

## ECH 41

# ECH 41 Triode-hexode frequency changer

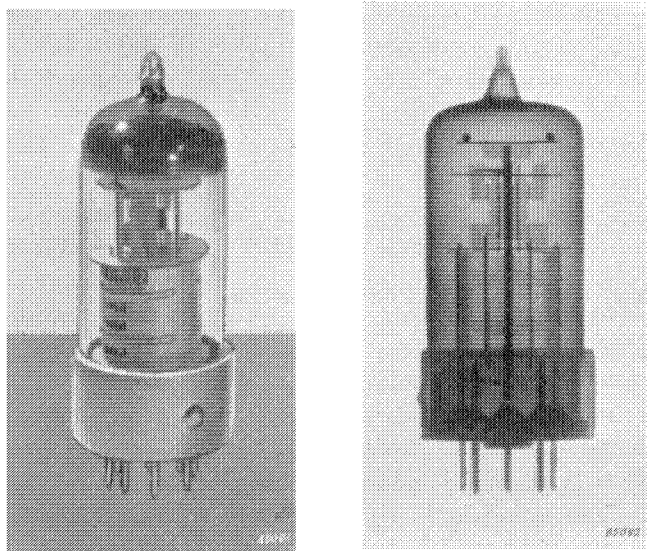


Fig. 1

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  $500 \mu\text{A}/\text{V}$  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  $100 \text{ pF}$ , 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  $V_o=0$ ) is  $1.9 \text{ mA}/\text{V}$ ; the effective slope of the oscillating valve is  $0.55 \text{ mA}/\text{V}$ , 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 kΩ between the supply voltage and the screen grids, with 47 kΩ between screen grids

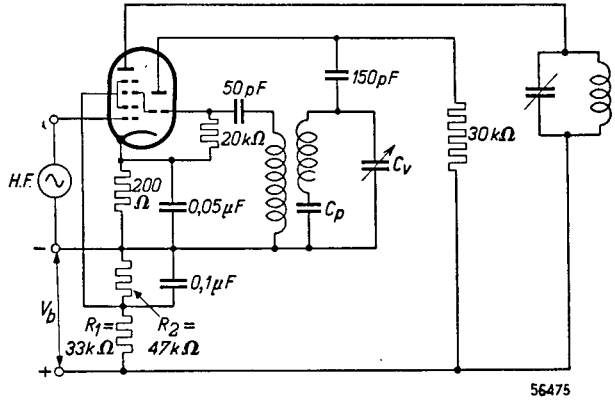


Fig. 2  
The ECH 41 used as frequency changer in a conventional type of circuit.

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  $R_1 = 18 \text{ k}\Omega$  and  $R_2 = 27 \text{ k}\Omega$ . To prevent squegging at the short-wave ends of the wave-bands, it is advisable to limit the oscillator grid leak to 20 kΩ 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 kΩ.

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-

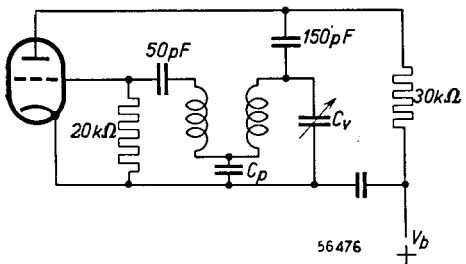


Fig. 3  
Oscillator circuit with feedback coil connected to the padding capacitor to secure an oscillator voltage that will vary but little over the whole of the wave-band.

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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.

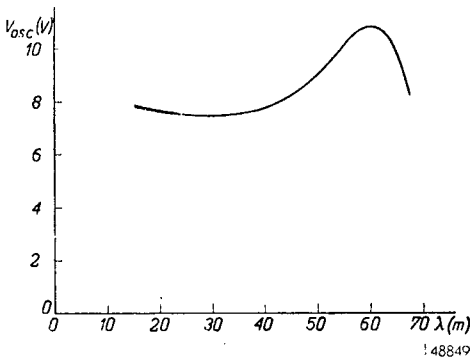


Fig. 5

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.

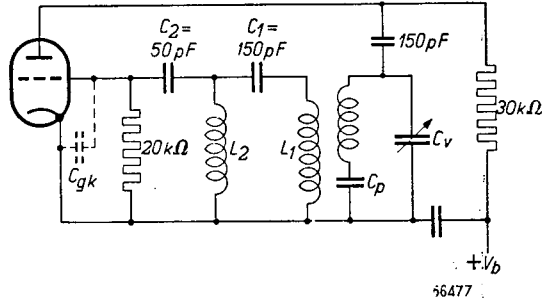


Fig. 4

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

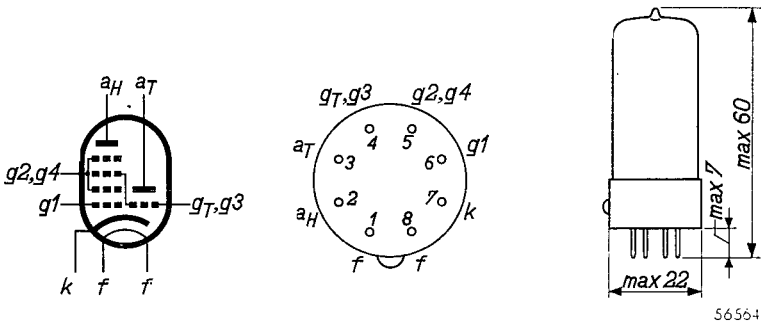


Fig. 6  
Electrode arrangement, electrode connections and maximum dimensions in mm of the ECH 41.

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**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	k $\Omega$
Resistor between screen grids and chassis . . . . .	$R_2$	=	47	k $\Omega$
Biasing resistor . . . . .	$R_k$	=	200	$\Omega$
Oscillator grid leak . . . . .	$R_{(gT+g3)}$	=	20	k $\Omega$
Oscillator grid current . . . . .	$I_{(gT+g3)}$	=	350	$\mu$ A
Grid bias . . . . .	$V_{g1}$	=	$\overbrace{-2 \quad -28}$	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	5 $\mu$ A/V
Internal resistance . . . . .	$R_i$	=	2.0	>5 M $\Omega$
Equivalent noise resistance . . . . .	$R_{eq}$	=	170	— k $\Omega$

**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	k $\Omega$
Grid leak . . . . .	$R_{(gT+g3)}$	=	20	k $\Omega$
Anode current . . . . .	$I_a$	=	4.9	mA
Grid current . . . . .	$I_{(gT+g3)}$	=	350	$\mu$ A
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 . . . . .	$\mu$	=	19	

Operating characteristics of the ECH 41 used as phase inverter

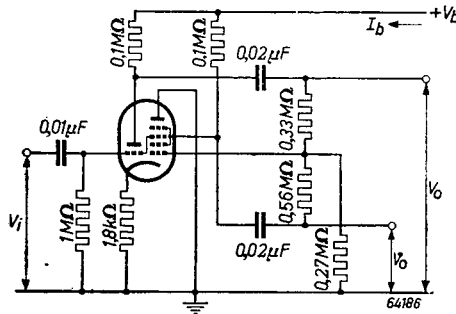


Fig. 7

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)

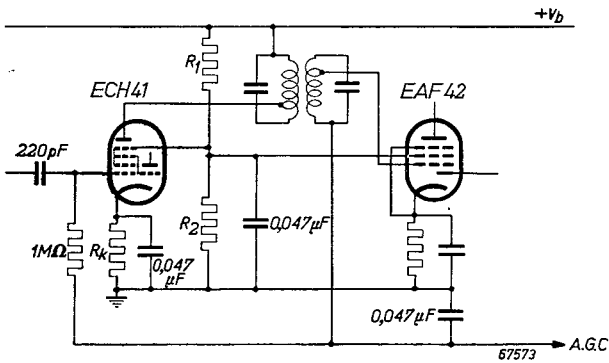


Fig. 8

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

## 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 $\Omega$
External resistance between cathode and third grid . . . . .	$R_{g3}$	= max.	3	M $\Omega$
External resistance between cathode and heater . . . . .	$R_{fk}$	= max.	20	k $\Omega$
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 $\Omega$
External resistance between cathode and heater . . . . .	$R_{fk}$	= max.	20	k $\Omega$
Voltage between cathode and heater . . . . .	$V_{fk}$	= max.	100	V

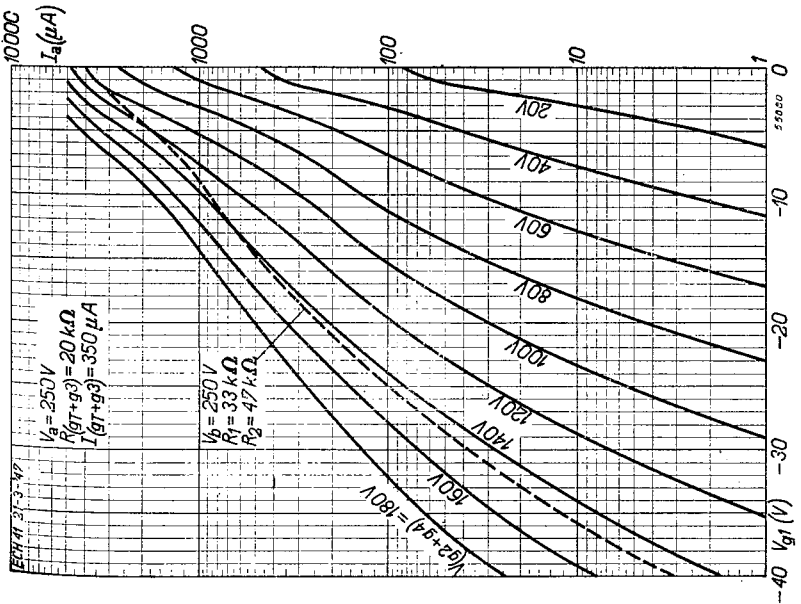
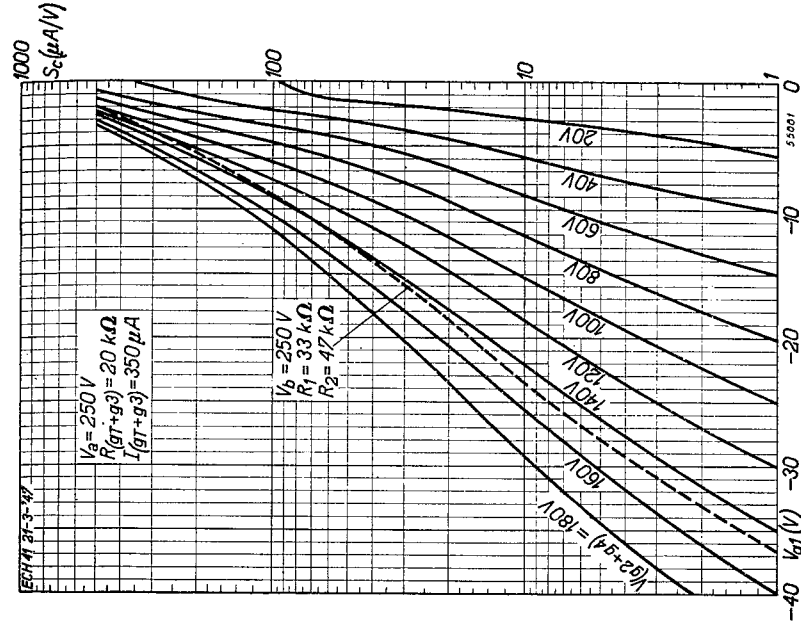


Fig. 9 Anode current  $I_a$  (Fig. 9) and conversion conductance  $S_c$  (Fig. 10) as functions of the grid bias  $V_{g1}$  for various values of the screen grid voltage  $V_{(g2+g4)}$ , with oscillator voltage of 8 V RMS on third grid producing a direct current  $I_{(g1+g3)}$  of 350  $\mu A$  through the grid leak  $R_{(g1+g3)}$  of 20 k $\Omega$ . 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).



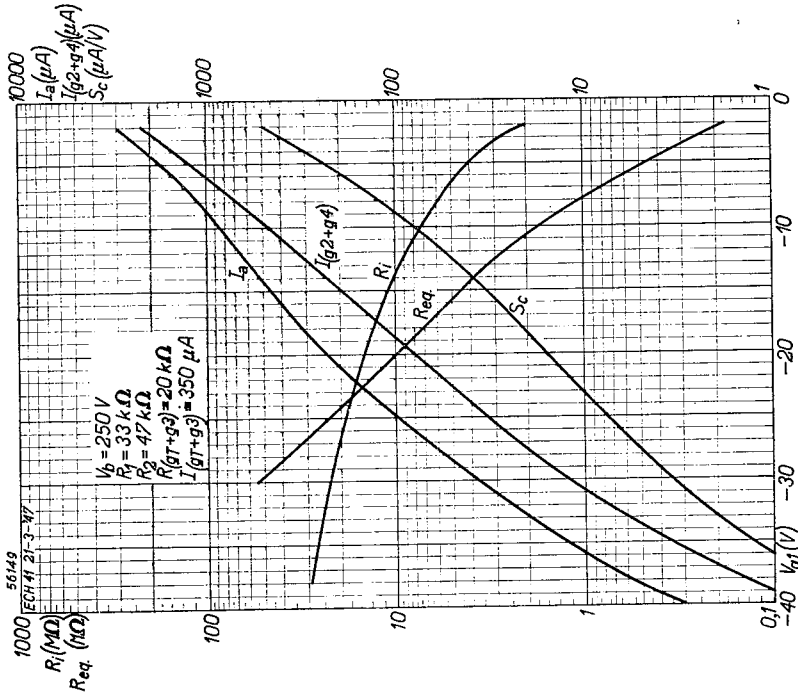


Fig. 11

Anode current  $I_a$ , screen grid current  $I_{(g_2+g_4)}$ , conversion conductance  $S_c$ , internal resistance  $R_i$ , and equivalent noise resistance  $R_{eq}$  of the hexode section as functions of the grid bias  $V_{g1}$ . The oscillator voltage on the third grid = 8V<sub>RMS</sub> and the screen grid voltage is derived from a potentiometer  $R_1, R_2$  (see Fig. 2).

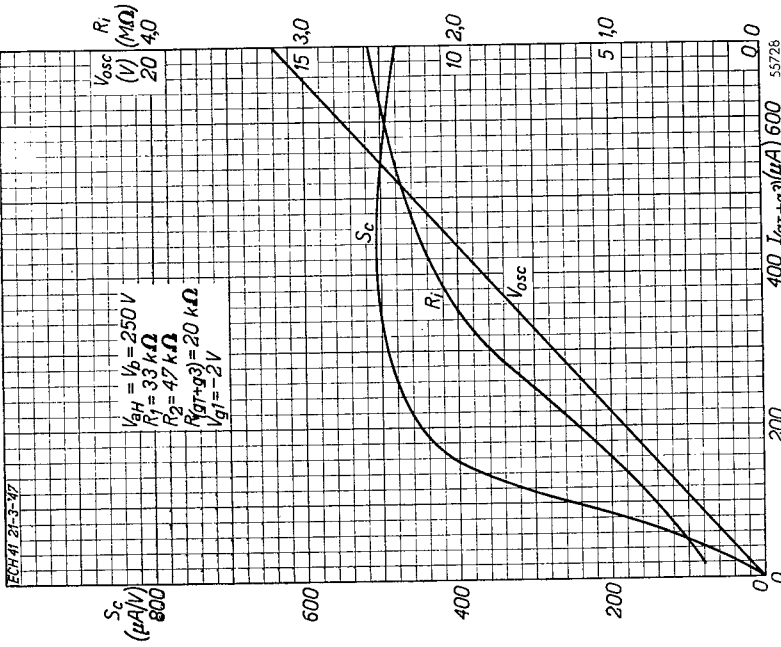


Fig. 12

Conversion conductance  $S_c$ , internal resistance  $R_i$ , and oscillator voltage  $V_{osc}$  of the hexode section as functions of the oscillator grid current  $I_{(g_1+g_3)}$  with grid bias  $V_{g1} = -2 V$  and oscillator grid leak  $R_{(g_1+g_3)} = 20 k\Omega$ . Screen grid voltage obtained from a potentiometer  $R_1, R_2$  (see Fig. 2).

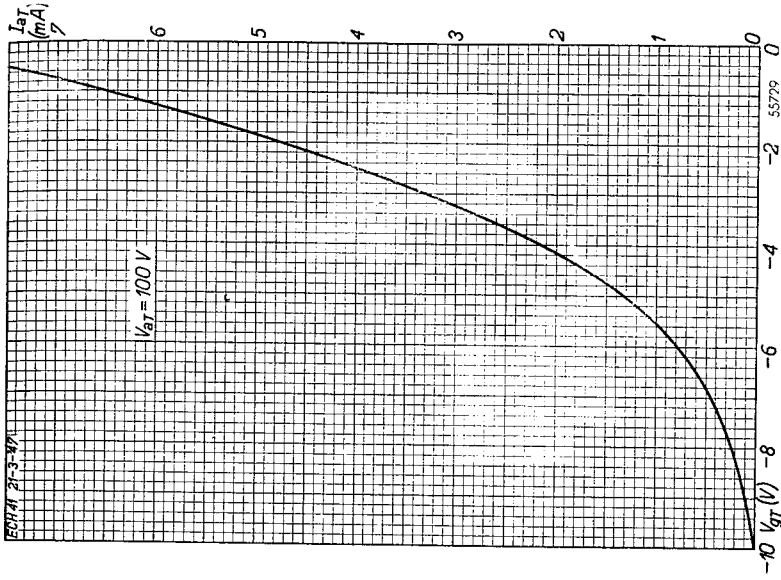


Fig. 14 Anode current  $I_{aT}$  of the triode section, as a function of the triode grid voltage  $V_{gT}$ , at an anode voltage  $V_{aT} = 100 \text{ V}$  (static characteristic).

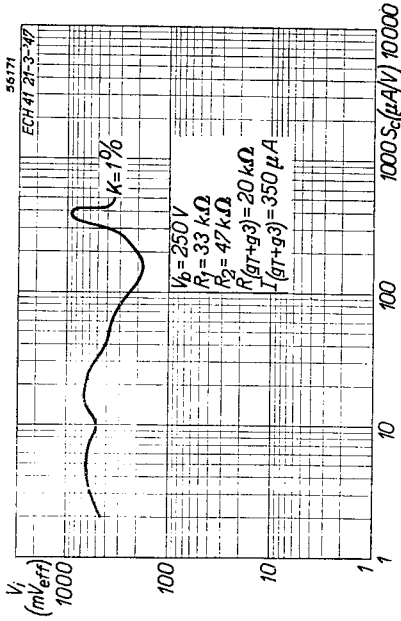


Fig. 13 Effective voltage  $V_i$  of an interfering signal on the control grid of the hexode section and producing 1% cross-modulation, as a function of the conversion conductance  $S_c$ . Oscillator voltage on third grid =  $8V_{RMS}$ , screen grid voltage derived from a potentiometer  $R_1, R_2$  (see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

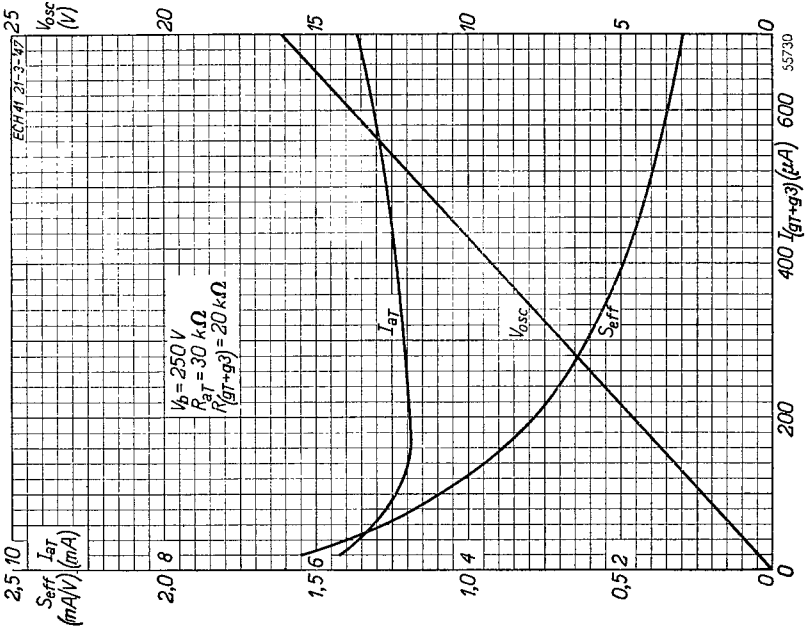


Fig. 16  
Anode current  $I_{aT}$ , oscillator voltage  $V_{osc}$  and effective slope  $S_{eff}$  of oscillating triode, as a function of the oscillator grid current  $I_{(gT+g3)}$ . For circuit diagram see Fig. 2.

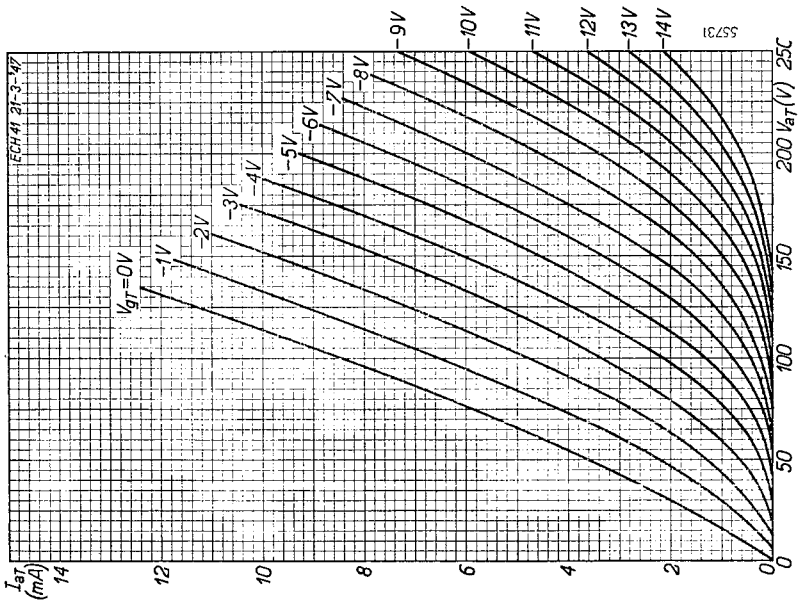


Fig. 15  
Anode current  $I_{aT}$  of the triode section, as a function of the triode anode voltage  $V_{aT}$ , at various values of the grid bias  $V_{gT}$  (static characteristic-).

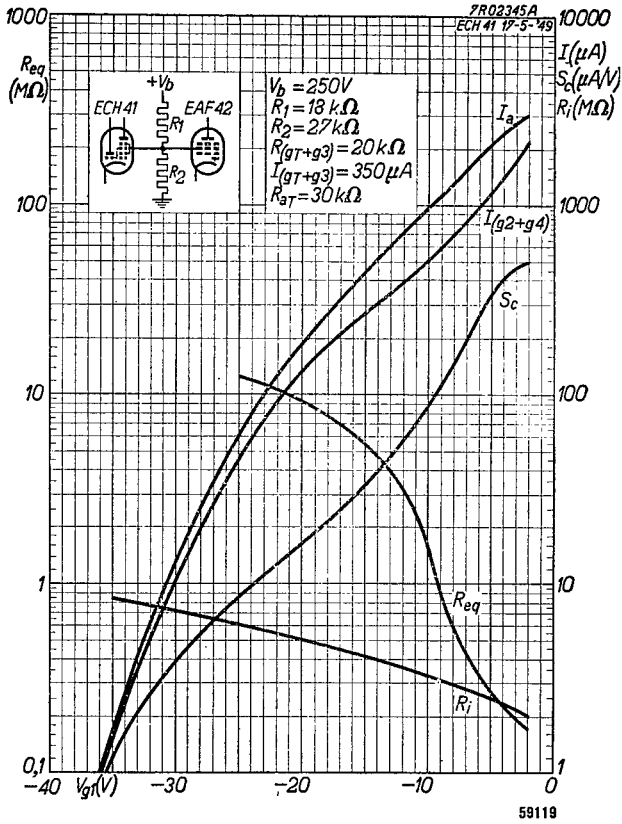


Fig. 17  
As Fig. 11, but with screen voltage of the ECH 41, together with that of the R.F. or I.F. amplifier EAF 42 derived from a common potentiometer.

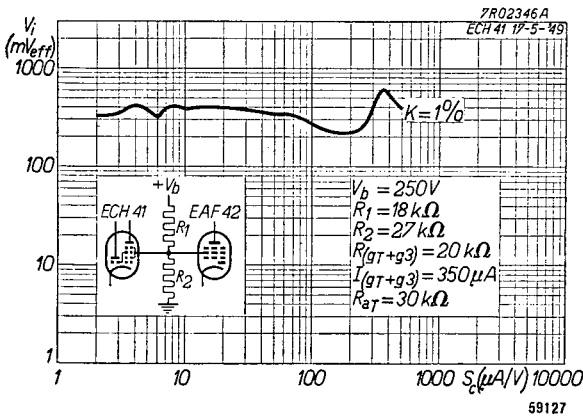


Fig. 18  
As Fig. 13, but with the screen grids of the ECH 41 and EAF 42 fed by means of a common potentiometer.