

ECC 40

ECC 40 Double triode

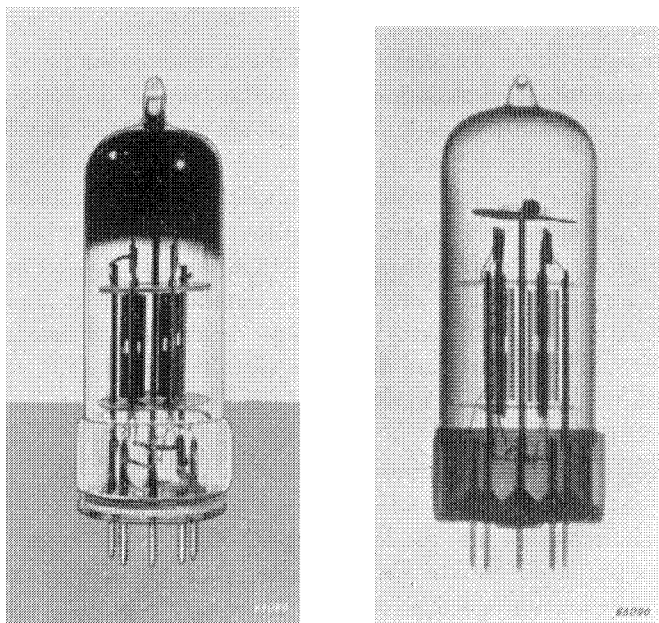


Fig. 1

Normal and X-ray photographs of the ECC 40 (approximately actual size).

The ECC 40 is an indirectly heated double triode, of which the two sections, apart from the heaters, are completely separate. This valve is intended primarily for use as an A.F. amplifier and phase inverter, but is also suitable for other purposes, for example as an oscillator, frequency changer, blocking oscillator, etc., in u.s.w apparatus. It is also being more and more widely used for electronic counters and calculating and accounting machines. The fact that the valve would often be called upon to meet much more stringent conditions than when used for normal A.F. amplification was taken into consideration in its development; to mention only one factor, the maximum permissible voltage between heater and cathode is 175 V, whereas a maximum of 50 V is usually high enough for E-type valves intended only for use in ordinary amplifiers and broadcast receivers.

The amplification factor of each section of the ECC 40 is 32 and the mutual conductance 2.9 mA V; each section is therefore capable of providing a reasonable gain while it will also function efficiently as an oscillator. The heaters of the two sections are connected in parallel and, as the heater current is 0.3 A in each case, the total heater current is 0.6 A at a voltage of 6.3 V.

The capacitances between the electrodes of both triodes are kept as low as possible. Thus the coupling between the sections is reduced to a minimum, which is a matter of great importance when the valve is used as a cascade amplifier. Since very high amplification is obtainable under such conditions, care must be taken with the wiring, as the circuit is otherwise liable to become unstable. If necessary, a neutralizing capacitor may be included between anode and grid of one of the triodes (see Fig. 4).

When it is intended to use the ECC 40 as an A.F. amplifier, it is important to know something of its microphonic tendencies: these, however, depend on whether the valve is to be used in a receiver or in an amplifier. In the former, it is usually located in the same cabinet as the speaker, but this is not usually the case in amplifiers; microphony is therefore less likely to occur in an amplifier, and greater amplification may be employed.

Let us first consider the question of receivers: it is generally safe to assume that there will be no risk of microphony in the circumstances outlined in the descriptions of the EAF 42 and EBC 41, when an alternating input voltage of at least 5 mV is required for the output valve to deliver 50 mW. When the ECC 40 is used in an A.F. amplifier, the likelihood of microphony is naturally dependent to a great extent on the position of the loudspeaker(s). To give some idea of the maximum gain which can be tolerated without special measures to prevent microphony, it is assumed that the sound level at the position of the ECC 40 corresponds to that obtained from a loudspeaker with an acoustic efficiency of 5% to which an input of 5 W is applied, the distance from the valve being about 10 cm. The gain can now be increased to the point where a voltage of 50 mV is needed for the input of the ECC 40. It should be pointed out, however, that the values mentioned in the foregoing are intended only as a general guide, and may well be adversely affected by actual working conditions (see description of the EBC 41).

In order to suppress hum as much as possible, it is recommended that a potentiometer, of which the sliding contact is earthed, be connected across the heater of the ECC 40, and adjusted until the hum is at a minimum. A suitable value for the resistance of the potentiometer would be 50 Ω .

It is also advisable that the impedance of the control grid circuit at the hum frequency be kept as low as possible: generally speaking, as long as this impedance is kept to within 0.3 M Ω in circuits such as those mentioned in connection with microphony, the hum will be sufficiently suppressed.

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TECHNICAL DATA OF THE DOUBLE TRIODE ECC 40

Heater data

Heating: indirect, A.C. or D.C., parallel feed. The heaters of the two sections are connected in parallel.

Heater voltage	V_f	=	6.3 V
Heater current	I_f	=	0.6 A

Capacitances (cold valve)

First triode section

Input capacitance	C_g	=	2.8 pF
Output capacitance	C_a	=	1.1 pF
Between grid and anode	C_{ag}	=	2.7 pF
Between grid and heater	C_{gf}	<	0.1 pF
Between cathode and heater . .	C_{kf}	=	3 pF

Second triode section

Input capacitance	$C_{g'}$	=	2.6 pF
Output capacitance	$C_{a'}$	=	0.7 pF
Between grid and anode	$C_{a'g'}$	=	2.8 pF
Between grid and heater	$C_{g'f}$	<	0.1 pF
Between cathode and heater . .	$C_{k'f}$	=	3 pF

Between the two triode sections

Between anode of section I and anode of section II	$C_{aa'}$	<	0.8 pF
Between grid of section I and grid of section II	$C_{gg'}$	<	0.1 pF
Between anode of section I and grid of section II	$C_{ag'}$	<	0.1 pF
Between anode of section II and grid of section I	$C_{a'g}$	<	0.1 pF

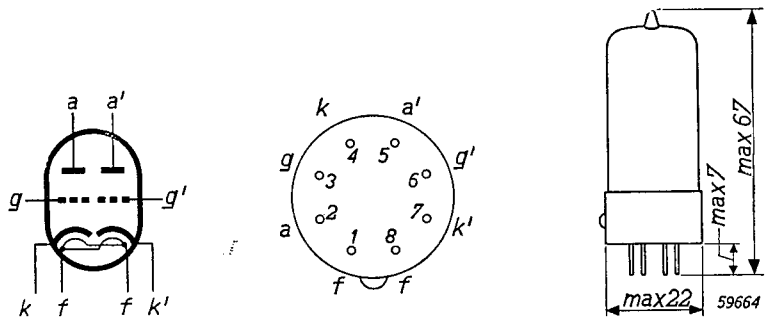


Fig. 2
Electrode arrangement, electrode connections and dimensions in mm of the ECC 40.

Typical characteristics of the ECC 40 (each section)

Anode voltage	V_a	=	250 V
Cathode resistor	R_k	=	920 Ω
Anode current	I_a	=	6 mA
Mutual conductance	S	=	2.9 mA/V
Internal resistance	R_i	=	11 k Ω
Amplification factor	μ	=	32

Limiting values of the ECC 40 (each 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.	1.5 W
Grid dissipation	W_g	= max.	0.1 W
Cathode current	I_k	= max.	10 mA
Grid current starting point . .	$V_g(I_g = +0.3 \mu A)$	= max.	-1.3 V
External resistance between grid and heater	R_g	= max.	1 M Ω
External resistance between heater and cathode . . .	R_{fk}	= max.	0.15 M Ω
Voltage between heater and cathode (<i>f</i> neg., <i>k</i> pos.) . .	V_{fk}	= max.	175 V
(<i>f</i> pos., <i>k</i> neg.)	V_{jk}	= max.	100 V

The ECC 40 used as an A.F. amplifier

A. Operating characteristics: one section

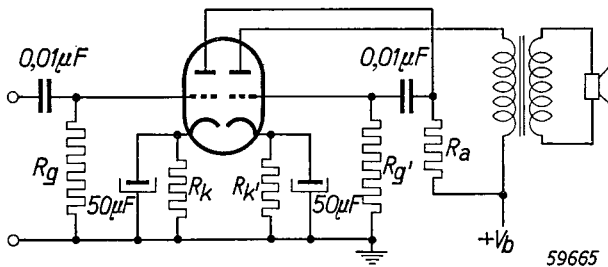


Fig. 3
The ECC 40 as combined A.F. amplifying and output valve.

Supply voltage	V_b	=	250	250 V
Anode resistor	R_a	=	0.1	0.22 M Ω
Cathode resistor	R_k	=	2.2	2.2 k Ω
Grid resistor	R_g	=	1	1 M Ω
Grid resistor, section II . . .	R'_g	=	0.33	0.68 M Ω
Anode current	I_a	=	1.4	0.9 mA
Output voltage	V_o	=	30	18 V _{RMS}
Amplification	V_o/V_i	=	24	25
Distortion	d_{tot}	=	2.2	1.3 %

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B. Operating characteristics: two sections in cascade (see Fig. 4)

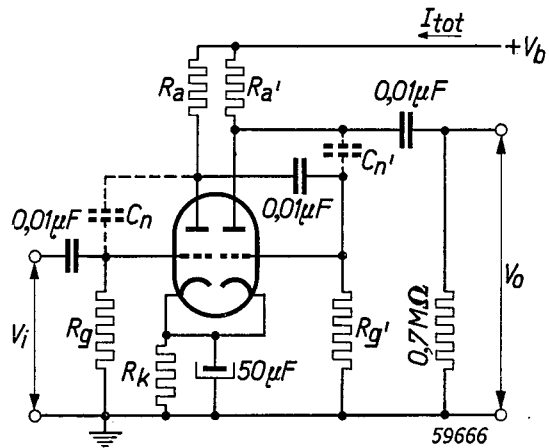


Fig. 4
The ECC 40 as A.F. cascade amplifier
 C_n and $C_{n'}$ are neutralizing capacitors, one of which may be used if the amplifier is rendered unstable by parasitic wiring capacitances. $R_g = R_{g'} = 1\text{ M}\Omega$; $R_k = 1\text{ k}\Omega$.

Supply voltage	V_b	=	250	250 V
Anode resistor, section I . . .	R_a	=	0.22	0.22 MΩ
Anode resistor, section II . . .	$R_{a'}$	=	0.1	0.22 MΩ
Total current	I_{tot}	=	2.5	2.0 mA
Amplification	V_o/V_i	=	740	780
Output voltage	V_o	=	30	18 V _{RMS}
Distortion	d_{tot}	=	1.9	1.2 %

Provided that the wiring is carefully laid out, it is possible, in spite of the high amplification, to ensure complete stability of the amplifier. If difficulties are encountered, a neutralizing capacitor (C_n or $C_{n'}$) may be connected between anode and grid of one of the triodes, a suitable value for all frequencies being about 4 pF.

The ECC 40 used as an output valve

A. Operating characteristics: one section used as a Class A output valve (Fig. 3)

Anode voltage	V_a	=	250 V
Cathode resistor	R_k	=	920 Ω
Anode current	I_a	=	6.0 mA
Mutual conductance	S	=	2.9 mA/V
Internal resistance	R_i	=	11 kΩ
Amplification factor	μ	=	32
Matching resistance	R_a	=	15 kΩ

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Output power	W_o	=	280 mW
Required alternating input voltage	V_i	=	3.9 V_{RMS}
Distortion	d_{tot}	=	8.5 %

B. Operating characteristics: both sections used in class A push-pull

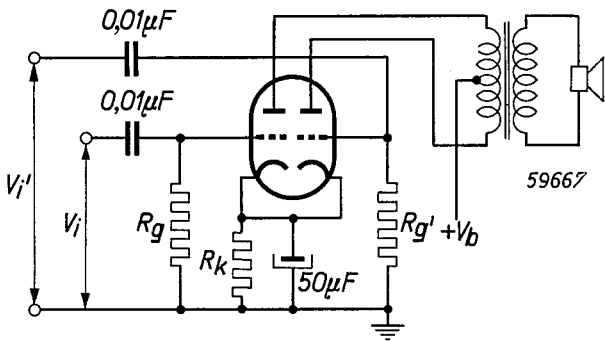


Fig. 5
The ECC 40 used as a push-pull output valve.

Anode voltage	V_a	=	250	V
Common cathode resistor	R_k	=	560	Ω
Matching resistance	$R_{aa'}$	=	30	k Ω
Alternating input voltage	$V_i = V_i'$	=	0	4.1 V_{RMS}
Anode current	I_a	=	2×5.2	2×5.6 mA
Output power	W_o	=	0	520 mW
Distortion	d_{tot}	=	—	1.0 %

The ECC 40 used as a phase inverter

As is generally known, the output stage in a push-pull amplifier or receiver will not function properly unless the alternating input voltage applied to the control grid of one of the output valves is equal to and in counter-phase with the input of the other valve. To obtain these voltages in modern mains receivers, it is usual to employ a circuit comprising two valves together with the necessary resistors and capacitors; the ECC 40, which is in effect two valves in one envelope, is ideal for this purpose. In the following paragraphs, a number of circuits employing the ECC 40 as a phase inverter are described in detail.

A. Phase inverter, using an unbypassed cathode resistor (Fig. 6)

Fig. 6 shows a circuit in which the first triode section serves as a normal A.F. amplifier. The amplified voltage is then applied to the second triode, which

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has equal, unbypassed resistors in its anode and cathode leads. The voltages across these resistors, equal but in counter-phase, are applied, through capacitors, to the control grids of the push-pull output valves. Since the high cathode resistance tends to produce a strong negative bias on the grid of the second triode, this grid is connected to the anode of the first triode. The value of the anode resistor of the first triode is such that a suitable bias is obtained on the grid of the second triode.

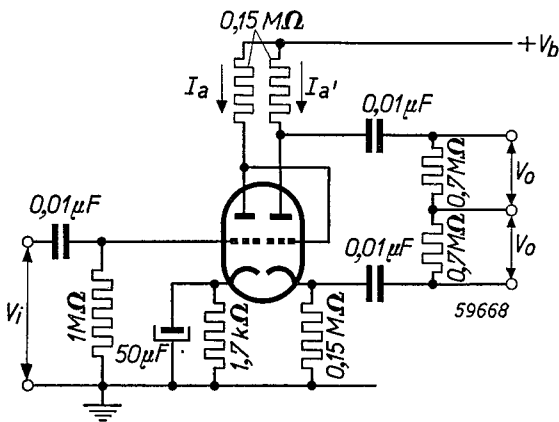


Fig. 6
The ECC 40 used as a phase inverter, with output voltages taken from similar resistors in the anode and cathode circuits of the second triode.

Supply voltage	V_b	= 250	350 V
Anode current, section I . . .	I_a	= 1.12	1.57 mA
Anode current, section II . . .	I_a'	= 0.55	0.78 mA
Amplification	V_o/V_i	= 27	27
Output voltage	V_o	= 18	30 V_{RMS}
Distortion	d_{tot}	= 1.0	1.0 %

B. Balanced phase inverter (Fig. 7)

Another circuit employing the ECC 40 as a phase inverter, but working on a completely different principle, is shown in Fig. 7. In this arrangement the first triode is again used as a normal A.F. amplifier, the amplified voltage being supplied, through capacitor C_1 and potentiometer R_1, R_g' , to the control grid of the second triode. The amplified voltages on the two anodes, V_o and V_o' , are applied, through capacitors C_1 and C_2 , to the control grids of the output valves.

To ensure equality of the voltages V_o and V_o' , it is essential that the ratio

$(R_1 + R_g)$ to R_g' is equal to the gain of the second triode system. This is the only disadvantage of the circuit: if the gain for some reason undergoes a change, V_o will no longer equal V_o' . On the other hand, this circuit has a distinct advantage over the arrangement described above in that the common cathode resistor requires no decoupling capacitor. Since the alternating components in the cathode currents of the two sections are equal and in counter-phase, their resultant is zero.

Supply voltage	V_b	=	250	350 V
Common cathode resistor	R_k	=	1.0	0.75 k Ω
R'_g (see Fig. 7)	R'_g	=	27.3	26.2 k Ω
Total current	I_{tot}	=	3.0	4.3 mA
Amplification	V_o/V_i	=	26	27.5
Output voltage	V_o	=	30	30 V _{RMS}
Distortion, triode I	d_{tot}	=	1.5	1.1 %
Distortion, triode II	d'_{tot}	=	0.5	0.3 %

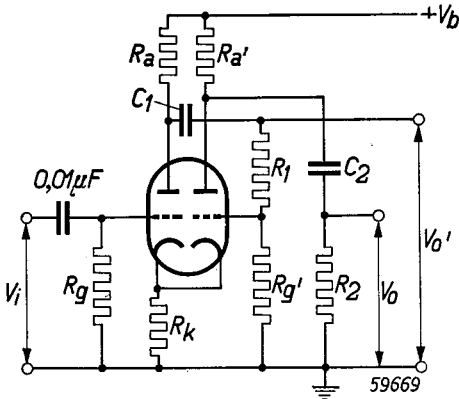


Fig. 7

The ECC 40 used as a balanced phase inverter. $R_g = R_1 = R_2 = 0.7$ M Ω . $R_a = R'_a = 0.1$ M Ω . $C_1 = C_2 = 0.01$ μ F.

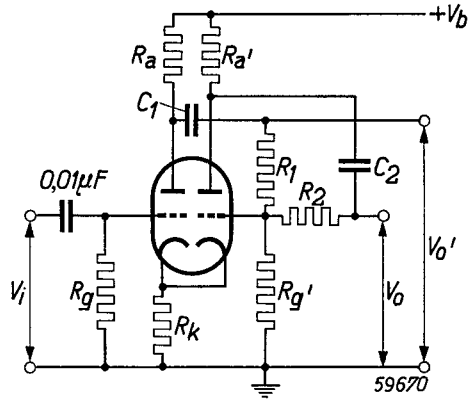


Fig. 8

The same circuit as in Fig. 7, but with negative feedback applied to the second triode by means of C_2 and R_2 . $R_g = 0.7$ M Ω . $R'_g = 0.22$ M Ω . $R_a = R'_a = 0.15$ M Ω . $R_k = 1.1$ k Ω . $R_1 = 0.41$ M Ω . $R_2 = 0.47$ M Ω . $C_1 = C_2 = 0.02$ μ F.

C. Balanced phase inverter circuit with feedback (Fig. 8)

To avoid the drawbacks inherent in the circuit described in para. B, the arrangement shown in Fig. 8 can be employed. In this case a balanced output is assured by using negative feedback to stabilize the gain of the second triode. By this method, variations in the valve characteristics are made to have much less effect on the equality of the counter-phase output voltages.

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The ECC 40 used as a generator of saw-tooth voltages (blocking oscillator)

Saw-tooth voltages are used for the movement of the spot across the screen of the cathode-ray tube in a television receiver or an oscillograph; various circuits have been designed for the purpose of generating these voltages, and one of these, the blocking oscillator, is described below. In this particular circuit the ECC 40 is used, only one section acting as the actual oscillator. In order to synchronize the scanning of the picture tube in television receivers with the point-to-point scanning of the object by the camera tube, synchronizing pulses are included in the transmitted signal. The second triode of the ECC 40 serves to feed these pulses to the blocking oscillator in a suitable manner.

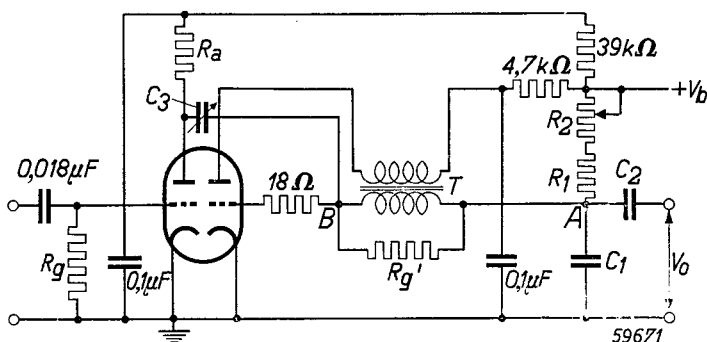


Fig. 9

The ECC 40 used as a generator of saw-tooth voltages. $C_1 = 560$ pF.
 $R_1 = 0.1$ MΩ. $R_2 = \text{max. } 0.1$ MΩ.

The circuit of the synchronized blocking oscillator is reproduced in Fig. 9. The action of the oscillator itself, comprising section II with appropriate circuit, can be described as follows: assume that at a given moment capacitor C_1 is charged to such an extent that the potential at the point A is strongly negative with respect to the cathode potential. The potential on the grid of the second triode is then equally negative, and the system is biased to cut-off.

The capacitor C_1 discharges through the resistors R_1 and R_2 , and the voltage across C_1 gradually decays until the triode is no longer biased to the point of cut-off. At this stage, anode current commences to flow through the primary of transformer T , producing in the secondary winding a voltage such that point B becomes positive with respect to point A. This accelerates the rise in anode current, so that the potential at B becomes more and more positive, and so on. The voltage on the grid consequently reaches a very high positive value with respect to cathode potential, and the capacitor C_1 is therefore very quickly charged by the grid current.

Since the anode voltage drops when the anode current increases, the increase in anode current is not unlimited, and, in a short time, the induced voltage between B and A becomes zero, and the grid potential again becomes strongly

negative, owing to the voltage across C_1 . The whole process then repeats itself.

The voltage across C_1 is taken by the capacitor C_2 to the output terminal. While C_1 is being discharged, the voltage between this terminal and earth increases gradually, to drop suddenly during the time that the triode is passing current. The required saw-tooth voltage across the output terminals is thus produced.

The frequency of the voltage can be regulated by means of the variable resistor R_2 ; with components of the values indicated in the circuit diagram, a frequency of about 15 kc/s will be obtained.

The synchronizing pulses are applied to the grid of triode I, the amplified pulses in the anode circuit being taken by trimmer C_3 to the point B in the circuit of triode II. This means that a positive voltage surge arrives at B at the correct moment, as a result of which C_1 , instead of being further discharged, is re-charged.

In other words, the rise in the saw-tooth voltage is checked at the correct moment, and the movement of the spot in the C.R. tube is thus synchronized with the scanning of the object at the transmitting station. A condition on which the success of the process depends is of course that the natural frequency of the oscillating circuit shall be slightly lower than the frequency of the synchronizing pulses.

The ECC 40 used in electronic counters

An instrument employed on an ever-increasing scale for industrial purposes is the electronic counter. This instrument is capable of counting objects, or recurring phenomena, with great accuracy and at a speed of almost 10^6 per second.

Essentially, the action of the instrument is as follows: for each object or phenomenon to be counted, an electrical impulse is generated by one means or another, and this impulse is applied to the counter. The electrical side of the instrument consists of a number of so-called "flip-flop" circuits which react to the applied impulses and enable them to be registered in the manner described in the following paragraphs.

An example of a circuit of this kind, for which the ECC 40 is particularly suitable, is shown in Fig. 10. The action is as follows: The grid voltages of the triode sections I and II both comprise two components, viz. a negative voltage produced by the common cathode resistor R_k , and a positive voltage across the grid leaks R_g and R_g' . These grid leaks form part of the potentiometers R_3 , R_a' , R_1 , R_g and R_3 , R_a , R_2 , R_g' .

Assume that at a given moment the grid of section II is positive with respect to the cathode. The anode current then flowing through R_a' and R_3 ensures that the voltage at point B, and therefore also that across R_g , remains low. As a result, the grid of section I becomes strongly negative with respect to the cathode, and the triode is thus biased to cut-off. Under these conditions the circuit is stable and will remain so until a sufficiently strong negative voltage impulse is applied to the input C_1 . When the impulse arrives, the electrical charge on C_1 increases and some of the electrons released from the

right-hand electrode of this capacitor as seen in the diagram pass through R_a , R_2 and R_g' , producing a drop in the voltage across R_g' and also reducing the anode current of section II to zero. Meanwhile, the voltage at B increases (as well as that across R_g), with the result that anode current flows in section I. The final outcome is that section I passes current whilst section II is quenched; in other words, the working conditions of the triodes I and II are reversed and this condition prevails until the next negative impulse again reverses the situation. In this case, however, the voltage at B drops suddenly, so that a negative impulse reaches the capacitor C_4 and is used to operate the next "flip-flop" circuit.

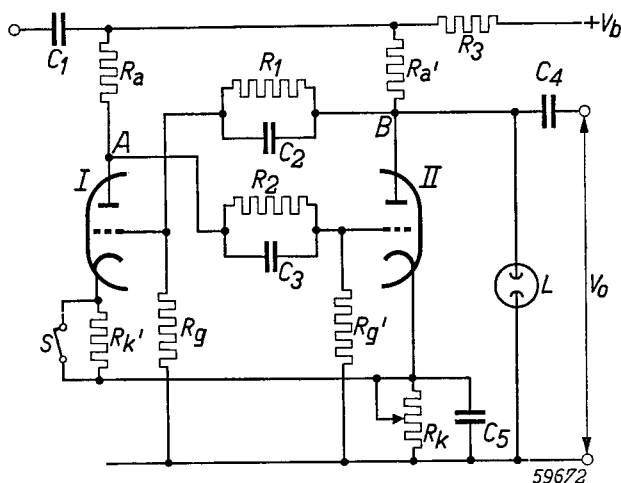
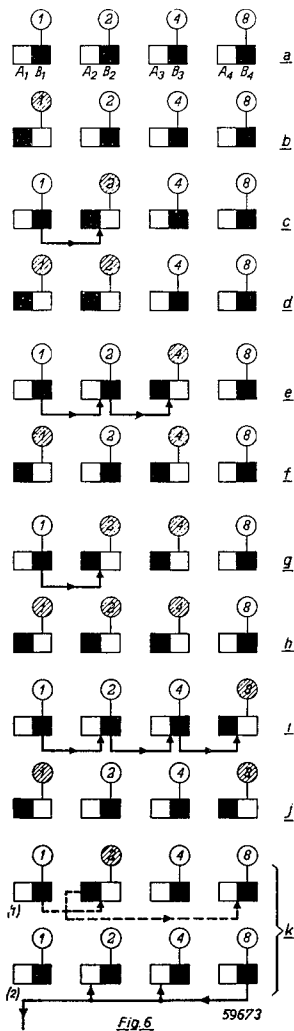


Fig. 10

The ECC 40 in a "flip-flop" circuit as used in electronic counters. $R_a=R_a'=22\text{ k}\Omega$; $R_1=R_2=0.1\text{ M}\Omega$; $R_3=10\text{ k}\Omega$; $R_g=R_g'=47\text{ k}\Omega$; $R_k=\text{max. } 6\text{ k}\Omega$; $R_k'=47\text{ k}\Omega$; $C_1=390\text{ pF}$; $C_2=C_3=150\text{ pF}$; $C_4=120\text{ pF}$; $C_5=0.27\text{ }\mu\text{F}$.

Some idea of the use of flip-flop circuits in a counter can be obtained from Fig. 11, which depicts various conditions in a set of four flip-flop circuits connected in series: the white panels represent triode systems which are not passing current, and the black panels those which are. When the first sections of a double triode become conductive, a number is illuminated by a neon tube (L in Fig. 10) connected in parallel with the second section: the number of the first flip-flop circuit is 1, that of the second 2; the third is numbered 4 and the fourth 8. In Fig. 11, the illuminated numbers are indicated by hatched lines.

When the first impulse is applied to the input, number 1 lights up (Fig. 11b), and with the second impulse number 2 (Fig. 11c); with the third impulse number 2 remains alight and 1 also appears (Fig. 11d), after which number 4 lights up (Fig. 11e), etc. At the ninth impulse the numbers 8 and 1 are both illuminated (Fig. 11j); a subsequent impulse will not light up 8 and 2,



but, with a suitable circuit, will actuate the next set of four flip-flop circuits, of which the first triode then illuminates number 10 (Fig. 11k₂). The first four circuits are then restored to their original settings, ready to count the next ten impulses. It will be obvious that, to count a number embodying n figures, $4n$ flip-flop circuits will be required. In the circuit shown in Fig. 10, a biasing resistor R_k' is connected in the cathode circuit of section I; this resistor, shorted by switch S , serves to restore the circuit to neutral, for which purpose the switch is opened so as to increase the bias in section I to the point where it will pass no current. The original circuit is restored when switch S is closed, the instrument being ready to commence counting again.

Fig. 11
Four flip-flop circuits in series for counting from 1 up to 9. For explanation see text.

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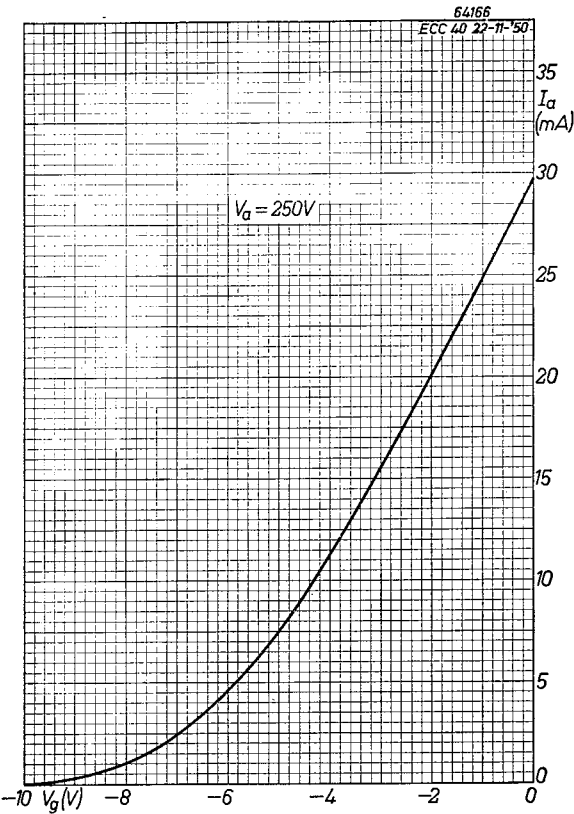


Fig. 12
 I_a/V_g characteristic of the
ECC 40 at an anode voltage
 $V_a = 250V$.

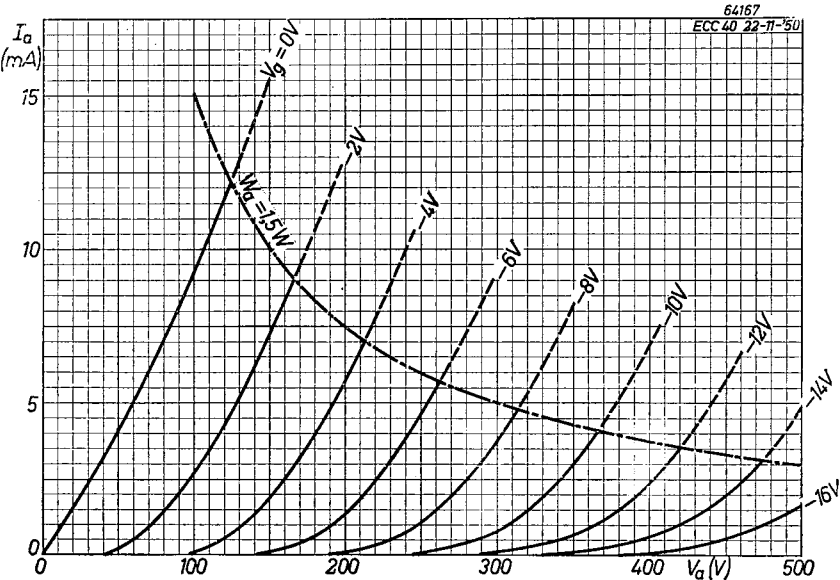


Fig. 13
 I_a/V_a characteristics of the
ECC 40. The dotted line
indicates the maximum per-
missible anode dissipation
 $W_a = 1.5W$.

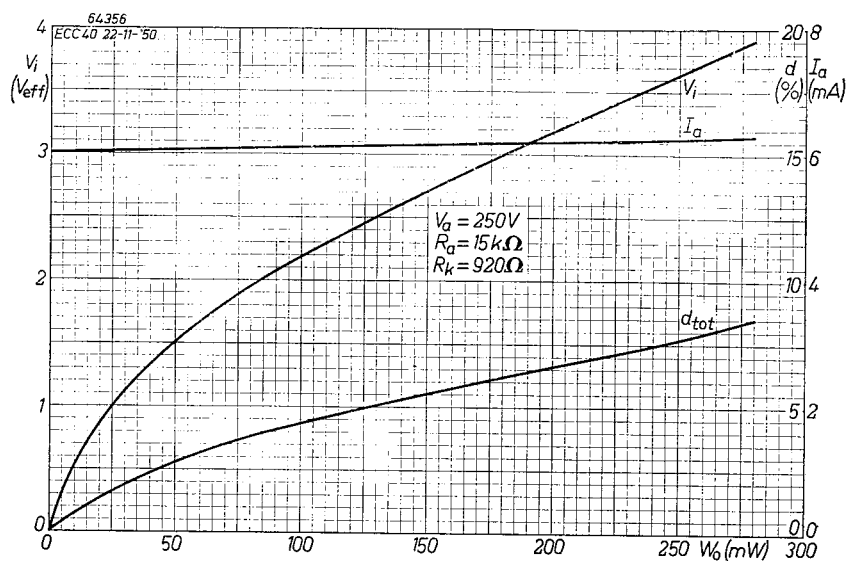


Fig. 14
Anode current I_a , required input voltage V_i and distortion d_{tot} of one triode section of the ECC 40 used as an output valve.

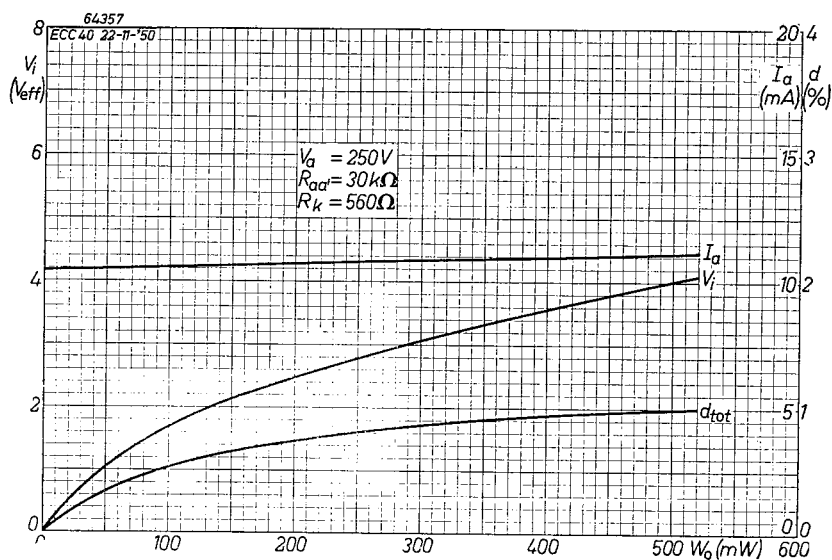


Fig. 15
As Fig. 14, for both sections of the ECC 40 connected in Class A push-pull.