

ECH 41

ECH 41 Triode-hexode frequency changer

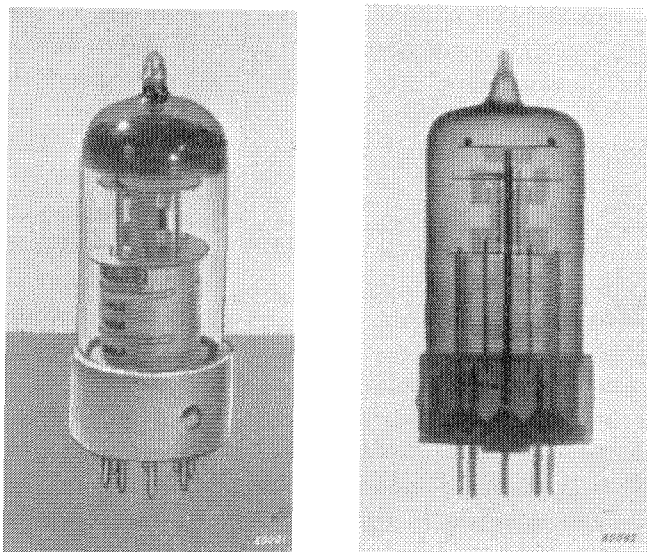


Fig. 1

Normal and X-ray photographs of the ECH 41 (approximately actual size).

The ECH 41 is a triode-hexode designed along the simplest possible lines, whilst retaining the best possible mixing properties. As the grid of the triode system and the modulator (third) grid of the hexode system are internally connected, the valve can be used as frequency changer only.

The conversion conductance of this valve is variable, being $500 \mu\text{A/V}$ at the working point, for an oscillator voltage of $8 V_{\text{RMS}}$. From Fig. 12 it will be seen that the conversion conductance varies only slightly with the oscillator voltage. Since the internal resistance of the valve is $2 \text{ M}\Omega$ at the working point, the anode can be connected to the “top” of the first I.F. transformer. Using I.F. transformer circuits with coils having a quality factor of $Q=140$ and critical coupling, with tuning capacitors of 100 pF , a conversion gain of about 90 is obtainable.

The initial slope of the triode section (i.e. the slope of the valve when not oscillating) (at $V_g=0$) is 1.9 mA/V ; the effective slope of the oscillating valve is 0.55 mA/V , with an oscillator voltage of $8 V_{\text{RMS}}$ (the effective slope is the quotient of the fundamental components of alternating anode current and alternating grid voltage). Although the initial slope is of a sufficiently high value to start the oscillation under normal circumstances, and the effective slope more than enough to maintain oscillation, it is advisable to use an extra coil in the short-wave band. Further reference is made to this point later.

Fig. 2 shows the ECH 41 used as frequency changer for medium and long wavelengths. To ensure that the very satisfactory internal resistance of the valve is retained when control is applied, the screen grids of the hexode system should be fed from a potentiometer, and a good arrangement consists in connecting a resistor of 33 k Ω between the supply voltage and the screen grids, with 47 k Ω between screen grids

and chassis. When the EAF 42, or EF 41 is used as I.F. amplifier, the screen grid voltage for this valve can be derived from the same potentiometer, thus saving a resistor and a decoupling capacitor. The recommended resistance values for this potentiometer are then $R_1=18$ k Ω and $R_2=27$ k Ω . To prevent squegging at the short-wave ends of the wave-bands, it is advisable to limit the oscillator grid leak to 20 k Ω and the capacitance between grid and feedback coil to about 50 pF; these values, however, should also be regarded as minima, since a further reduction would unnecessarily impair the characteristics of the circuit.

In order to minimize frequency drift due to mains voltage fluctuations and the action of A.G.C., the tuned circuit is incorporated in the anode circuit of the triode; parallel feed is then employed to ensure that no D.C. voltage will reach the variable capacitor. This also tends to produce a constant oscillator voltage over the entire wave-band. The recommended value for the parallel resistor is about 30 k Ω .

An even more constant oscillator voltage is ensured throughout the whole wave-band if the lower end of the feedback coil is connected to the padding capacitor (Fig 3). By this means an inductive coupling is combined with a capacitive coupling as in the Colpitts oscillator; at the lower values of the tuning capacitor the inductive feedback predominates, at high values the capacitive coupling. The two types of coupling therefore supplement each other and the oscillator voltage remains prac-

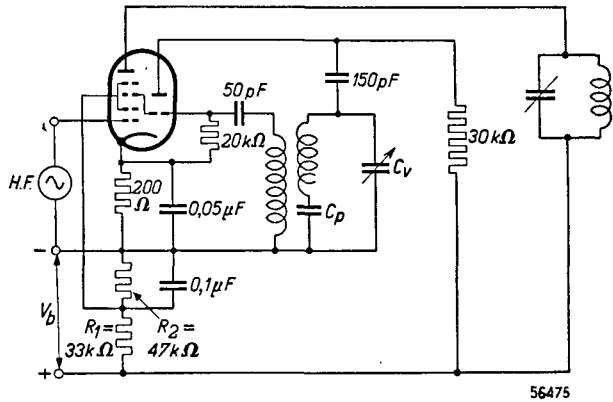


Fig. 2
The ECH 41 used as frequency changer in a conventional type of circuit.

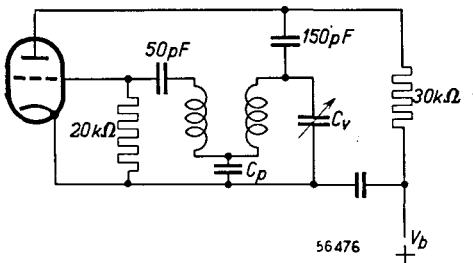


Fig. 3
Oscillator circuit with feedback coil connected to the padding capacitor to secure an oscillator voltage that will vary but little over the whole of the wave-band.

tically constant throughout the wave-band.

In view of the fact that the impedance of the oscillator circuit is lowest on short waves, this circuit should be given careful consideration in the case of short-wave reception. To ensure a satisfactory oscillator voltage, the coupling of the coil system should be made fairly tight

$$(t = \frac{\text{alternating grid voltage}}{\text{alternating anode voltage}} = \text{approx. } 0.5).$$

This naturally has the disadvantage of more pronounced frequency drift when gain control is applied and a greater likelihood of squegging, particularly at the short wavelengths of the wave-band. These difficulties are overcome in the circuit shown in Fig. 4, which employs less feedback (e.g. $t=0.35$) but an extra coil, L_2 , between grid capacitor and feedback coil.

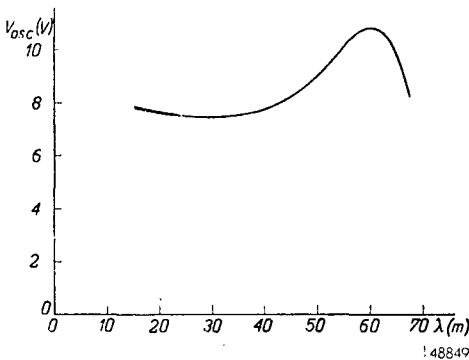


Fig. 5

Variations in the oscillator voltage as a function of the wavelength, relative to the circuit shown in Fig. 4.

roughly 1 kc/s, even at the lower end of the short-wave range. Furthermore, as a result of the looser coupling between oscillator circuit and feedback coil, the effects of the parallel capacitance of the grid circuit are not transmitted to the tuned circuit to the same extent. This results in a wider frequency range, which is usually desirable on the short-wave band. Particulars of practical interest concerning the extra coil will be found in the description of circuit I, on page 123.

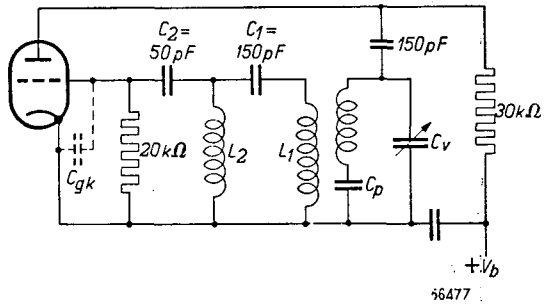


Fig. 4

Oscillator circuit for short waves. An extra coil, L_2 , is introduced between grid capacitor and feedback coil, thus increasing the oscillator voltage at the upper end of the wave-band.

The oscillator voltage induced in the feedback coil L_1 is here divided between the isolating capacitor C_1 and the coils L_1 and L_2 , and an oscillator voltage gain is obtained at the resonant frequency. Coil L_2 is so proportioned that this resonant frequency occurs outside the wave-band, say at $\lambda=60$ m. The reduced inductive coupling at 50 m is then supplemented by the voltage gain across L_2 , producing a voltage which varies as a function of the wavelength in the manner depicted in Fig. 5.

By using the extra coil, the risk of squegging is completely eliminated, and the frequency drift caused by the gain control is restricted to

TECHNICAL DATA OF THE TRIODE-HEXODE ECH 41

Heater data

Heating : indirect, A.C. or D.C., parallel feed

Heater voltage	V_f	=	6.3 V
Heater current	I_f	=	0.23 A

Capacitances (cold valve)

Hexode section

Input	C_{g1}	=	3.4 pF
Output	C_a	=	6.0 pF
Anode - control grid	C_{ag1}	<	0.1 pF
Control grid - heater	C_{g1f}	<	0.15 pF

Triode section

Input	$C_{(gT+g3)}$	=	4.8 pF
Output	C_a	=	1.5 pF
Anode - grid	$C_{a(gT+g3)}$	=	1.2 pF

Between triode and hexode sections

Between control grids	$C_{(gT+g3)-g1H}$	<	0.35 pF
Hexode anode - triode grid	$C_{(gT+g3)-aH}$	<	0.2 pF

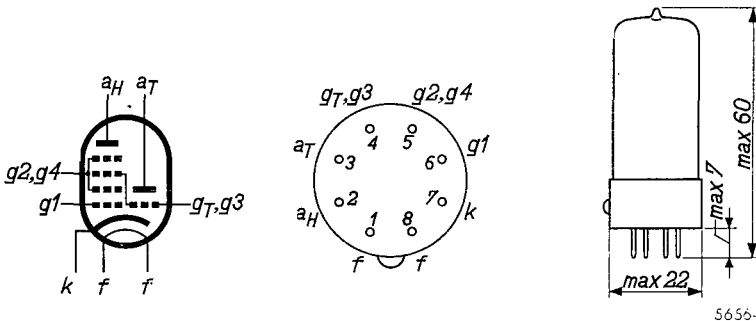


Fig. 6
Electrode arrangement, electrode connections and maximum dimensions in mm of the ECH 41.

ECH 41

Operating characteristics of the hexode section used as mixer (see Figs. 2 and 9 to 12 inclusive)

Anode and supply voltage	$V_{aH}=V_b$	=	250	V
Resistor between supply voltage and screen grids	R_1	=	33	kΩ
Resistor between screen grids and chassis	R_2	=	47	kΩ
Biasing resistor	R_k	=	200	Ω
Oscillator grid leak	$R(gT+g^3)$	=	20	kΩ
Oscillator grid current	$I(gT+g^3)$	=	350	μA
Grid bias	V_{g1}	=	$\overbrace{-2 \quad -28}$	V
Screen grid voltage	$V(g^2+g^4)$	=	105	147 V
Anode current	I_{aH}	=	3.0	— mA
Screen grid current	$I(g^2+g^4)$	=	2.2	— mA
Conversion conductance	S_c	=	500	5 μA/V
Internal resistance	R_i	=	2.0	>5 MΩ
Equivalent noise resistance	R_{eq}	=	170	— kΩ

Operating characteristics of the triode section used as oscillator (see Figs. 2 and 16)

Supply voltage	V_b	=	250	V
Anode resistor	R_a	=	30	kΩ
Grid leak	$R(gT+g^3)$	=	20	kΩ
Anode current	I_a	=	4.9	mA
Grid current	$I(gT+g^3)$	=	350	μA
Oscillator voltage	V_{osc}	=	8	V _{RMS}
Effective slope	S_{eff}	=	0.55	mA/V

Typical characteristics of the triode section (see Figs. 14 and 15)

Anode voltage	V_a	=	100	V
Grid bias	V_g	=	0	V
Anode current	I_a	=	8.5	mA
Slope	S	=	1.9	mA/V
Amplification factor	μ	=	19	

Operating characteristics of the ECH 41 used as phase inverter

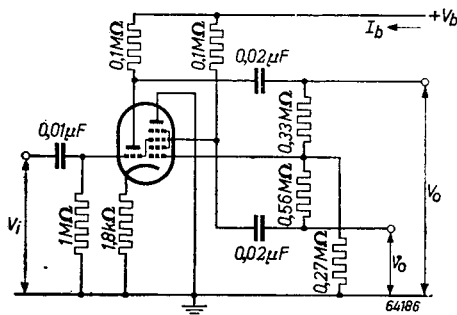


Fig. 7

Supply voltage V_b (V)	Total current I_b (mA)	Amplification V_o/V_i	Distortion (%) at an output voltage of		
			5 V_{RMS}	10 V_{RMS}	15 V_{RMS}
250	3.0	10	0.8	1.3	1.8
350	4.2	10	0.7	1.2	1.6

Operating characteristics of the hexode section used as frequency changer, with screen grids of ECH 41 and I.F. amplifier EAF 42 fed by means of a common potentiometer (see Fig. 17)

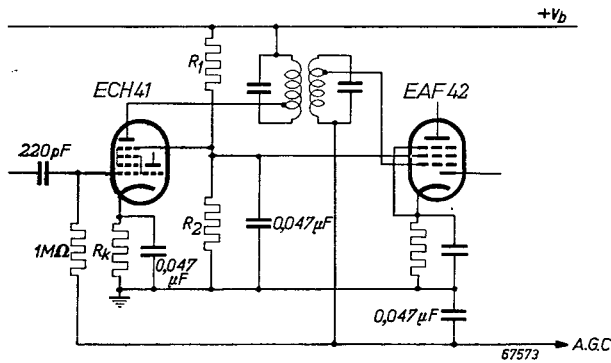


Fig. 8

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Anode and supply voltage	$V_{aH} = V_b$	=	250	V
Potentiometer for screen grid feed (see Fig. 8)	$\begin{cases} R_1 \\ R_2 \end{cases}$	=	18	k Ω
Biasing resistor	R_k	=	27	k Ω
Oscillator grid leak	$R_{(gT+g3)}$	=	200	Ω
Oscillator grid current	$I_{(gT+g3)}$	=	20	k Ω
		=	350	μ A
Grid bias	V_{g1}	=	$\overbrace{-2 \quad -23.5}$	V
Screen grid voltage	$V_{(g2+g4)}$	=	105	147 V
Anode current	I_{aH}	=	3.0	— mA
Screen grid current	$I_{(g2+g4)}$	=	2.2	— mA
Conversion conductance	S_c	=	500	10 μ A/V
Internal resistance	R_i	=	2.0	>5 M Ω
Equivalent noise resistance	R_{eq}	=	170	— k Ω

Limiting values of the hexode section

Anode voltage, valve biased to cut-off	V_{a_0}	= max.	550	V
Anode voltage	V_a	= max.	300	V
Anode dissipation	W_a	= max.	0.8	W
Screen grid voltage, valve biased to cut-off	$V_{(g2+g4)_0}$	= max.	550	V
Screen grid voltage	$V_{(g2+g4)}$	= max.	125	V
Screen grid dissipation	$W_{(g2+g4)}$	= max.	0.3	W
Grid current starting point	$V_{g1}(I_{g1} = +0.3 \mu\text{A})$	= max.	—1.3	V
Cathode current	I_k	= max.	7	mA
External resistance between cathode and control grid	R_{g1}	= max.	3	M Ω
External resistance between cathode and third grid	R_{g3}	= max.	3	M Ω
External resistance between cathode and heater	R_{fk}	= max.	20	k Ω
Voltage between cathode and heater	V_{fk}	= max.	100	V

Limiting values of the triode section

Anode voltage, valve biased to cut-off	V_{a_0}	= max.	550	V
Anode voltage	V_a	= max.	175	V
Anode dissipation	W_a	= max.	0.9	W
Grid current starting point	$V_g(I_g = +0.3 \mu\text{A})$	= max.	—1.3	V
Cathode current	I_k	= max.	5.5	mA
External resistance between cathode and grid	R_g	= max.	3	M Ω
External resistance between cathode and heater	R_{fk}	= max.	20	k Ω
Voltage between cathode and heater	V_{fk}	= max.	100	V

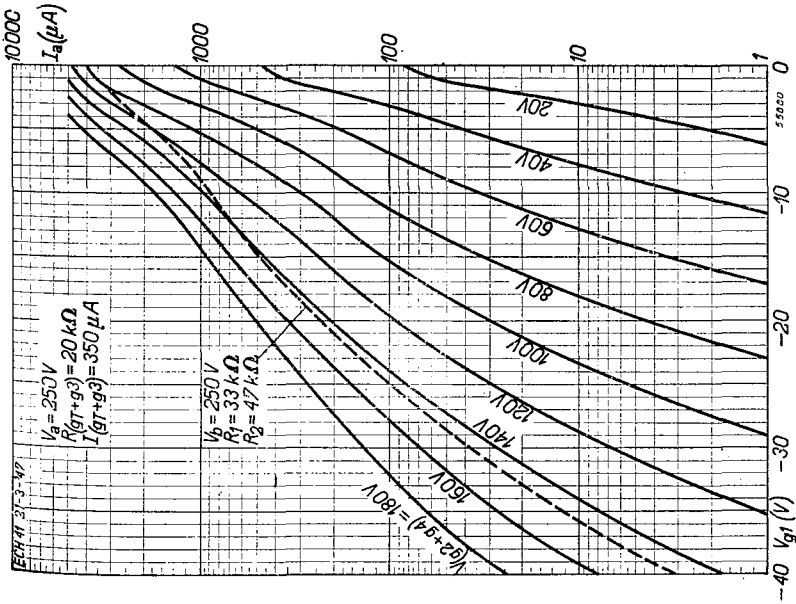
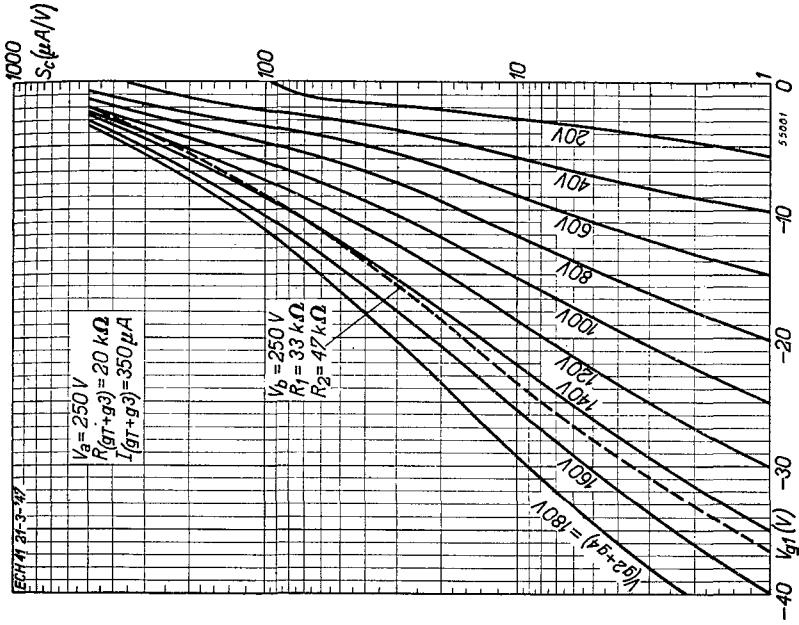


Fig. 9

Anode current I_a (Fig. 9) and conversion conductance S_c (Fig. 10) as functions of the grid bias V_{g1} for various values of the screen grid voltage V_{g2} (20V to 180V), with oscillator voltage of 8 V RMS on third grid producing a direct current I_{g1+g3} of 350 μA through the grid leak R_{g1+g3} of 20 k Ω . The dotted lines indicate the I_a (Fig. 9) and S_c (Fig. 10) when V_{g2+g4} is derived from a potentiometer R_1 , R_2 connected between the supply voltage and chassis (see Fig. 2).

Fig. 10



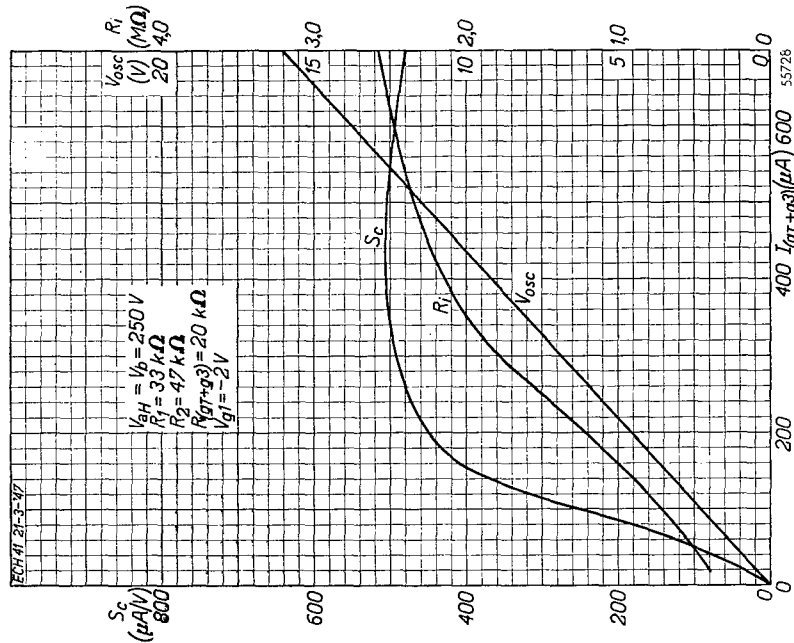


Fig. 12

Conversion conductance S_c^{osc} , internal resistance R_i and oscillator voltage V_{osc} of the hexode section as functions of the oscillator grid current I_{g1T+g3} with grid bias $V_{g1} = -2$ V and oscillator grid leak $R(gT+g3) = 20$ k Ω . Screen grid voltage obtained from a potentiometer R_T , R_g (see Fig. 2).

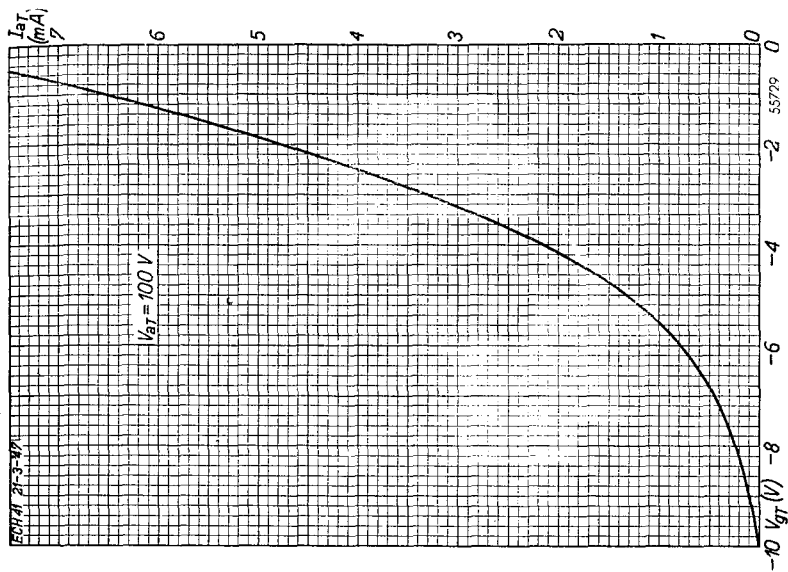


Fig. 14
Anode current I_{aT} of the triode section, as a function of the triode grid voltage V_{gT} , at an anode voltage $V_{aT} = 100 \text{ V}$ (static characteristic).

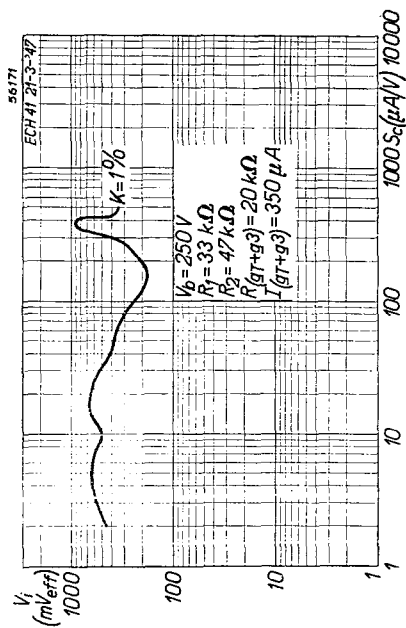


Fig. 13
Effective voltage V_i of an interfering signal on the control grid of the hexode section and producing 1% cross-modulation, as a function of the conversion conductance S_c . Oscillator voltage on third grid $\approx 8 \text{ V}_{rms}$, screen grid voltage derived from a potentiometer R_1, R_2 (see Fig. 2).

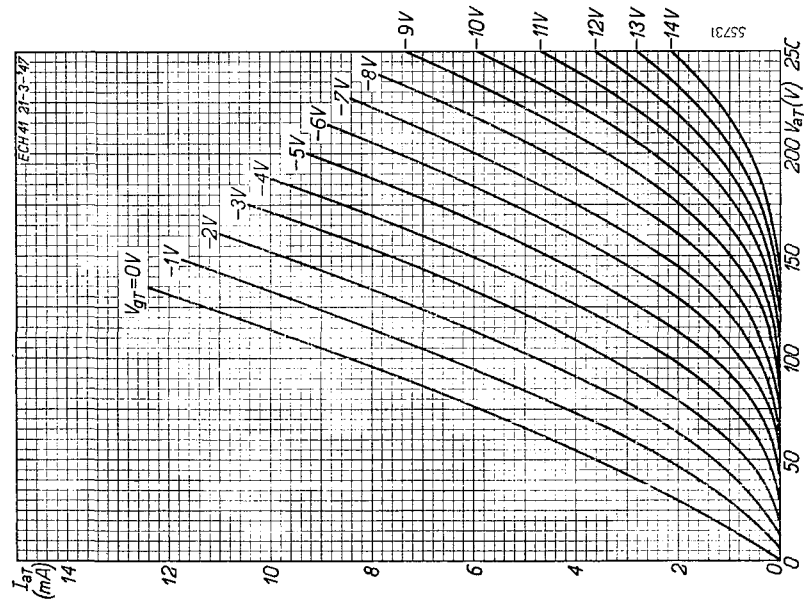


Fig. 15

Anode current I_{aT} of the triode section, as a function of the triode anode voltage V_{aT} , at various values of the grid bias V_{gT} (static characteristic.).

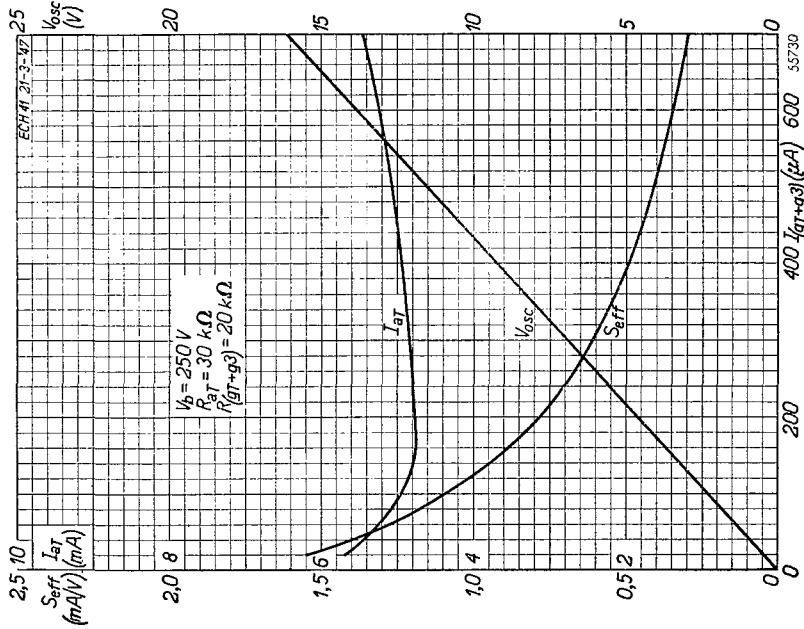


Fig. 16

Anode current I_{aT} , oscillator voltage V_{osc} and effective slope S_{eff} of oscillating triode, as a function of the oscillator grid current I_{gT+g3} . For circuit diagram see Fig. 2.

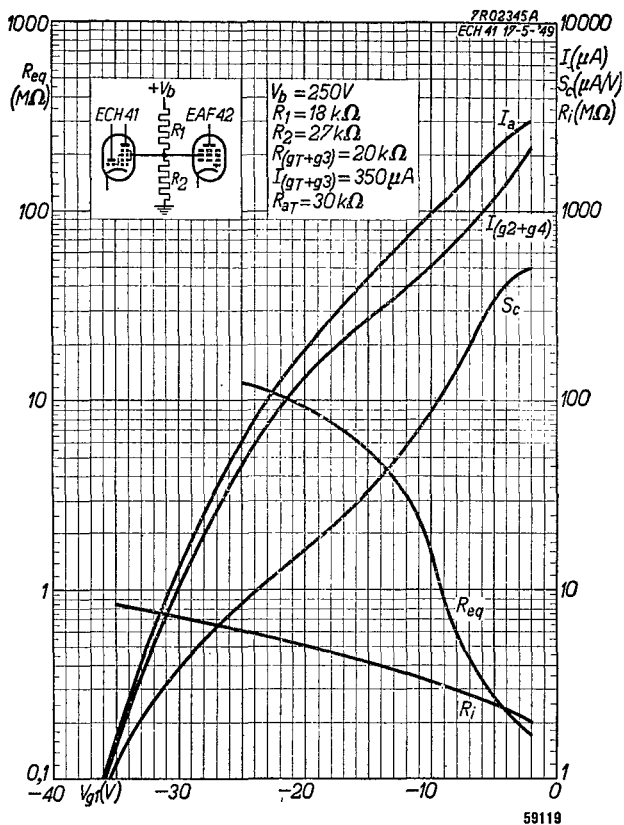


Fig. 17

As Fig. 11, but with screen voltage of the ECH 41, together with that of the R.F. or I.F. amplifier EAF 42 derived from a common potentiometer.

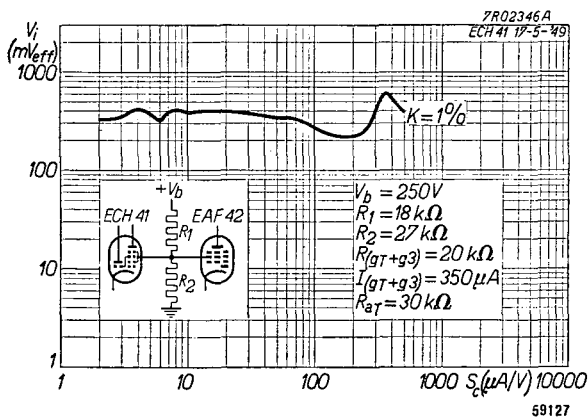


Fig. 18

As Fig. 13, but with the screen grids of the ECH 41 and EAF 42 fed by means of a common potentiometer.