

EH 2 Heptode

This pentagrid valve can be employed very successfully on very short wavelengths as a controlled modulator in conjunction with a separate oscillator, and also as R.F. or I.F. amplifier with limited control range.

The action of this valve is similar to that of a hexode in that, when used as modulator, the input signal is applied to the first grid and the oscillator signal to the third. The 2nd and 4th grids are screen grids having their own separate contacts on the base of the valve. The fifth grid which, regarded superficially, constitutes the main point of difference with the earlier type of hexode, is a suppressor grid, whose purpose is to improve the internal resistance and to ensure satisfactory performance when the valve is used in A.C./D.C. receivers with 100 V on the anode.

When the EH 2 is employed as frequency-changer a separate oscillator has many advantages; a triode such as the EBC 3 has an initial mutual conductance (at $V_g = 0$, $S = 3.0 \text{ mA/V}$) that will guarantee stability of oscillation also in the short-wave range. A variable- μ modulator valve should meet the following requirements:

- 1) Conversion conductance should be sufficiently high.
- 2) Required oscillator voltage should be as low as possible.
- 3) Currents due to transit-time must not occur.

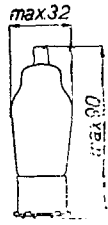


Fig. 1
Dimensions in mm

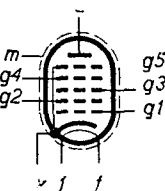


Fig. 2
Arrangement of electrodes and base connections.

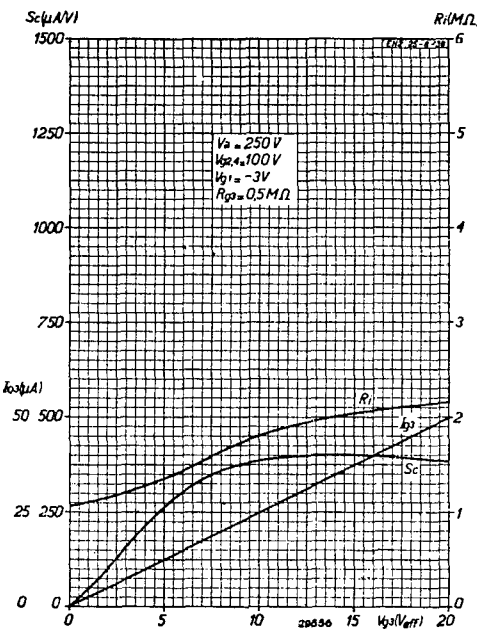


Fig. 3
Conversion conductance, internal resistance and oscillator-grid current as a function of the oscillator voltage on grid 3, at 250 V anode, 100 V screen and -3 V bias on grid 1.

- 4) Parallel input impedance should remain as high as possible, down to the very shortest wavelengths.
- 5) A satisfactory compromise between the least possible background noise, narrow range of bias for full control of the valve and also least possible cross-modulation.
- 6) Negligible frequency drift arising from the automatic gain control or from mains voltage variations.
- 7) Least possible coupling between input and oscillator circuits (inductive effect).

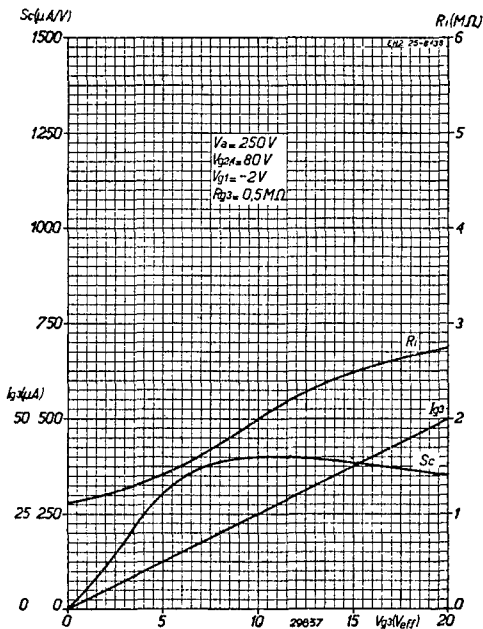


Fig. 4
Conversion conductance, internal resistance and oscillator current as a function of the oscillator voltage on grid 3, with 250 V anode, 80 V screen and -2 V bias on grid 2.

conversion conductance as a function of the oscillator voltage and these figures show that the values at very much lower oscillator voltages are still quite reasonable. This is important for short-wave reception.

3) The question of transit time current has also been satisfactorily dealt with. The electrons encounter a certain amount of delay in the field between grids 2 and 3, but at very high frequencies some of them, as a result of the alternating field produced by the oscillator voltage on grid 3, acquire so much kinetic energy that, despite the negative bias on grid 1,

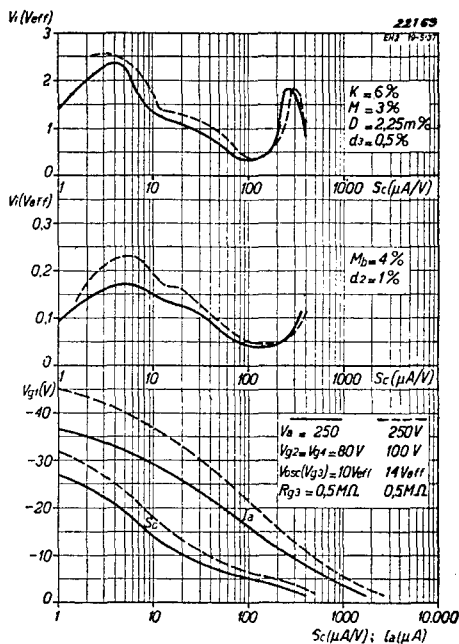


Fig. 5
Upper diagram. EH 2 used as a frequency changer. Alternating input voltage as a function of the conversion conductance as controlled by the bias on grid 1, with 6 % cross-modulation.
Centre diagram. Alternating input voltage as a function of the conversion conductance as controlled by the bias on grid 1, with 4 % modulation hum.
Lower diagram. Conversion conductance and anode current as a function of the bias on grid 1

1) In the EH 2 the required conversion conductance is ensured by the high conductance of the 1st grid with respect to the anode current (when using this valve as a straight amplifier and at $V_{g3} = 0$). This conductance is 1.8 mA/V.

2) With regard to the required oscillator voltage, the characteristic of the conductance of the first grid in relation to the anode current, as a function of the voltage on the 3rd grid, is the deciding factor. The more steeply this characteristic drops when the bias on the 3rd grid (V_{g3}) is increased, the lower the peak oscillator voltage on the grid. Due to the particular construction of the first grid, this conductance is so high that when grids 2 and 4 are given a potential of 100 V the oscillator voltage necessary for the normal conversion conductance is approximately 14 V_{eff}, which can be supplied by any ordinary oscillator. Figs 3 and 4 reproduce the

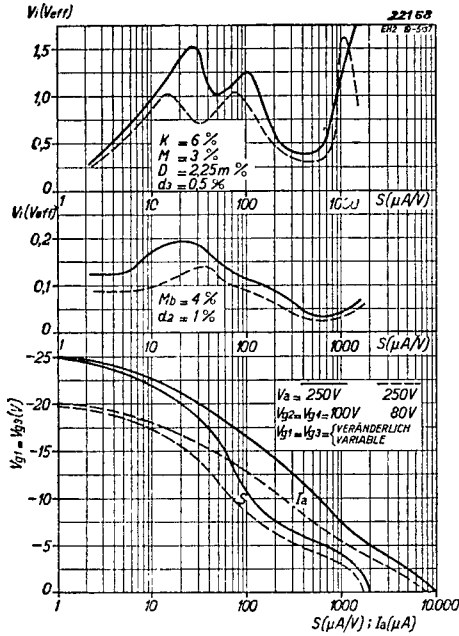


Fig. 6

EH 2 used as an R.F. or I.F. amplifier.
Upper diagram. Alternating input voltage as a function of the mutual conductance when controlled by a similar bias on grids 1 and 3, with 6 % cross-modulation.
Centre diagram. Alternating input voltage as a function of the mutual conductance when controlled by the bias on grids 1 and 3, with 4 % modulation hum.
Lower diagram. Mutual conductance and anode current as a function of the bias on grids 1 and 3.

to mains voltage fluctuations that may be regarded as extremely slight. The drift arising from variations in the mutual conductance is also very small, since this is caused by differences in the capacitance of grid 3 which in themselves are negligible.

7) The heptode EH 2 will not produce any electrical coupling effects between oscillator and input grids, because grid 3 in no way influences the electrons in the neighbourhood of grid 1:

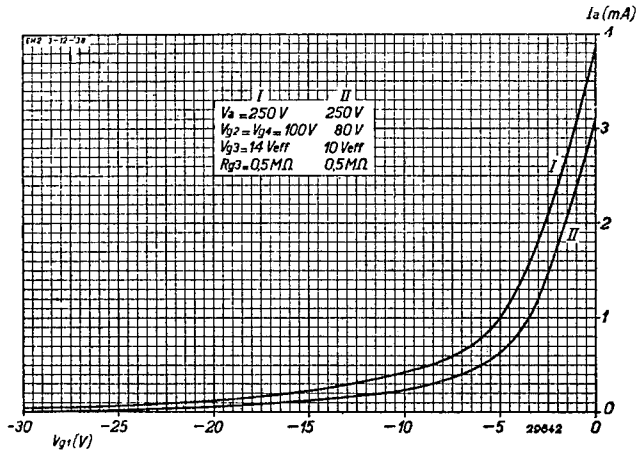


Fig. 7

Anode current as a function of the voltage on grid 1. EH 2 used as a frequency-changer.

they return in the direction of this grid: this will take place when the period of the alternating field corresponds in order of size to that of the transit time required by the electron between these grids. This transit time is reduced by making the space between grids 3 and 2 small, but normally this procedure has an adverse effect on other properties of a heptode and in this respect the EH 2 represents the best possible compromise.

4) The parallel input impedance in the short-wave range shows a considerable improvement over other types, by reason of the very small spacing of $g_1 - k$ and $g_2 - g_1$. At 15 metres and on a signal frequency of 500 kc/s above the oscillator frequency ($f_{osc} = f_i + 500$ kc/s) the following values of input impedance and capacitance were obtained by actual measurement:

$$R_{input} = 30,000 \text{ ohms}$$

$$C_{input} = 6.3 \mu\mu F$$

5) In the development of the EH 2 every effort has been made to keep the noise factor as low as possible, whether the valve be used as frequency-changer or as R.F. amplifier. As will be seen from Figs 5 and 6, the alternating input voltage with 6 % cross-modulation, when under the effect of control, is in either case less than 0.3 V_{eff} .

6) When used with a separate oscillator valve, the valve has a frequency drift due

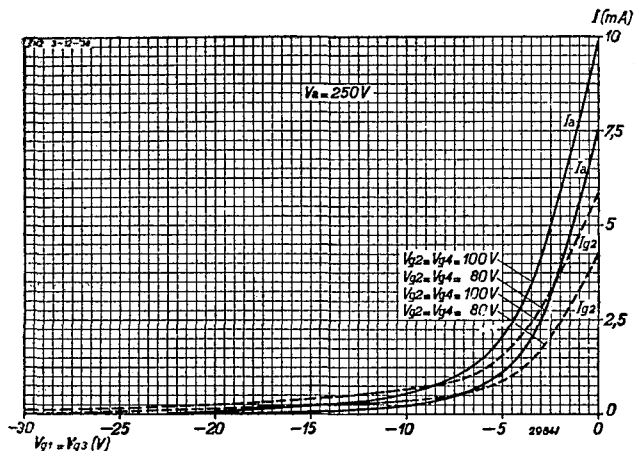


Fig. 8
Anode and screen-grid current as a function of the voltage on grids 1 and 3 when using the EH 2 as R.F. or I.F. amplifier.

there is therefore no negative capacitance between grids 1 and 3.

The normal capacitance exists between the electrodes mutually, this being about $0.2 \mu\text{F}$, which on very short waves does result in retroaction from the oscillator voltage to the

input circuit, although if the oscillator frequency is taken higher than the input frequency this will not affect the performance of the valve.

HEATER RATINGS

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

Heater voltage $V_f = 6.3 \text{ V}$

Heater current $I_f = 0.200 \text{ A}$

CAPACITANCES

$$C_{ag1} < 0.0015 \mu\text{F}$$

$$C_{g1} = 5 \mu\text{F}$$

$$C_a = 11 \mu\text{F}$$

$$C_{g1g3} = 0.2 \mu\text{F}$$

OPERATING DATA: EH 2 used as frequency-changer

Anode voltage	$V_a =$	250	250 V
Screen-grid voltage	$V_{g2,1} =$	100	80 V
Grid leak, oscillator	$R_{g3} =$	0.5	0.5 M ohm
Oscillator voltage, grid 3	$V_{osc} =$	14	10 V_{eff}
Cathode resistor	$R_k =$	530	380 ohms
Grid bias	$V_{g1} =$	-3 -25	-2 -20 V
Anode current	$I_a =$	1.85	1.8 mA
Screen current	$I_{g2} + I_{g4} =$	3.8	3.5 mA
Conversion conductance	$S_c =$	400 < 10	400 < 10 $\mu\text{A/V}$
Internal resistance	$R_i =$	2 > 10	2 > 10 M ohms

OPERATING DATA: EH 2 used as R.F. or I.F. amplifier

Anode voltage	$V_a =$	250	250 V
Screen-grid voltage	$V_{g2} = V_{g4} =$	100	80 V
Cathode resistor	$R_k =$	430	310 ohms
Grid bias	$V_{g1} = V_{g3} =$	-3 -25	-2 -20 V
Anode current	$I_a =$	4.2	4 mA
Screen current	$I_{g2} + I_{g4} =$	2.8	2.5 mA
Mutual conductance	$S =$	1400 < 2	1400 < 2 $\mu\text{A/V}$
Internal resistance	$R_i =$	1 > 10	1 > 10 M ohms

When the EF 6 is used as oscillator the oscillator voltage will be somewhat higher and, in the short-wave range, in contrast with octodes such as the EK 2, the oscillator frequency should be higher than the input frequency, as is usual on the medium and long waves. The other coupling, established by the capacitance between g_1 and g_3 , then provides a voltage across the input circuit of the same frequency as the oscillator, and the phase of this voltage is such that it tends to augment the conversion amplification. In the uncontrolled condition the bias on grid 1 should be -2 V with 80 V on screens 2 and 4, or -3 V with 100 V on the screens. The control voltage from the A.G.C. is in this case applied only to the first grid. The two screens (2 and 4) should be fed from a generously proportioned potential divider.

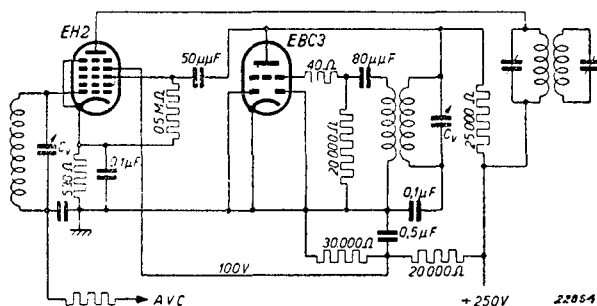


Fig. 10
Circuit diagram of the EH 2 used as frequency-changer with the EBC 3 as oscillator