KCH 1 Triode-hexode

The KCH 1 is a frequency-changer for battery superheterodyne receivers. It consists of a combination of hexode for mixing the input signal with the signal generated by the oscillator, and a triode for use as the latter.

Every effort has been made in the development of this valve to attain the highest possible conversion conductance, with a low filament current consumption. The main object was to produce a mixer valve for battery receivers that would give a reliable performance on short waves and also permit of automatic gain control on that wave range, with a minimum of interference due to frequency drift and so on.

Because of the rapid control required in battery receivers, great care has been taken to ensure good characteristics from the aspect of cross-modulation. A variation in the grid bias of from —0.5 to —17 V, with an anode potential of 135 V and "sliding" screen voltage, is sufficient to reduce the conversion conductance to one-hundredth. Without control the conversion conductance is 325 μA/V.

The screen-grid voltage of the hexode section of the KCH 1 may be arranged so as to be self-adjusting; this saves the current that would otherwise pass through the potential divider and operates the valve as economically as possible. On a battery voltage of 135 V, with a resistor of 67,000 ohms in series with the screen, the total load on the anode battery is only 5 mA. With a fixed screen potential, control of the conversion conductance is considerably more rapid, but the cross-modulation characteristics are not so favourable.

Further, when the valve is operated on a fixed screen voltage the internal resistance during the control period, even on a low battery voltage, increases rapidly, whereas if a screen series resistor is used the internal resistance commences to decrease. This is explained by the fact that the screen voltage, when self-adjusting, closely approaches the same value as the anode voltage when control is applied; due to secondary emission the internal resistance drops, until the anode voltage has decreased so far in response to

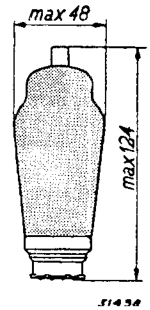

Fig. 1
Dimensions in mm.

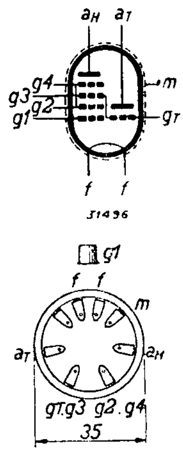

Fig. 2
Arrangement of electrodes and base connections.

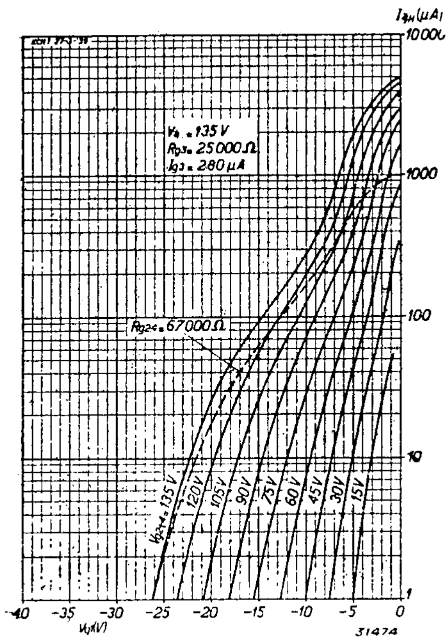

Fig. 3
Anode current of the hexode unit as a function of the grid bias, with the screen-grid voltage as parameter. The broken lines show the anode current in the case of the controlled valve, with the screen fed from the 135 V battery through a resistor of 67,000 ohms.

the control that the internal resistance again rises. The curve relating to the internal resistance of the valve when under control, as a function of the grid bias, shows a decrease at —5 V. At V_a = 135 V and $R_{g2,4}$ = 67,000 ohms, the internal resistance diminishes to 0.5 megohm, whilst on V_a = 90 V and $V_{g2,4}$ = 29,000 ohms the minimum is 0.1 megohm. Although a value of 0.5 megohm is still quite serviceable, 0.1 megohm must be regarded as too low, as the selectivity of the associated I.F. circuit is then reduced too much. On a low battery voltage, therefore, a fixed screen voltage will normally be preferred, or alternatively, potential-divider feed; the latter need take only a very small amount of current, viz. 0.5—1 mA.

Much attention has been given to the oscillator section of this valve to ensure reliable oscillation when the valve is to be used in conjunction with ordinary standard coils and circuits. Every effort has also been made to procure the highest possible conductance in the triode section at the threshold of oscillation; this is 1.3 mA/V at an anode potential of 70 V, and constant oscillation is thus guaranteed.

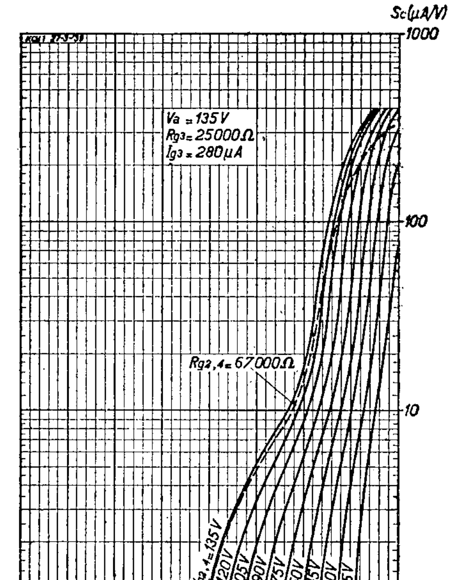

Fig. 4
Conversion conductance as a function of the grid bias, with the screen voltage as parameter. The broken line refers to the conductance when control is applied to the valve, with the screen fed from the 135 V battery through a resistor of 67,000 ohms.

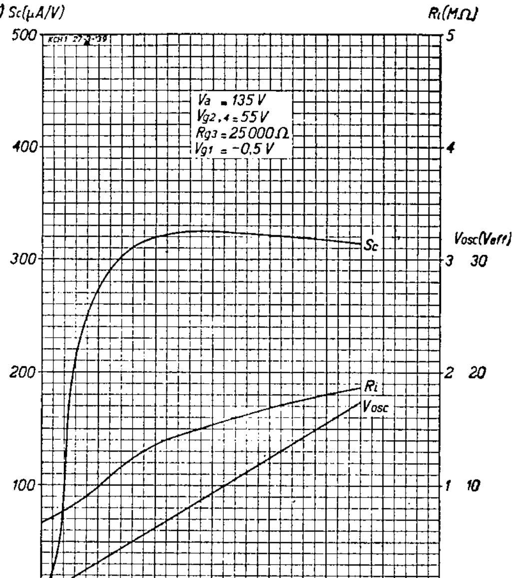

Fig. 5
Conversion conductance *Sc*, internal resistance *Ri* and effective oscillator voltage *Vosc* as functions of the oscillator-grid current I_{g3} (grid leak of oscillator, Rg_3 = 25,000 ohms), at Va = 135 V and a fixed screen voltage of 55 V.

FILAMENT RATINGS

Heating: direct by battery; parallel supply.

Filament voltage . . . . V_f = 2.0 V

Filament current . . . . I_f = 0.18 A

CAPACITANCES

a. Hexode section.	b. Triode section.	Between hexode and triode.
$C_{g1} = 7\ \mu\mu F$	$C_{gf} = 13.5\ \mu\mu F$	$C_{gTg1H} < 0.4\ \mu\mu F$
$C_a = 16\ \mu\mu F$	$C_{af} = 3.6\ \mu\mu F$	
$C_{ag1} < 0.05\ \mu\mu F$	$C_{ag} = 3.5\ \mu\mu F$	

OPERATING DATA: Hexode section

a) FIXED SCREEN-GRID VOLTAGE

Anode voltage	V_a =	90 V			135 V		
Screen-grid voltage	$V_{g2,4}$ =	55 V			55 V		
Grid leak	R_{g3} =	25,000 ohms			25,000 ohms		
Oscillator-grid current	I_{g3} =	280 μA			280 μA		
Grid bias	V_{g1} =	—0.5 [1])	—8 [2])	—9.5 [3])	—0.5 [1])	—8 [2])	—9.5 [3])
Anode current	I_a =	1 mA	—	—	1 mA	—	—
Screen current	$I_{g2,g4}$ =	1.2 mA	—	—	1.2 mA	—	—
Conversion conductance	S_c =	320	3	1	325	3	1 μA/V
Internal resistance	R_i =	0.7	> 4	> 5	1.5	> 10	> 10 M ohms

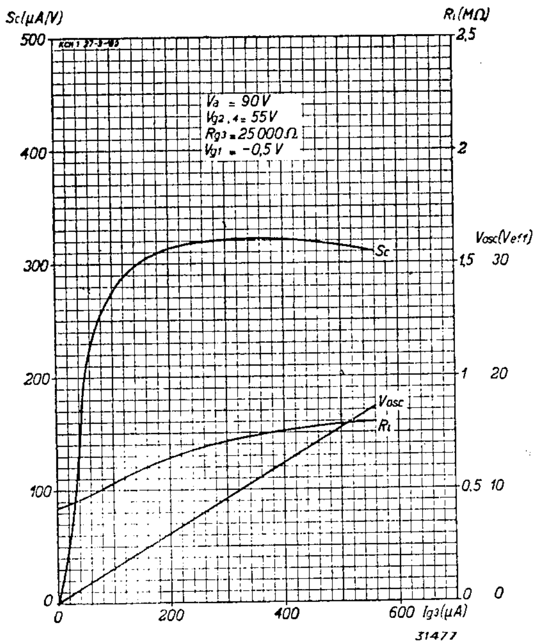

Fig. 6
Conversion conductance *Sc*, internal resistance *Ri* and effective oscillator voltage *Vosc* as functions of the oscillator-grid current Ig_3 (oscillator grid leak Rg_3 = 25,000 ohms), with *Va* = 90 V and fixed screen voltage of 55 V.

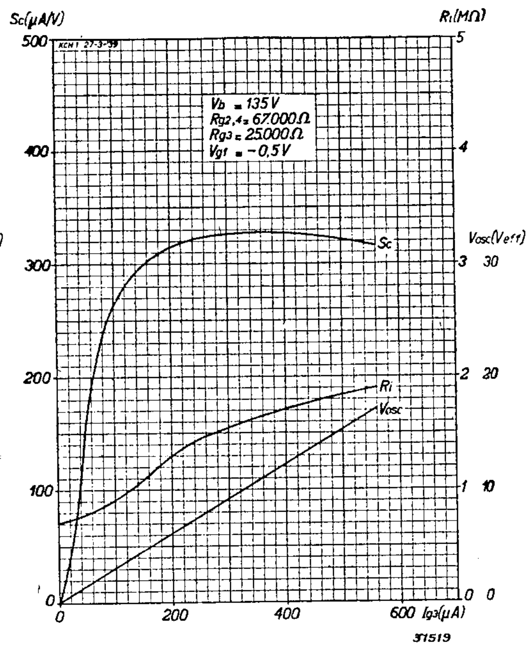

Fig. 7
Conversion conductance *Sc*, internal resistance *Ri* and effective oscillator voltage *Vosc* as functions of the oscillator-grid current Ig_3 (oscillator grid leak Rg_3 = 25,000 ohms), with *Va* = 135V and screen fed from 135 V battery through a resistor of 67,000 ohms.

b) WITH SCREEN SERIES RESISTOR

Anode voltage	V_a =	90 V			135 V		
Screen series resistor	$R_{g2,4}$ =	29,000 ohms			67,000 ohms		
Grid leak	R_{g3} =	25,000 ohms			25,000 ohms		
Oscillator grid current	I_{g3} =	280 μA			280 μA		
Grid bias	V_{g1} =	—0.5 [1]	—12 [2]	—15 [3]	—0.5 [1]	—17 [2]	—20 V [3]
Screen-grid voltage	$V_{g2,4}$ =	55	—	90	55	—	135 V
Anode current	I_a =	1	—	—	1	—	— mA
Screen-grid current	$I_{g2,g4}$ =	1.2	—	—	1.2	—	— mA
Conversion conductance	S_c =	320	3	1	325	3	1 μA/V
Internal resistance	R_i =	0.7 [4]	> 0.9	> 1	1.5 [5]	> 1	> 1.5 M ohms

For footnotes see next page.

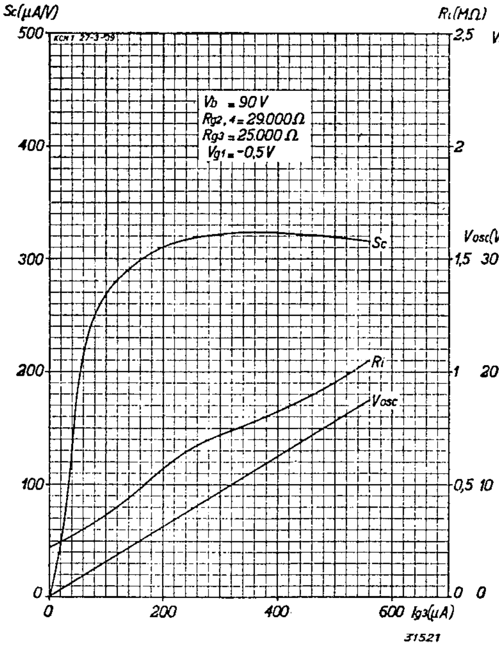

Fig. 8
Conversion conductance *Sc*, internal resistance *Ri* and effective oscillator voltage *Vosc* as functions of the oscillator-grid current Ig_3 (oscillator grid leak Rg_3 = 25,000 ohms), with Va = 90 V and screen fed from 90 V battery through a resistor of 29,000 ohms.

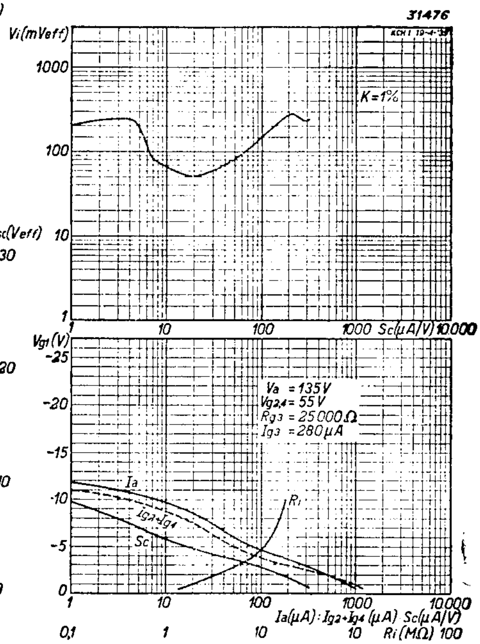

Fig. 9
With 135 V anode voltage and fixed screen voltage 55 V;
Upper diagram. Alternating grid voltage of interfering signal (effective value) as a function of the conversion conductance, with 1 % cross-modulation.
Lower diagram. Conversion conductance *Sc*, anode current *Ia*, screen current $Ig_2 + Ig_4$ and internal resistance *Ri* as functions of the grid bias Vg_1.

c) SCREEN FED FROM A POTENTIAL DIVIDER

Anode voltage .	V_a =	90 V			90 V		
Potential divider resistor. . . .	R_1 [6]) =	16,000 ohms			22,000 ohms		
Potential divider resistor. . . .	R_2 [6]) =	55,000 ohms			110,000 ohms		
Potentiometer current. . . .	I_p =	1 mA			0.5 mA		
Grid leak. . . .	R_{g3} =	25,000 ohms			25,000 ohms		
Oscillator-grid current. . . .	I_{g3} =	280 μA			280 μA		
Grid bias. . . .	V_{g1} =	—0.5 [1])	—9.5 [2])	—11 V[3])	—0.5[1])	—10[2])	—12 [3]) V
Screen-grid voltage. . . .	$V_{g2,4}$ =	55	—	70 V	55	—	75 V
Anode current .	I_a =	1	—	— mA	1	—	— mA
Screen current .	$I_{g2,g4}$ =	1.2	—	— mA	1.2	—	— mA
Conversion conductance .	S_c =	320	3	1	325	3	1 μA/V
Internal resistance . .	R_i =	0.7	> 2	> 3	0.7	> 1.5	> 2.5 M ohms

[1]) Without control
[2]) Conversion conductance controlled to 1 : 100
[3]) Limit of control
[4]) With a grid bias of –5 V the internal resistance is approx. 0.1 megohm
[5]) With a grid bias of –6 V the internal resistance is approx. 0.4 megohm
[6]) See circuit diagram, Fig. 16.

OPERATING DATA: triode section used as oscillator

Anode voltage	V_a =	70	—	— V
Battery voltage.	V_b =	—	90	135 V
Anode series resistor	R_a =	—	22,000	22,000 ohms
Anode current with I_g = 280 μA and R_{g1} = 25,000 ohms	I_a =	3	2	3 mA
Anode current ($V_g = 0, I_g = 0$)	I_a =	2.4	—	— mA
Mutual conductance at threshold of oscillation ($V_g = 0$, $I_g = 0$)	S_o =	1.3	1.1	1.3 mA/V
Amplification factor, with $V_g = 0, I_g = 0$	μ =	28	28	28

MAXIMUM RATINGS: Hexode section

Anode voltage	V_a	= max. 135 V
Anode dissipation	W_a	= max. 1.5 W
Screen-grid voltage without control on the valve (I_a = 1 mA)	$V_{g2,4}$	= max. 60 V
Screen voltage, valve under control (I_a < 0.2 mA)	$V_{g2,4}$	= max. 135 V
Screen-grid dissipation.	$W_{g2,4}$	= max. 1 W
Cathode current	I_k	= max. 8 mA
External resistance between control grid and cathode	R_{g1k}	= max. 3 M ohms
Grid voltage at grid current start (I_{g1} = + 0.3 μA)	V_{g1}	= max. —0.2 V

MAXIMUM RATINGS: Triode section

Anode voltage	V_a	= max. 80 V
Anode dissipation	W_a	= max. 0.5 W
Grid voltage at grid current start (I_g = + 0.3 μA)	V_g	= max. — 0.2 V
External resistance between grid and cathode . . .	R_{gk}	= max. 50,000 ohms

APPLICATIONS

A few further remarks may be added to the above. In order to limit frequency drift as much as possible, the oscillator circuit should be connected to the anode of the triode unit of the KCH 1; the reaction coil is therefore connected to the grid. At a wavelength of 15 metres, the drift will then be 3 kc/s with a grid voltage variation of from —2 to —15 V, which means that this valve is quite suitable for automatic gain control in the short-wave range. For the medium and long waves, the "bottom" end of the reaction coil should be connected to the "top" of the padding capacitor; the inductive coupling will then be assisted by the capacitive reaction through the

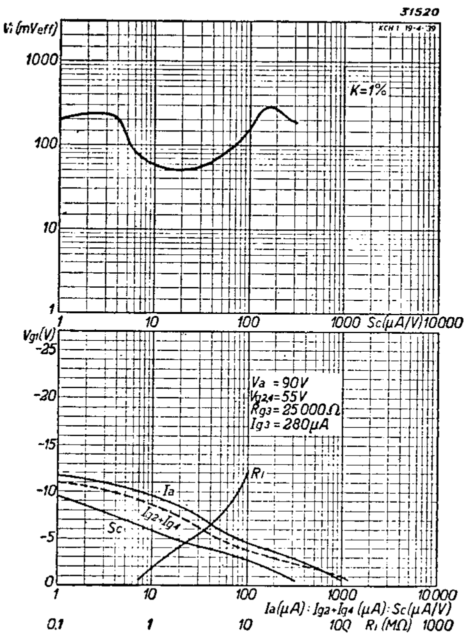

Fig. 10
With 90 V anode voltage and fixed-screen voltage of 55 V:
Upper diagram. Alternating grid voltage of the interfering signal (effective value) as a function of the conversion conductance, with 1 % cross-modulation.
Lower diagram. Conversion conductance *Sc*, anode current *Ia*, screen-grid current $Ig_2 + Ig_4$ and internal resistance *Ri*, as functions of the grid bias Vg_1.

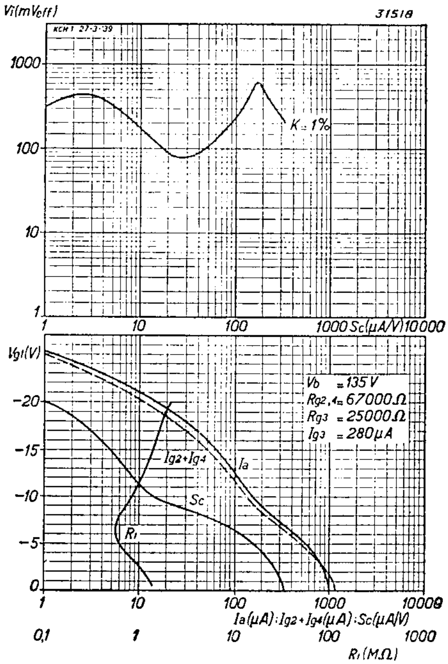

Fig. 11
With 135 V anode voltage and screen fed through a resistor of 67,000 ohms from a 135 V battery:
Upper diagram. Alternating grid voltage of the interfering signal (effective value) as a function of the conversion conductance with 1 % cross-modulation.
Lower diagram. Conversion conductance *Sc*, anode current *Ia*, screen-grid current $Ig_2 + Ig_4$ and internal resistance *Ri* as functions of the grid bias Vg_1.

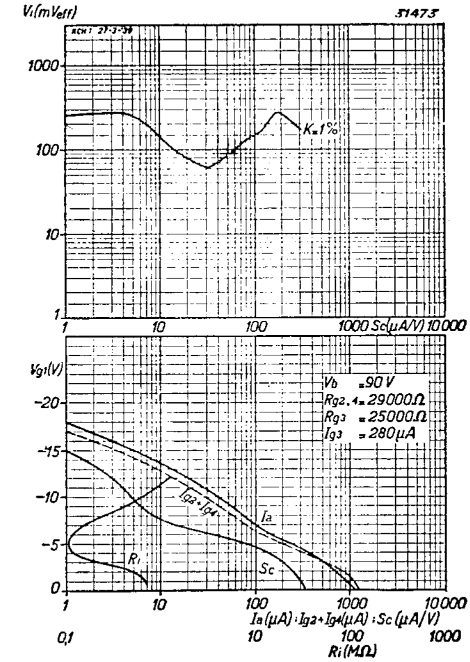

Fig. 12
With 90 V anode voltage and screen fed through a resistor of 29,000 ohms from a 90 V battery:
Upper diagram. Alternating grid voltage of the interfering signal (effective value) as a function of the conversion conductance, with 1 % cross-modulation.
Lower diagram. Conversion conductance *Sc*, anode current *Ia*, screen-grid current $Ig_2 + Ig_4$ and internal resistance *Ri* as functions of the grid bias Vg_1.

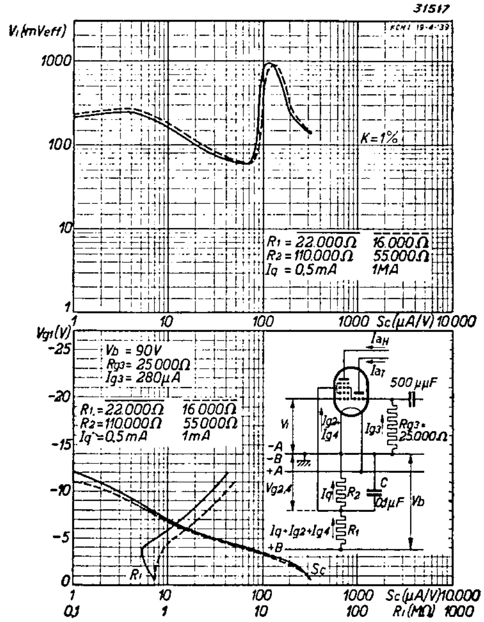

Fig. 13
With 90 V anode voltage and screen fed from a potential divider carrying a current of 0.5 mA (full line), or 1 mA (broken line):
Upper diagram. Alternating grid voltage of interfering signal (effective value), as a function of the conversion conductance, with 1 % cross-modulation.
Lower diagram. Conversion conductance *Sc*, and internal resistance *Ri*, as functions of the grid bias Vg_1.

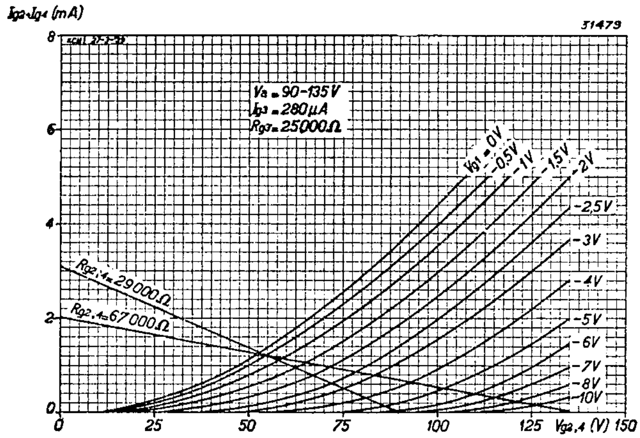

Fig. 14
Screen-grid current $Ig_2 + Ig_4$ as a function of the screen voltage $Vg_{2,4}$ with grid bias Vg_1 as parameter. The resistance lines for $Rg_{2,4}$ = 67,000 ohms for a battery voltage of 135 V, and for $Vg_{2,4}$ with reference to a 90 V battery are also given.

latter. This ensures more uniform oscillation throughout the whole wave-range. For short waves a padding capacitor is not usually employed. A grid capacitor of some 50 to 70 $\mu\mu$F will give reliable oscillation on long waves, with very little frequency drift on the short waves. A value of 25,000 ohms is recommended for the grid-leak resistor as this will prevent over-oscillation and will at the same time not damp the oscillator circuit too heavily. When a 135 V battery is used, it is advisable to feed the anode through a resistor of 22,000 ohms; this resistor is in parallel with the oscillator circuit for the high frequencies, thus slightly damping the circuit. Fig. 16 shows the circuit diagram of the KCH 1 when used on a 90 V or 135 V battery. If on a 90 V battery supply the resistor in series with the anode is any lower than 7,000 ohms, the damping of the oscillator circuit is considerably increased, but, on the other hand, if the 22,000 ohms resistor is used, the conductance at the threshold of oscillation will be reduced. With the last mentioned value, however, oscillation is more reliable, which is, of course, the more preferable result. To avoid any possibility of parasitic oscillation, a small resistor of 30 to 50 ohms can be included in the first grid circuit.

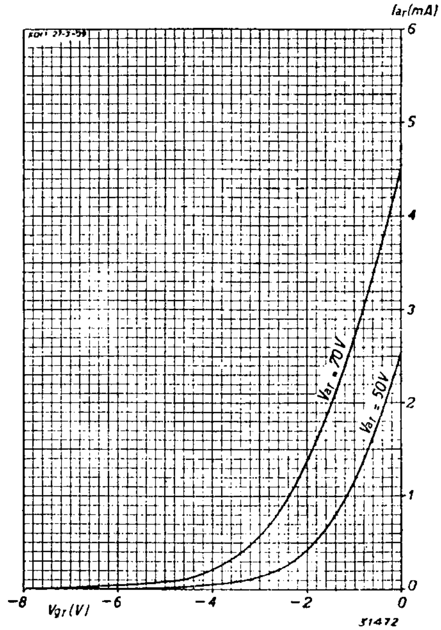

Fig. 15
Anode current of the triode section, I_aT, as a function of the grid bias V_gT, with V_aT = 50 and 70 V.

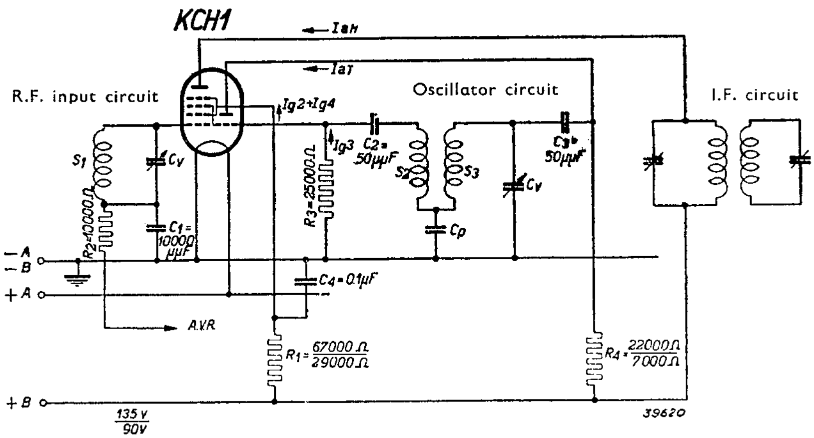

Fig. 16
Circuit diagram showing the KCH 1 employed as a frequency-changer in a battery receiver operated from a 135 V or 90 V battery.