

R.F. DOUBLE TRIODE ECC 81

DESCRIPTION

The ECC 81 is a double triode on Noval base, intended primarily for use as oscillator-mixer and as R.F. amplifier in television receivers. A centre-tapped heater is employed, giving alternative ratings of 6.3 V, 0.3 A and 12.6 V, 0.15 A.

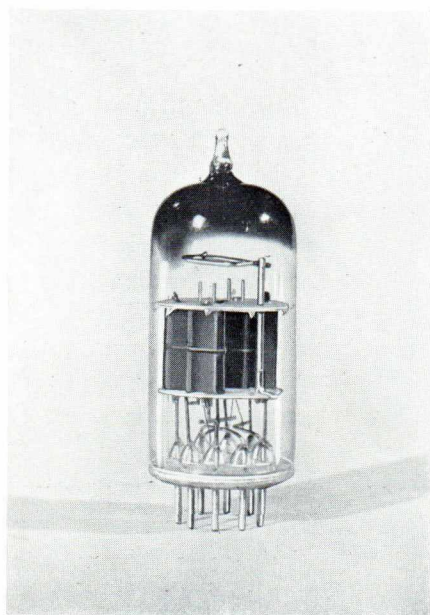


Fig. 2. The double triode ECC 81.

The higher performance of a triode compared with a pentode in the frequency range from 100 Mc/s to 300 Mc/s is well known and the provision of two high-quality triodes with separate cathodes in a single envelope ensures maximum circuit economy and flexibility. This double triode is suitable for all the radio-frequency stages in a receiver, i.e. R.F. amplifiers, mixers and local oscillators.

The electrical characteristics of the tube have been designed to meet the combined requirements of an efficient amplifier and a general-purpose radio-frequency triode. The interelectrode capacitances have therefore been kept low and the slope and the amplification factor fairly high.

APPLICATION

1. THE ECC 81 AS R.F. AMPLIFIER

In the 100 Mc/s to 300 Mc/s frequency bands the noise level due to static and cosmic noise is very low, but full advantage of these favourable conditions can only be gained when the receiver noise level is reduced to a minimum. This can be done by using triodes in the R.F. amplifier and mixer stages.

A triode can be connected in three ways — grounded grid, grounded cathode and grounded anode. The theoretical noise factors for the three circuits are very similar but the terminal impedances are different and in practice it has been found that the grounded-grid and grounded-cathode circuits give the best results.

The grounded-grid circuit has been widely used as a single-stage amplifier, since the grid forms an effective screen between input and output circuits and reduces regenerative feedback to a tolerable level.

A single grounded-cathode stage can be used but neutralization of the feedback impedance between anode and grid is difficult, especially when the circuit has to operate over a range of frequencies. However, when the grounded-cathode stage is followed by a grounded-grid amplifier the voltage gain of the first stage is approximately unity and neutralization can be accomplished in a simple way. This cascade combination of two triodes has an overall stability and voltage gain as good as those of an equivalent pentode but with the lower noise factor of a triode. Using an ECC 81, this circuit can be constructed with one tube.

In some receivers it may be advantageous to use a balanced push-pull circuit and then again the ECC 81 is eminently suitable. The receiver designer is therefore able to choose any one of a number of circuits according to individual requirements.

Grounded grid

A typical grounded-grid circuit is shown in fig. 3. This circuit is essentially a feedback amplifier, as the output current flows through the input circuit. The input impedance due to feedback is $(R_i + R_a)/(\mu + 1)$, where R_a is the resonant anode load

resistance. For values of R_a which are small compared with R_i , this expression reduces to $1/S$, which is about $200\ \Omega$ for the ECC 81. The input impedance is therefore very low and the voltage gain in the aerial circuit L_1 is small, but on the other hand the bandwidth is very large and over a very wide range of frequencies no tuning is necessary. The cathode coil L_1 can be used to match directly to an unbalanced feeder by means of a suitable tap, or it may be replaced by a balance-to-unbalance transformer to match a balanced feeder.

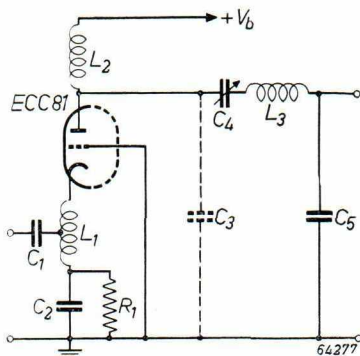


Fig. 3. One section of the ECC 81 as a grounded-grid amplifier.

An auto-transformer may be used for the output coupling but at the higher frequencies a π -filter is more convenient. The input capacitance of this filter C_3 is the output capacitance of the tube. The capacitance C_5 is adjusted to give impedance matching to the subsequent stage and C_4 is the tuning capacitor. The input impedance of the filter is approximately $(C_5/C_3)^2 R_{in}$, where R_{in} is the input impedance of the next stage, and this has to be matched to the output impedance of the tube for optimum power transfer. This output impedance is $R_i + \mu R_g$, where R_g is the total effective dynamic resistance in the grid circuit. R_1 , C_2 and L_2 are the bias components and the choke for the anode supply.

Typical figures for the performance of an ECC 81 in this circuit at a frequency of 200 Mc/s are: gain 12 db and noise factor 7.5 at a bandwidth of 6 Mc/s. In a practical circuit arrangement the two halves of the ECC 81 may be used separately for different frequency bands or, alternatively, may be connected in parallel as a single triode with double the slope and half the anode impedance.

Grounded cathode

In contrast with a pentode a single grounded-cathode triode amplifier is not suitable as a radio-

frequency amplifier in a receiver since the necessary neutralization of the anode-grid feedback capacitance is difficult to maintain, especially over a wide range of frequencies. Without neutralization stability can be achieved by employing a very low voltage gain, with a resultant loss in voltage sensitivity and an increase in noise level due to the second amplifier or mixer.

These disadvantages can be eliminated by using a cascade combination of two triodes, i.e. the two sections of an ECC 81. A non-critical neutralizing circuit can then be used purely to obtain the minimum noise factor and without affecting the stability. A typical circuit is shown in fig. 4. In this circuit L_2 is the coil for compensating the anode-grid capacitance of the first triode. Either L_3 or L_5 may be tuned to the signal frequency, L_4 and L_3 or L_5 being R.F. chokes.

The anode of the grounded-cathode triode is coupled to the cathode of the second triode, which is a grounded-grid amplifier. The input impedance of the grounded-grid stage is approximately $1/S$, so that the voltage gain of the first triode is unity. The output current of the first stage flows through the cathode circuit of the second stage, with the result that the overall gain of the system is SR_a , i.e. that of a pentode with equivalent mutual conductance. The combined circuit is stable, the overall

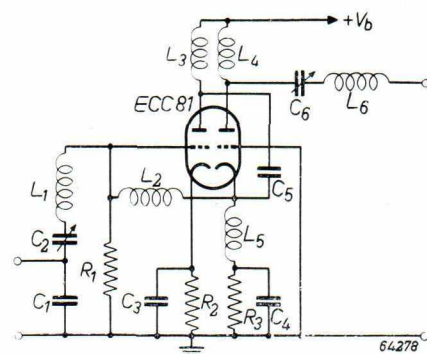


Fig. 4. Cascade combination of the two triodes of the ECC 81. One section is operating as a grounded-cathode and the other as a grounded-grid amplifier.

gain is high, and owing to the power gain of the first stage and the negative feedback of the grounded-grid amplifier the noise factor is that of the first triode.

Typical performance figures for a circuit of the type illustrated at a frequency of 200 Mc/s are: gain 13 db and noise factor 6.5 at a bandwidth of 11.5 Mc/s.

This cascade combination of the ECC 81 is very

suitable for use in a tuner in conjunction with another ECC81 operating as mixer and local oscillator. For some television applications it may be necessary to provide two distinct frequency bands with switched channels in each band. Channel selection can be accomplished by tuning all the R.F. amplifier and oscillator circuits, but the relatively complex tuning mechanism tends to lower the performance of the receiver compared with a fixed-tuned circuit. An alternative is to use a high intermediate frequency and to increase the bandwidth of the R.F. amplifier circuits, so that channel selection can be achieved by tuning the local

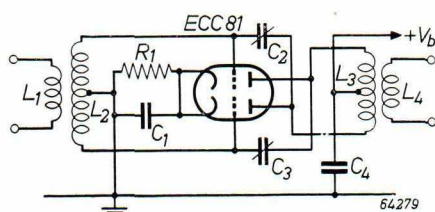


Fig. 5. The ECC 81 as a push-pull R.F. amplifier.

oscillator only. The image frequency is thereby placed outside the television bands and, although the performance of the wide-band circuits is not so good, the deterioration due to the necessity for tuning is eliminated. Owing to its high input impedance the EF 80 pentode is very suitable as a high-frequency I.F. amplifier. The reduced gain to be obtained with a wide-band R.F. amplifier increases the contribution of the mixer to the total noise and a triode mixer is therefore essential.

Push-pull amplifier

A push-pull amplifier may be conveniently constructed around an ECC 81. This circuit has a high L -to- C ratio, high gain and low noise factor. A typical circuit for operation at 200 Mc/s is shown in fig. 5.

A balanced input transformer L_1L_2 couples the balanced feeder to the control grids, and neutralizing capacitors (C_2, C_3) of the order of 1 pF are cross-connected between the respective anodes and grids. The output may be unbalanced and fed into a single-ended mixer and local oscillator, or balanced and fed into a push-pull mixer with push-pull local oscillator using two additional ECC 81 tubes. Typical performance figures for this R.F. amplifier are: gain 21 db, bandwidth 2.5 Mc/s, noise factor 5.

2. THE ECC 81 AS FREQUENCY CHANGER

As a frequency changer in high-frequency receivers the ECC 81 possesses two distinct advantages: the separate mixer and oscillator sections are contained in a single envelope, and the noise level of a triode mixer is sufficiently low to allow its use with a relatively low-gain, wide-band R.F. amplifier.

The conversion characteristics are given in figs 13, 14 and 15, p. 15-16, and it will be seen that the maximum conversion conductance is 2 mA/V at $V_b = 170$ V. Curves are also given for the anode impedance R_i and for the effective mutual conductance S , which is the value obtained when the tube is driven by both an oscillator voltage and a signal voltage of 100 mV at intermediate frequency.

A typical frequency changer circuit with the ECC 81 is shown in fig. 6. The oscillator voltage for the mixer is derived from a small capacitor of the order of 1–2 pF connected directly between the oscillator circuit and the mixer grid. This capacitor should be adjusted until the optimum oscillator drive is obtained. The oscillator voltage at the mixer grid should be 2–2.5 V according to the anode voltage used, and the drive should be adjusted so that when tuning over a frequency range its minimum value is equal to the optimum value. This is necessary to avoid an excessive spread in performance from tube to tube due to the rapid decrease in conversion conductance at low oscillator voltages.

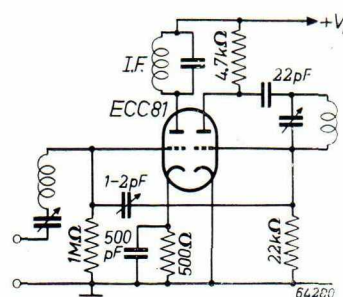


Fig. 6. The ECC 81 as a frequency changer.

The curves were obtained with a grid leak of 1 MΩ and no cathode bias was used. At $V_a = 170$ V the grid current for optimum drive is 3.3 μA, which represents a bias of 3.3 V.

In the event of a complete or partial failure of the oscillator circuit the cathode current of the mixer would become excessive. It is therefore desirable to operate the valve with cathode bias. The cathode current at optimum drive is 6.0 mA, so that a 500 Ω cathode resistor is required. Under these

conditions any value of grid leak less than 1 M Ω may be used but a high value is desirable to limit grid current. The grid current will be zero for an oscillator voltage less than that required to overcome the grid-current starting point and to drive the valve into grid current on the oscillator peaks.

The high mutual conductance of the ECC 81 makes it an efficient local oscillator at high frequencies and this tube may be used with any of the conventional oscillator circuits, of which fig. 6 gives an example. Typical performance figures for a frequency changer of this type operating in con-

junction with a push-pull R.F. amplifier as illustrated in fig. 5 are: total gain (between 50 Ω aerial and 2.2 k Ω anode load of the mixer) 31 db, bandwidth 7 Mc/s, noise factor 9. When this circuit is used in a television receiver operating without inter-carrier sound or in an F.M. receiver, vibrations in the air surrounding the tube or of the chassis may give rise to a modulation of the oscillator frequency. This can be avoided by using a screening can around the tube and, if necessary in a particular case, a resilient tube holder.

TECHNICAL DATA

HEATER DATA

Heating: indirect by A.C. or D.C.;
series or parallel supply

Heater voltage	V_f	6.3	12.6 V
Heater current	I_f	0.3	0.15 A

BASE CONNECTIONS AND DIMENSIONS (in mm)

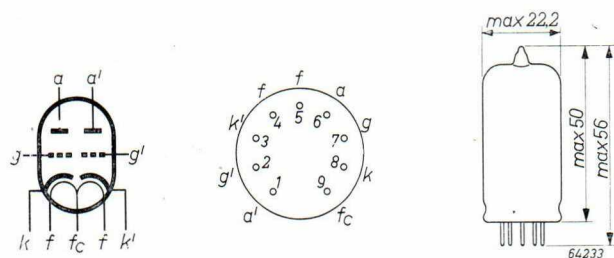


Fig. 7.

Mounting position: any

CAPACITANCES

	Section 1	Section 2
C_{ag}	1.45	1.45 pF
C_g	2.5	2.5 pF
C_a	0.45	0.35 pF
C_{ka}	0.15	0.15 pF
C_{kf}	2.5	2.5 pF
$C_{k(g+f)}$	5	5 pF
$C_{a(g+f)}$	1.6	1.5 pF
$C_{gg'}$	< 0.005 pF	
$C_{aa'}$	< 0.4 pF	

TYPICAL CHARACTERISTICS

Anode voltage	V_a	170	200	250 V
Grid bias	V_g	-1 *)	-1.5	-2.35 V
Anode current	I_a	10	10	10 mA
Mutual conductance	S	6	5.5	4.9 mA/V
Amplification factor	μ	62	57	43

*) At this adjustment grid current may occur. In case where this is inadmissible it is advisable to adjust the bias at -1.5 V.

LIMITING VALUES (each section)

Anode voltage at zero anode current	V_{ao}	max. 550 V
Anode voltage	V_a	max. 300 V
Anode dissipation	W_a	max. 2.5 W
Cathode current	I_k	max. 15 mA
Heater voltage during warming up period for both sections together		max. 9.5 V *)
(for V_f normal = 6.3 V)		max. 19 V
(for V_f normal = 12.6 V)		
Voltage between heater and cathode	V_{kf}	max. 90 V
External resistance between control grid and cathode with automatic bias	R_g	max. 1 M Ω
External resistance between heater and cathode	R_{kf}	max. 20 k Ω

*) When the ECC 81 is used in a receiver or any other circuit with series supply of the heaters it is necessary to use a device limiting the initial current after switching on. This may be an NTC resistor in series with the heater chain.

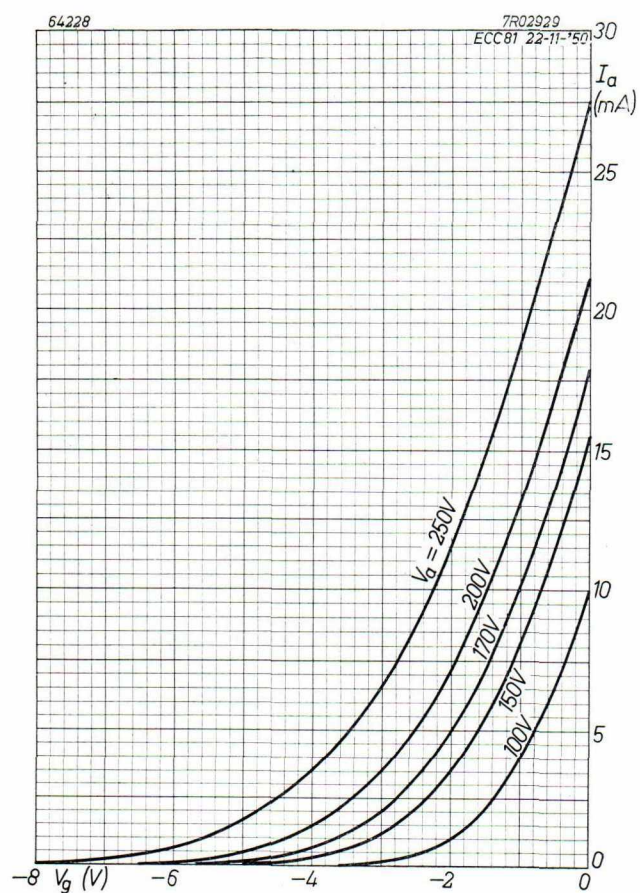


Fig. 8.
Anode current plotted
against grid voltage, with
anode voltage as para-
meter.

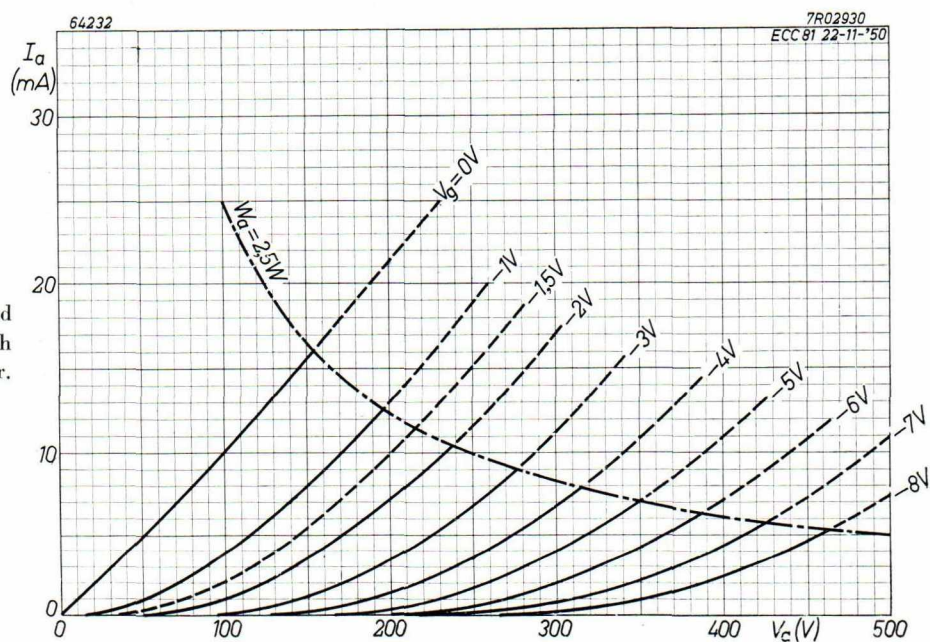


Fig. 9.
Anode current plotted
against anode voltage, with
grid voltage as parameter.

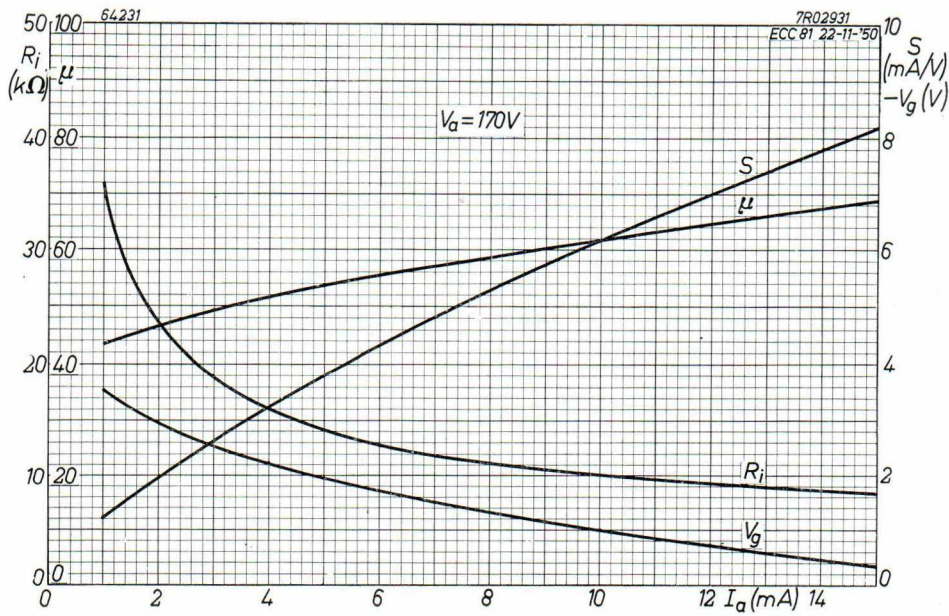


Fig. 10.
Mutual conductance, amplification factor, internal resistance and grid voltage plotted against anode current, for anode voltage of 170 V.



Fig. 11.
Mutual conductance, amplification factor, internal resistance and grid voltage plotted against anode current, for anode voltage of 200 V.

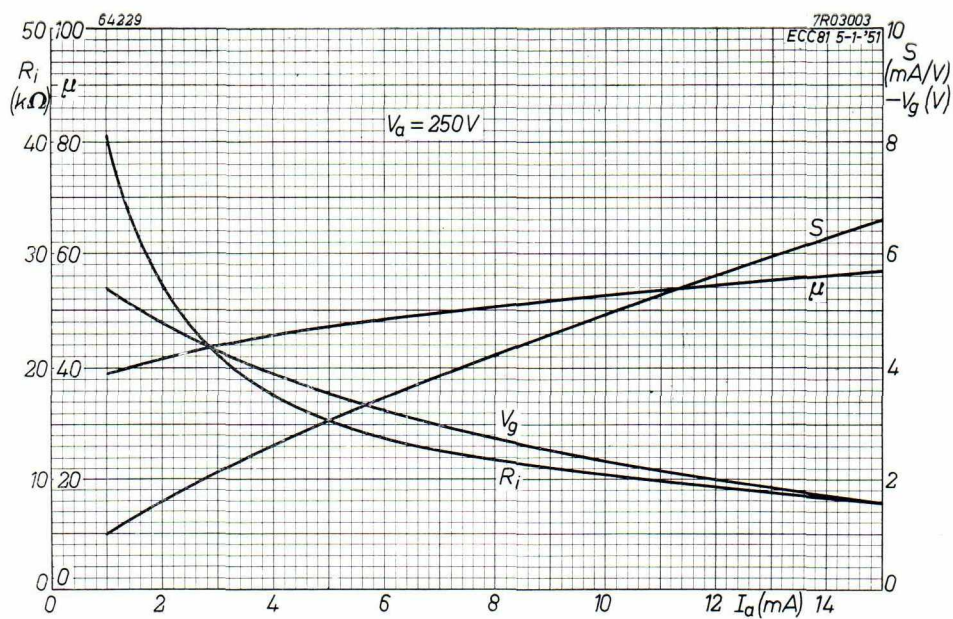


Fig. 12.
Mutual conductance, amplification factor, internal resistance and grid voltage plotted against anode current, for anode voltage of 250 V.

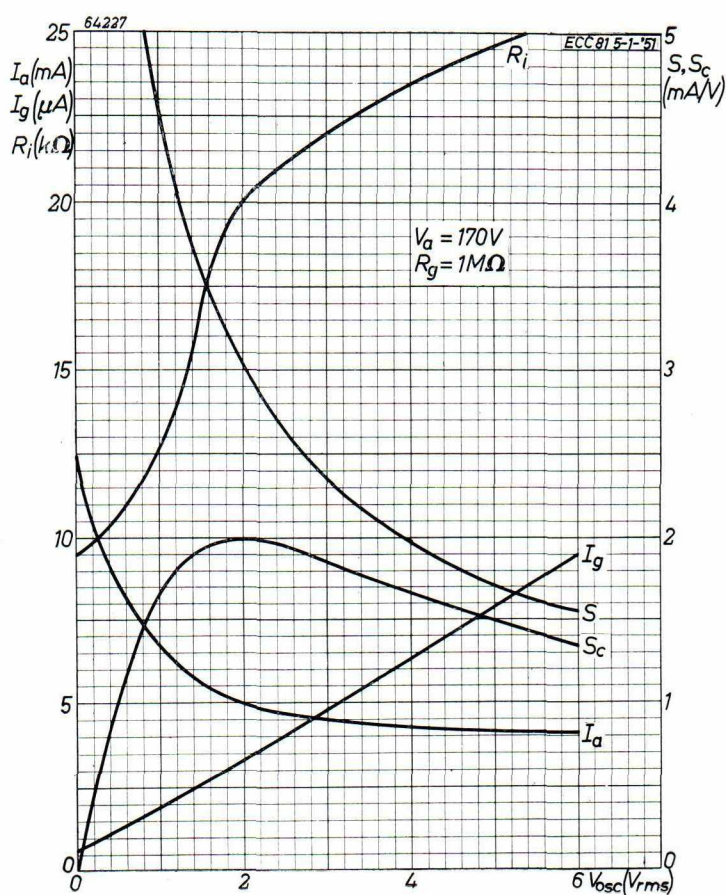


Fig. 13.
Performance curves of the ECC 81 as frequency changer at anode voltage of 170 V. S is the effective mutual conductance for a signal of 100 mV at intermediate frequency.

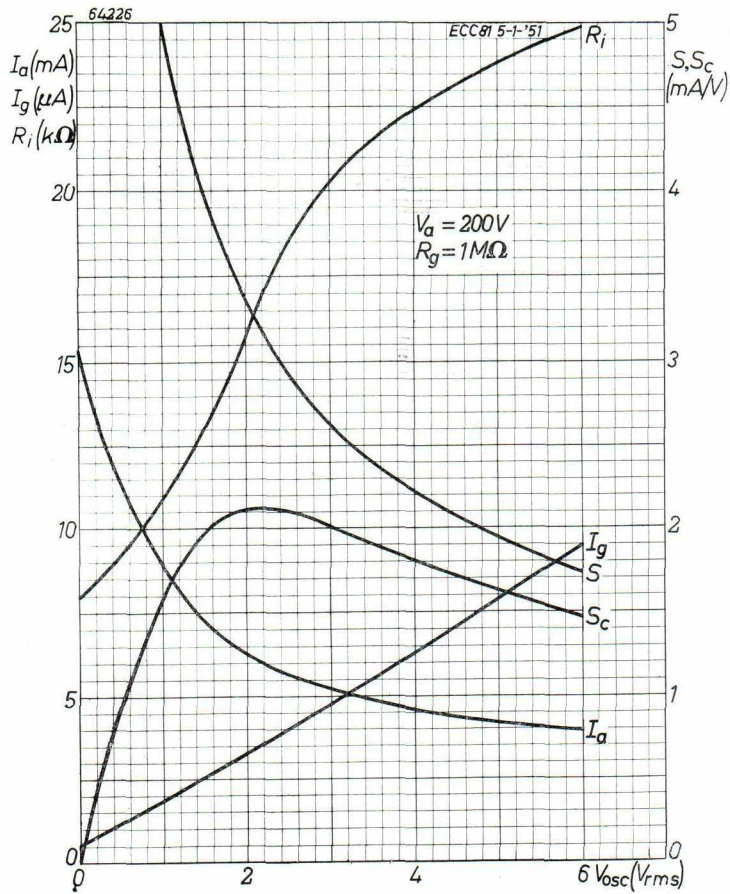


Fig. 14.
Performance curves of the
ECC 81 as frequency chan-
ger at anode voltage of
200 V. S is the effective
mutual conductance for a
signal of 100 mV at inter-
mediate frequency.

Fig. 15.
Performance curves of the
ECC 81 as frequency chan-
ger at anode voltage of
250 V. S is the effective
mutual conductance for a
signal of 100 mV at inter-
mediate frequency.

