

# U.H.F. OSCILLATOR TRIODE EC 81

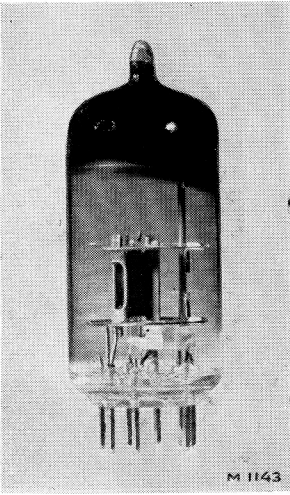


Fig. 11. Photograph of the tube EC 81 (actual size).

The EC 81 is an indirectly heated triode designed for oscillator service at ultra high frequencies, the maximum frequency being about 1200 Mc/s ( $\lambda = 25$  cm). At 750 Mc/s ( $\lambda = 40$  cm) an output of 1.1 watts can be obtained: at 500 Mc/s ( $\lambda = 60$  cm) 2.9 watts and at 300 Mc/s ( $\lambda = 1$  m) 4.2 watts. If higher output power is required, two tubes can be connected in push-pull. The mutual conductance of the EC 81 is high ( $S = 5.5$  mA/V); the amplification factor is 16.

The EC 81 is an excellent oscillator for a great number of applications, such as in transmitters, as a local oscillator in receivers for Citizens Radio and professional equipment, in beam transmitters for radio links, in balloon sondes and measuring equipment, etc.

The generation of ultra-high frequencies with the EC 81 has become possible by taking the measures described in the Introduction. The capacitances between the various electrodes have been made very small, thanks to the exceedingly small dimensions of the electrode system. This has been achieved by shaping the anode in a special way, so as to combine small capacitance with a high heat dissipation.

The operating characteristics of the EC 81 are given below, under various conditions with reference to the constancy of the supply voltage.

In the first place, the data and maximum values under normal operating conditions are given.

In this case the maximum admissible anode dissipation is 3.5 watts. The heater can be fed from a 6.3 volts supply source if a resistor of 3 ohms is connected in series. At a frequency of 750 Mc/s an output of 0.6 watts can be obtained.

In the second place, operating data and maximum values are given under absolute maximum conditions. The maximum admissible value of the anode dissipation is then 5 watts, the anode voltage 300 volts, and the cathode current 30 mA. It must be stressed that these values should never be exceeded under any usual condition of supply voltage variation, load variation, or manufacturing tolerances in the equipment itself.

When the tube is operated with the maximum cathode current of 30 mA, it will be necessary to feed the heater from a supply source of 6.3 volts, the fluctuations

of which do not exceed  $\pm 3\%$ . In that case the output obtainable at 750 Mc/s is 1.1 watts.

**TECHNICAL DATA**

**HEATER DATA**

Heating: indirect by a.c. or d.c.; parallel supply

Heater voltage . . . . .  $V_f = 6.3 \text{ V}^1)$

Heater current . . . . .  $I_f = 0.2 \text{ A}$

**CAPACITANCES (measured with tube cold)**

Input capacitance . . . . .  $C_g = 1.8 \text{ pF}$

Output capacitance . . . . .  $C_a = 0.7 \text{ pF}$

Capacitance between grid and anode . . . . .  $C_{ag} = 1.6 \text{ pF}$

Capacitance between grid and heater . . . . .  $C_{gf} < 0.25 \text{ pF}$

Capacitance between cathode and heater . . . . .  $C_{kf} = 2.3 \text{ pF}$

**ELECTRODE ARRANGEMENT**

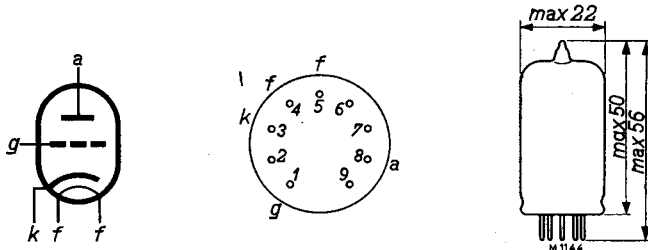


Fig. 12. Electrode arrangement, electrode connections and maximum dimensions in mm (noval base).

**TYPICAL CHARACTERISTICS**

Anode voltage . . . . .  $V_a = 120 \quad 150 \text{ V}$

Grid voltage . . . . .  $V_g = -2 \quad -2 \text{ V}$

Anode current . . . . .  $I_a = 20 \quad 30 \text{ mA}$

Mutual conductance . . . . .  $S = 4.0 \quad 5.5 \text{ mA/V}$

Amplification factor . . . . .  $\mu = 16 \quad 16$

**OPERATING CHARACTERISTICS AS OSCILLATOR**

**NORMAL OPERATING CONDITIONS (ANODE VOLTAGE NOT STABILIZED)**

*Limiting values*

Anode voltage . . . . .  $V_a = \text{max.} \quad 275 \text{ V}$

Anode dissipation . . . . .  $W_a = \text{max.} \quad 3.5 \text{ W}$

Cathode current . . . . .  $I_k = \text{max.} \quad 20 \text{ mA}$

<sup>1)</sup> When using a heater voltage of 6.3 volts, the fluctuations of the voltage must not exceed  $\pm 3\%$ . In this case the absolute value of the cathode current amounts to 30 mA. When the heater voltage fluctuations exceed 3%, a resistor of 3 ohms must be connected in series with the heater. In this case the maximum admissible cathode current is 20 mA.

Heater supply voltage . . . . .	$V_{bf}$	=	6.3	V
Heater series resistor . . . . .	$R_f$	=	3	$\Omega$
Frequency . . . . .	$f$	=	750	375 Mc/s
Anode voltage . . . . .	$V_a$	=	220	275 V
Anode current . . . . .	$I_a$	=	18.6	17.2 mA
Grid current . . . . .	$I_g$	=	1.5	2.8 mA
Input power . . . . .	$W_{ia}$	=	4.1	4.7 W
Output power . . . . .	$W_o$	=	0.6	2.1 W

NORMAL OPERATING CONDITIONS (ANODE VOLTAGE STABILIZED)

Limiting values

Anode voltage	} (absolute maxima)	}	$V_a$	= max. 300 V $\pm$ 1%
Anode dissipation			$W_a$	= max. 5 W <sup>2)</sup>
Cathode current			$I_k$	= max. 20 mA

Heater supply voltage . . . . .	$V_{bf}$	=	6.3	V
Heater series resistor . . . . .	$R_f$	=	3	$\Omega$
Frequency . . . . .	$f$	=	750	375 Mc/s
Anode voltage . . . . .	$V_a$	=	290	300 V
Anode current . . . . .	$I_a$	=	19.6	18.6 mA
Grid current . . . . .	$I_g$	=	0.4	1.5 mA
Input power . . . . .	$W_{ia}$	=	5.7	5.6 W
Output power . . . . .	$W_o$	=	0.7	2.2 W

OPERATING CONDITIONS (HEATER AND ANODE VOLTAGE STABILIZED)

Limiting values (absolute maxima)

Anode voltage	} (absolute maxima)	}	$V_a$	= max. 300 V $\pm$ 1%
Anode dissipation			$W_a$	= max. 5 W <sup>2)</sup>
Cathode current			$I_k$	= max. 30 mA

Heater voltage . . . . .	$V_f$	=	6.3 <sup>3)</sup>	V
Frequency . . . . .	$f$	=	750	375 Mc/s
Anode voltage . . . . .	$V_a$	=	220	300 V
Anode current . . . . .	$I_a$	=	27.7	26.3 mA
Grid current . . . . .	$I_g$	=	2.3	4.0 mA
Input power . . . . .	$W_{ia}$	=	6.1	7.9 W
Output power . . . . .	$W_o$	=	1.1	3.8 W

<sup>2)</sup> This value must be adjusted for each tube separately.

<sup>3)</sup> See note on page 14.

LIMITING VALUES

*Absolute maxima*

Anode voltage in cold state . . . . .	$V_{ao}$ = max.	550 V
Anode voltage . . . . .	$V_a$ = max.	300 V
Anode dissipation . . . . .	$W_a$ = max.	5 W
Cathode current . . . . .	$I_k$ = max.	30 mA
Grid bias . . . . .	$V_g$	= max. 100 V
Grid current start . . . . .	$V_g$ ( $I_g = 0.3 \mu A$ )	= max. -1.3 V
Grid current . . . . .	$I_g$	= max. 7.5 mA
External resistance between grid and cathode	$R_g$	= max. 1 M $\Omega$
External resistance between cathode and heater	$R_{fk}$	= max. 20 k $\Omega$
Voltage between cathode and heater	$V_{fk}$	= max. 100 V

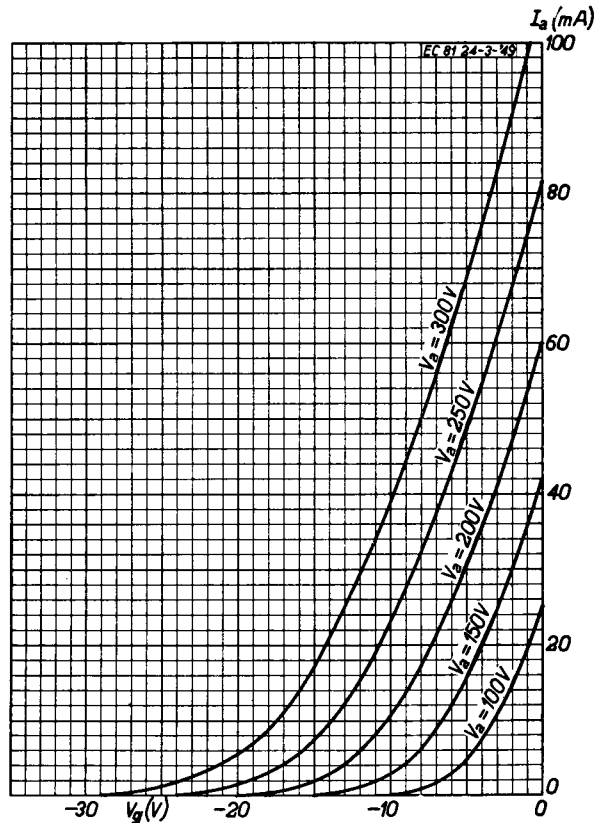


Fig. 13.  $I_a|V_g$  characteristics of the EC 81.

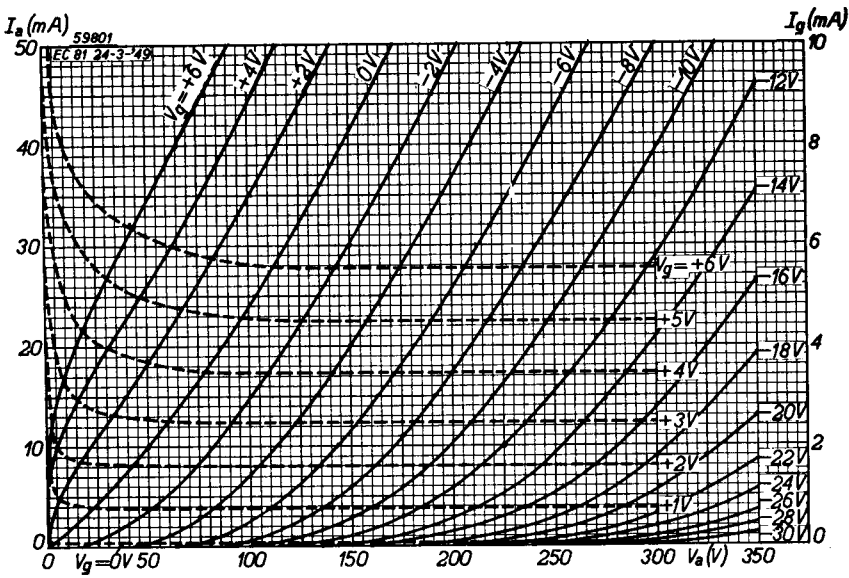


Fig. 14.  $I_a/V_a$  characteristics (drawn) and  $I_g/V_a$  characteristics (dashed) of the EC 81.

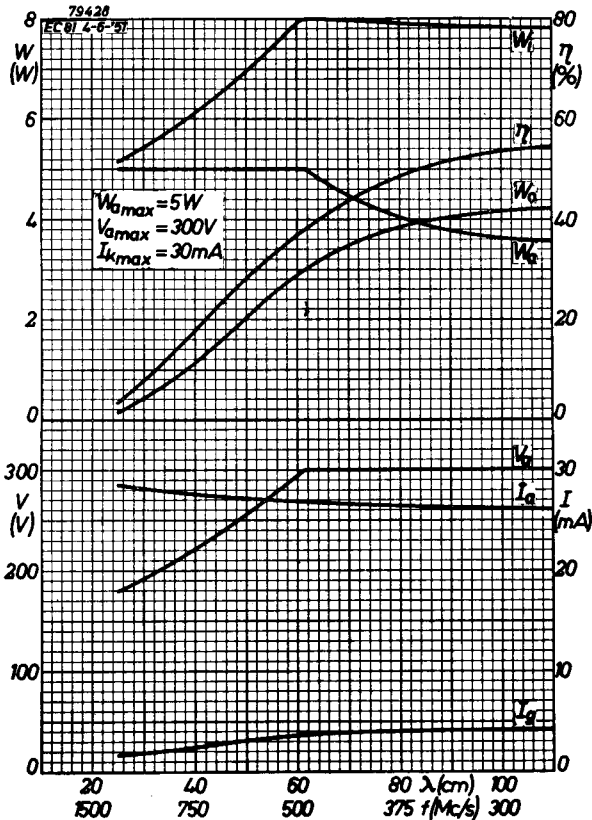


Fig. 15. Operating characteristics of the EC 81 as an oscillator. The output power ( $W_o$ ), the anode dissipation ( $W_a$ ), the anode input power ( $W_i$ ), the anode voltage ( $V_a$ ), the anode current ( $I_a$ ) and the grid current ( $I_g$ ) are plotted as functions of the frequency  $f$  and the wavelength  $\lambda$ . The maximum values of the anode voltage (300 V), the anode dissipation (5 W) and the cathode current (30 mA) are absolute maximum ratings.

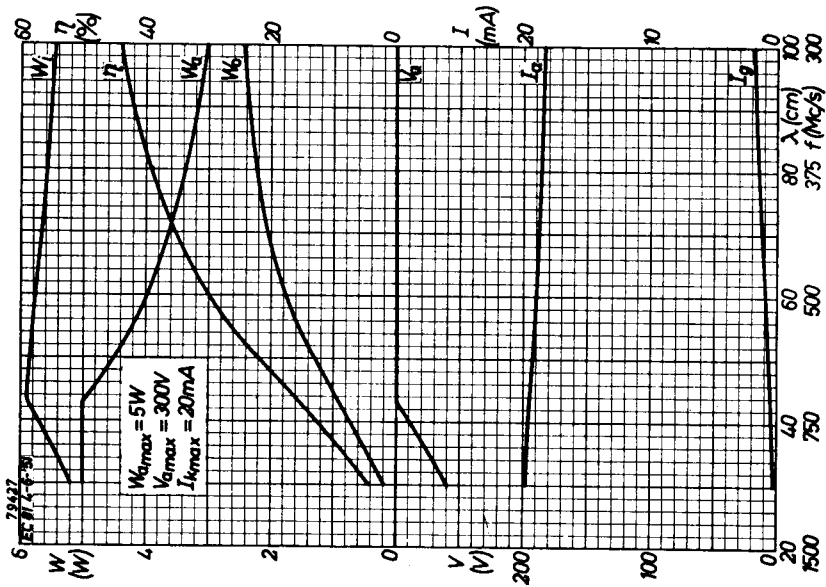


Fig. 16. As fig. 15, the anode voltage and dissipation being maximum, but with reduced cathode current. The maximum values of the anode voltage (300 V) and the anode dissipation (5 W) are absolute maximum ratings, that of the cathode current (20 mA) is a design-centre rating.

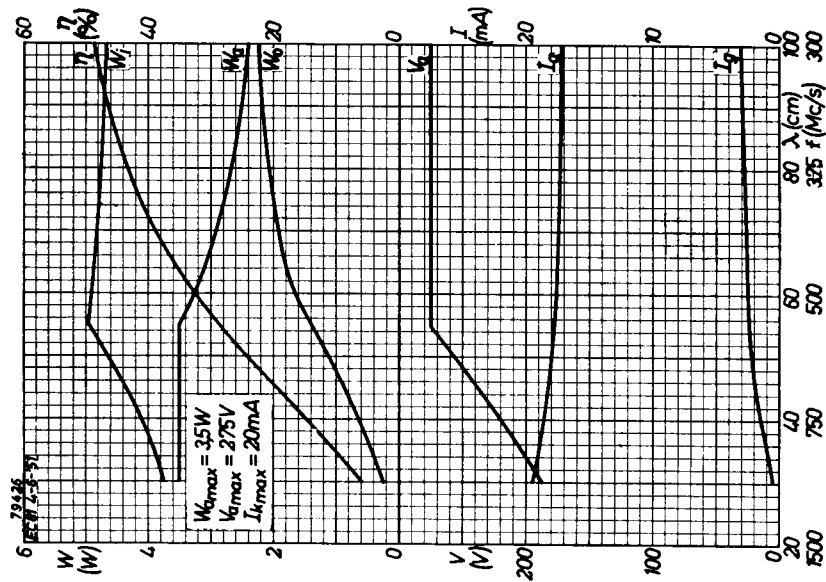


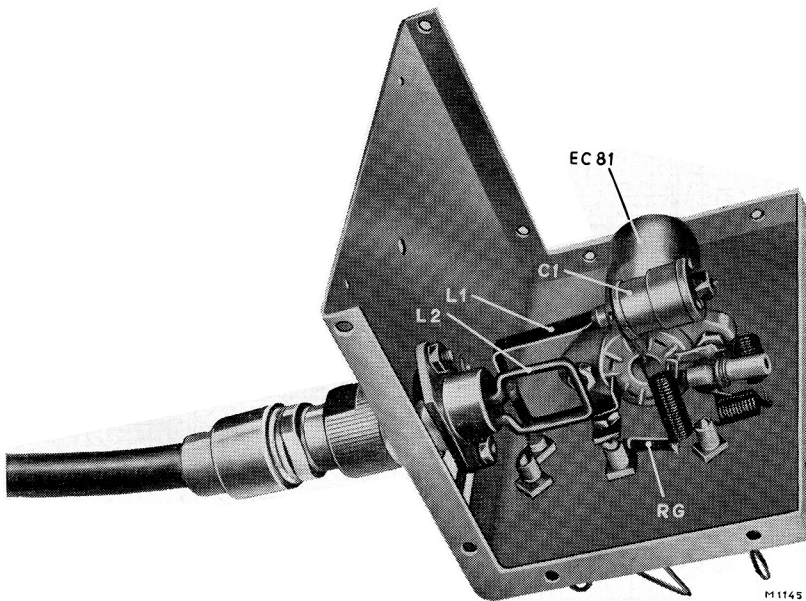
Fig. 17. As fig. 15, under normal operating conditions. The maximum values of the anode voltage (275 V), the anode dissipation (3.5 W) and the cathode current (20 mA) are design-centre ratings.

## BASE AND SOCKET

The EC 81 is provided with a standard noval base. Owing to the very high frequencies at which the tube can be used, the material of the socket must answer very high requirements. The tube socket type 5908/46 is recommended. In order to diminish as far as possible the capacitances between the various electrode leads, it is recommended to remove the unused contacts of the socket. At the highest frequencies the tube must be used without socket. The small dimensions and the normal operating voltages make the EC 81 specially suitable for use in fixed and mobile equipment. The tube can be mounted in all positions; if, however, shocks have to be expected, or if the tube is not used in an upright position, it is recommended that the tube be supported.

In order to obtain sufficient cooling, the tube must be installed in such a way that air can circulate freely around it. This is of special importance if the tube is used with its maximum admissible anode dissipation.

## SIMPLE U.H.F. OSCILLATOR WITH THE EC 81



*Fig. 18. Photograph of a compact and simple construction of an oscillator with the EC 81 tube (frequency = 470 Mc/s,  $\lambda = 64$  cm).*

In figs 18 and 19, a compact and simple construction of an oscillator with the EC 81 is shown. The coil of the oscillator circuit is made of a bent strip ( $L_1$ ), the tuning capacitor ( $C_1$ ) is a normal trimming capacitor. The results obtained with this oscillator at a frequency of 470 Mc/s are shown in figs 20 to 22.

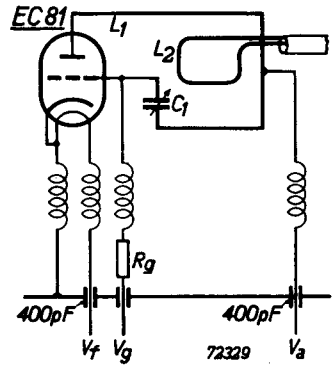


Fig. 19. Circuit diagram of the oscillator of fig. 18. For the value of the grid leak, see fig. 20-22.

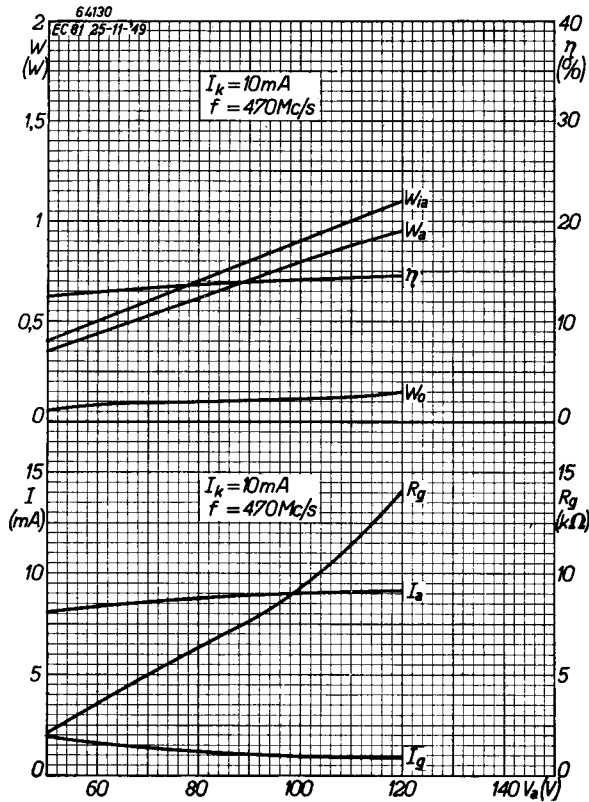
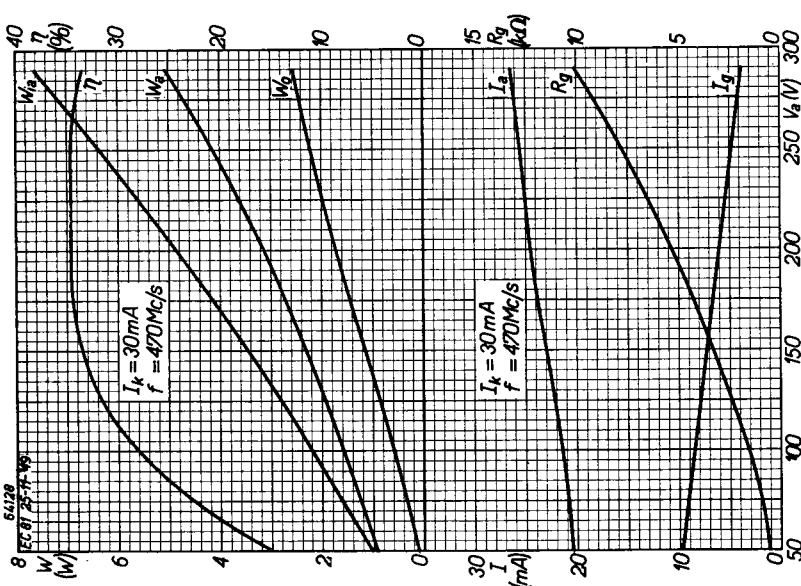
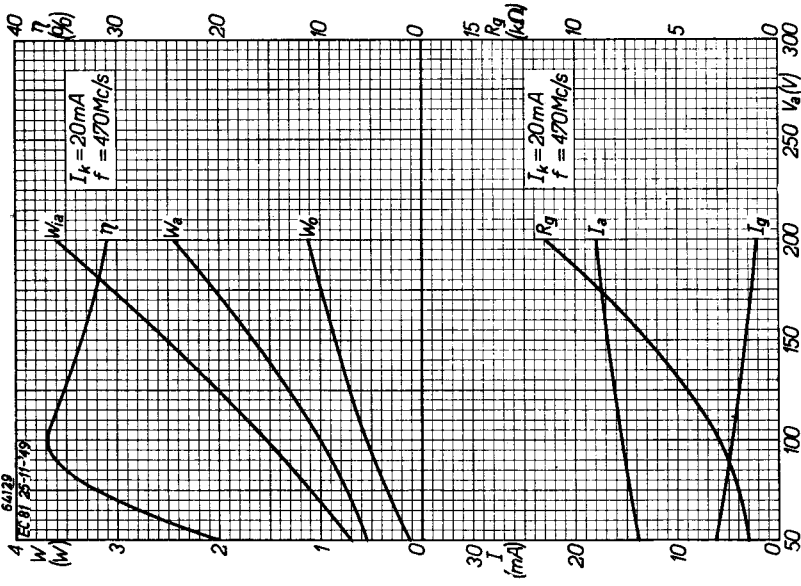


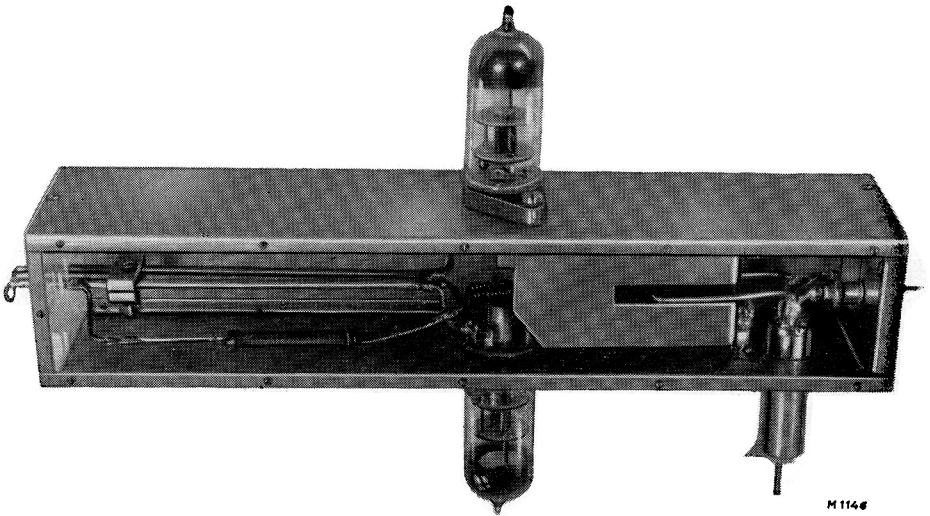
Fig. 22. As fig. 20, but at a cathode current of 10 mA.



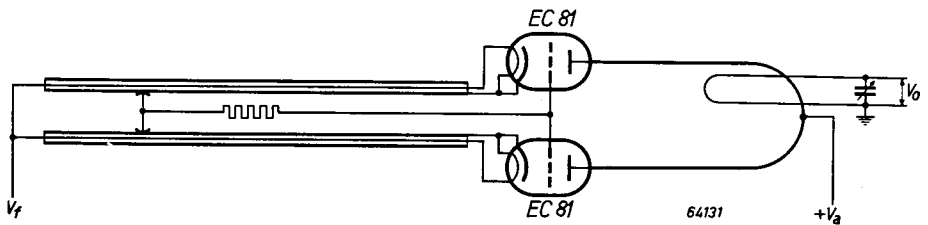


Figs 20 and 21. Operating characteristics of the EC 81 as an oscillator at 470 Mc/s, measured in the arrangement according to figs 18 and 19. The power output ( $W$ ), the anode dissipation ( $W_a$ ) the anode input power ( $W_{in}$ ), the efficiency ( $\eta$ ), the anode current ( $I_a$ ), the grid current ( $I_g$ ) and the optimum value of the grid leak ( $R_g$ ) are plotted as functions of the anode voltage at a cathode current of 30 mA (fig. 20) and 20 mA (fig. 21). (The absolute maximum ratings of the anode voltage, the anode dissipation and the cathode current are 300 V, 5 W and 30 mA respectively).

## OSCILLATOR WITH TWO TUBES EC 81 PUSH-PULL FOR APPROX. 440 Mc/s



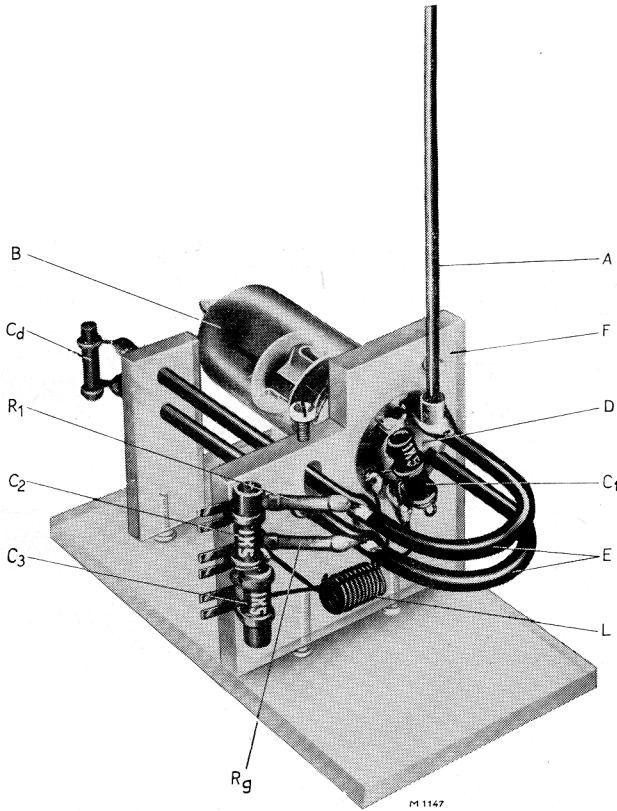
*Fig. 23. Photograph of a push-pull oscillator with two EC 81 tubes for a frequency of 440 Mc/s. The obtainable output power is 7 W.*



*Fig. 24. Circuit diagram of the oscillator of fig. 23.*

In figs 23 and 24 a push-pull oscillator with two tubes type EC 81 is shown. The oscillator circuit is a bent metal plate connected between the anodes. This oscillator is intended for use with impulse modulation at 440 Mc/s, and is capable of delivering an output power of 7 watts.

## SIMPLE OSCILLATOR WITH THE EC 81 FOR USE IN BALLOON SONDES AT 395 Mc/s



*Fig. 25. Photograph of a simple oscillator with a EC 81 for use in balloon sondes.*

In figs 25 and 26 are shown the mechanical set-up and the circuit diagram of an oscillator with the tube EC 81 operating at a frequency of 395 Mc/s, designed for use in balloon sondes.

The oscillator circuit, inserted between the anode and the grid, consists of a parallel-wire transmission line, half-a-wavelength long, which acts like an open circuit (parallel-resonant circuit). Its length is reduced at one side by the anode-grid capacitance of the tube, and for the sake of symmetry it is shortened at the other side by a dummy capacitor  $C_d$ .

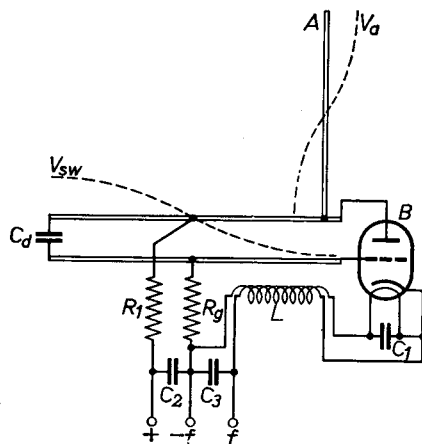
Feedback is accomplished by the inner-electrode capacitances and a cathode impedance consisting of a coil  $L$ , which permits of accurate adjustment ( $100\text{ V}$ ;  $35\text{ mA}$ ). To make the distance short from the cathode connection to the dead point of the line, between which the cathode impedance is inserted, the line has been bent in a U-shape.

The coil  $L$  is formed of a bifilar winding, to provide the heater current. 'A' represents the antenna, which is directly connected to the anode.

Tuning within  $\pm 20\text{ Mc/s}$  is possible by changing the spacing between the two Lecher bars in the vicinity of the dead point, by means of a screw.

In order to prevent r.f. appearing across the heater, the extremities have been interconnected by a capacitor.

In the application described above, the EC 81 is used beyond its ratings. Since the tube life need not be long in this case, this adjustment is not objectionable.



*Fig. 26. Circuit diagram of the oscillator of fig. 25.*

#### PARTS LIST

$C_1, C_2, C_3$	By-pass capacitor . . . . .	$\pm 100\text{ pF} \pm 50\%$ ceramic
$C_d$	Dummy capacitor . . . . .	$3.3\text{ pF}$ ceramic
$L$	Cathode coil . . . . .	6 windings, 2 wires parallel $r = 10\text{ mm}$ $dk = 5\text{ mm}$ (inner diameter) $d_{ar} = 0.6\text{ mm}$ (enamelled)
$R_g$	Grid resistor . . . . .	$1\text{ K}\Omega$ $1/8$ watt
$R_1$	Anode stop resistor (against super regenerative oscillating)	$\pm 30\ \Omega$ $1/8$ watt
$A$	Aerial rod . . . . .	$r = \pm 300\text{ mm}$ (to be adjusted in the field for max. output) $d = 2\text{ to }3\text{ mm}$

*Simple oscillator with the EC 81 for use in balloon sondes at 395 Mc/s*

---

<i>B</i>	Tube . . . . .	EC 81
<i>F</i>	Frame . . . . .	perspex or hardpaper
<i>D</i>	Socket . . . . .	ceramic without shield base (type 5908/03)
<i>E</i>	Lecher system . . . . .	2 × brass rod or brass tube 3 mm diameter distance      10 mm length        130 mm bent around 20 mm diameter