

LINE OUTPUT PENTODE PL 81

DESCRIPTION

The PL 81 is an all-glass power pentode on Noval base and with a top anode connection, specifically designed for operation as a line output tube. In spite of its small dimensions the average tube will

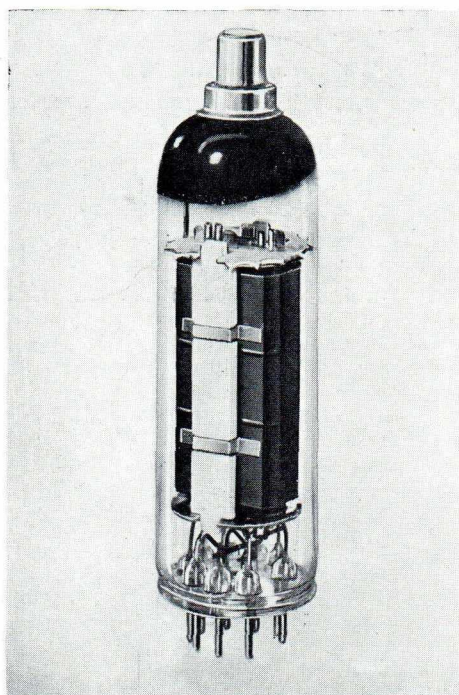


Fig. 97. The line output pentode PL 81 (actual size).

deliver a peak anode current of 380 mA at an anode voltage of 70 V and a screen-grid voltage of 170 V. The anode is adequately insulated to withstand positive and negative voltage peaks of 7 kV.

Quite apart from the use of the PL 81 in a television receiver, for which it is primarily intended, two of these pentodes can also be used in the final stage of an A.F. power amplifier. At a supply voltage of only 170 V two tubes PL 81 in push-pull B will deliver a power output of 13.5 W and at a V_b of 200 V the output is 20 W.

APPLICATION

In the line output circuit of a modern television receiver the line output pentode PL 81 will normally be used in conjunction with a booster diode type PY 80. The booster diode circuit is a device whereby the energy in the line output circuit (transformer and deflection coils), which would otherwise be dissipated uselessly in damping resistors during the flyback period, is recovered and used for boosting the H.T. supply voltage. This is particularly advantageous in equipment employing the DC/AC (transformerless) technique where the available H.T. supply voltage rarely exceeds 170 to 200 V.

The H.T. boost therefore permits operation of the line output tube at a higher anode supply voltage with corresponding reduction in anode current. In addition, it makes available a higher H.T. supply voltage for such purposes as the first-anode voltage of the picture tube and the anode voltage of the frame output stage. Another advantage connected with the use of a booster circuit consists in the fact that the voltage across the line output transformer is kept constant during the scan by the booster diode, which results in a more linear scan.

The E.H.T. voltage for the second anode of the picture tube can be obtained in many different ways, but the most convenient and efficient method used nowadays is to rectify the flyback pulses occurring at the anode of the line output tube by means of a special diode, the EY 51.

It is thus seen that the applications of the PL 81 line output pentode, the PY 80 booster diode and the EY 51 E.H.T. rectifier are closely interrelated. For this reason, in the following pages the application notes relating to these tubes have been combined. A line output circuit is given using standard components and suitable for horizontal double-D deflection with a picture tube type MW 22-16 or MW 31-16 operating at 9 kV second-anode voltage. Since the operation of a line output stage greatly depends upon the amplitude and shape of the driving voltage used, also the circuiting of the line multivibrator and the synchronizing stage is given.

1. A CIRCUIT FOR HORIZONTAL DEFLECTION FOR THE PICTURE TUBES MW 22-16 OR MW 31-16 OPERATING AT 9 kV SECOND-ANODE VOLTAGE

A complete circuit diagram is given in fig. 98. In this circuit the functions of the tubes are as follows:

ECH 42	synchronizer
ECL 80	line multivibrator
PL 81	line output
PY 80	booster
EY 51	E.H.T. rectifier

The operation of the line output circuit can best be understood by assuming a linear saw-tooth current to be present in the deflection coils; see fig. 99. For double-D deflection a current of about 900 mA peak-to-peak is required in the line coils incorporated in the deflection and focusing unit type 10914. The self-inductance of the line coils is 3.77 mH and the resistance 4.7 Ω , so that at a line frequency of 15,625 c/s (625 lines) a practically constant voltage v_s of about 60 V is developed

The voltage v_s across the secondary L_7 is stepped up by the booster winding L_8 to about 210 V during the scanning period. During this period the voltage between the points 4 and 6 is such that the anode of the booster diode PY 80 is positive with respect to the H.T. supply line V_{b1} . During the scan, therefore, the diode conducts, with the result that this voltage is effectively added to the H.T. supply. The voltage between the cathode of the PY 80 and earth is 410 V and this voltage is available for the anode supply of the PL 81, whilst it can also be used to feed the first anode of the picture tube and the anode of the frame output stage.

It should be realized that as a result of the large step-up the PY 80 is subjected to a very large peak inverse voltage. The tube, however, is adequately insulated to withstand this condition. It is, however, essential that a suitable insulation is provided in the tube holder, the cylindrical centre shield of which should be removed, whilst it is also advisable to remove the contacts 1, 6 and 7, thus further reducing the risk of flashover and minimizing the leakage through the holder. In addition, certain

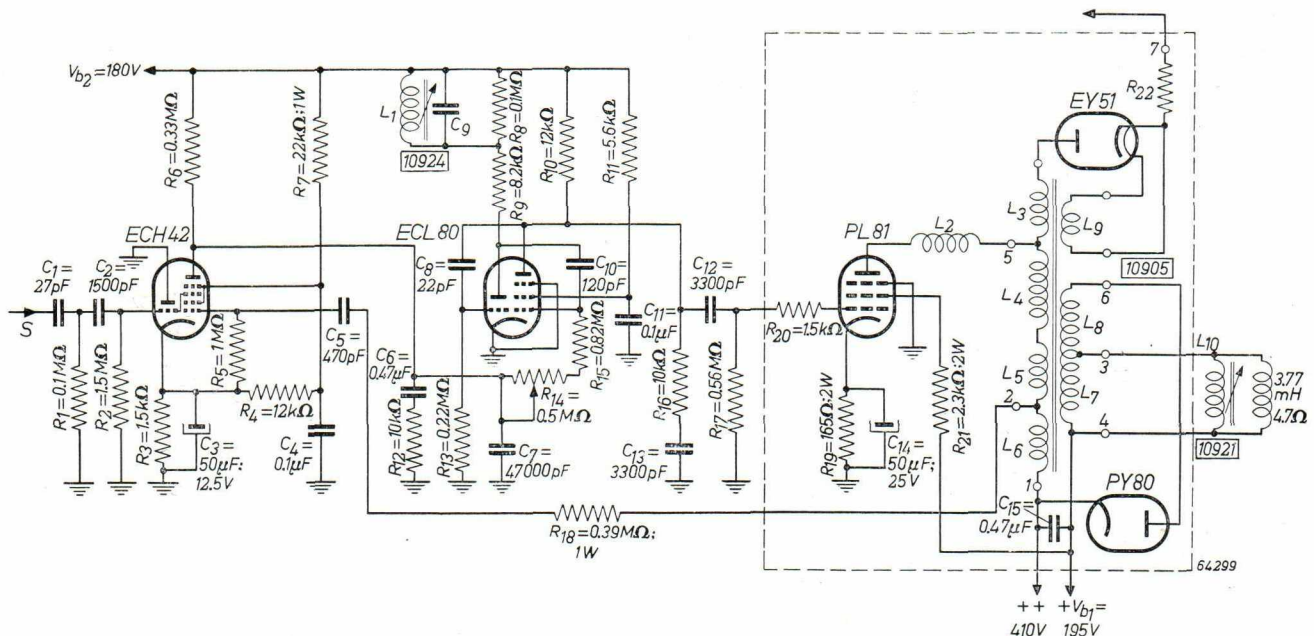


Fig. 98. Circuit for horizontal scanning of a double-D picture tube MW 22-16 or MW 31-16 operating at 9 kV second-anode voltage. The heater current of the ECH 42 is 0.23 A, so that a shunt resistor of 90 Ω is required across this heater.

during the scan. During the flyback a large sinusoidal voltage peak v_{pk} occurs. The line coils are shunted by a variable inductor type 10921, the self-inductance of which can be varied between 8.8 and 32 mH, for adjusting the current in the deflection coils.

types of holder may have to be mounted in a plate of insulating material.

The boosted H.T. supply allows of the turns ratio between the primary and the secondary of the transformer, that is between $L_4 L_5 L_6$ and L_7 , being much greater than is possible without H.T. boost,

and this results in a proportional reduction in the current consumption of the line output tube. With the transformer type 10905 the turns ratio is 6.35 to 1, and this means that the anode voltage of the PL 81 is about $410 - 6.35 \times 60 = 29 \text{ V}$

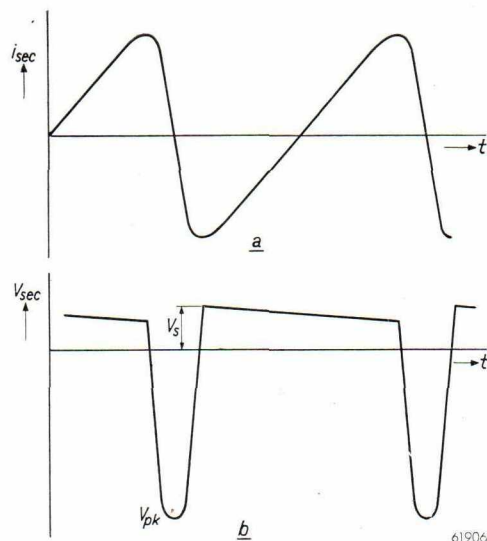


Fig. 99. The deflection current *a* and the voltage across the secondary of the line-output transformer *b*.

during the scanning period. Owing to resistance in the transformer windings and in the deflection coils the voltage drop across the primary is not entirely constant; a voltage varying between 23 and 43 V during the scan has actually been measured between anode and cathode of the PL 81. This low anode voltage might result in excessive screen-grid dissipation and for this reason a screen-grid resistor, R_{21} , has been included, whilst a cathode resistor has been used to prevent an overload of the anode upon failure of the driving voltage. The coil L_2 is incorporated in the anode connector cable for the PL 81 and serves to prevent the penetration of V.H.F. oscillations, which might occur at the beginning of the scan, into the line output circuit.

From fig. 99 it may be seen that when the anode of the PL 81 is negative with respect to the H.T. line during the scan, a very high positive voltage peak will occur during the flyback period. This can be rectified for obtaining the E.H.T. for the picture tube. For this purpose an overwind, L_3 , is provided on the transformer, and a rectifier type EY 51, the heater of which is fed from a separate winding L_9 , is used for the rectification. The EY 51 and the protecting resistor R_{22} are also incorporated in the line output transformer assembly. It will be noticed that no separate reservoir capacitor is used and it is therefore necessary to use a picture tube with

external conductive coating, such as the MW 22-16 or the MW 31-16, the capacitance of which between the internal and the external coating serves as reservoir capacitor.

In order to prevent interference with other circuits of the receiver — or with other television or broadcast receivers in the neighbourhood — it is advisable to enclose the line output circuit in a perforated screening cage. This screening is indicated in fig. 98 by the broken line.

The currents and voltages of the line output circuit are as follows:

Average values:

Supply voltage V_{b1}	195 V
Current from supply	78 mA
Anode current PL 81	65 mA
Screen-grid current PL 81	21 mA
Current drawn from 410 V terminal	13 mA
Voltage across R_{19}	15.6 V
Screen-grid voltage	143 V
E.H.T. (terminal 7)	
at 100 μA	9.8 kV
at 200 μA	9.2 kV

Peak values:

Anode current PL 81	140 mA
Screen-grid current PL 81	65 mA
Ripple at C_{15}	0.5 V
Driving voltage PL 81 peak-to-peak	130 V

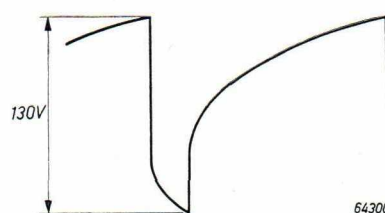


Fig. 100. Shape of the driving voltage for the PL 81.

The driving voltage of the PL 81 has a shape as represented in fig. 100, and this voltage is obtained with the multivibrator circuit equipped with ECL 80. During the flyback the line output pentode is cut off by the negative pulse, thereby preventing any additional damping, which otherwise would reduce the available peak voltage for rectification of the E.H.T.

A multivibrator with equal time constants in the grid circuits gives an output which is symmetrical, that is to say, the rectangular positive and negative blocks are of equal duration. This circuit is of the asymmetrical type, so that the duration of the

negative pulse is slightly longer than the flyback period of the line-output circuit, which is approximately 16% of the cycle.

In order to improve the frequency stability of the multivibrator a tuned circuit, L_1C_9 , has been taken up in the anode circuit of the triode section. This circuit is tuned to 15,625 c/s with the aid of an adjustable "Ferroxcube" core. The free-running frequency of the multivibrator can further be adjusted with R_{14} of 0.5 M Ω . L_1 and C_9 are available as one unit under the type number 10924. The nominal self-inductance of L_1 is 10 mH and the regulating range is from 6 to 14 mH. C_9 has a capacitance of 10,000 pF.

A novel circuit, which is very insensitive for interference, has been used for synchronizing the multivibrator. A sync. signal of 75 V peak-to-peak is applied to the grid of the triode section of the ECH 42, which is internally connected with the third grid of the hexode. This signal can be obtained with the sync. separator described in the application notes of the ECL 80. Grid rectification takes place in the triode section of the ECH 42, with the result that the third grid of the hexode section is at cathode potential only during the sync. pulses, whilst it is heavily negative during the intervals between the pulses. There is, therefore, a possibility of anode current flowing in the hexode, provided this section is not blocked by a negative voltage on the first grid. This grid is supplied with a part of the alternating voltage occurring across the primary of the line-output transformer; see terminal 2. The flyback pulses of the latter voltage are positively directed, so that grid rectification again takes place and the hexode section is consequently blocked during the intervals between the flyback pulses. Anode current can therefore only flow in the hexode section when both the sync. pulses and the line-flyback pulses occur simultaneously, whilst the average value of the anode current is determined by the degree of overlapping of these pulses. This is illustrated in fig. 101, in which the shape of the pulses is idealized.

As a result of the anode current pulses a voltage drop occurs in the anode resistor R_6 and the pulsatory character of this drop is smoothed out by C_6 and C_7 . The voltage at C_7 is applied via R_{14} and R_{15} to the control grid of the pentode section of the multivibrator and thus influences the frequency. In order to prevent hunting, it is necessary to include a resistor R_{12} in series with C_6 .

If it is assumed that the relative position of the

pulses represented in fig. 101 applies to the steady state condition, it will be clear that when the frequency of the multivibrator increases, that is when the pulses V_{g1H} move to the left relative to V_{gT} , the average anode current of the hexode section of the ECH 42 will also increase. This results in a

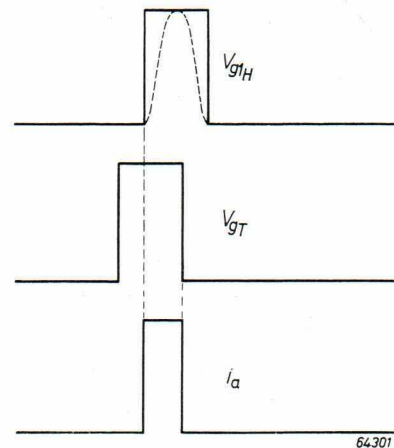


Fig. 101. The anode current i_a in the hexode section of the ECH 42 varies with the relative position of the pulses V_{gT} and V_{g1H} on the triode and hexode grids respectively.

higher voltage drop in R_6 , as a consequence of which the frequency deviation of the multivibrator is reduced. The same reasoning can be applied for the case where the frequency of the multivibrator decreases. In this case the anode current of the ECH 42 will decrease, resulting in a lower voltage drop in R_6 , which also tends to reduce the frequency deviation. It is thus seen that the multivibrator frequency is kept constant and "in phase" with the sync. pulses. In the absence of a signal, or if, as a result of an interference burst, the sync. signal fails for some time, it is necessary that the frequency of the multivibrator is maintained. For this reason the resistors R_3 , R_4 and R_7 have been so chosen that the anode currents with and without sync. signal are about equal.

On closer examination of fig. 101 it appears that the sync. pulse starts before the flyback pulse, so that the time available for the flyback of the line output circuit is reduced. This is not so serious as it might seem at first sight. Actually, the shape of the flyback pulse V_{g1H} is approximately sinusoidal, see dotted line, whilst the amplitude is very large. Therefore the hexode section of the ECH 42 can only draw current during the peak of the sinusoidal pulse, so that it is quite possible to adjust R_{14} in such a way that the beginnings of the flyback pulses and the sync. pulses coincide.

Finally, in the actual circuit differentiation has been applied for the sync. pulse, see C_1 and R_1 in fig. 98, as otherwise during the frame pulses the average anode current of the hexode would change, this resulting in curved sides at the top of the picture. It is therefore seen that fig. 101 only serves to explain the principal behaviour of the synchronizing system.

COMPONENTS FOR THE LINE OUTPUT CIRCUIT

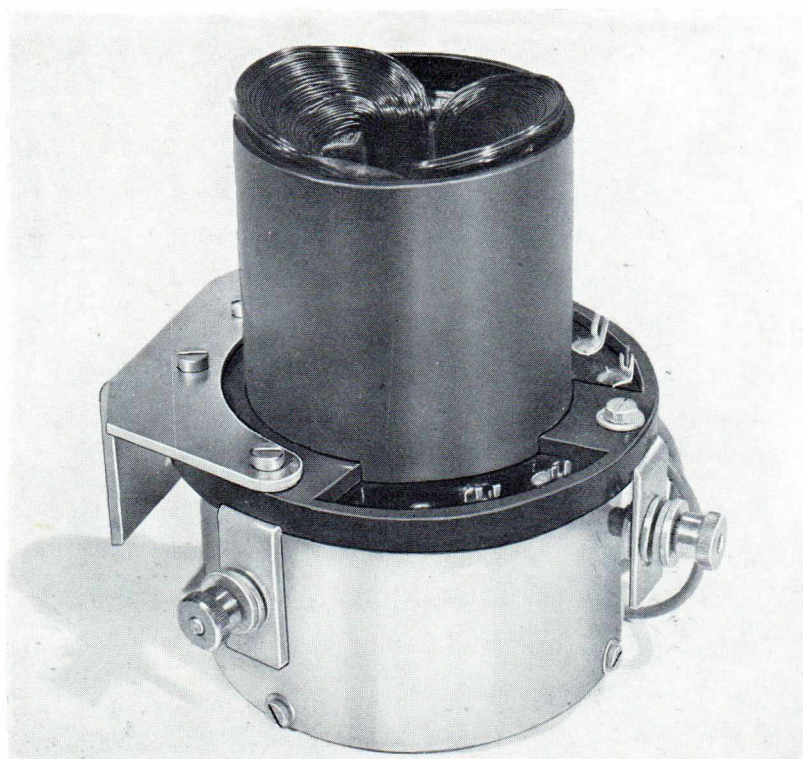
a. DEFLECTION AND FOCUSING UNIT TYPE 10914

It has already been indicated that the line output circuit is matched to the line coils incorporated in the deflection and focusing unit type 10914. This unit is intended for use in conjunction with the picture tubes MW 22-16 or MW 31-16. The data are

given below, whilst the connections and dimensions are represented in fig. 103.

Technical data

Line coils:	Inductance	3.77 mH
	Resistance	4.7 Ω
	Sensitivity (MW 22-16)	36.5 mA/cm at 9 kV
Frame coils:	Resistance	9.5 Ω
	Inductance	6.75 mH
	Sensitivity (MW 22-16)	31.5 mA/cm at 9 kV
Focus coil:	Resistance	4676 Ω
	Current	25 mA approx.
Maximum operating temperature 85 °C		
Terminals (see fig. 103)	2 — 6 line coils	
	1 — 5 frame coils	
	3 — 4 focus coil	
	5 screen.	



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Fig. 102. The deflection and focusing unit type 10914.

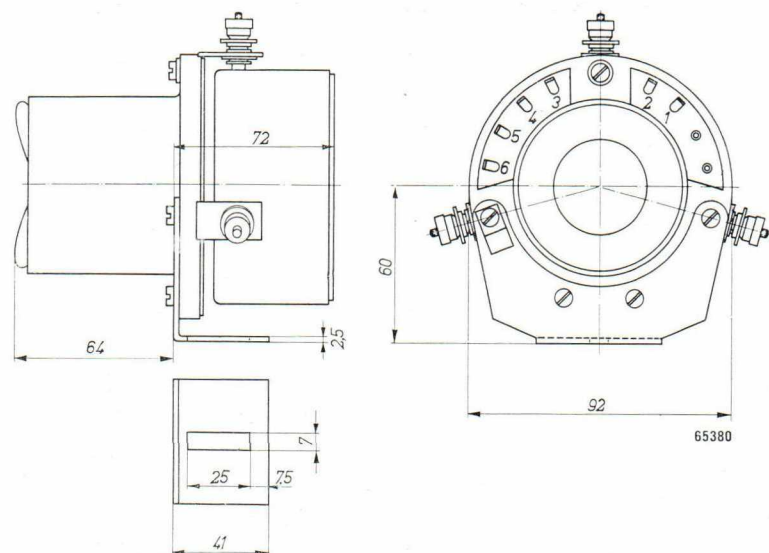


Fig. 103. Dimensions and connections of the deflection and focusing unit type 10914.

b. LINE OUTPUT TRANSFORMER TYPE 10905

This transformer has already been discussed in the preceding text in connection with the line output circuit of fig. 98. The data are given below and a dimensional drawing is represented in fig. 105.

Technical data

Type number 10905
 For use with line output pentode PL 81 and booster diode PY 80
 Line repetition rate 15,625 lines per second
 Inductance of primary

(terminals 1 and 5) 156 mH at 500 c/s with 30 mA D.C.

Turns ratio primary-secondary

(terminals 1 — 5 and 3 — 4)

6.35 : 1

Maximum operating temperature

85 °C

Terminals (see fig. 105) 1 cathode booster

2 tap on primary for sync.

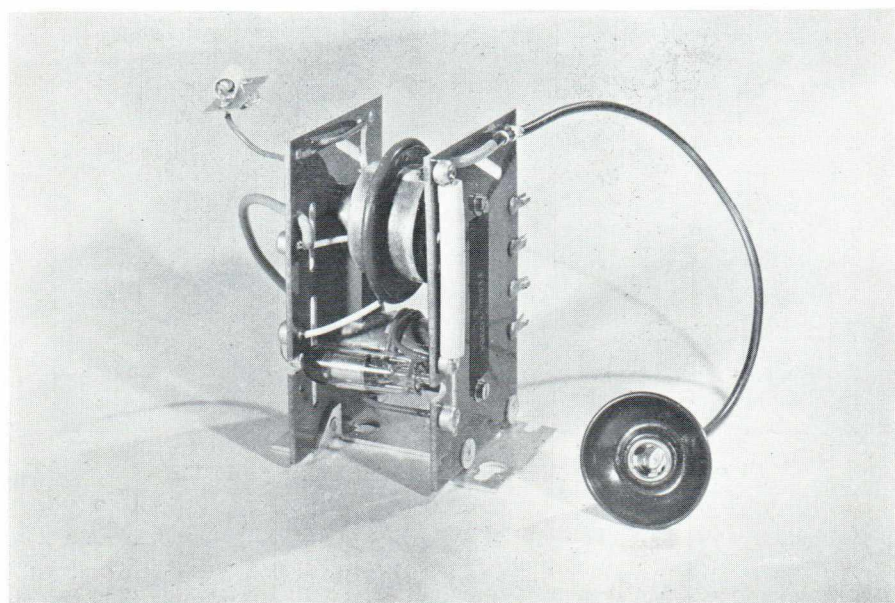
3 line coil

4 line coil and H.T. supply

5 anode output pentode

6 anode booster

7 + E.H.T.



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Fig. 104. The line-output transformer type 10905.

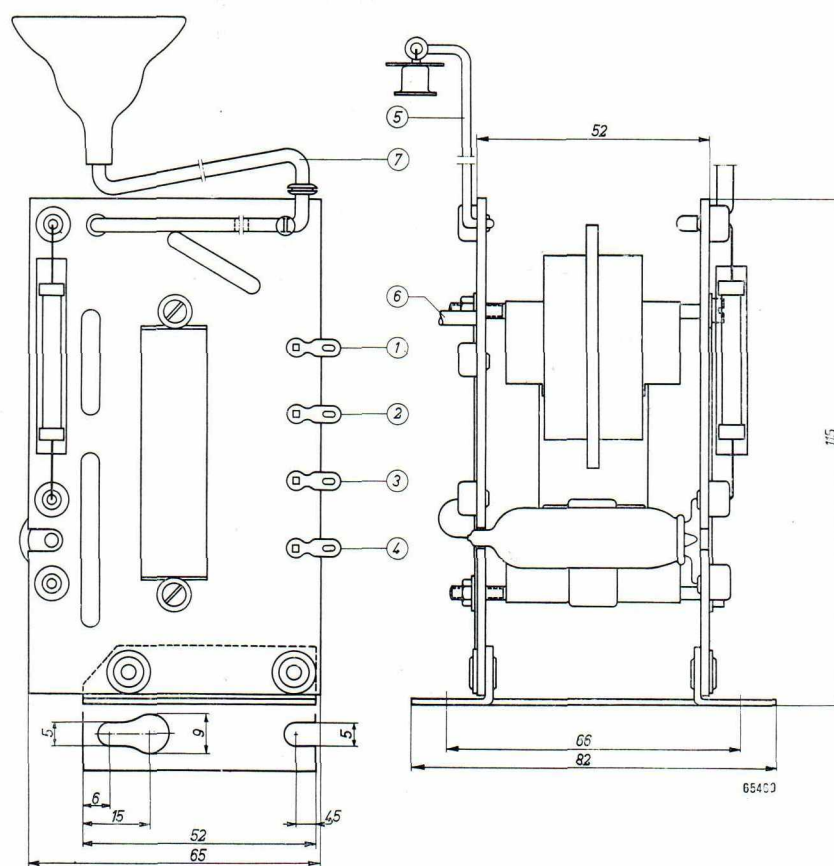


Fig. 105. Dimensions and connections of the line-output transformer type 10905.

*c. LINE AMPLITUDE CONTROL UNIT
TYPE 10921*

The line amplitude control unit type 10921 is a variable inductor with "Ferroxcube" core serving to adjust the width of the image on the screen of

the picture tube. It has been designed for use with the line-output transformer type 10905 and the line coils of the deflection and focusing unit type 10914. The data are given below and a dimensional drawing is represented in fig. 106.

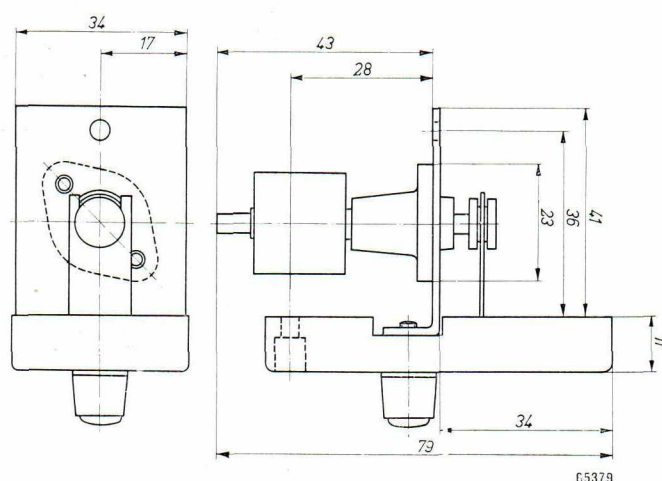


Fig. 106. Dimensional drawing of the line amplitude control unit type 10921.

Technical data

Type number	10921
Minimum inductance	8.8 mH
Maximum inductance	32 mH
Maximum operating temperature	85 °C

*d. TUNED CIRCUIT FOR LINE
MULTIVIBRATOR TYPE 10924*

This unit comprises an inductor with a nominal self-inductance of 10 mH and an adjustable

"*Ferroxcube*" core. A fixed mica tuning capacitor of 10,000 pF has been built in. The tuned circuit serves to improve the frequency stability of a multivibrator driving the line-output stage.

Technical data

Type number	10924
Minimum inductance	6 mH
Maximum inductance	14 mH
Fixed tuning capacitor	10,000 pF
Maximum operating temperature	85 °C

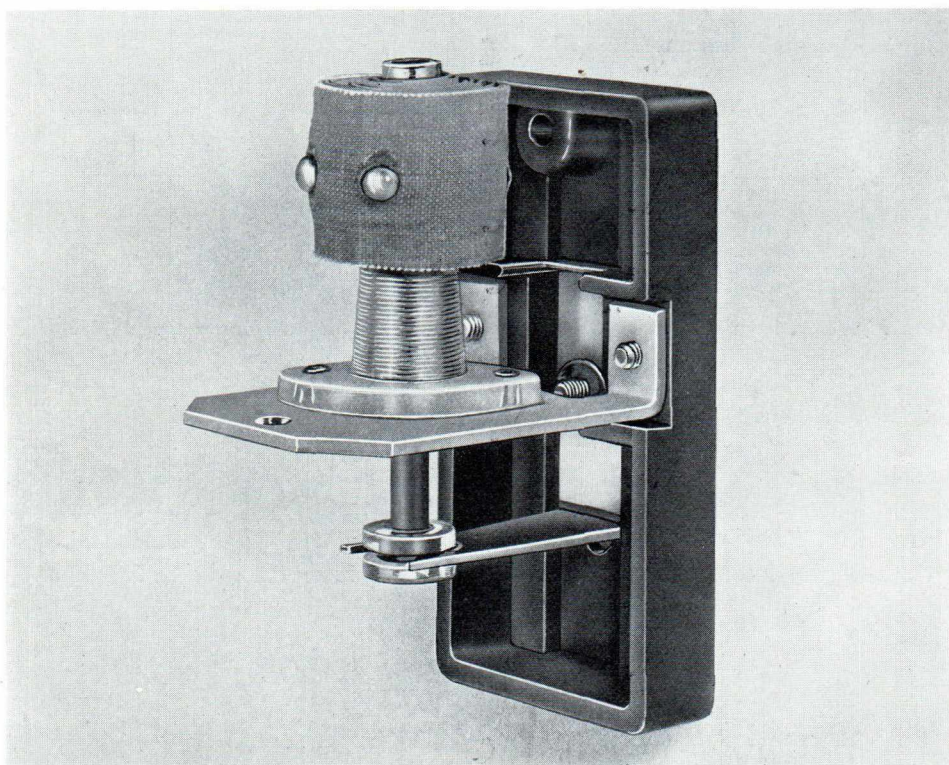


Fig. 107. The line amplitude control unit type 10921.

TECHNICAL DATA OF THE PL 81

HEATER DATA

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

Heater voltage	V_f	21.5 V
Heater current	I_f	0.3 A

BASE CONNECTIONS AND
DIMENSIONS (in mm)

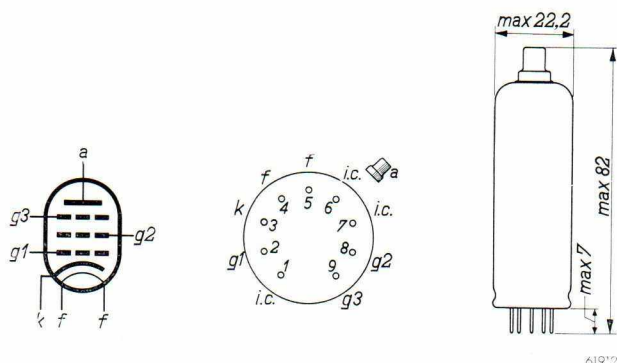


Fig. 108.

Mounting position: any

CAPACITANCES

C_{g1}	14.7 pF
C_a	6 pF
C_{ag1}	< 0.8 pF
C_{ak}	< 0.1 pF
C_{g1f}	< 0.2 pF

TYPICAL CHARACTERISTICS

Anode voltage	V_a	170	200 V
Suppressor-grid voltage	V_{g3}	0	0 V
Screen-grid voltage	V_{g2}	170	200 V
Control-grid voltage	V_{g1}	-22	-28 V
Anode current	I_a	45	40 mA
Screen-grid current	I_{g2}	3	2.8 mA
Mutual conductance	S	6.2	6 mA/V
Internal resistance	R_i	10	11 kΩ
Amplification factor between screen grid and control grid	μ_{g2g1}	5.5	5.5

To allow for spread between individual tubes and for deterioration during life, the circuit should be designed around a peak anode current not exceeding 250 mA at $V_a = 70$ V, $V_{g2} = 170$ V. At these voltages with $V_{g1} = -1.0$ V, the average new tube may be expected to give a peak current of 380 mA.

For $V_a = 70$ V and $V_{g2} = 200$ V the corresponding values for the peak current are 310 mA and 470 mA respectively.

OPERATING CONDITIONS AS A.F. POWER
AMPLIFIER (two tubes in push-pull B)

Anode voltage	V_a	170	200	V
Suppressor-grid voltage	V_{g3}	0	0	V
Screen-grid supply voltage	V_{g2}	170	200	V
Grid bias	V_{g1}	-27	-31.5	V
Screen-grid resistor	R_{g2}	1	1	kΩ
Matching resist- ance between anodes	$R_{aa'}$	2.5	2.5	kΩ
Input signal	V_i	0 ~ 19	0 ~ 22.5	V _{rms}
Anode current	I_a	2x20	2x73	2x25 2x87 mA
Screen-grid current	I_{g2}	2x1.5	2x10	2x2 2x12.5 mA
Power output	W_o	0	13.5	0 20 W
Total distortion	d_{tot}	—	5.5	— 5.5 W

LIMITING VALUES

Anode voltage at zero anode current	V_{a0}	max. 550 V
Anode voltage	V_a	max. 250 V
Peak anode voltage	$\pm V_{ap}$	max. 7 kV ¹⁾
Screen-grid voltage at zero screen-grid current	V_{g20}	max. 550 V
Screen-grid voltage	V_{g2}	max. 250 V
Control grid voltage (grid current + 0.3 μA)	V_{g1}	max. -1.3 V
Heater voltage during warming-up period		max. 32 V
Voltage between heater and cathode	V_{kf}	max. 200 V
Cathode current	I_k	max. 180 mA
Anode dissipation	W_a	max. 8 W ²⁾
Screen-grid dissipation	W_{g2}	max. 4.5 W ²⁾
External resistance between control grid and cathode	R_{g1}	max. 0.5 MΩ
External resistance between heater and cathode	R_{kf}	max. 20 kΩ

¹⁾ Maximum pulse duration 18% of one cycle, with a maximum of 18 μsec.

²⁾ $W_a + W_{g2}$ may not exceed 10 W.

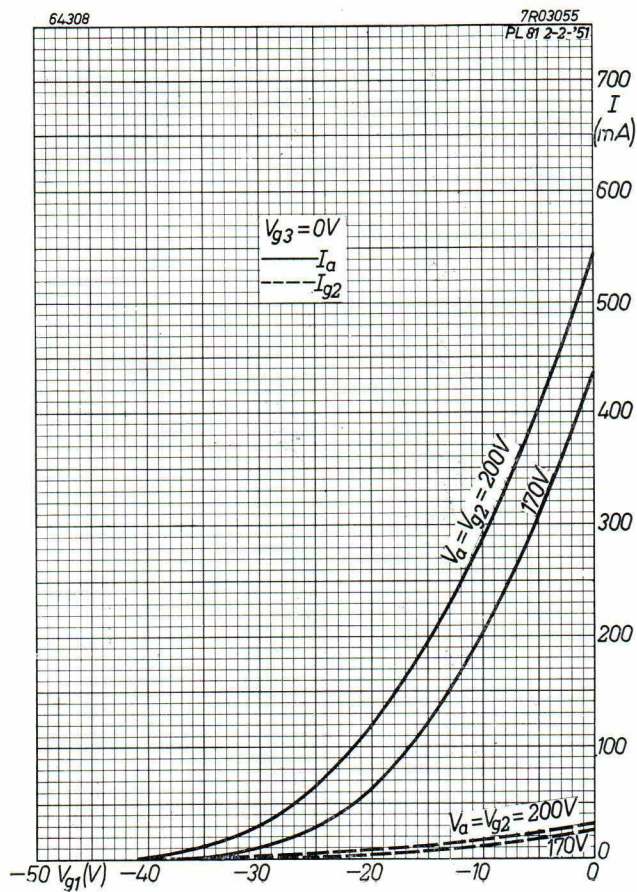
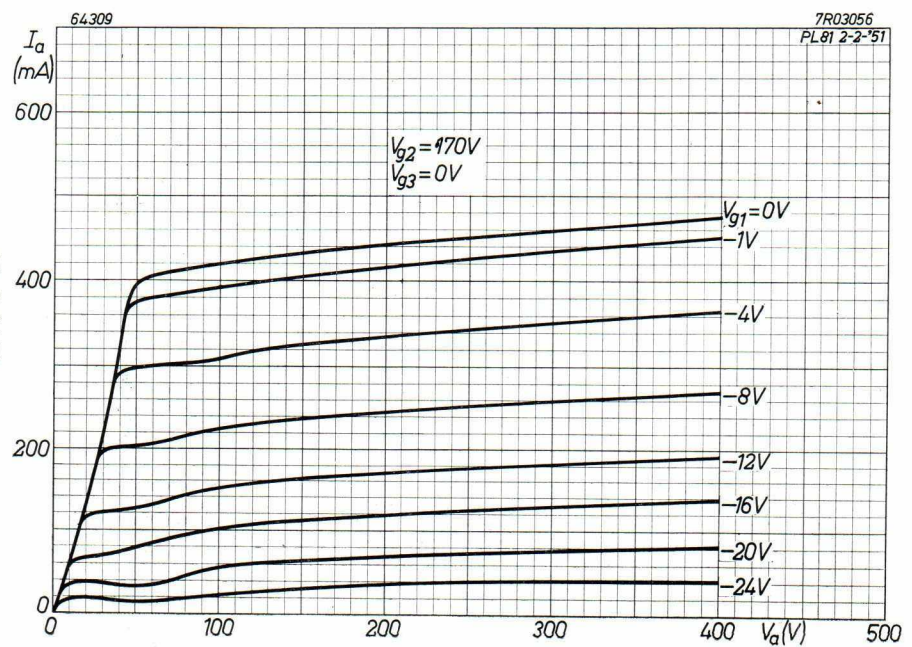


Fig. 109.
Anode current and screen-grid current plotted against control-grid voltage, with anode and screen-grid voltage as parameter.

Fig. 110.
Anode current plotted against anode voltage for screen-grid voltage of 170 V, with control-grid voltage as parameter.



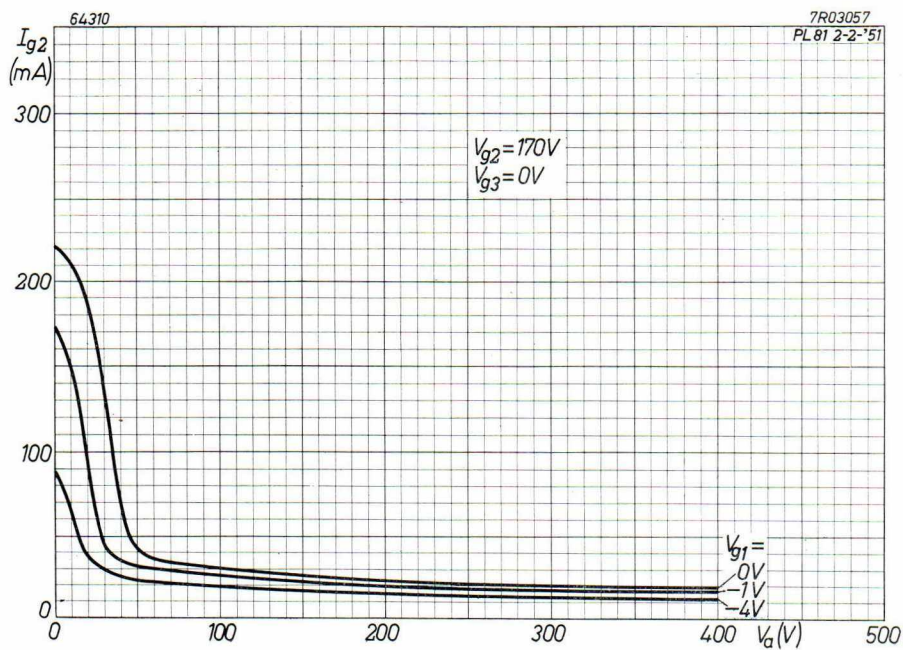


Fig. 111.

Screen-grid current plotted against anode voltage for screen-grid voltage of 170 V, with control-grid voltage as parameter.

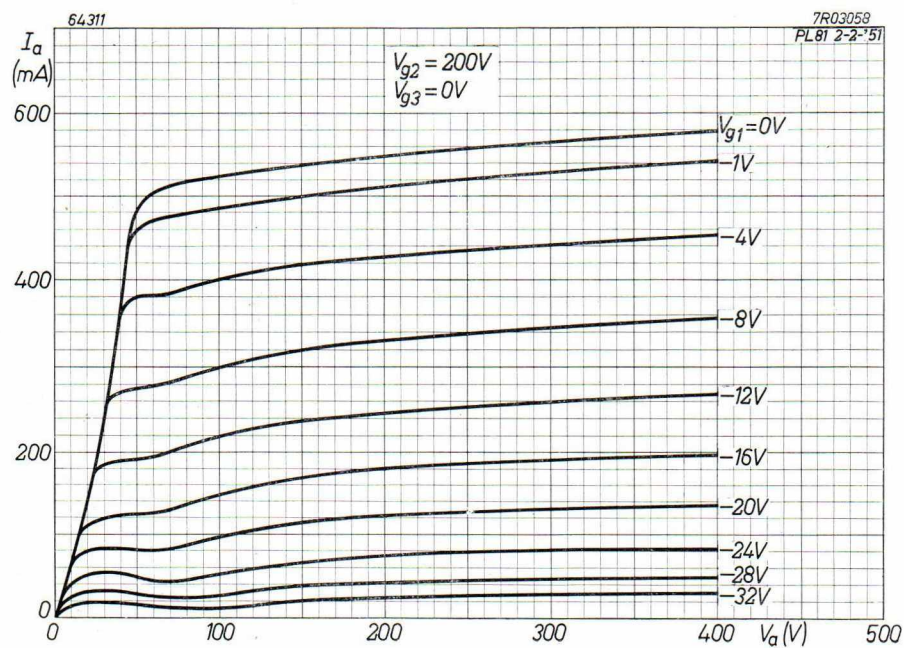


Fig. 112.

Anode current plotted against anode voltage for screen-grid voltage of 200 V, with control-grid voltage as parameter.

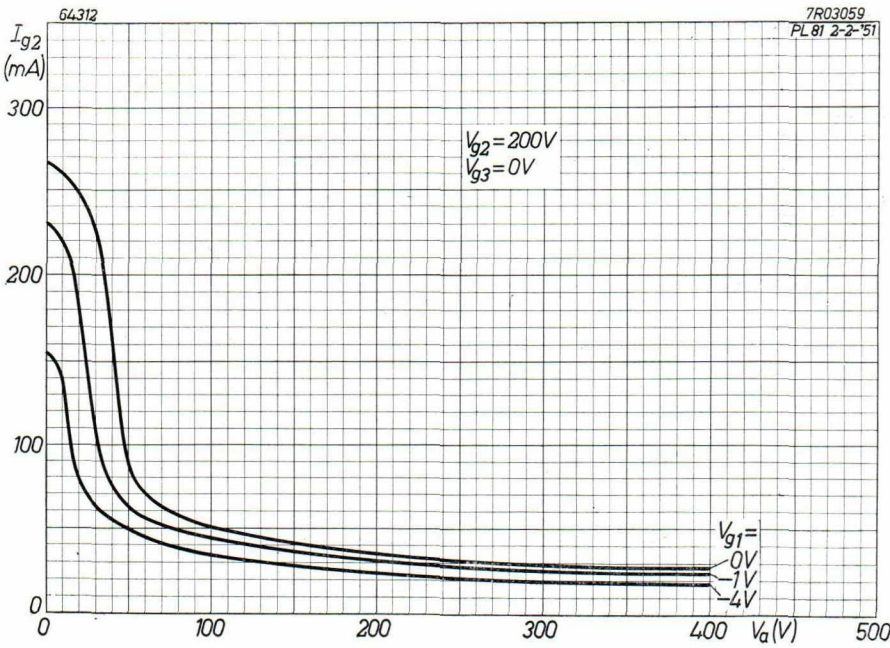
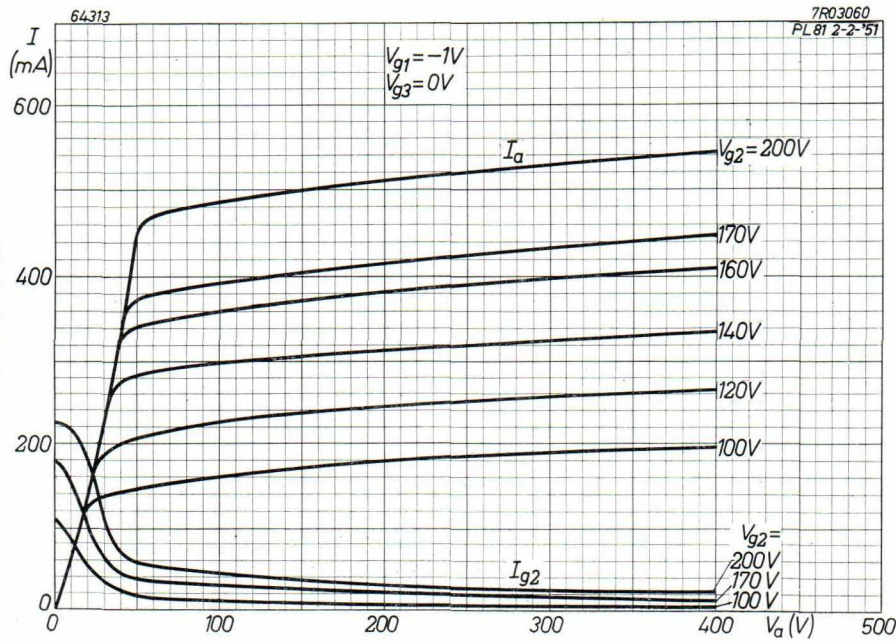


Fig. 113.
Screen-grid current plotted against anode voltage for screen-grid voltage of 200 V, with control-grid voltage as parameter.

Fig. 114.
Anode current and screen-grid current plotted against anode voltage for control-grid voltage of -1 V, with screen-grid voltage as parameter.



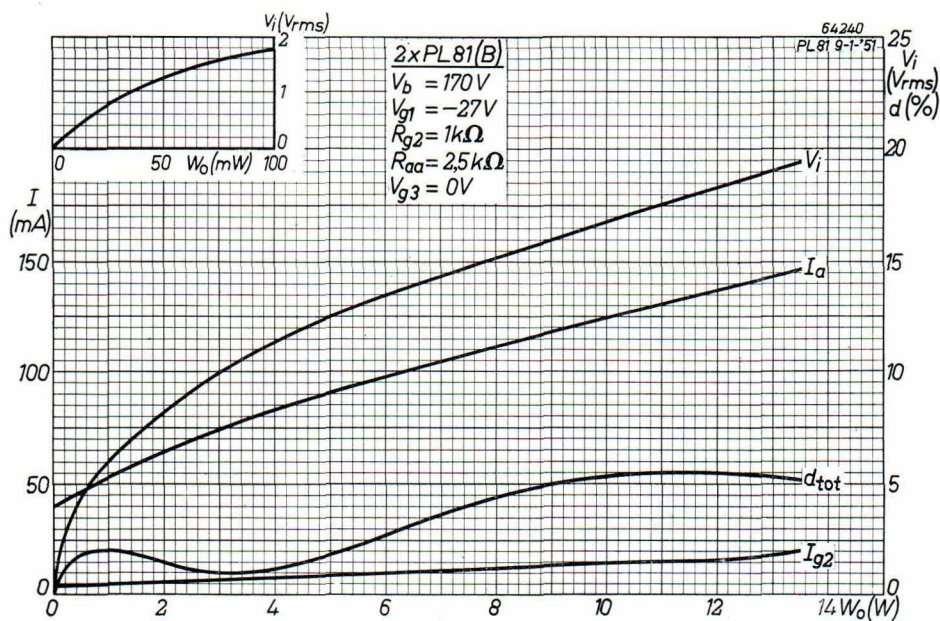


Fig. 115.

Anode current, screen-grid current, input voltage and total distortion plotted against output power of two tubes PL 81 in push-pull B for anode and screen-grid supply voltage of 170 V.

Fig. 116.

Anode current, screen-grid current, input voltage and total distortion plotted against output power of two tubes PL 81 in push-pull B for anode and screen-grid supply voltage of 200 V.

