Valves for A.C./D.C. receivers

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Valves for operating on both alternating and direct current are referred to briefly as A.C./D.C. valves. A full range of Philips valves is available for such receivers, all working on a heater current of 200 mA, which represents quite a low current consumption in the heater circuit. The original series of A.C./D.C. valves comprised the following:

Type No.	Type of valve	Heater voltage
CB 2	Double diode	13 V
CBC 1	Double-diode-triode	13 V
CC 2	Triode	13 V
CF 3	Variable-mu pentode	13 V
CF 7	Pentode	13 V
CH 1	Hexode	13 V
CK 1	Octode	13 V
CL 1	5 W output pentode (also for car radio)	13 V
CL 2	8 W output pentode	24 V
CL 4	Steep-slope 9 W output pentode	33 V
CY 1	Half-wave rectifying valve	20 V
CY 2	Half-wave rectifying valve and voltage doubler	30 V

This range has now been completed by the addition of a 4-channel octode, the CK 3, a double-diode pentode CBL 1 and a steep-slope output pentode for low mains supplies, the CL 6.
Of the modern "Miniwatt", E-type valves, quite a number are also suitable for A.C./D.C. receivers, namely those whose current consumption is 200 mA at 6.3 V; these valves can be connected with their heaters in series with any other specific A.C./D.C. valves and comprise the so-called pre-amplifiers, such as R.F. pentodes, frequency-changers and A.F. amplifiers; output valves and rectifying valves in general require more heater power than 1.26 W and their current consumption is therefore more than 200 mA. They are, of course, not suitable for series feeding. In the design of A.C./D.C. receivers, incorporating the red"E"-type valves, a choice must be made from among the valves in the existing range as far as output and rectifying valves are concerned. For the mixer stage the triode-hexode ECH 3 is recommended.

In order to complete the range of A.C./D.C. valves, using the 1.26 W, E-types, the following should also be added.

Type No.	Type of valve	Heater voltage
CBL 1	Double-diode output pentode	44 V
CK 3	4-channel octode	19 V
CL 4	Steep-slope output pentode	33 V
CL 6	Steep-slope output pentode for 100 V supply	35 V
CY 1	Half-wave rectifying valve.	20 V
CY 2	Half-wave rectifying valve and voltage doubler	30 V

In the following pages the data and characteristics of the 200 mA valves are given; the red pre-amplifier valves (E-type) have already been fully described in the foregoing.

CBL 1 Double-diode output pentode

The CBL 1 is a combination of double-diode and steep-slope pentode for A.C./D.C. receivers, both units being housed in a common envelope; the cathode is also common to both.
The pentode unit is comparable with the high-mutual-conductance output pentode CL 4.
In view of the considerable heater power required, the heater voltage, with a current of 200 mA, is 44 V. The two diodes are mounted below the pentode section, on each side of the cathode, with the anodes, which are almost semi-cylindrical in shape, level with each other; the diodes are, therefore, electrically identical. Further, the diode unit is separated from the pentode section by a screen and, to ensure that the grid of the pentode cannot be affected in any way by the diodes, and also to prevent hum, the control-grid connection is taken out to a top cap on the envelope.

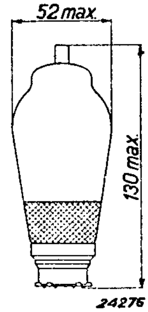


Fig. 1
Dimensions in mm.

HEATER RATINGS

Heating: indirect by A.C. or D.C., series supply.

Heater voltage	V_f	= 44 V
Heater current	I_f	= 0.200 A

CAPACITANCES

C_{ag1}	< 1.0 μμF	$C_{d'f}$	< 0.5 μμF
$C_{d'a}$	< 0.2 μμF	C_{df}	< 1 μμF
C_{da}	< 0.4 μμF	$C_{d'k}$	= 3.5 μμF
$C_{d'g1}$	< 0.15 μμF	C_{dk}	= 3.6 μμF
C_{dg1}	< 0.15 μμF	$C_{d'd}$	< 0.25 μμF

OPERATING DATA

Anode voltage	V_a	= 200 V
Screen-grid voltage	V_{g2}	= 200 V
Cathode resistor	R_k	= 170 ohms
Grid bias	V_{g1}	= —8.5 V
Anode current	I_a	= 45 mA
Screen-grid current	I_{g2}	= 6 mA
Mutual conductance	S	= 8 mA/V
Internal resistance	R_i	= 40,000 ohms
Load resistor	R_a	= 4,500 ohms
Output power with 10 % distortion	W_o	= 4 W
Alternating input voltage for 4 W output	V_i	= 5 V_{eff}
Sensitivity (W_o = 50 mW)	V_i	= 0.5 V_{eff}

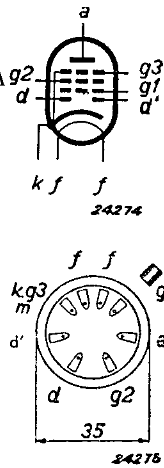


Fig. 2
Arrangement of electrodes and base connections

MAXIMUM RATINGS

Pentode section:

V_{ao}	= max. 550 V
V_a	= max. 250 V
W_a	= max. 9 W
V_{g2o}	= max. 550 V
V_{g2}	= max. 250 V
W_{g2} (V_i = 0)	= max. 1.2 W
W_{g2} (W_o = max)	= max. 2 W
I_k	= max. 70 mA
V_{g1} (I_{g1} = + 0.3 μA)	= max. —1.3 V
R_{g1k}	= max. 1 M ohm
R_{fk}	= max. 5,000 ohms
V_{fk}	= max. 175 V [1])

[1]) Direct voltage or effective value of alternating voltage

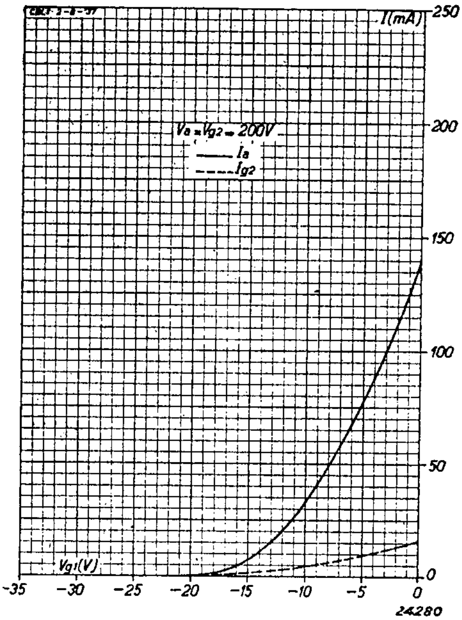


Fig. 3
Anode and screen current as a function of the grid bias at V_a = V_{g2} = 200 V.

Diode section:

Voltage on anode of diode	V_d	= V_d'	= max. 200 V
Diode current	I_d	= I_d'	= max. 0.8 mA
Diode voltage at diode current start (I_d = I_d' = + 0.3 μA)	V_d	= V_d'	= max. -1.3 V

The characteristics relating to the increase in the voltage ($\triangle$ V) across the grid leak, as plotted against theun modulated R.F. voltage, and for the A.F. voltage V_{LF} across the grid leak as a function of the 30 % modulated R.F. voltage applied to one of the diodes, are exactly the same as those of the EB 4, so for these data the reader is referred to the last-mentioned valve.

Grid bias must be provided only by means of a cathode resistor; semi-automatic bias is also permissible, but the cathode current of the valve must then be definitely in excess of 50 % of the total current passing through the resistor producing the voltage drop.

In general, the capacitance of the decoupling capacitor should be at least 2 μF, but for better reproduction of the lower audio frequencies an electrolytic capacitor of 25 tot 50 μF capacitance is better. Leads to the valve contacts should be kept as short as possible and a resistor of about 1000 ohms in the control-grid lead will often be found necessary.

It should be observed that any A.F. amplification between the detector diode and the pentode section of the valve may possibly give rise to trouble due to hum or microphony. Any such amplification should therefore not exceed at most 15 times.

Tables I and II provide an idea of the power delivered, having regard to the voltage drop across the output transformer. The theoretical circuit diagrams employed to obtain the values given in these tables are depicted in the figures relating to the EL 2 valve.

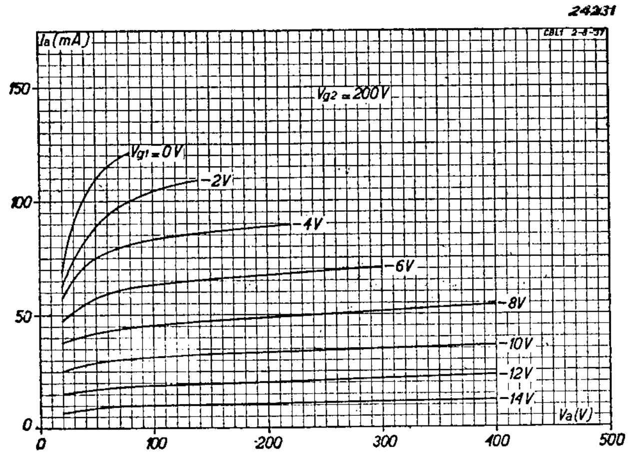


Fig. 4
Anode current as a function of the anode voltage at Vg_2 = 200 V, for different values of grid bias.

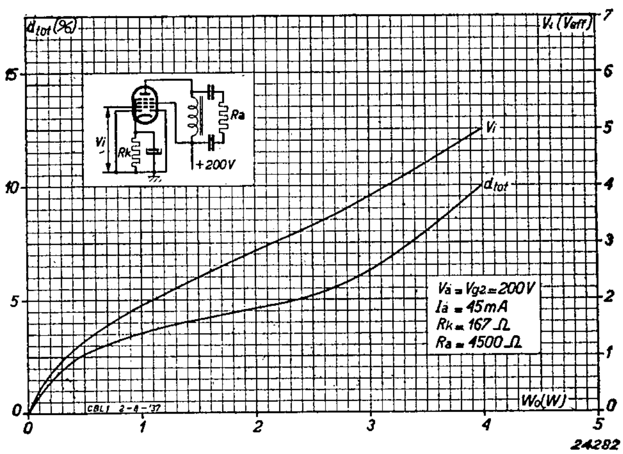


Fig. 5
Alternating grid voltage and total distortion as functions of the output power.

TABLE I

Output power and grid input voltage as functions of the voltage drop in the output transformer, on an effective anode voltage of 200 V D.C.

$I_a = 45$ mA

Effective D.C. volts on the anode V_a (V)	Supply voltage V_b (V)	Screen-grid series resistor R_{g_2} (ohm)	Voltage drop across output transf. V_{tr} (V)	With 10 % distortion: Ext. anode res. R_a (ohm)	With 10 % distortion: Alt. grid volts V_i (Veff)	With 10 % distortion: Output power W_o (W)	With 5 % distortion: Ext. anode res. R_a (ohm)	With 5 % distortion: Alt. grid volts V_i (Veff)	With 5 % distortion: Output power W_o (W)	Loss in power in output transf. $\frac{W_{tr} \times 100}{W_o}$ (%)
200	200	0	0	4,500	4.4	4.0	4,500	2.7	2.1	—
200	210	1,800	10	4,500	4.3	3.7	4,500	2.5	1.8	10
200	220	3,400	20	4,500	4.25	3.6	4,500	2.4	1.6	20
200	230	5,000	30	4,500	4.2	3.5	4,500	2.3	1.5	30
200	250	8,500	50	4,500	4.1	3.3	4,500	2.3	1.5	50

TABLE II

Output power and grid input voltage as functions of the voltage drop in the output transformer when the screen and supply voltage = 200 V.

$I_a = 45$ mA

Effective D.C. volts on the anode V_a (V)	Supply voltage V_b (V)	Screen-grid voltage V_{g_2} (V)	Voltage drop across output transf. V_{tr} (V)	With 10 % distortion: Ext. anode res. R_a (ohm)	With 10 % distortion: Alt. grid volts V_i (Veff)	With 10 % distortion: Output power W_o (W)	With 5 % distortion: Ext. anode res. R_a (ohm)	With 5 % distortion: Alt. grid volts V_i (Veff)	With 5 % distortion: Output power W_o (W)	Loss in power in output transf. $\frac{W_{tr} \times 100}{W_o}$ (%)
200	200	200	0	4,500	4.4	4.0	4,500	2.7	2.1	0
190	200	200	10	4,200	4.4	3.5	4,200	2.5	1.85	11
180	200	200	20	4,000	4.3	3.4	4,000	2.6	1.75	22
170	200	200	30	3,800	4.3	2.9	3,800	2.7	1.65	35
150	200	200	50	3,350	4.2	2.6	3,350	2.9	1.65	66

Note: The loss of power due to the resistance of the output transformer is calculated on the assumption that $R_{prim} = n^2 R_{sec}$.

CK 3 Octode

This is an octode of the 4-channel type; with the exception of the heater ratings it is similar to the EK 3, for A.C./D.C. receivers. With a view to its use on 100 V mains, the sixth grid has been modified slightly, but the data as given for the EK 3 also apply to this valve, which offers the same advantages with respect to frequency drift, induction effect, conversion conductance, cross-modulation, oscillator slope, etc.

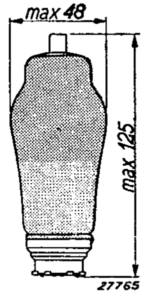


Fig. 1
Dimensions in mm

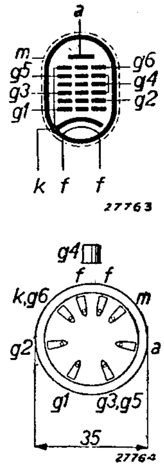


Fig. 2
Arrangement of electrodes and base connections.

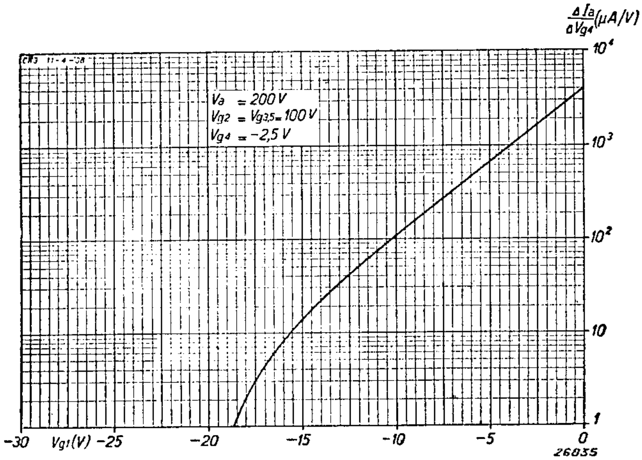


Fig. 3
Conductance of the 4th grid as a function of the direct voltage on grid 1.

HEATER RATINGS

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

Heater voltage . . . . V_f = 19 V

Heater current . . . . I_f = 0.200 A

CAPACITANCES

C_{ag4} < 0.1 μμF	C_{g1g4} = 1.1 μμF
C_a = 16.5 μμF	C_{g2} = 8.6 μμF
C_{g1} = 14 μμF	C_{g4} = 15.2 μμF

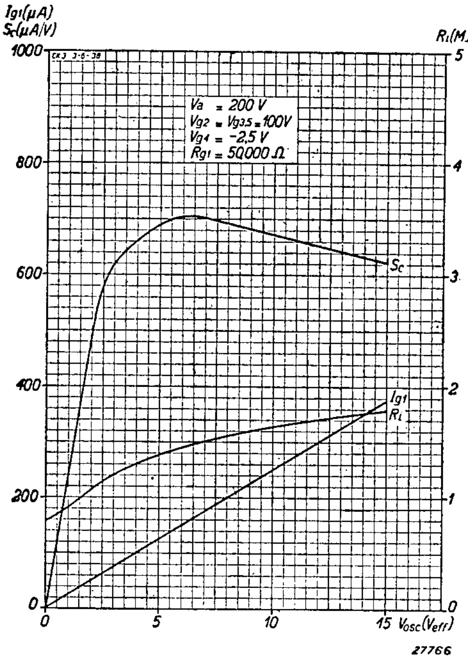


Fig. 4
Internal resistance, conversion conductance and oscillator-grid current as functions of the oscillator voltage, for a grid leak of 50,000 ohms, with Va = 200 V.

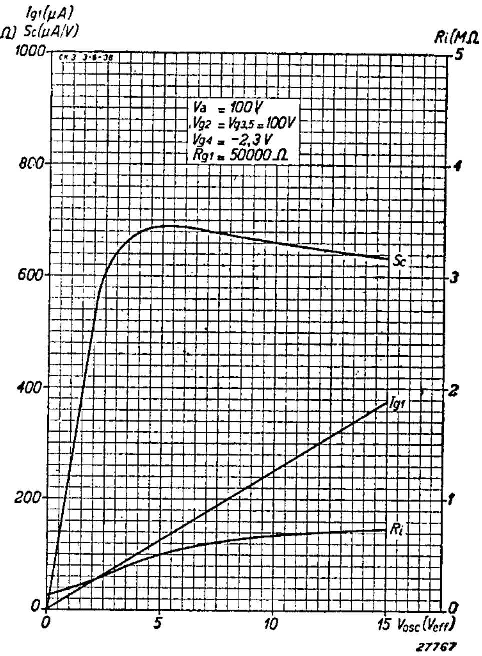


Fig. 5
Internal resistance, conversion conductance and oscillator-grid current as functions of the oscillator voltage, for a grid leak of 50,000 ohms, with Va = 100 V.

OPERATING DATA: CK 3 used as frequency-changer 200 V

Anode voltage	V_a	= 200 V		
Screen-grid voltage	$V_{g3,5}$	= 100 V		
Oscillator-anode voltage	V_{g2}	= 100 V		
Grid leak, oscillator	R_{g1}	= 50,000 ohms		
Alternating oscillator voltage, grid 1	$V_{g1(osc)}$	= 12 V_{eff}		
Oscillator-grid current	I_{g1}	= 300 μA		
Cathode resistor	R_k	= 190 ohms		
Bias, grid 4	V_{g4}	= —2.5 V [1])	—38 V [2])	—42 V [3])
Anode current	I_a	= 2.5 mA	—	—
Screen-grid current	$I_{g3} + I_{g5}$	= 5.5 mA	—	—
Oscillator-anode current	I_{g2}	= 5 mA	—	—
Conversion conductance	S_c	= 650	6.5	3 μA/V
Internal resistance	R_i	= 1.7	> 10	> 10 M ohms
Conductance: grid 1 with respect to grid 2 ($V_{osc} = 0$)	S_{g1g2}	= 4 mA/V	—	
Oscillator-anode current at threshold of oscillation ($V_{osc} = 0$)	I_{g2}	= 18 mA	—	

[1]) Without control.
[2]) Conductance reduced to one-hundredth of uncontrolled value.
[3]) Limit of control.

100 V

Anode voltage	V_a	= 100 V		
Screen-grid voltage	$V_{g3,5}$	= 100 V		
Oscillator-anode voltage	V_{g2}	= 100 V		
Oscillator grid leak	R_{g1}	= 50,000 ohms		
Alternating oscillator voltage, grid 1	$V_{g1(osc)}$	= 12 V_{eff}		
Oscillator-grid current	I_{g1}	= 300 μA		
Cathode resistor	R_k	= 175 ohms		

Bias, grid 4	V_{g4}	= —2.3 V [1]	—38 V [2]	—42 V [3]
Anode current	I_a	= 2.5 mA	—	—
Screen-grid current	$I_{g3} + I_{g5}$	= 5.5 mA	—	—
Oscillator-anode current	I_{g2}	= 5 mA	—	—
Conversion conductance	S_c	= 650	6.5	3 μA/V
Internal resistance	R_i	= 0.7	> 10	> 10 M ohms
Conductance, grid 1 with respect to grid 2 ($V_{osc} = 0$)	S_{g1g2}	= 4 mA/V	—	—
Oscillator-anode current at threshold of oscillation ($V_{osc} = 0$)	I_{g2}	= 18 mA	—	—

[1]) Without control.
[2]) Conductance reduced to one-hundredth of uncontrolled value.
[3]) Limit of control.

MAXIMUM RATINGS

Anode voltage in cold condition	V_{a0}	= max. 550 V
Anode voltage	V_a	= max. 300 V
Anode dissipation	W_a	= max. 1 W
Screen voltage in cold condition	$V_{g3,50}$	= max. 550 V
Screen voltage	$V_{g3,5}$	= max. 150 V
Screen dissipation	$W_{g3,5}$	= max. 1 W
Oscillator-anode voltage, cold	V_{g20}	= max. 550 V
Oscillator-anode voltage	V_{g2}	= max. 150 V
Oscillator-anode dissipation	W_{g2}	= max. 1 W
Cathode current	I_k	= max. 23 mA
Grid voltage at grid current start ($I_{g4} = +0.3\,\mu$A)	V_{g4}	= max. —1.3 V
External resistance between grid 4 and cathode	R_{g4k}	= max. 3 M ohms
External resistance between grid 1 and cathode	R_{g1k}	= max. 100,000 ohms
External resistance between heater and cathode	R_{fk}	= max. 20,000 ohms
Voltage between heater and cathode (direct voltage or effective value of alternating voltage)	V_{fk}	= max. 100 V

The frequency drift in this octode will be at its minimum when the tuned oscillator circuit is coupled to the oscillator anode; the coupling coil is then connected to the control grid and Fig. 7 shows the method of arranging the feeds. The direct voltage is applied to the oscillator anode across a resistor of 30,000 ohms.

The direct voltage on the oscillator anode must be 100 V; on 110 V mains this is of the same order as the supply voltage and the series resistor should then actually be much less than 30,000 ohms, but this, again, is not feasible since the oscillator circuit is damped by this resistor and either the oscillator voltage in the short and medium ranges would then be too small, or it would not be possible to maintain it. An alternative method is to use the CK 3 in the other type of circuit, shown in Fig. 8, although a drawback to this arrangement is that extra contacts have to be provided in the wave-change switch for changing over the padding capacitor C_p. However, Fig. 9 offers a better solution that can be quite serviceable on a high intermediate frequency, provided that the padding capacitance is kept fairly small. In the long-wave range, for instance, this capacitance is of the order of 200 $\mu\mu$F, but this is insufficient for by-passing the feed resistor of 5,000 ohms and would produce too much damping of the oscillator circuit; in the other wave ranges, in which C_p is of a higher value, this does not apply to such an extent, so that the type of circuit shown in Fig. 7 may be used for the long-wave range and that of Fig. 9 for the other ranges; the combined circuit is shown in Fig. 10. On long waves, when switches S_1 and S_2 are open, the circuit closely resembles that of Fig. 7, although the feed is not applied at the extreme "top" of the circuit. The oscillator circuit is thus fairly heavily damped by the resistor of 5,000 ohms, but on long waves it is not a difficult matter to obtain a sufficiently tight coupling.

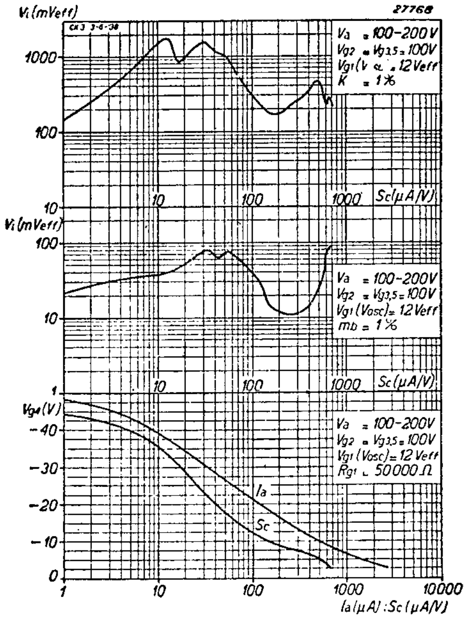


Fig. 6

Upper diagram. Input signal as a function of the conversion conductance as controlled by the bias on the 4th grid, with 1 % cross-modulation. (Conductance and voltage on logarithmic scale)

Centre diagram. Input signal as a function of the conversion conductance as controlled by the bias on the 4th grid, with 1 % modulation hum. (Conductance and voltage on logarithmic scale)

Lower diagram. Conversion conductance and anode current (logarithmic scale) as a function of the bias on grid 4 (on linear scale).

On the medium waves, with S_1 closed, the circuit is as shown in Fig. 9; the padding capacitor is large enough, as is also the case for the short waves.

If it is necessary to isolate the tuning capacitor from the D.C. supply of 100 V, a fixed capacitor of fairly high capacitance is placed in series with it, although this is superfluous if the tuned oscillator circuit is connected to the first grid. The frequency drift due to control of the voltage on the 4th grid is then somewhat more, but this must be accepted if control on the valve is essential.

It should be noted that no account has been taken of the 100 V D.C. occurring on the contacts of the wave-change switch and in many instances this will not be acceptable in view of prevailing safety precautions. High-capacitance isolating capacitors then have to be included, but if this is considered too costly the only alternative is to connect the tuned oscillator circuit to the first grid.

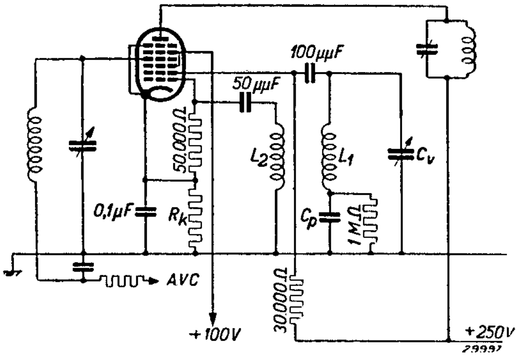


Fig. 7
Oscillator anode fed through a resistor of 30,000 ohms. This circuit is not suitable for the CK 3 when used on 100 V supply.

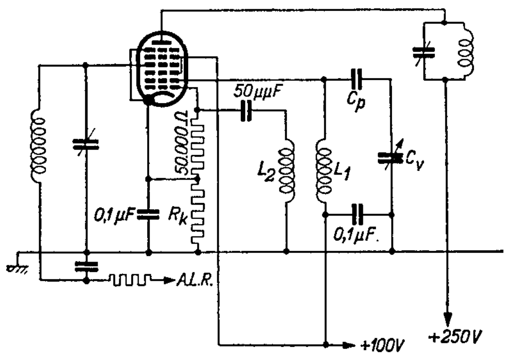


Fig. 8
Oscillator anode fed through the tuning coil. This arrangement is suitable for 100 V supply but has the disadvantage that the padding capacitors for the different wave ranges have to be switched.

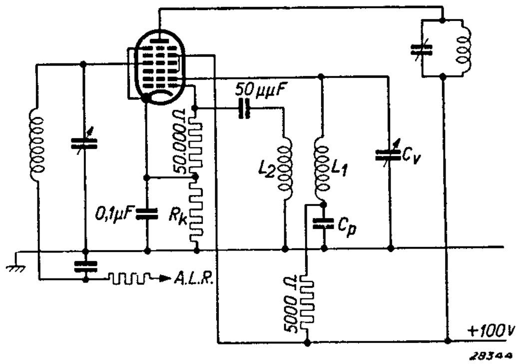


Fig. 9
Oscillator anode fed through the tuning coil using a series resistor of 5,000 ohms.

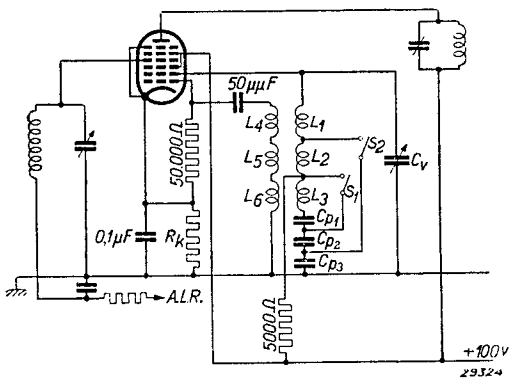


Fig. 10
Combination of circuits of Figs 7 and 9

CL 4 Output pentode

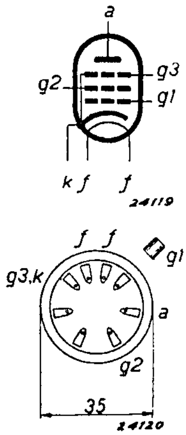


Fig. 2
Arrangement of electrodes and base connections.

The CL 4 is an indirectly-heated 9 W output pentode of high mutual conductance, especially for use in A.C./D.C. receivers; it lends itself admirably to the construction of simple types of receivers. As the mutual conductance, as stated, is very high, the heater power is also on the high side; the current with 33 V is 200 mA.

The CL 4 may be employed either as a Class A amplifier or in balanced output circuits, and in the latter instance will deliver 8 W with 1.5 % distortion; with a potential of 250 V on both anode and screen, as much as 13.5 W can be obtained from this valve with 5.7 % distortion (the anode-to-anode load is 6,000 ohms). The cathode biasing resistor must then be 175 ohms and the alternating grid voltage 12.5 $V_{(eff)}$, per grid.

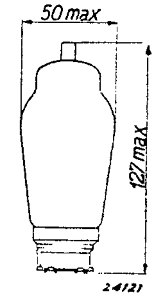


Fig. 1
Dimensions in mm.

HEATER RATINGS

Heating: indirect, by A.C. or D.C., series supply.

Heater voltage	V_f	= 33 V
Heater current	I_f	= 0.200 A

CAPACITANCES

Anode-grid	C_{ag1}	< 1 μμF

OPERATING DATA: CL 4 used as single output valve

Anode voltage	V_a	= 200 V
Screen-grid voltage	V_{g2}	= 200 V
Cathode resistor	R_k	= 170 ohms
Grid bias	V_{g1}	= —8.5 V
Anode current	I_a	= 45 mA
Screen-grid current	I_{g2}	= 6 mA
Mutual conductance	S	= 8 mA/V
Internal resistance	R_i	= 35,000 ohms
Load resistor	R_a	= 4,500 ohms
Output power with 10 % distortion	W_o	= 4 W
Alternating input voltage	V_i	= 5 V_{eff}
Sensitivity (W_o = 50 mW)	V_i	= 0.5 V_{eff}

OPERATING DATA: CL 4 used in balanced stage (2 valves)

Anode voltage	V_a	= 200 V
Screen-grid voltage	V_{g2}	= 200 V
Cathode resistor	R_k	= 135 ohms
Anode current (without signal)	I_{ao}	= 2 × 33 mA
Anode current at max. modulation	I_{amax}	= 2 × 40 mA
Screen-grid current (without signal)	I_{g2o}	= 2 × 3.5 mA
Screen-grid current at max. modulation	I_{g2max}	= 2 × 6 mA
Load resistor, anode-to-anode	R_{aa}	= 4,500 ohms
Output power at max. modulation	W_o	= 8 W
Total distortion at max. modulation	d_{tot}	= 1.5 %

MAXIMUM RATINGS

V_{ao}	= max. 400 V
V_a	= max. 250 V
W_a	= max. 9 W
V_{g2o}	= max. 400 V
V_{g2}	= max. 250 V
W_{g2}	= max. 2 W
I_k	= max. 70 mA
$V_{g1}(I_{g1}=+0.3\mu A)$	= max. —1.3 V
R_{g1k}	= max. 1 M ohm
R_{fk}	= max. 5,000 ohms
V_{fk}	= max. 125 V [1])

[1]) Direct voltage or effective value of alternating voltage.

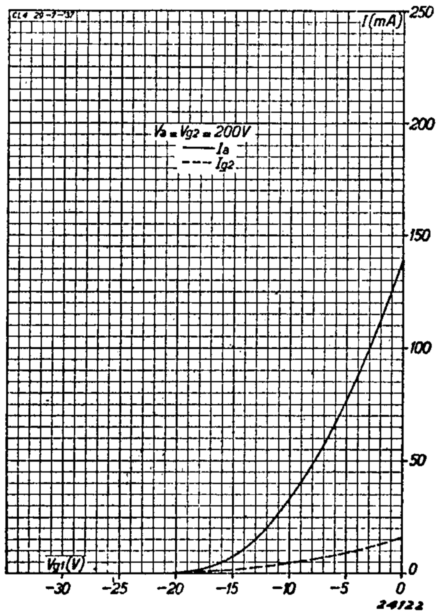


Fig. 3
Anode current as a function of the grid bias at $V_a = V_{g2} = 200$ V.

Grid bias is to be obtained only by means of a cathode resistor; semi-automatic bias may be employed provided that the cathode current of the valve is more than 50 % of the current passing through the resistor producing the voltage drop. The decoupling capacitor should, generally speaking, be 2 μF, but for better reproduction of the lower tones it is better to use an electrolytic capacitor of 25 to 50 μF.

Leads to the valve contacts must be kept as short as possible, whilst a resistor of about 100 ohms in the control grid circuit is often desirable. Tables I and II relating to the CBL 1 also apply to this valve; they provide details of the output power, having regard to the voltage drop in the output transformer. The circuits employed for the measurements given in these tables are reproduced in the text relating to the EL 2.

In balanced output circuits employing two type CL 4 valves, a suitable pre-amplifier is the EBC 3, the EF 6 connected as triode, or the CL 4, also connected as triode. A satisfactory ratio for the coupling transformer is 1 : (2 + 2) for the EBC 3 and EF 6 (as triode), or 1 : (3 + 3) for the CL 4 (as triode).

The CL 4 is also very useful in A.C./D.C. receivers employing negative feed-back to reduce distortion and to improve the frequency-response curve of the amplifier.

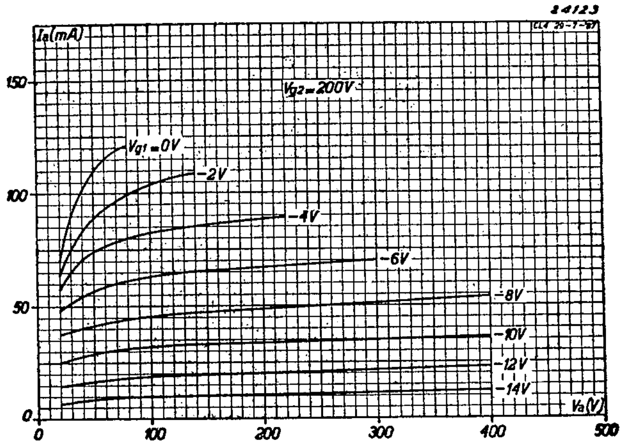


Fig. 4
Anode current as a function of the anode voltage at V_{g_2} = 200 V, for different values of grid bias.

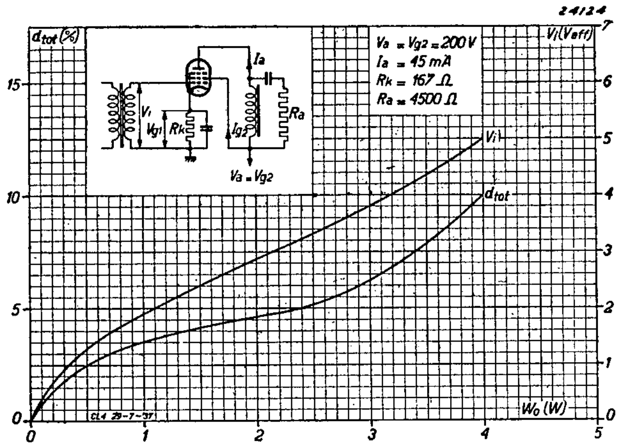


Fig. 5
Alternating grid voltage and total distortion as functions of the output power of the CL 4 when used as a single output valve.

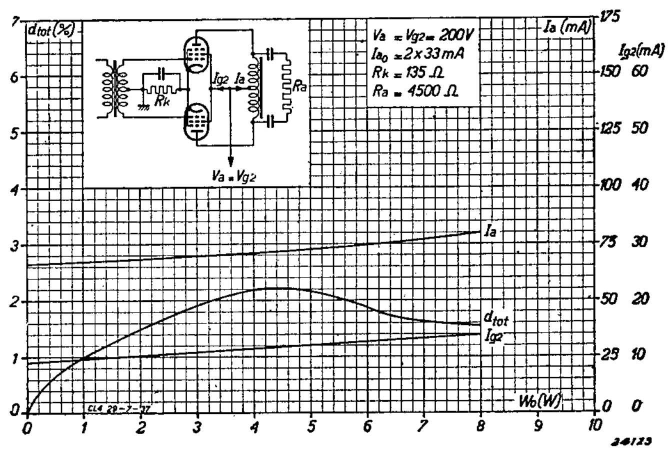


Fig. 6
Anode current, screen current and total distortion as functions of the output power for two CL 4 valves in a balanced output stage.

CL 6 Output pentode

The CL 6 is a highly sensitive output pentode designed for use in A.C./D.C. receivers operating on low-voltage mains. In such cases the screen voltage needs to be about 100 V, this being the reason why the CL 6, as well as the CL 2, has been designed on that basis. With $V_a = V_{g2} = 100$ V, the anode current is 50 mA, which gives the CL 6 an output of 5 W. The mutual conductance is then 8.5 mA/V and, when properly matched, the valve delivers 2.1 W with 10 % distortion. The alternating grid voltage under these conditions is 5.6 $V_{(eff)}$, the sensitivity being 0.62 $V_{(eff)}$.

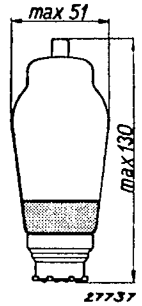


Fig. 1
Dimensions in mm.

The high mutual conductance of this valve is an advantage in that, in receivers designed to use the CL 4 as pre-amplifier valve, the CL 6 can also be employed without any modification to the circuit. In A.C./D.C. receivers for use on low-voltage mains, another advantage of the steep-slope pentode is that, owing to the high conductance, the alternating grid voltage is very much lower than in an average output valve. As the bias is produced by means of a cathode resistor, or by the voltage drop across a resistor in the negative H.T. line, and therefore reduces the amount of anode voltage available for the output valve, it is obviously an advantage to ensure that the grid bias takes the smallest possible proportion of the direct voltage available. The necessary bias for the CL 6 is —8.3 V, with $V_a = V_{g2} = 100$ V, as against —15 V in the case of the CL 2. The CL 6 thus ensures a voltage which is 6.7 V higher, this being a not inconsiderable difference, on low-voltage mains.

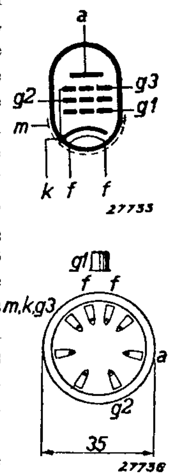


Fig. 2
Arrangement of electrodes and base connections.

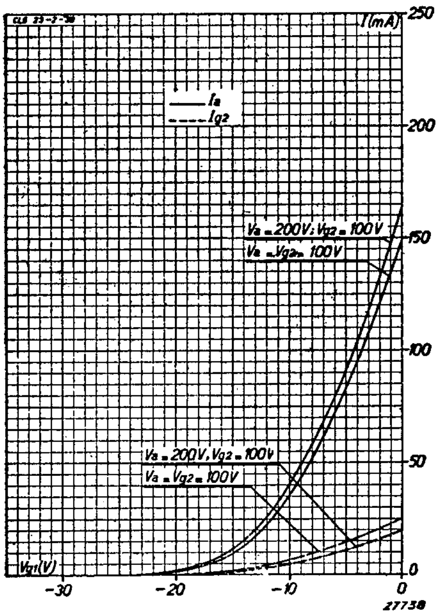


Fig. 3
Anode current and screen current as functions of the grid bias, with $V_{g2} = 100$ V and V_a = 100 and 200 V.

A.C./D.C. receivers are often designed for switching over from high to low-voltage mains and vice versa, and in view of this the possibility of using an anode potential of 200 or 250 V has also been taken into account in the design of the valve; at the higher anode voltages it can be used as a 9 W output valve. The screen potential must in no case exceed 125 V and should, therefore, always be applied through a resistor or potential divider. For A.C./D.C. sets operating only on high-voltage mains it is more economical to use the CL 4.

With 200 V on the anode and 100 V on the screen, the mutual conductance is

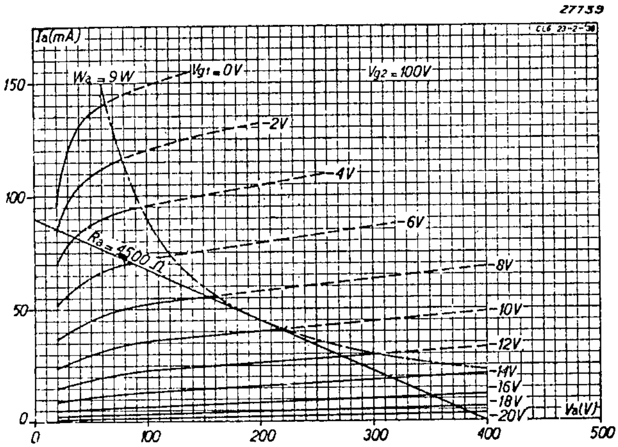


Fig. 4
Anode current as a function of the anode voltage at Vg_2 = 100 V, with grid bias as parameter.

8 mA/V, in which case the valve is similar to the CL 4. The output power with 10 % distortion is 4 W, the alternating grid voltage being 5.6 V(eff). As receivers designed for switching to either high or low-voltage mains generally give some trouble in the switching of the biasing (cathode) resistor, the same resistor is employed on a working voltage of 200 as on 100 V. With a view to ensuring a low current, in order to obtain the least possible voltage drop in the rectifier smoothing circuit, it is usual to connect a resistor in series with the screen.

The bias resistor for a working voltage of 100 V, is 140 ohms, from which it follows that the resistance in series with the screen, on 200 V, should be 27,000 ohms, this giving an output of 2.6 W with 8 % distortion. In order to obtain a higher output, A.C./D.C. sets intended for use on low voltages are frequently provided with a balanced output stage, in which case the CL 6 delivers 4 W with 5 % distortion, on $V_a = V_{g2}$ = 100 V; the alternating grid voltage is 6.7 V(eff) per grid. In small portable amplifiers for operation on all mains voltages the CL 6 in a balanced output stage is very useful in view of its suitability for switching over from high mains to low and vice versa. On anode voltages of 200 and 250 V the power is quite considerable, this being another feature in its favour in small amplifiers. A balanced circuit with 125 V on the screens and 200 V on the anodes will deliver a maximum of 12 W with 1.8 % distortion, whilst with an anode voltage of 250, 13.5 W with 6.3 % distortion can be obtained.

The grid connection of this valve is placed at the top of the envelope in order to keep hum at a minimum.

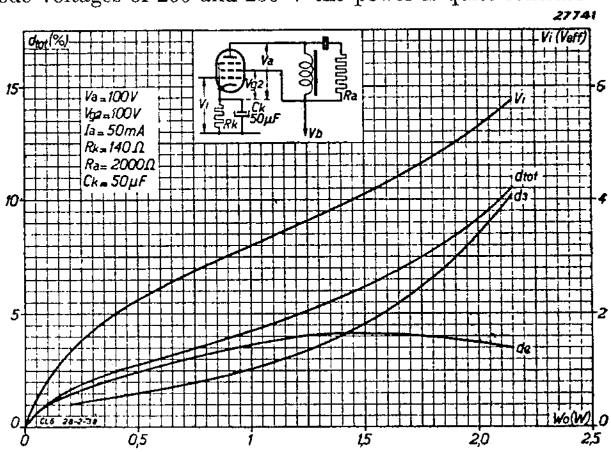


Fig. 5
Total distortion, 2nd and 3rd harmonic distortion and alternating grid voltage of the CL 6 when used as single output valve with automatic bias. $Va = Vg_2$ = 100 V.

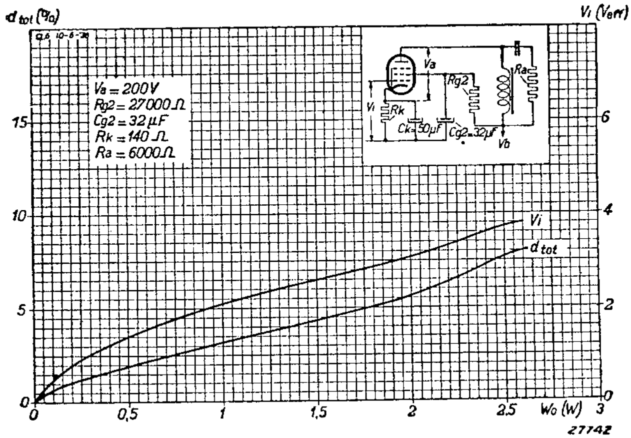


Fig. 6
Total distortion and alternating grid voltage; CL 6 used as single output valve with automatic bias. $Va = 300$ V, $Rg = 27{,}000$ ohms.

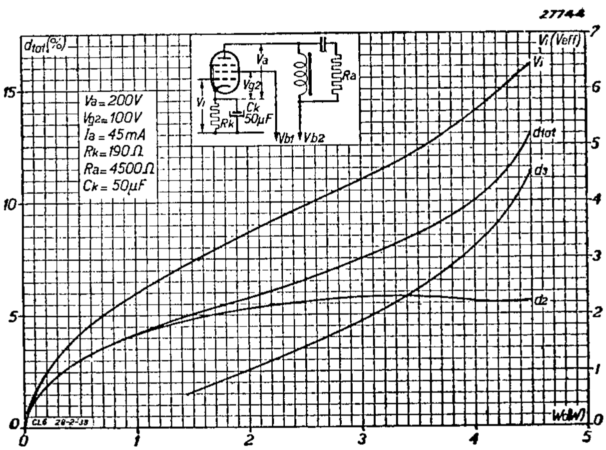


Fig. 7
Total distortion, 2nd and 3rd harmonic distortion and alternating grid voltage; CL 6 used as single output valve with automatic bias. $Va = 200$ V, $Vg_2 = 100$ V.

HEATER RATINGS

Heating: indirect by A.C. or D.C., series supply.
Heater voltage . . . . $V_f = 35$ V
Heater current . . . . $I_f = 0.200$ A

CAPACITANCES

Anode-grid . . . . $C_{ag1} < 0.5$ μμF

OPERATING DATA: CL 6 used as single output valve

Anode voltage	V_a	= 100 V	200 V	200 V
Screen-grid voltage	V_{g2}	= 100 V	—	100 V
Screen series resistor	R_{g2}	= —	27,000 ohms	—
Screen decoupling capacitor	C_{g2}	= —	32 μF	—
Cathode resistor	R_k	= 140 ohms	140 ohms	190 ohms
Grid bias	V_{g1}	= —8.3 V	—	—9.5 V
Anode current	I_a	= 50 mA	45 mA	45 mA
Screen-grid current	I_{g2}	= 9 mA	4.5 mA	5.5 mA
Mutual conductance	S	= 8.5 mA/V	—	8 mA/V
Internal resistance	R_i	= 12,000 ohms	—	22,000 ohms
Load resistor	R_a	= 2,000 ohms	6,000 ohms	4,500 ohms
Output power	W_o	= 2.1 W	2.6 W	4 W
Distortion	d_{tot}	= 10 %	8 %	10 %
Alternating grid voltage	V_i	= 5.6 V_{eff}	3.8 V_{eff}	5.6 V_{eff}
Sensitivity ($W_o = 50$ mW)	V_i	= 0.62 V_{eff}	0.42 V_{eff}	0.47 V_{eff}
Amplification factor: grid 2 with respect to grid 1	μ_{g2g1}	= 7.0	—	6.5

OPERATING DATA: CL 6 used in balanced stage (2 valves)

Anode voltage	V_a	= 100 V	200 V	200 V	250 V
Screen-grid voltage	V_{g2}	= 100 V	—	125 V	125 V
Common screen series resistor	R_{g2}	= —	10,000 ohms	—	—
Cathode resistor, per valve	R_k	= 190 ohms	190 ohms	250 ohms	365 ohms
Anode current ($V_i = 0\,V$)	I_{ao}	= 2 × 42	2 × 45	2 × 45	2 × 36 mA
Anode current at max. modulation	$I_{a\,max}$	= 2 × 42	2 × 40	2 × 51	2 × 43 mA
Screen current ($V_i = 0\,V$)	I_{g2o}	= 2 × 7.5	2 × 5.2	2 × 5	2 × 4.1 mA
Screen current at max. modulation	I_{g2max}	= 2 × 12.5	2 × 6.2	2 × 11.7	2 × 12.5 mA
Load resistor between anodes	R_{aa}	= 3,000	6,000	4,400	7,000 ohms
Output power	W_o	= 4 W	6.8 W	12.1 W	13.5 W
Distortion at max. modulation	d_{tot}	= 5.6 %	3.5 %	1.8 %	6.3 %
Alternating input voltage, per grid	V_i	= 6.7 V_{eff}	5.9 V_{eff}	11 V_{eff}	13.7 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_{g2o}	= max. 550 V
Screen-grid voltage	V_{g2}	= max. 125 V
Screen dissipation (W_o = max.)	W_{g2}	= max. 1.5 W
Screen dissipation ($V_i = 0\,V$)	W_{g2}	= max. 1.0 W
Cathode current	I_k	= max. 70 mA
Grid voltage at grid current start ($I_{g1} = +\ 0.3\ \mu$A)	V_{g1}	= max. —1.3 V
External resistance between grid and cathode	R_{g1k}	= max. 1 M ohm
External resistance between heater and cathode	R_{fk}	= max. 5,000 ohms
Peak value of voltage between heater and cathode	V_{fk}	= max. 175 V

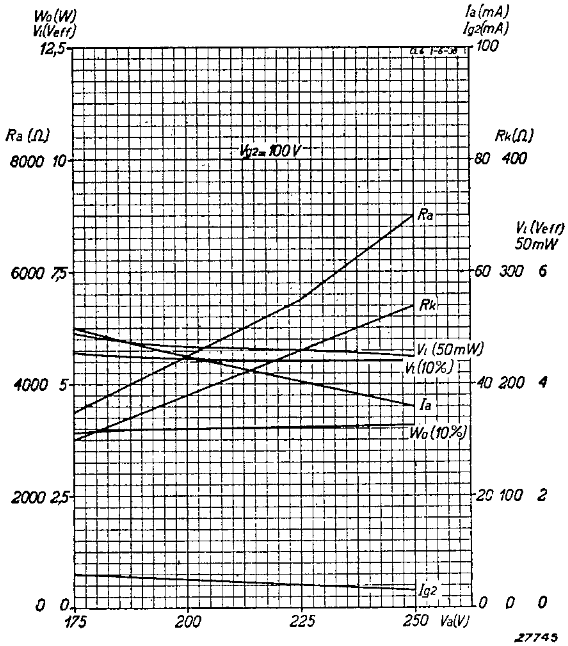


Fig. 8

Output power with 10 % distortion	Wo (10 %)	as functions of the anode voltage (within the range 175 to 250 V), for operation at Wa = 9 W, with constant screen voltage Vg_2 = 100 V.
Alternating grid voltage at 10 % distortion	Vi (10 %)	
Sensitivity	Vi (50 mW)	
Cathode resistor	Rk	
Anode current	Ia	
Screen-grid current	Ig_2	
Load resistor	Ra	

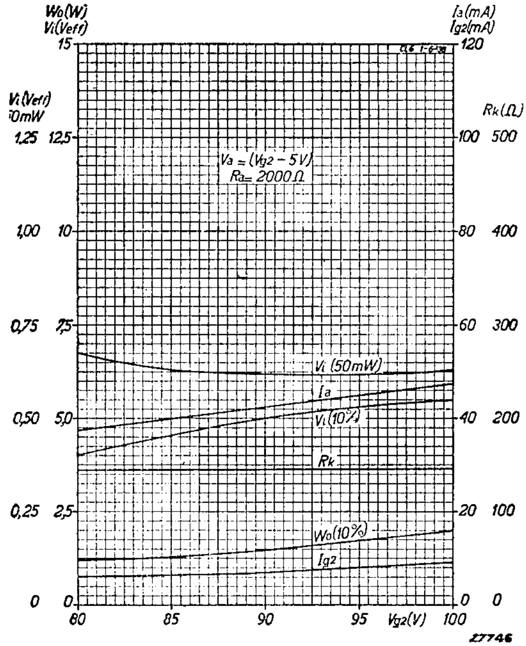


Fig. 9

Output power with 10 % distortion. . . .	*Wo* (10 %)	as functions of the screen voltage (in the range 80 to 100 V), with an anode voltage 5 V lower than that of the screen.
Alternating grid voltage at 10 % distortion	*Vi* (10 %)	
Sensitivity	*Vi* (50 mW)	
Cathode resistor	*Rk*	
Anode current.	*Ia*	
Screen current	I_{g_2}	

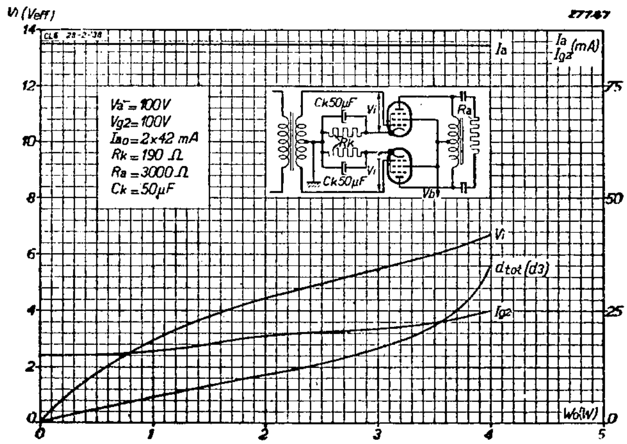


Fig. 10
Anode current *Ia*, screen current Ig_2, total distortion *dtot* (= d_3) and alternating grid voltage *Vi* as functions of the output power *Wo* for two type CL 6 valves in a balanced circuit with $Va = Vg_2 = 100$ V.

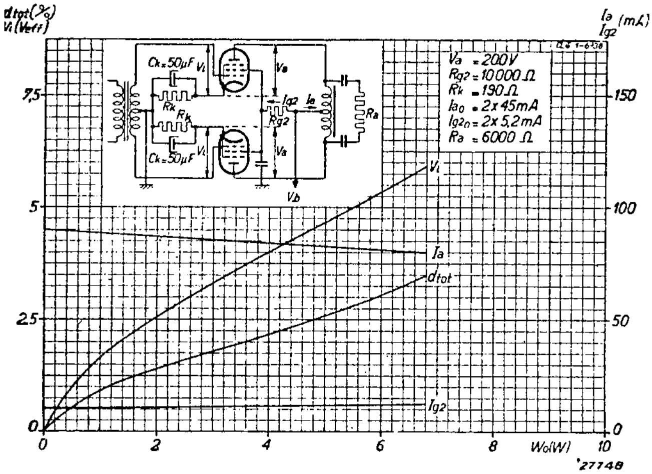


Fig. 11
Anode current I_a, screen current I_{g_2}, total distortion *dtot* and alternating grid voltage V_i as functions of the output power of the CL 6 in a balanced circuit with $V_a = 200$ V, using the same cathode resistor as for $V_a = V_{g_2} = 100$ V.

In order to show the performance of the CL 6 at other working voltages than those given in the standard data, various values have been included in the curves of Figs. 8 and 9, not only as functions of the anode voltage at a constant screen-grid potential with continuous anode dissipation, with respect to higher feed voltages, but also as plotted against V_{g_2} in the case of an anode voltage which is 5 V lower than that of the screen. In the latter instance an average voltage drop of 5 V in the output transformer has been taken into account.

Grid bias must be obtained by means of a cathode resistor only (auto. bias); semi-automatic bias is permissible only when the cathode current of the CL 6 is in excess of 50 % of the total current passing through the resistor that produces the voltage drop; the maximum value for the grid leak, as shown in the Maximum Ratings, must then be reduced in accordance with the following:

$$\frac{\text{Cathode current of the output valve}}{\text{Total current passing through resistor producing the voltage drop}} \times R_{g1k}.$$

In this case, moreover, it must be remembered that the current in those valves which are subjected to control will affect the bias of the output valve; in other words, when the control is operating, the bias very quickly becomes too low and the anode current of the output valve too high.

The high mutual conductance of the valve must also be considered in the design of the receiver, as it may otherwise result in R.F. feed-back and oscillation. Leads to the valve contacts must be kept as short as possible, and a resistor of about 1,000 ohms in the control-grid lead is recommended. With 100 V on the anode, the optimum value of the load resistance is 2,000 ohms; with 200 V anode, 4,500 ohms. In A.C./D.C. receivers for both high and low-voltage mains operation a switch must be provided in the output transformer circuit that will ensure the best possible matching conditions on different anode voltages.

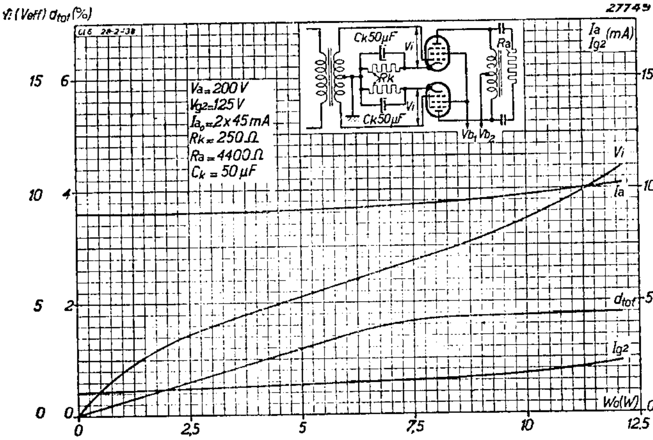


Fig. 12
Anode current I_a, screen-grid current I_{g_2}, total distortion d_{tot} and alternating grid voltage V_i, as functions of the output power W_o for two CL 6 valves in a balanced circuit with V_a = 200 V, and V_{g_2} = 125 V.

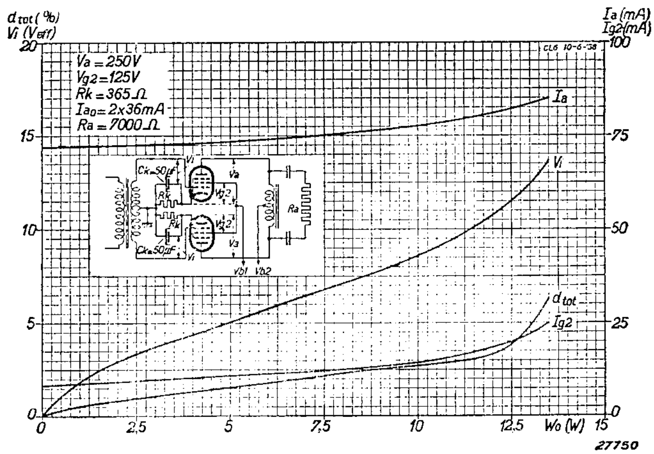


Fig. 13
Anode current I_a, screen current I_{g_2}, total distortion d_{tot} and alternating grid voltage V_i as functions of the output power for two type CL 6 valves in a balanced circuit with V_a = 250 V, and V_{g_2} = 125 V.

CY 1 Rectifying valve

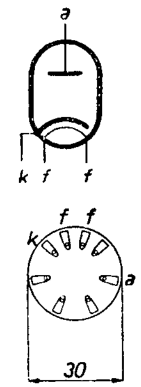


Fig. 2
Arrangement of electrodes and base connections.

Philips CY 1 is a half-wave rectifying valve taking a heater current of 200 mA at 20 volts. The internal resistance is very low and the anode current therefore produces only a very slight decrease in the voltage. In the applications of the CY 1, it is well to bear in mind that the peak voltage between filament and cathode must not exceed 450 V; on high mains voltages, when large-capacitance smoothing capacitors are used, a resistor should be included in the anode circuit to safeguard the valve. The minimum value of this resistor will be found in the following table:

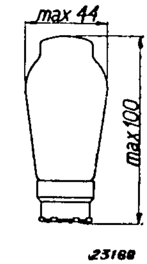


Fig. 1
Dimensions in mm

Mains voltage	Smoothing capacitor	Series resistor
Max. 250 V	32 μF	Min. 125 ohms
	16 μF	Min. 75 ohms
	8 μF	0 ohms
Max. 170 V	32 μF	Min. 75 ohms
	16 μF	Min. 30 ohms
	8 μF	0 ohms
Max. 127 V	32 μF	0 ohms
	16 μF	0 ohms
	8 μF	0 ohms

HEATER RATINGS

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

Heater voltage . . . V_f = 20 V

Heater current . . . . I_f = 0.200 A

MAXIMUM RATINGS

Anode voltage, A.C.

V_i = max. 250 $V_{(eff)}$

Direct current I_o = max. 80 mA

Voltage between heater and cathode . . . V_{fk} = max. 450 V

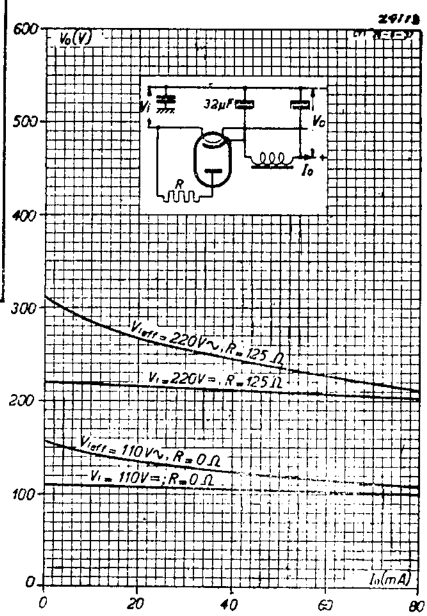
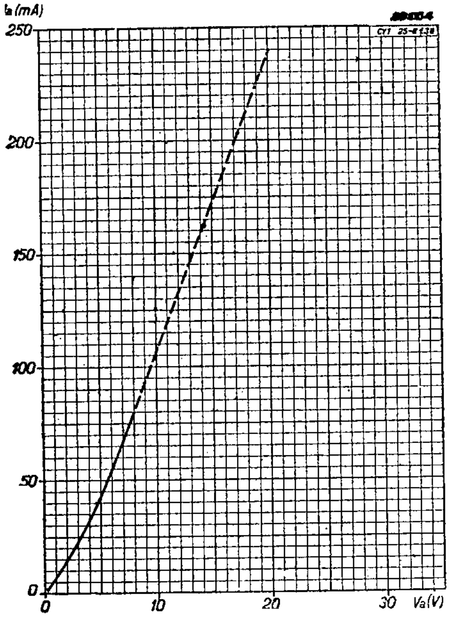
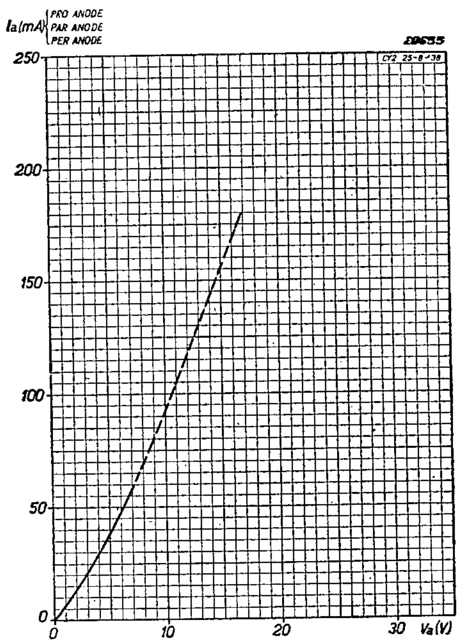


Fig. 3
Loading characteristics of the CY 1.



CY 1

Fig. 4
Anode current as a function of the applied voltage.



CY 2

Fig. 5
Anode current as a function of the applied direct voltage, per anode.

CY 2 Rectifying valve and voltage doubler

The CY 2 has a split cathode and two anodes and can be used either as a half-wave rectifying valve (see fig. 3) or as a voltage doubler. In the former case the valve will deliver 120 mA, whilst as voltage doubler it gives a maximum of 60 mA at roughly twice the voltage when used as rectifying valve.

It should be noted that the peak voltage between cathode and filament must in no case exceed 450 V and, on high-voltage mains, with large smoothing capacitors, a protecting resistor should be included in the anode circuit; minimum values for this resistor are given in the table below.

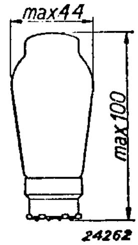


Fig. 1
Dimensions in mm.

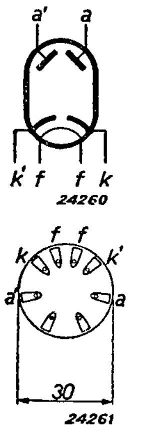


Fig. 2
Arrangement of electrodes and base connections.

Mains voltage	Smoothing capacitor	Series resistor
Max. 250 V	32 µF	Min. 125 ohms
	16 µF	Min. 75 ohms
	8 µF	0 ohms
Max. 170 V	64 µF	Min. 75 ohms
	16 µF	Min. 30 ohms
	8 µF	0 ohms
Max. 127 V	32 µF	0 ohms
	16 µF	0 ohms
	8 µF	0 ohms

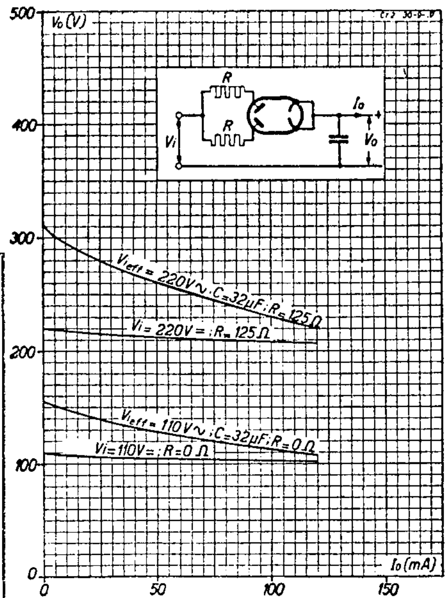


Fig. 3
Loading characteristics of the CY 2 employed as half-wave rectifying valve.

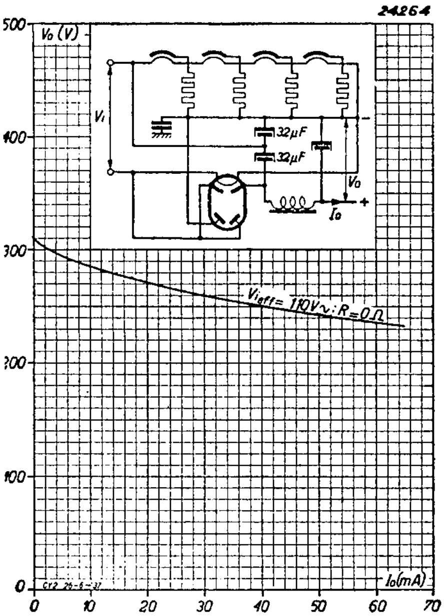


Fig. 4
Loading characteristic of the CY 2 used as a voltage doubler. This curve also applies to both voltage-doubling circuits

HEATER RATINGS

Heating: indirect by A.C. or D.C., series supply.
Heater voltage . . . . V_f = 30 V
Heater current . . . . I_f = 0.200 A

MAXIMUM RATINGS

1) As half-wave rectifying valve.
   Alternating anode voltage . . . . V_i = max. 250 $V_{(eff)}$
   Direct current . . . . I_o = max. 120 mA
2) As voltage doubler
   Alternating anode voltage . . . . V_i = max. 127 $V_{(eff)}$
   Direct current . . . . I_o = max. 60 mA

Voltage between heater and cathode (peak value) . . . . V_{fk} = max. 450 V