DK 21 Battery Octode

This is a frequency changer for superheterodyne battery receivers designed for use with an octode. It is a directly heated valve with a filament voltage of 1.4 V and is therefore suitable for operation by means of a dry battery. The filament current at the rated voltage is only 50 mA and the filament can be connected in series with other 50 mA valves.

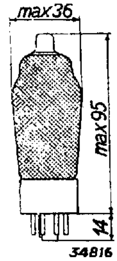
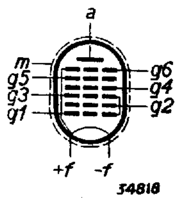


Fig. 1
Dimensions in mm.

The principle of the DK 21 departs to a certain extent from that of conventional octodes and pentagrids, although the first grid is none the less employed as oscillator grid and the fourth as control grid.

As in the case of the octode EK 3, which works with four electron streams, the DK 21 follows the multi electron-stream system. Fig. 4 shows a cross section through the electrodes, in reference to which the working will now be described.



In the conventional type of octode (e.g. AK 2), the potential in the plane of the control grid is sufficiently positive due to the first positive screen (usually designated g_3). In the DK 21, however, the first screen is omitted (see Fig. 4) and its function taken over by the oscillator electrode g_2, consisting of 4 rods: Figs. 3 and 4 show how these rods are mounted in relation to the first grid; their influence across the first grid is such as to render the emerging electron stream sufficiently strong. The streams flow mainly between the rods to the control grid g_4, but a small portion arrives directly at the oscillator electrode g_2. In this way the electron streams are not dispersed by the turns of a screen grid, after the manner of the ordinary octode or heptode (pentagrid): in other words, the electrons are not deflected in various arbitrary directions, but move in an orderly stream along predetermined paths, and this has a very beneficial effect on the conductance of the 4th grid as also on the conversion conductance of the valve, which is proportional to it.

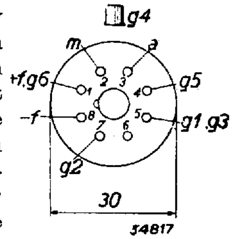


Fig. 2
Arrangement and sequence of contacts.

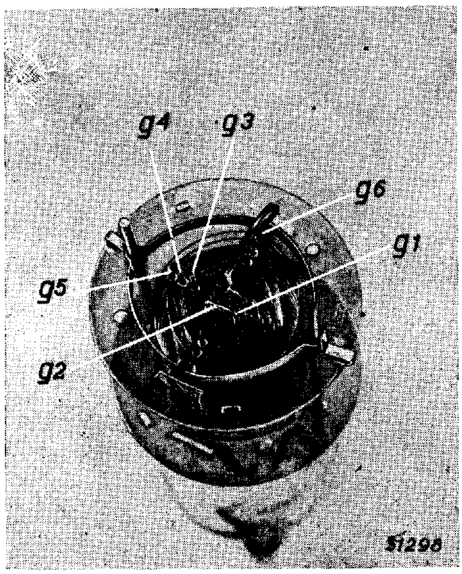


Fig. 3
Photographic view of interior of the octode DK 21 (without anode).

Assuming that all electrons move towards the 4th grid at the same velocity, at a certain potential in the plane of the 4th grid they will all continue to flow in the direction of the anode. At a slightly lower potential all the electrons will return simultaneously.

This means that the conductance of

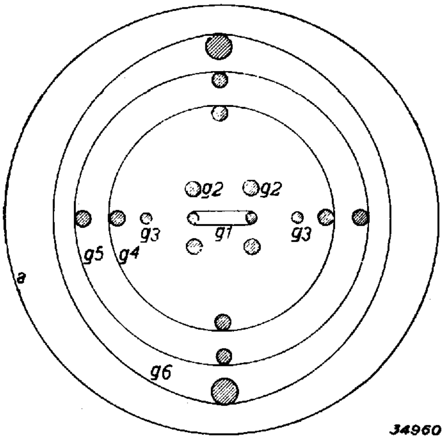


Fig. 4
Diagrammatic cross section through the electrode system of the DK 21.

the 4th grid is extremely good. On the other hand, when the electrons are deflected more or less laterally by the turns of a screen grid, not all of them move towards the 4th grid at the same velocity: due to the deflection, velocity in the direction perpendicular to the grid is reduced, whilst the velocity component in the tangential direction is increased. In the DK 21 this latter component, as far as return of the electrons before the grid or their movement towards the anode is concerned, does not play any part at all. If the electrons move at different velocities on their way to the grid, some of them will return from the grid at one voltage and some at another, which considerably reduces the conductance of the 4th grid.

Most pentodes and heptodes have a screen grid wound in such a way that it produces streams of electrons in the most divergent directions, and the conductance is then so much the lower, but in a valve constructed on the electron-bunching principle, the conductance is very much greater.

In the octode having four electron bundles, as mentioned in part II (see p. 106), this electron bunching is carried out by means of slots in the positive screen plates, whereas in the DK 21 the four rods of the oscillator anode serve the same purpose. In this way a mutual conductance of about 500 μA/V is obtained at an anode current of only 1.5 mA, which is twice the figure in respect of the earlier battery octode type KK 2.

The mutual conductance of the oscillator section of the DK 21 is also improved by reason of the special construction, in that electrons that do not pass through the 4th grid pass exclusively to the oscillator anode. In consequence, the whole current is available for purposes of oscillation and it is due to this that the short wave characteristics of the valve are so good at a very low current consumption, although no control is possible in that range.

The principle of the octode, upon which the construction of the DK 21 is based, would involve the disadvantage of inductive effects unless special precautions were taken to prevent this. In the EK 2 and EK 3 the effect is counteracted by inserting

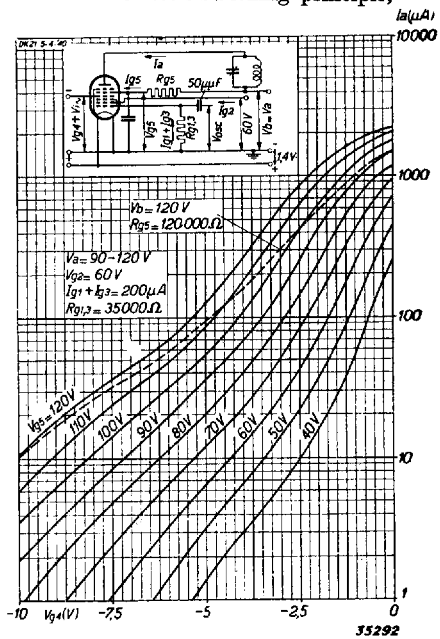


Fig. 5.
Anode current as a function of grid bias at Va = 90 — 120 V, with the voltage of grid 5 as parameter. The broken line shows the anode current when the screen is fed from the 120 V source through a resistance of 120,000 Ohms.

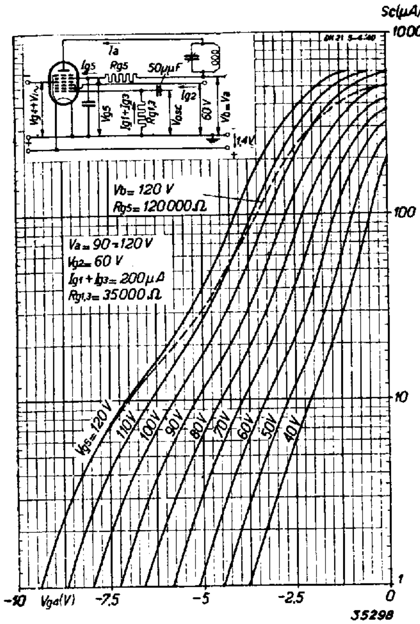


Fig. 6
Conversion conductance as a function of grid bias at Va = 90 — 120 V, with the voltage of grid 5 as parameter. The broken line shows the conversion conductance when the screen is fed from the 120 V source through a resistance of 120,000 Ohms.

a condenser, or condenser with resistance, in series between the oscillator and control grids (grids 1 and 4). The compensation is accomplished very simply with the DK 21, in that, close to the supports of the 4th grid, two rods are mounted, in electrical contact with grid 1. In this manner a capacitance is established between grids 1 and 4 which compensates capacitance between the oscillator anode g_2 and grid g_4 as well as that arising from the electronic coupling.

The DK 21 is a variable-mu valve and can therefore be included in the automatic gain control circuit. Since in most battery receivers there is usually only a very small voltage available for the A.G.C., every care has been taken to ensure a sharp control. To regulate the conversion conductance to 1/100 of the initial value the grid bias should be about 8 V. In the short wave range it is not advisable, in view of frequency drift, to control the DK 21, but at wavelengths of upwards of 200 m the drift is sufficiently slight.

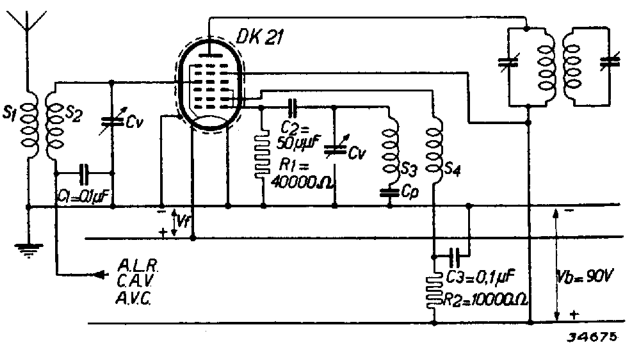


Fig. 7
Circuit diagram showing the Octode DK 21 employed as frequency-changer.

FILAMENT RATINGS

Heating: direct, with battery, rectified alternating current, or D.C.; series or parallel.

Filament voltage	V_f	= 1.4 V
Filament current	I_f	= 0.050 A

CAPACITANCES

Anode-control grid	C_{ag4}	< 0.1 pF
Anode capacitance	C_a	= 9.4 pF
Control grid capacitance	C_{g4}	= 9.2 pF
Oscillator grid capacitance	$C_{(g1+g3)}$	= 7.0 pF
Oscillator anode capacitance	C_{g2}	= 5.9 pF
Oscillator anode-control grid	C_{g2g4}	< 0.9 pF
Oscillator grid-control grid	$C_{(g1+g3)g4}$	= 1.3 pF

OPERATION DATA FOR THE MIXER SECTION

a) at 90 V and with fixed screen grid voltage

Supply or anode voltage	$V_b = V_a$ =	90 V	
Screen grid voltage	V_{g5} =	90 V	
Oscillator grid leak	$R_{g1,3}$ =	35,000 Ohms	
Oscillator anode resistance	R_{g2} =	12,500 Ohms	
Current flow through grid leak of oscillator during oscillation	$I_{g1} + I_{g3}$ =	200 μA	
Grid bias	V_{g4} =	0 V[1]	—6 V[2]
Oscillator anode voltage	V_{g2} =	60 V	—
Anode current	I_a =	1.5 mA	—
Oscillator anode current	I_{g2} =	2.4 mA	—
Screen grid current	I_{g5} =	0.25 mA	—
Conversion conductance	S_c =	500 μA/V	5 μA/V
Internal resistance	R_i =	1.25 M Ohms	> 10 M Ohms

b) at 120 V and with sliding screen grid voltage

Screen supply or anode voltage	$V_a = V_b$ =	120 V	
Screen grid resistance	R_{g5} =	120,000 Ohms	
Oscillator grid leak	$R_{g1,3}$ =	35,000 Ohms	
Oscillator anode grid resistance	R_{g2} =	25,000 Ohms	
Current flow through grid leak of the oscillator during oscillation	$I_{g1}+I_{g3}$ =	200 μA	
Grid bias	V_{g4} =	0 V[1]	—8 V[2]
Oscillator anode voltage	V_{g2} =	60 V	—
Anode current	I_a =	1.5 mA	—
Oscillator anode current	I_{g2} =	2.4 mA	—
Screen grid current	I_{g5} =	0.25 mA	—
Screen voltage	V_{g5} =	90 V	120 V
Conversion conductance	S_c =	500 μA/V	5 μA/V
Internal resistance	R_i =	1.5 M Ohms	> 10 M Ohms

[1]) Valve not controlled.

[2]) Conversion conductance controlled to 1/100.

RATINGS AND OPERATING DATA FOR THE OSCILLATOR SECTION

Supply voltage	V_b	=	90 V	120 V
Oscillator anode resistance	R_{g2}	=	12,500 Ohms	25,000 Ohms
Oscillator anode voltage during oscillation	V_{g2}	=	60 V	60 V
Oscillator grid leak	$R_{g1,3}$	=	35,000 Ohms	35,000 Ohms
Current flow through grid leak of the oscillator to give the required oscillating voltage	$I_{g1}+I_{g3}$	=	200 μA	200 μA
Oscillator anode current during oscillation	I_{g2}	=	2.4 mA	2.4 mA
Oscillator anode current, quiescent (V_{osc} = 0 V; V_{g2} = 60 V)	I_{g2}	=	—	3.1 mA
Mutual conductance at commencement of oscillation (V_{osc} = 0 V; I_{g2} = 3.1 mA)	S_{g2g1}	=	—	0.95 mA/V
Gain factor (V_{osc} = 0 V; I_{g2} = 3.1 mA)	μ_{g2g1}	=	—	8.5

MAXIMUM RATINGS

Anode voltage	V_a	= max. 135 V
Anode dissipation	W_a	= max. 0.3 W
Screen grid voltage	V_{g5}	= max. 135 V
Screen grid dissipation	W_{g5}	= max. 0.05 W
Oscillator anode voltage	V_{g2}	= max. 80 V
Oscillator anode dissipation	W_{g2}	= max. 0.3 W
Cathode current	I_k	= max. 5 mA
Grid current commences at (I_{g4} = +0.3 μA)	V_{g4}	= max. +0.2 V
Max. external resistance between grid 4 and filament	R_{g4f}	= max. 3 M Ohms
Max. external resistance between grid 1 + 3 and filament	$R_{g1,3f}$	= max. 0.1 M Ohm
Minimum limit for the filament voltage	V_f	= min. 1.1 V
Maximum limit for the filament voltage	V_f	= max. 1.5 V

APPLICATIONS

The DK 21 was expressly designed for use as frequency-changer in battery superheterodyne receivers and more especially for sets in which the filament current is to be as low as possible. The H.T.battery may be between 90 and 135 V and filament voltage is taken from a dry battery, or an accumulator with resistance in series. This valve will still work in conventional circuits when the H.T.voltage has dropped from 90 to 60 V and the filament voltage to 1.1 V, although, naturally, the conversion conductance is then considerably less.

The external circuit of the DK 21 is extremely simple and Fig. 7 shows the arrangement for use as frequency changer. It is advisable to couple the tuned oscillator circuit to the first grid and to feed back by way of the oscillator anode, since this is the only method of obtaining reliable oscillation when normal types of coil are used. To ensure stable oscillation, the oscillator anode should be connected to the HT battery through a series resistance and not direct to one of the battery tappings. Due to the constructional details mentioned above, the inductance effect is negligibly small (max. induced voltage about 0.4 V), and the consequent effect upon the conductance in normal circuits is barely perceptible.

It is recommended that the positive side of the voltage be connected to pin No. 1 (see Fig. 2), with which the suppressor grid is also in contact: this gives a higher conversion conductance than in the opposite case. Finally, it should be noted that grid current commences to flow only when the control grid carries a small positive potential, so that no grid bias need be applied to this grid.

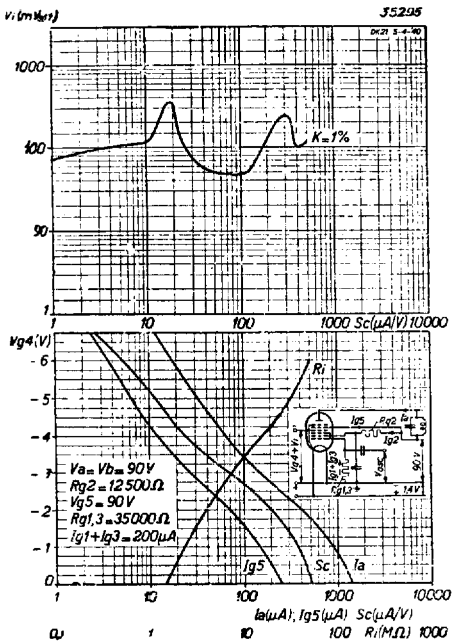


Fig. 8
Upper diagram; Alternating grid voltage at 1 % cross modulation, as function of conversion conductance at $Va = Vb = Vg_5 = 90$ V. *Lower diagram;* conversion conductance *Sc*, anode current *Ia*, screen current Ig_5 and internal resistance *Ri* as a function of grid bias.

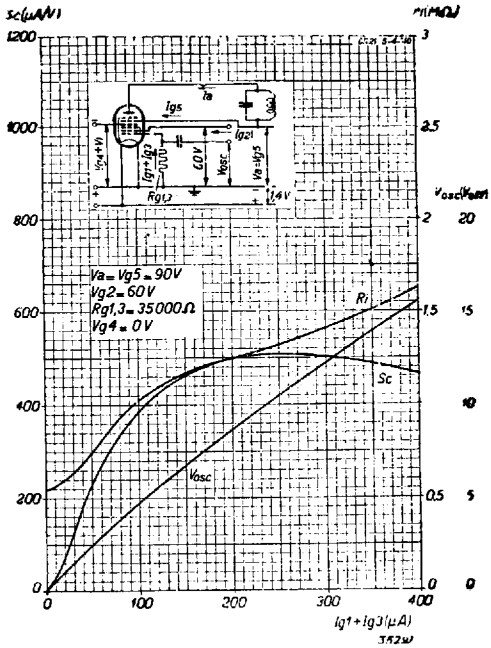


Fig. 9
Conversion conductance *Sc*, internal resistance *Ri*, and alternating oscillator voltage *Vosc* (effective) as a function of oscillator grid current $Ig_1 + Ig_3$, at $Va = Vg_5 = 90$ V.

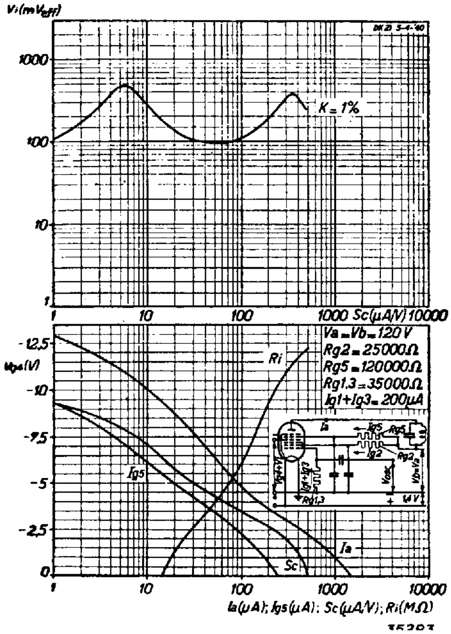


Fig. 10

Upper diagram; Alternating grid voltage with 1 % cross modulation, as a function of conversion conductance, at $Va = Vb = 120$ V. *Lower diagram;* Conversion conductance *Sc*, anode current *Ia*, screen grid current Ig_5 and internal resistance *Ri* as a function of grid bias.

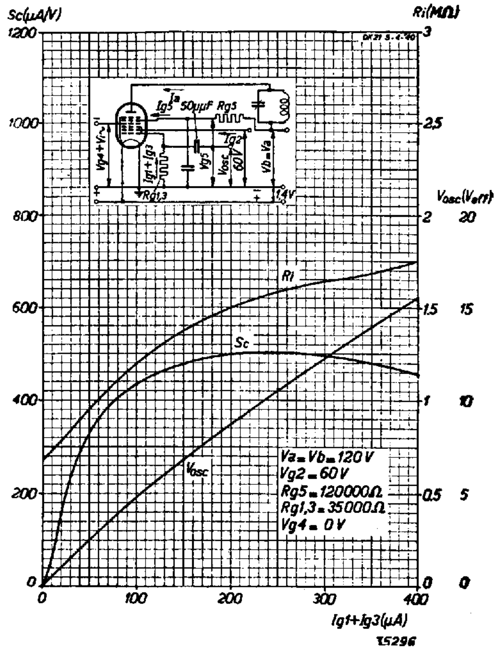


Fig. 11

Conversion conductance *Sc*, internal resistance *Ri* and alternating oscillator voltage *Vosc* (effective value), as function of oscillator grid current $Ig_1 + Ig_3$, at $Va = Vb = 120$ V