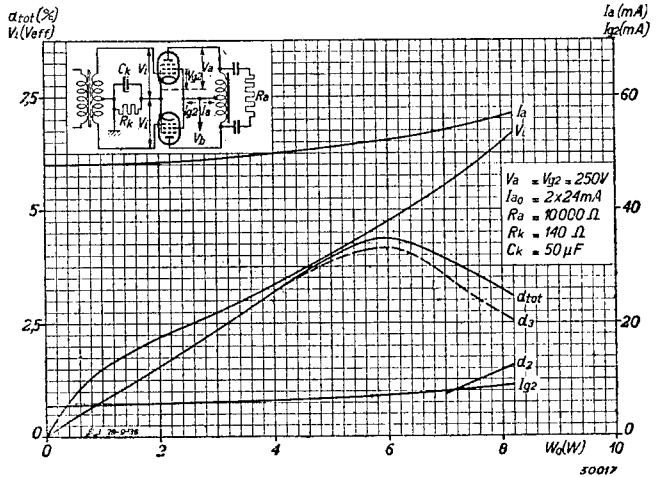

Fig. 9

Anode current Ia, screen current Ig_2, total distortion, 2nd and 3rd har-
monic distortion and alternating grid voltage Vi as functions of
the output power Wo, for 2 EL 3 valves in a balanced circuit, with
$$Va = Vg_2 = 250 \text{ V.}$$

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