DK 40 Battery octode

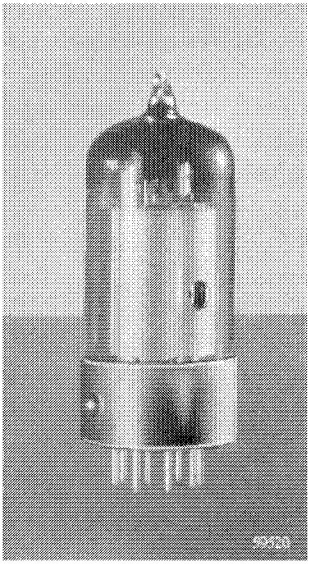


Fig. 1
The battery octode DK 40 (approximately actual size).

The DK 40 is an octode designed for use with a low-tension battery of 1.4 V. The filament current is 50 mA. It can be used in receivers with H.T. batteries of between 67.5 and 135 V, but it is necessary to keep the voltages on the screen grid (grid 5) and the oscillator anode (grid 2) at 67.5 V, to avoid exceeding the maximum permissible dissipation of these electrodes.

When a battery giving more than 67.5 V is employed, grids 2 and 5 can be directly connected to a tapping on the battery or, alternatively, they can be fed separately or together from the full battery voltage through a dropping resistor. The latter arrangement necessitates one or two extra resistors and decoupling capacitors, but it certainly has the advantage that, towards the end of the effective life of the battery, a considerable drop in the battery voltage makes but little difference to the conversion conductance. When grids 2 and 5 are connected directly to the 67.5 battery terminals, the valve will continue to function until the voltage drops to 45 V, but by then the conversion conductance is greatly reduced.

In normal use the DK 40 consumes a total current of about 4 mA, the conversion conductance being about 425 μA/V. In cases where economy in current consumption is essential, the valve can be incorporated in circuits in which the oscillator anode (grid 2) voltage is 45 V; the total current is then only 2.7 mA, with reasonable conversion conductance, viz. 370 μA/V. The latter arrangement is not recommended for short-wave work, however.

The arrangement of the electrodes in the DK 40 is the same as that in the DK 21, a valve which has given excellent results in use. Taking into account the low anode current, the conversion conductance is high, whilst induction effect and frequency drift are only slight; the characteristics of the valve as an oscillator are quite outstanding.

Briefly, the design is as follows: The second grid takes the form of four rods which serve as the oscillator anode, while the third grid is formed by two more such rods. Due to the absence of positive grid wires in the path of the electrons flowing towards the fourth grid (input grid), they approach it in uniform beams instead of spreading out, and therefore all the electrons reach the fourth grid at roughly the same velocity. With a certain bias applied to this grid, almost all the electrons pass through, whilst a slightly higher bias causes them all to turn back; this means that the slope of the grid is high. Since the conversion conductance of the valve is directly related to

the normal slope of the fourth grid, it follows that the conversion conductance must also be high.
The absence of a screen grid between cathode and fourth grid, moreover, means that the electron stream, repelled by the latter grid, can only proceed to the second grid; the whole of this current is therefore available for oscillation. This is the reason why the oscillatory properties of the valve are good in spite of the low total consumption of current.
Generally speaking, valves designed on the principle of the octode all have the disadvantage of pronounced "induction effect"; this is a capacitive and electronic coupling between the oscillator section of the valve and the fourth grid, resulting in a voltage at oscillator frequency on the fourth grid, and thus across the input circuit.
This induced voltage not only affects the proper functioning of the valve — resulting in a reduction of the conversion conductance — but also increases the frequency drift. Furthermore, the coupling between the input circuit and the aerial may result in radiation and consequent interference with neighbouring receivers.
All these things are to be avoided as much as possible, and in the DK 40 this is effected by the third grid. The latter is connected to the oscillator grid (grid 1) and therefore carries the oscillator voltage; now the geometry of the electrodes is such that the capacitive coupling between grids 3 and 4 largely counteracts the "induction effect". In this way the unpleasant consequences of the "induction effect" are avoided, whilst the influence of the third grid on the general performance of the valve is negligible, since the two rods of which this "grid" consists are located in the electronic "shadow" of the supports of grid 1.

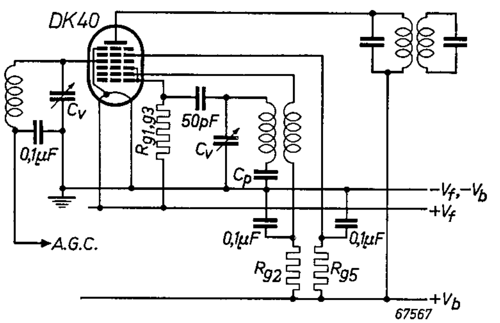


Fig. 2
The DK 40 employed as a frequency changer.

To ensure satisfactory performance of the oscillator section of the valve, the following points should be taken into consideration:
1) The tuned circuit should be connected to grid 1.
2) If a voltage dropping resistor is to be included in the oscillator anode circuit (grid 2), this must be in series with the coupling coil (i.e. not parallel-fed).
3) The grid leak in the oscillator circuit should be connected between this grid and L.T. positive (contact 1 of the valveholder).
4) For the oscillator grid leak 35 kΩ is the most suitable value, with a capacitor of 50 pF; this will ensure satisfactory working of the oscillator section of the valve in the normal broadcast bands. Higher values than those suggested may involve some risk of squegging at the short-wave ends of the bands, whereas lower values merely make the oscillator performance less satisfactory.

As the DK 40 was designed for use in high-performance receivers of the more expensive type too, everything possible has been done to fulfil this object. Microphony, for instance, has been made the subject of special investigation. In this respect the DK 40 shows a considerable improvement over earlier battery types of frequency changers, and it can safely be used in receivers intended for high output.

In connection with electrical measurements on frequency changers for battery operation, the following may be of interest. One of the factors determining the characteristics of any frequency changer is, quite naturally, the value of the oscillator voltage, which can be measured by means of a valve-voltmeter; alternatively, the current through the oscillator grid resistor can be taken as a measure of the oscillator voltage. The advantage of the latter method is that a direct current is measured instead of an alternating R.F. voltage, so that a simple meter will serve the purpose without affecting the working of the oscillator in any way. This cannot be said of a valve-voltmeter, whose damping and input capacitance always tend to modify the oscillator voltage and frequency.

In the case of battery frequency changers, however, measurement of the direct current also raises a difficulty; if a number of valves of the same type be made to operate on the same oscillator voltage, the individual grid current values will be found to exhibit a certain amount of spread, caused by differences in the contact potential between the oscillator grid and the filament among the various specimens thus tested. Apart from the grid current, this variation in contact potential has no effect on the performance of the valve, but if the grid current is taken as a measure of the oscillator voltage for the purpose of deciding upon the operating point of the valve, the voltage may be found to vary considerably between one sample and another, and these differences will certainly affect the performance of the valve.

For accurate measurements on battery-operated frequency changers, therefore, it is advisable to determine the oscillator voltage by one of the following methods.

a) Construct a calibration curve for the valve to be measured, plotting the values of the direct current flowing in the oscillator grid circuit as a function of the oscillator voltage, as measured with a valve-voltmeter. The voltmeter is then disconnected, after which the oscillator voltage can be determined from the D.C. grid current and the curve, for every measurement.

b) Apply a variable bias in series with the grid leak (between grid leak and filament), using a low-resistance potentiometer with decoupling capacitor and battery. The potentiometer should be so adjusted that, for a given oscillator voltage (measured with a valve-voltmeter) the D.C. grid current reaches a value that can be read from the curves in Figs. 14 to 18 (say 140 μA at an oscillator voltage of 8 V_{RMS}). When the voltmeter is disconnected, the oscillator voltage can then be ascertained from the grid current with the aid of the curves.

The latter method amounts to this, that the contact potential between grid 1 and filament is so far compensated by the applied grid bias that the resultant voltage between grid and filament reaches a certain value; at this value, which is the mean value of the contact potential, the curves I_{g1+g3} are then plotted as a function of the oscillator voltage (see Figs. 14 to 18).

TECHNICAL DATA OF THE BATTERY OCTODE DK 40

Filament data

Heating: direct, from battery, rectified A.C.. or D.C.: series or parallel feed

In parallel with other valves:

Filament voltage .	V_f	=	1.4 V
Filament current .	I_f	=	50 mA

In series with other valves:

Filament voltage .	V_f	=	1.3 V

Capacitances (measured on the cold valve)

Input capacitance . .	C_{g4}	=	6.9 pF
Output capacitance	C_a	=	9.6 pF
Between anode and control grid	C_{ag4}	<	0.16 pF
Input capacitance, oscillator section	C_{g1+g3}	=	5.6 pF
Output capacitance, oscillator section	C_{g2}	=	5.0 pF
Between oscillator anode and input grid	C_{g2g4}	=	0.9 pF
Between oscillator grid and input grid	$C_{(g1+g3)g4}$	=	1.1 pF

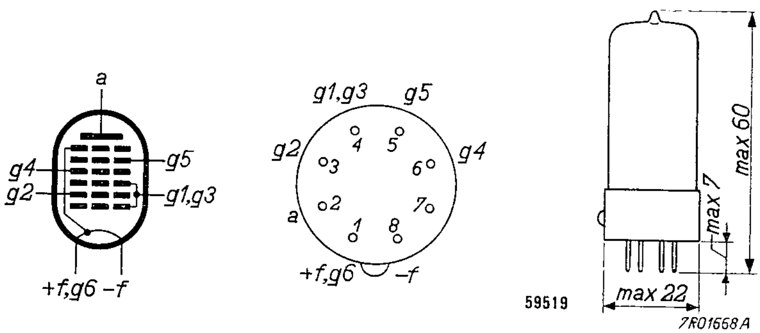


Fig. 3
Electrode arrangement, electrode connections and maximum dimensions in m of the DK 40.

DK 40

Operating characteristics

Anode and supply voltage	$V_a = V_b =$	67.5		90		V
Series resistor, grid 5	R_{g5} =	0		90		kΩ
Series resistor, grid 2	R_{g2} =	0		8.5		kΩ
Oscillator grid leak	R_{g1+g3} =	35		35		kΩ
Oscillator voltage	V_{osc} =	8		8		V_{RMS}
Grid bias	V_{g4} =	0—9.5		0—12.5		V
Voltage, grid 5	V_{g5} =	67.5	67.5	67.5	90	V
Voltage, grid 2	V_{g2} =	67.5	—	67.5	—	V
Anode current	I_a =	1.0	—	1.0	—	mA
Current, grid 5	I_{g5} =	0.25	—	0.25	—	mA
Current, grid 2	I_{g2} =	2.6	—	2.6	—	mA
Conversion conductance	S_c =	425	4.25	425	4.25	μA/V
Internal resistance	R_i =	0.9	>10	1.0	>10	MΩ
Equivalent noise resistance	R_{eq} =	67	—	67	—	kΩ

Anode and supply voltage	$V_a = V_b =$	120		135		V
Series resistor, grid 5	R_{g5} =	210		270		kΩ
Series resistor, grid 2	R_{g2} =	20		26		kΩ
Oscillator grid leak	R_{g1+g3} =	35		35		kΩ
Oscillator voltage	V_{osc} =	8		8		V_{RMS}
Grid bias	V_{g4} =	0—16.5		0—18.5		V
Voltage, grid 5	V_{g5} =	67.5	120	67.5	135	V
Voltage, grid 2	V_{g2} =	67.5	—	67.5	—	V
Anode current	I_a =	1.0	—	1.0	—	mA
Current, grid 5	I_{g5} =	0.25	—	0.25	—	mA
Current, grid 2	I_{g2} =	2.6	—	2.6	—	mA
Conversion conductance	S_c =	425	4.25	425	4.25	μA/V
Internal resistance	R_i =	1.0	>10	1.0	>10	MΩ

Valve used in economy circuit (not suitable for S.W.)

Anode and supply voltage	$V_a = V_b$ =	67.5		V
Series resistor, grid 5	R_{g5} =	0		Ω
Series resistor, grid 2	R_{g2} =	15		kΩ
Oscillator grid leak	R_{g1+g3} =	35		kΩ
Oscillator voltage	V_{osc} =	8		V_{RMS}
Grid bias	V_{g4} =	0 —9.5		V
Voltage, grid 5	V_{g5} =	67.5	67.5	V
Voltage, grid 2	V_{g2} =	45	—	V
Anode current	I_a =	0.85	—	mA
Current, grid 5	I_{g5} =	0.19	—	mA
Current, grid 2	I_{g2} =	1.5	—	mA
Conversion conductance	S_c =	370	3.7	μA/V
Internal resistance	R_i =	1.0	>10	MΩ

Typical characteristics of the oscillator section (filament, 1st grid and 2nd grid; g_1 and g_3 connected to +f)

Anode voltage	V_a	= 67.5	67.5	V
Screen grid voltage	V_{g5}	= 67.5	67.5	V
Grid bias	V_{g4}	= 0	0	V
Oscillator anode voltage	V_{g2}	= 67.5	45	V
Oscillator anode current	I_{g2}	= 2.9	1.3	mA
Slope of osc. anode with respect to osc. grid	S_{g2g1}	= 1.2	0.9	mA/V
Amplification factor of osc. anode with respect to osc. grid	μ_{g2g1}	= 14	14	

Limiting values

Anode voltage	V_a	= max.	135	V
Anode dissipation	W_a	= max.	0.2	W
Screen grid voltage	V_{g5}	= max.	135	V
Screen grid dissipation	W_{g5}	= max.	0.02	W
Oscillator anode voltage	V_{g2}	= max.	100	V
Osc. anode dissipation	W_{g2}	= max.	0.2	W
Cathode current	I_k	= max.	5	mA
Grid current starting point	$V_{g4}(I_{g4} = +0.3\mu A)$	= max.	—0.2	V
External resistance between control grid and filament	R_{g4}	= max.	3	MΩ
Oscillator grid leak	R_{g1+g3}	= max.	35	kΩ

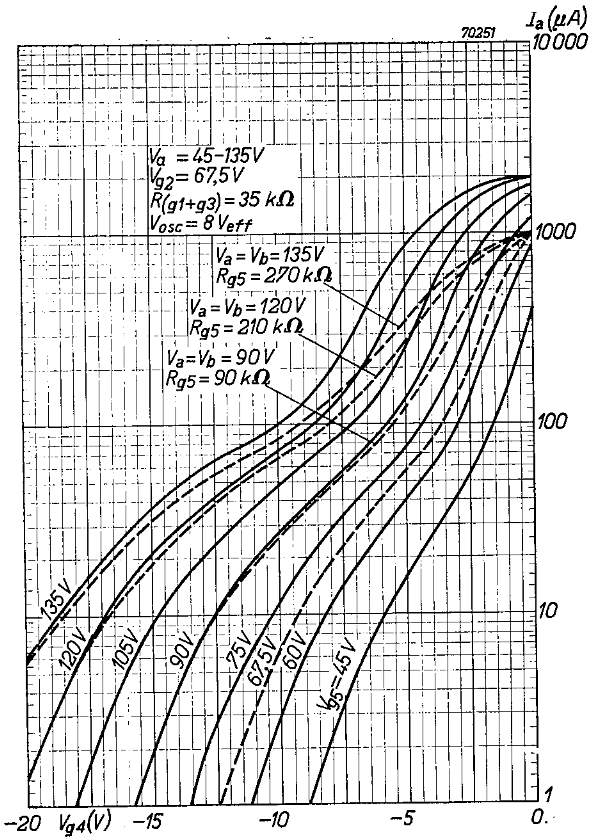


Fig. 4

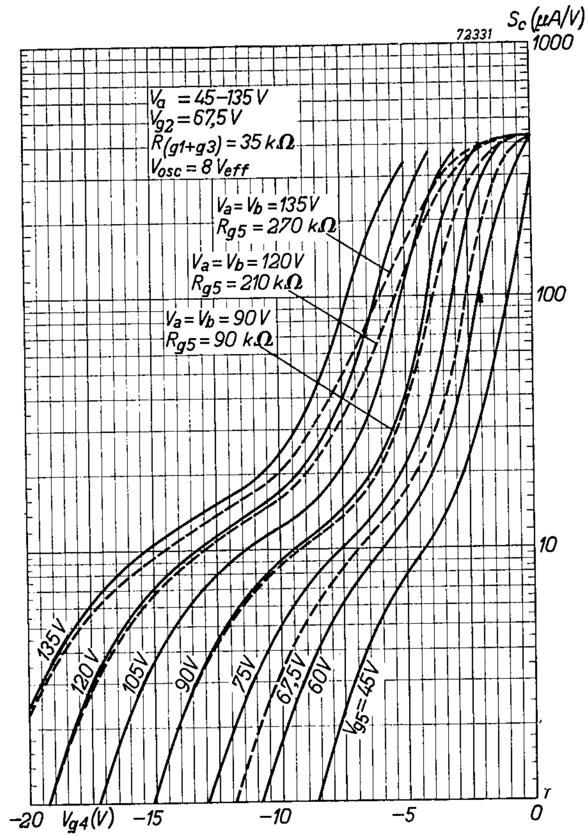


Fig. 5

Anode current (I_a, Fig. 4) and conversion conductance (S_c, Fig. 5) of the DK 40 as functions of the grid bias (V_{g4}), at different battery voltages. The broken curves indicate the anode current and conversion conductance with different resistors in the screen grid lead (grid 5). Measurements taken on an oscillating valve. in the circuit shown in Fig. 2.

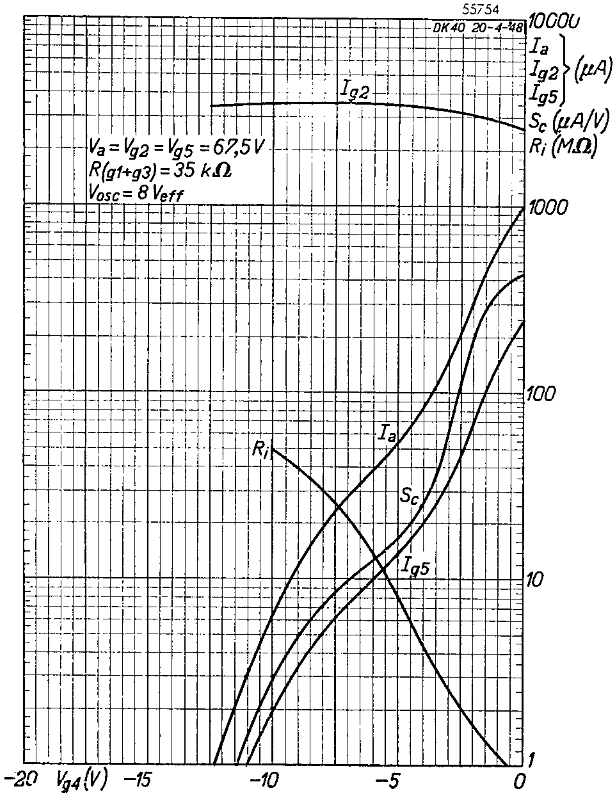


Fig. 6

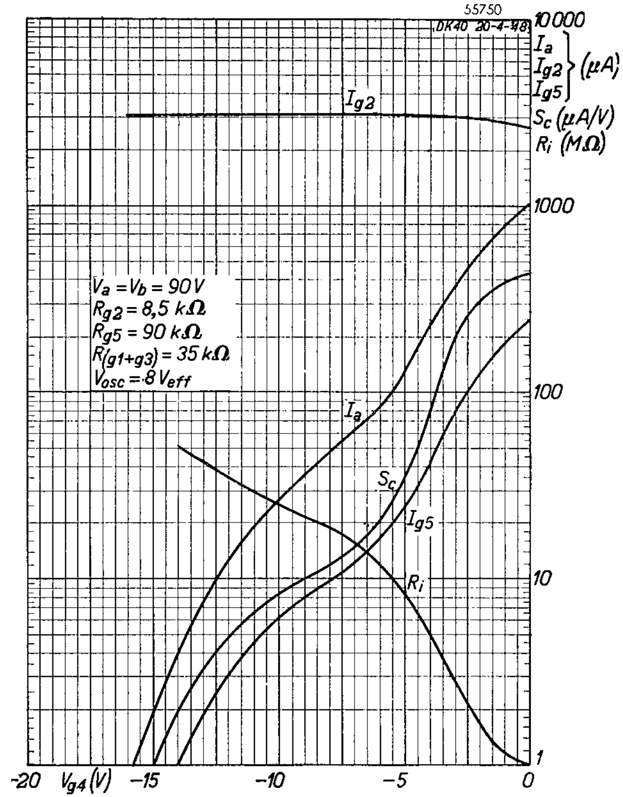


Fig. 7

Anode current (I_a), screen grid current (I_{g5}), oscillator anode current (I_{g2}), conversion conductance (S_c) and internal resistance (R_i) of the DK 40 as functions of the grid bias (V_{g4}). Measurements taken on an oscillating valve, in the circuit shown in Fig. 2. Fig. 6: battery voltage 67.5 V; Fig. 7: battery voltage 90 V.

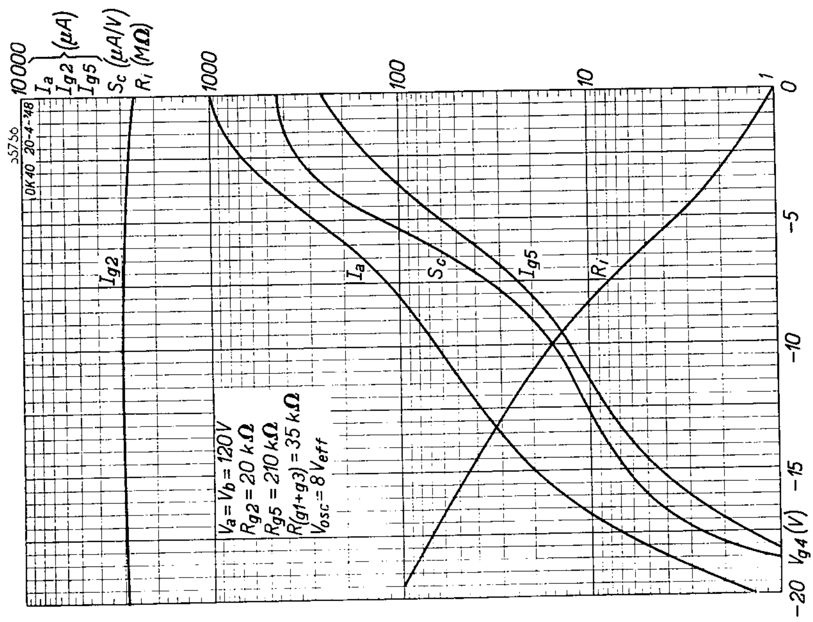


Fig. 8

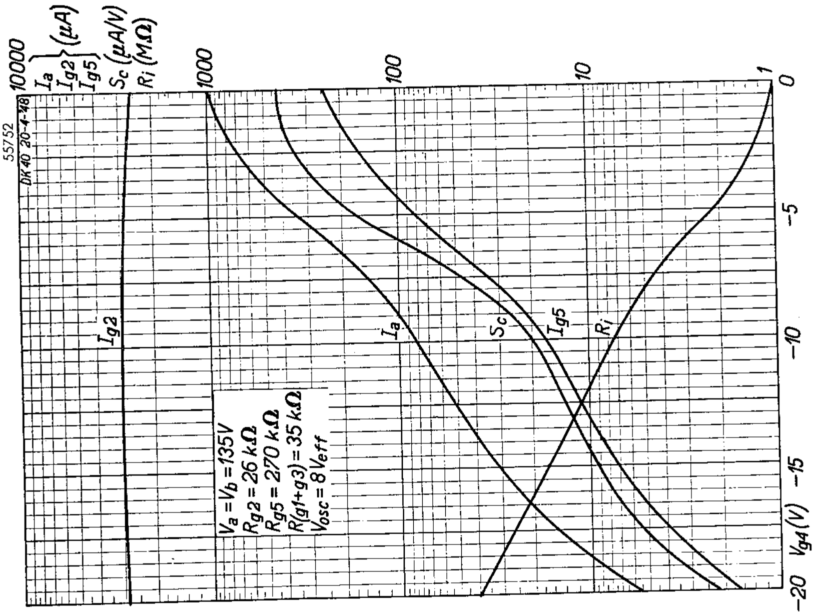


Fig. 9

As Fig. 6, but for battery voltages 120 V (Fig. 8) and 135 V (Fig. 9).

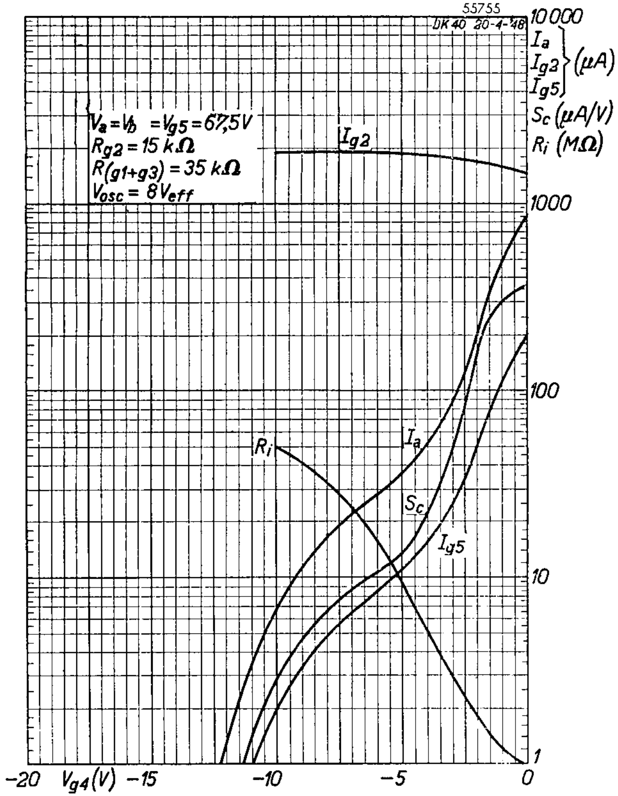


Fig. 10
As Fig. 6, but for the economy circuit (oscillator anode voltage $V_{g2} = 45$ V).

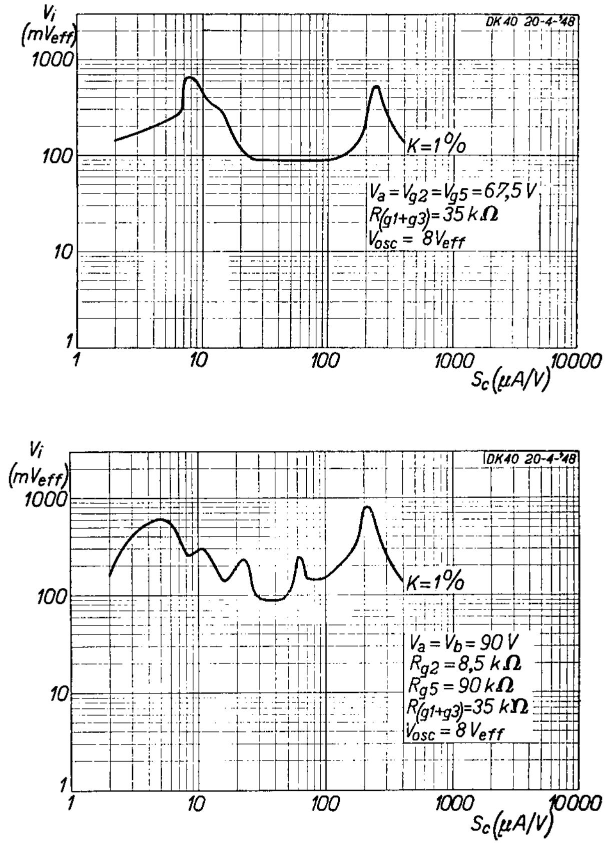


Fig. 11
Effective voltage (V_i) of an interfering signal on the control grid, producing 1% cross modulation, as a function of the conversion conductance (S_c). Upper Fig.: battery voltage 67.5 V; lower Fig.: battery voltage 90 V.

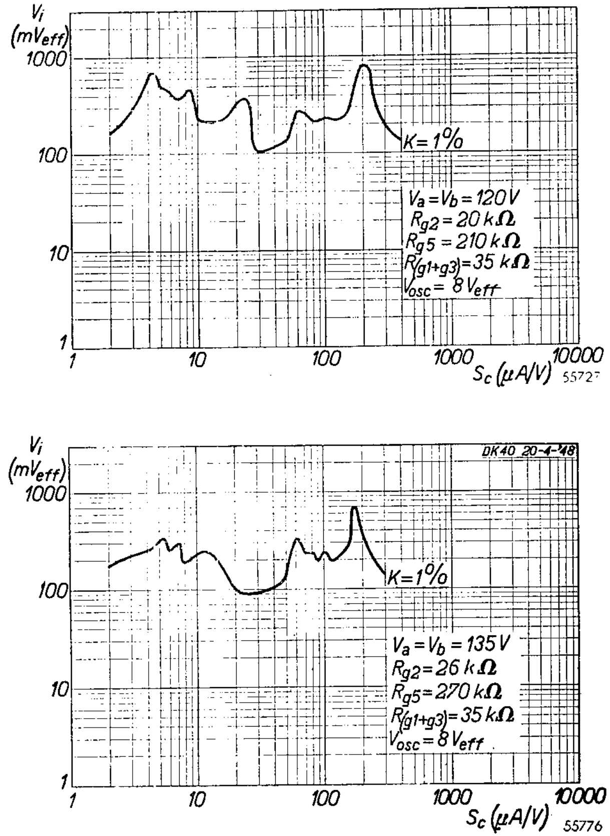


Fig. 12
As Fig. 11: upper Fig.: battery voltage 120 V; lower Fig.: battery voltage 135 V.

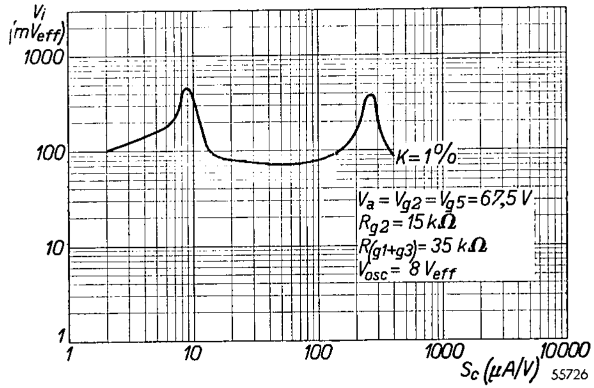


Fig. 13
As Fig. 11, but for the economy circuit (oscillator anode voltage $V_{g2} = 45$ V).

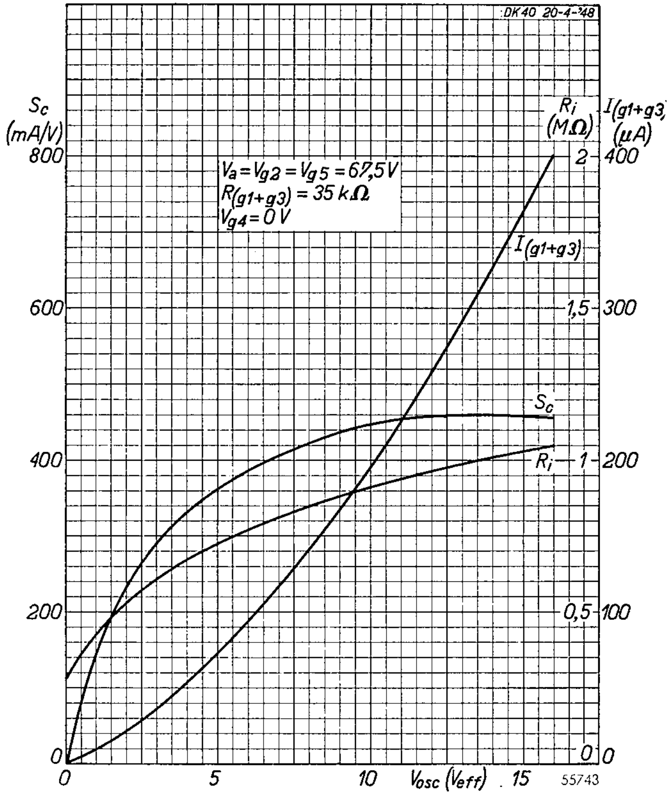


Fig. 14

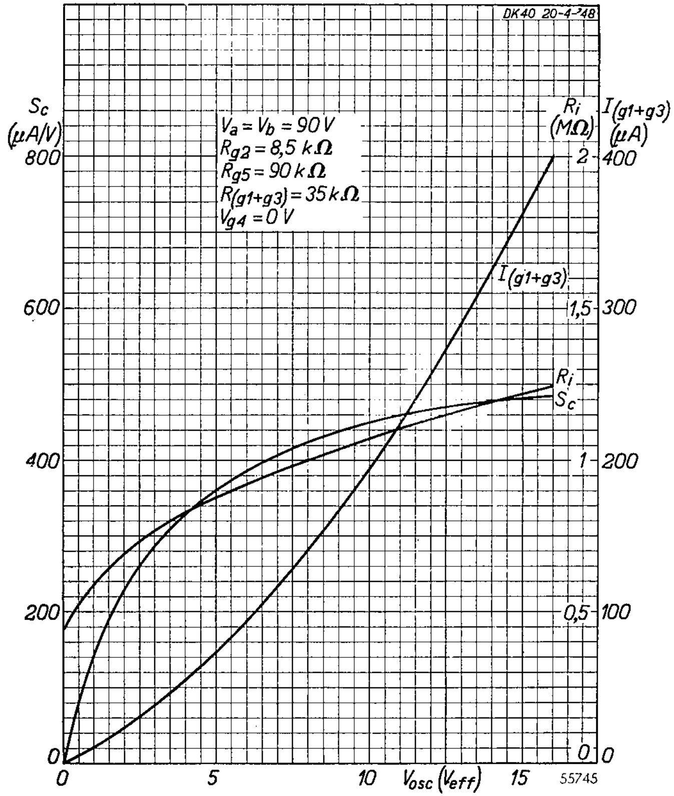


Fig. 15

Conversion conductance (S_c), internal resistance (R_i) and oscillator current (I_{g1+g3}) as functions of the oscillator voltage (V_{osc}). Fig. 14: battery voltage 67.5 V. Fig. 15: battery voltage 90 V.

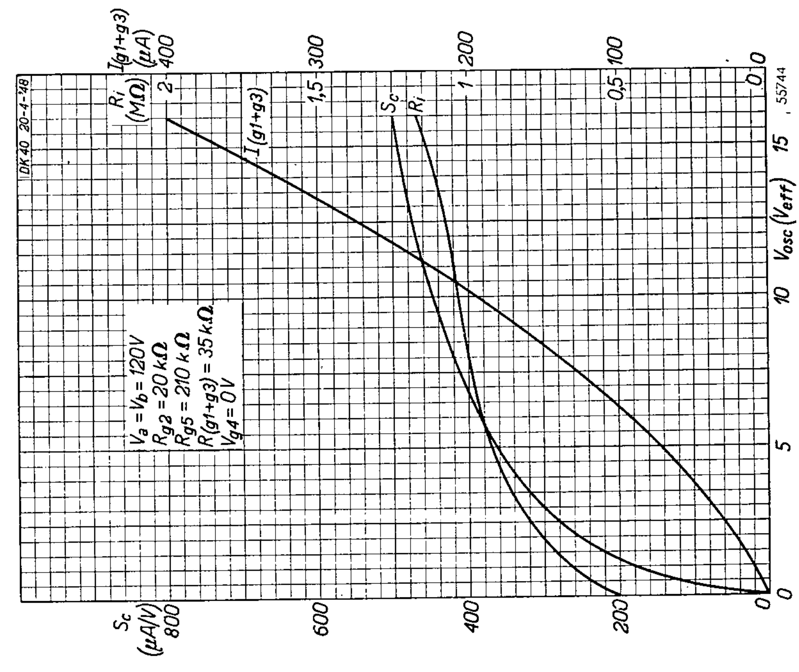


Fig. 16
As Fig. 14, but with 120 V battery.

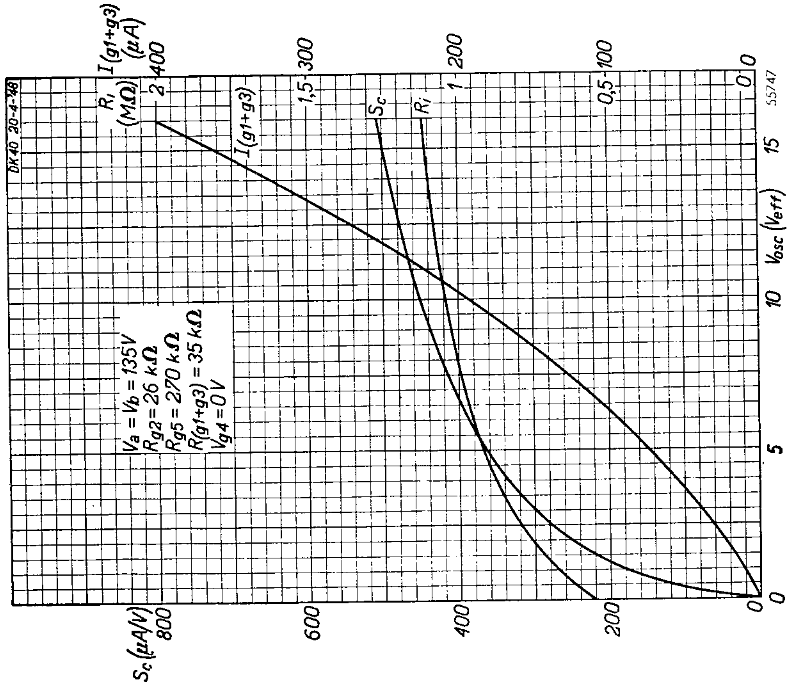


Fig. 17
As Fig. 14, but with 135 V battery.

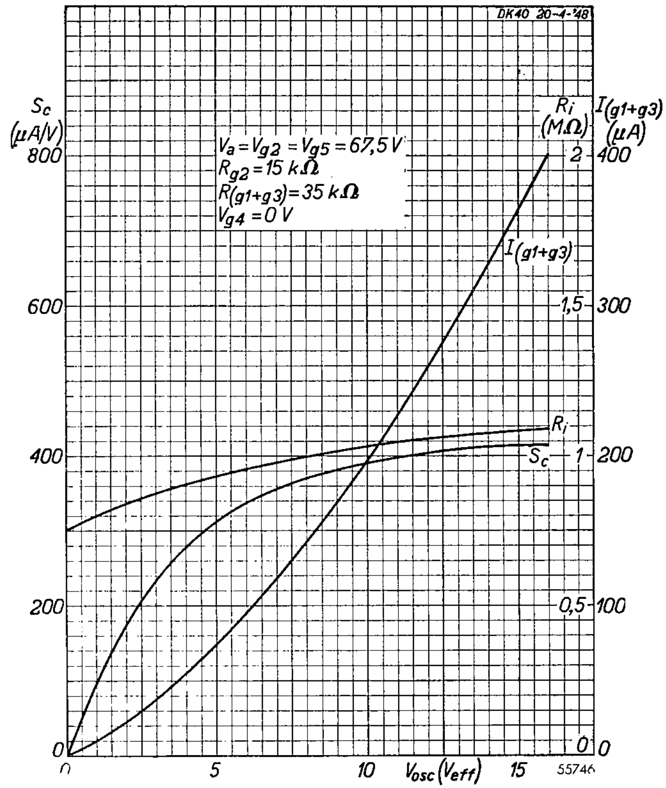


Fig. 18
As Fig. 14, but for the economy circuit (oscillator anode voltage $V_{g2} = 45$ V).

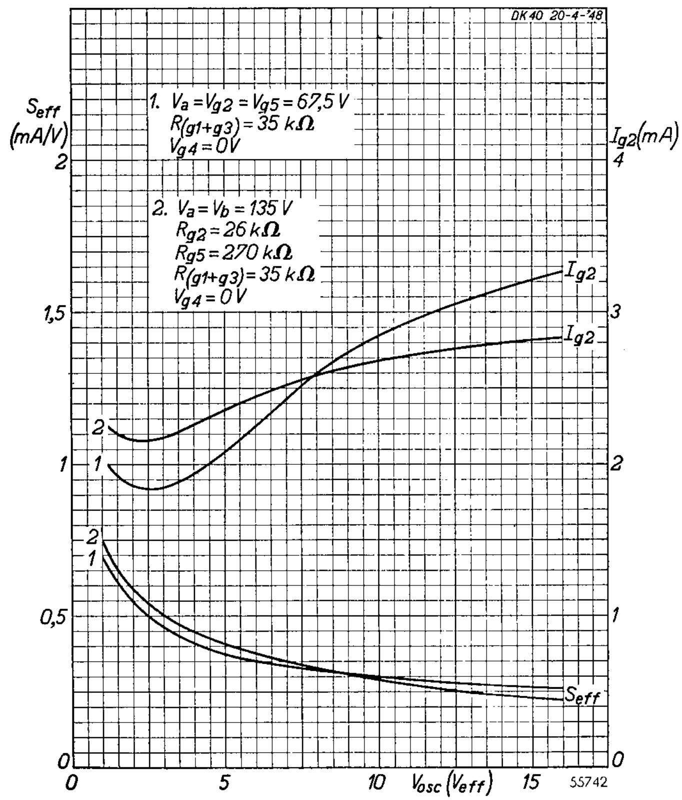


Fig. 19
Effective slope (S_{eff}) of the oscillator section (filament and grids 1 and 2) and oscillator anode current (I_{g2}) as functions of the oscillator voltage (V_{osc}), for battery voltages of 67.5 and 135 V.

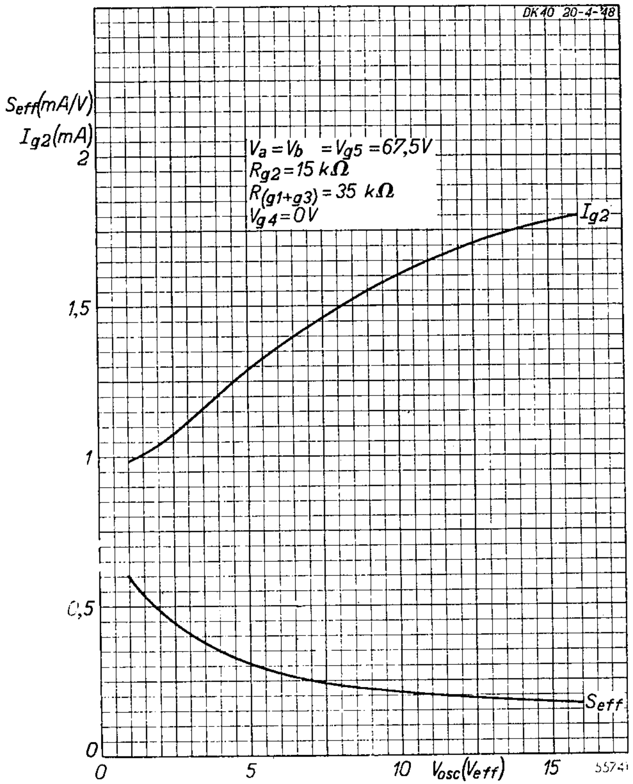
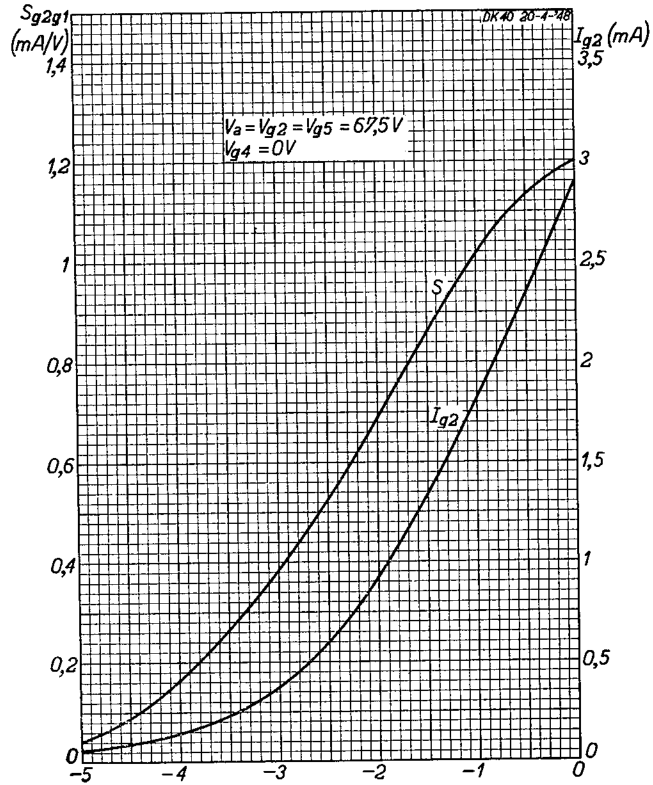


Fig. 20
As Fig. 19, but for the economy circuit (oscillator anode voltage $V_{g2} = 45$ V).



V_{g1} (with respect to + f)

Fig. 21
Static slope (S_{g2g1}) of the oscillator section (filament and grids 1 and 2), and oscillator anode current (I_{g2}) as functions of the bias on the first grid, at a battery voltage of 67.5 V.

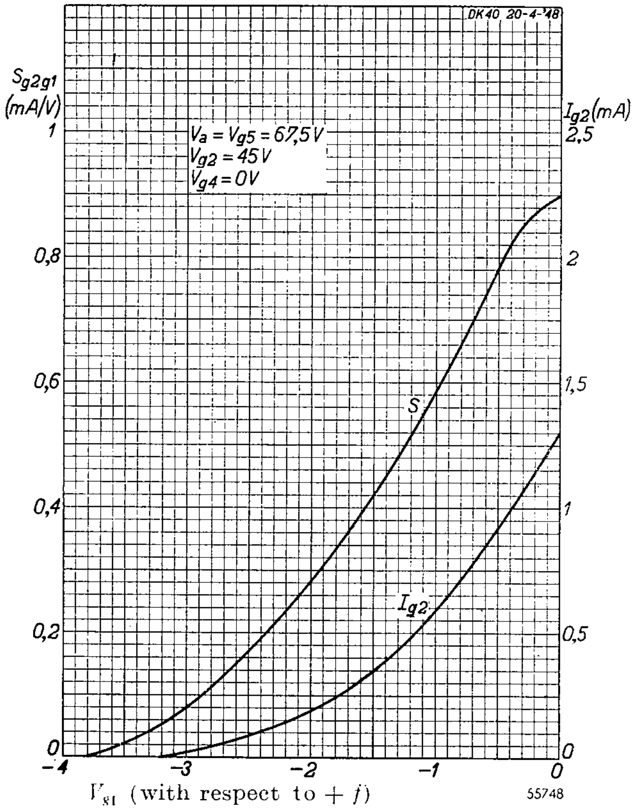


Fig. 22
As Fig. 21, but employing the economy circuit (oscillator anode voltage $V_{g2} = 45$ V).