PREFACE

R.F. amplifiers in mobile and small transmitting equipment, operating at frequencies higher than 100 Mc/s, are preferably designed with push-pull circuits. These circuits offer the advantages of low parasitic capacitances, low radiation and simple construction. To keep the power consumption as low as possible and the tube complement small, tetrodes with a high stage gain are mostly used for this purpose. When the two tube systems required for push-pull operation are mounted in a single envelope, the inductances between the cathodes and screen grids can be made low. They can be reduced to an ultimate limit when a common cathode and a common screen grid are used for both tube sections; this construction opens, moreover, the possibility of internal neutralization.

The double tetrodes QQE 06/40, QQE 03/20 and QQE 03/12 have been developed in accordance with these ideas. This Bulletin deals with the type QQE 06/40 which has already been widely and successfully applied since it was introduced several years ago.

The QQE 06/40 with its hard-glass envelope gives excellent and stable performance in the frequency range up to 500 Mc/s. Its high stage gain, internal neutralization, small dimensions and rigid construction render it very suitable in mobile transmitters, while it is also widely used in the pre-stages of medium-sized fixed transmitters. Other applications are pulse-amplifiers, hard tube modulators in radar equipment and wide-band amplifiers in oscilloscopes and measuring circuits.

Complete technical data, including operating conditions for use as a push-pull class B modulator, frequency tripler and pulse modulator are given in this Bulletin, together with some practical circuits.

The RETMA designation 5894 has been allocated to this tube.

CONTENTS

QQE 06/40 DOUBLE TETRODE

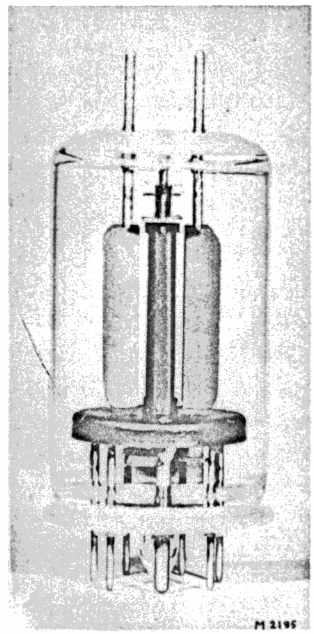
Fig. 1. The QQE 06/40

The QQE 06/40 is a transmitting double tetrode especially made for use in mobile equipment, but owing to its attractive properties it is also a useful tube in the pre-stages of stationary transmitters with higher output power. It can be used as an R.F. amplifier and oscillator tube, as a frequency tripler, and finally as an A.F. modulator tube. Other applications are: output tube in broad-band amplifiers for oscillographs, hard-tube modulator in radar equipment or pulse modulator.

In class C telegraphy circuits one QQE 06/40 can give an output of 90 W at 200 Mc/s with an efficiency of 66%, whilst at 500 Mc/s an output of 60 W is still available at an efficiency of 66%. These favourable results are to be attributed to the fact that the QQE 06/40 embodies in its design features which have been incorporated to meet the requirements set to the frequency range between 200 and 500 Mc/s; it does not imply, however, that the tube should not be used at lower frequencies.

Transmitting tubes with two electrode systems in one envelope have been known for some 20 years. In the first designs the electrodes not carrying any R.F. voltage (the cathode and the screen grids) were connected in pairs by short wires or strips, and the centres (neutral points) of the interconnections passed through the envelope, as were each of the two control grids and the two anodes. A difficulty was experienced with these tubes due to the self-inductance formed by the interconnections of the cathodes and of the screen grids. At very high frequencies the influence of these self-inductances cannot be ignored.

The self-inductance between the cathodes causes undesired inverse feedback and constitutes a positive component of input damping, so that, in order to obtain a given output, a larger driving power is required.

The influence of the self-inductance between the screen grids is manifest in a negative resistance, which is zero only at one given frequency and may reach such a value at lower frequencies that, to avoid self-oscillation, some form of neutralization must be applied, especially with tubes having a high mutual conductance. Below the frequency just referred to, this neutralization can be attained by inserting capacitors of a certain value between the anode of the one section and the control grid of

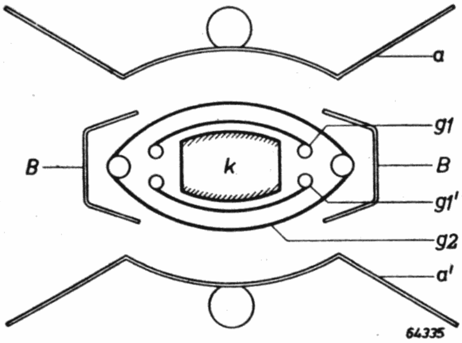

Fig.2. Horizontal cross-section of the QQE 06/40 (cf. Fig.3).

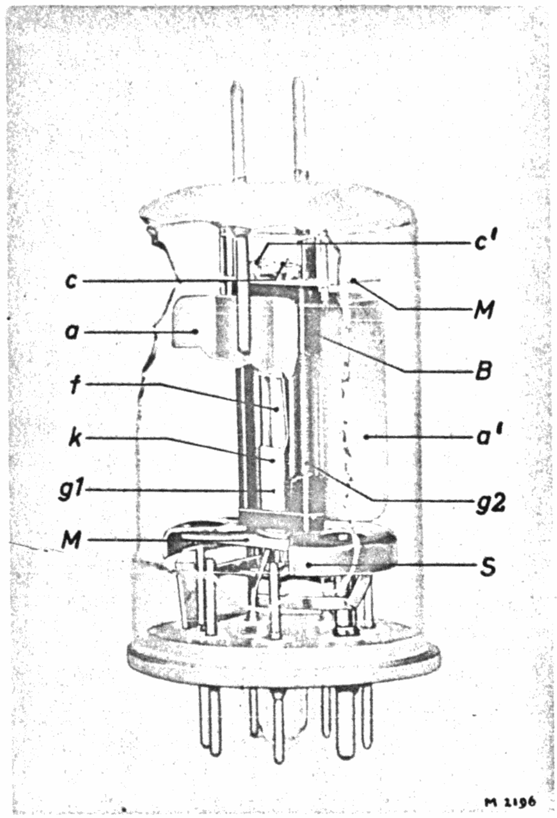

Fig.3. Construction of the double tetrode QQE 06/40. The heater *f* is surrounded by the cathode *k*, one of the emitting surfaces ~~being visible~~. One control grid g_1 and the screen grid g_2 are shown; moreover, the beam plate *B*, the anodes *a* and *a'*, the mica spacers *M* and the screen *S*. The bended rods c and c' are connected to the supporting rods of g_1 and g_1' respectively, forming neutralizing capacitors with the anode leads of the anodes *a'* and *a*.

the other. Above that frequency these capacitors must be connected between each anode and its corresponding control grid. The measures which have been taken in the design of the QQE 06/40 to avoid the above-mentioned complications will be discussed with reference to Figs. 2 and 3.

The QQE 06/40 is provided with one directly heated cathode the cross section of which is roughly rectangular. Only the long, slightly convex sides are coated with an emitting material, so that the tube has in fact two cathodes interconnected by the shorter sides of the rectangular cathode body. The self-inductance of these short and wide "connecting strips" mounted in parallel is so small that even at frequencies of 500 Mc/s the aforementioned effect of self-inductance in the cathode interconnections is quite negligible.

The tube is provided with two heaters which can be connected either in series or in parallel. A short distance away from and facing each of the emitting surfaces are two control grids. One single screen grid is placed around the system comprising the cathode and the two control grids. The screen grid is wound on two supporting rods. This construction avoids the necessity of separate leads for the two halves of the screen grid and thus also completely eliminates the self-inductance of those leads. At the same time, however, the possibility is lost of taking advantage of the compensating effect of this self-inductance in a certain frequency range with regard to the positive feedback of the anode to its corresponding control grid. In the absence of such a compensation the tube might tend to oscillate in that range.

This tendency to oscillate is counteracted in the QQE 06/40 by introducing two small neutralizing capacitors. Each of these capacitors is formed by the lead of one anode and a short length of wire welded onto one of the extended supporting rods of the control grid of the other tetrode section. This neutralizing capacitance is made almost equal to that between an anode and its corresponding control grid. In this way a neutralization is obtained that is independent of the frequency at which the tube is operated.

The anodes are molybdenum plates, coated on both sides with zirconium powder to reduce the secondary emission coefficient, to improve the radiation of heat and to act as a getter.

A definite advantage of the special construction is that the internal capacitances are low. The input capacitance is only 3.2 pF and the output capacitance 10.5 pF as against 7.0 pF and 14.5 pF respectively of former constructions with separate cathodes.

On either side of the screen grid a U-shaped beam plate is provided which is connected to the cathode, the object of this being to prevent deflection of the electrons from the shortest path to the anodes and to assist in obtaining the correct space-charge conditions between the screen grid and the anodes, so that the secondary electrons cannot reach the screen grid when the anode current is high and the anode voltage is low. Since the beam plates prevent them from following long trajectories, all the electrons have roughly the same, shortest possible transit time. Without such a measure there would be differences in transmit time, and at very high frequencies these differences would adversely affect the efficiency of the tube.

The feedback of each anode upon its corresponding control grid is quite insignificant, thanks to the built-in neutralizing capacitors, so that the QQE 06/40 will not oscillate unless external feedback is purposely applied. In amplifiers the absence of internal feedback ensures a high degree of stability.

Owing to the extremely low self-inductance and resistance of the cathode lead, only a small driving power is required. In Fig.19 the output and the efficiency for the two sections of the QQE 06/40 connected as a push-pull amplifier have been plotted as a functions of the frequency and wavelength. It is seen, for instance, that at frequencies below 200 Mc/s (wavelength > 1.5 m) an output of 90 W can be obtained with an efficiency of 75%, and that at a frequency of 430 Mc/s these figures are still 66 W and 64% respectively.

Owing to the exceptionally rugged construction of the electrode system, which makes the tube resistant to severe shocks, the tube lends itself eminently for use in mobile installations, the more so as, in dimensioning the heater, particular attention has been paid to the limited capacity of the supply sources in these installations. The two sections of the heater of the tube can be connected either in parallel or in series as required, the total heater consumption being 6.3 V, 1.8 A or 12.6 V 0.9 A respectively.

During stand-by operation, the heater power can be reduced by switching off one heater section. It is switched on simultaneously with the anode supply when the transmitter must be used. Full output is then available within 12 sec.

TECHNICAL DATA

Electrical

Cathode: indirectly heated, oxide coated

	Heater sections in parallel	series	
Heater voltage 1)	6.3	12.6	V
Heater current	1.8	0.9	A
pins	5-(1+7)	1-7	

Direct interelectrode capacitances

	each unit	both units in push-pull	
Output capacitance	3.2	2.1	pF
Input capacitance	10.5	6.7	pF
Anode to grid No. 1 (internally neutralized) max.	0.08		pF

Amplification factor (each unit)
grid No. 2 to grid No. 1 — 8.2

Mutual conductance (each unit)
at anode current = 30 mA — 4.5 mA/V

Mechanical

Mounting position	Vertical with base up or down. Horizontal with anode pins in one horizontal plane.
Cooling	Radiation and convection. When the tube is used at frequencies above 150 Mc/s it may be necessary to direct a low velocity air flow on the bulb and the anode seals.

Bulb temperature	max. 200	°C
Temperature of anode seals	max. 200	°C
Temperature of base pin seals	max. 180	°C
Overall length	max. 108.5	mm
Seated length	max. 94.5	mm
Diameter	max. 46	mm
Base	Septar	
Socket	40203	
Clips	40623	
Net weight	60	g
Shipping weight	155	g

1) The tube may be used with only half the heater energised during the stand-by period of a transmitter in order to reduce heater current consumption during this time.

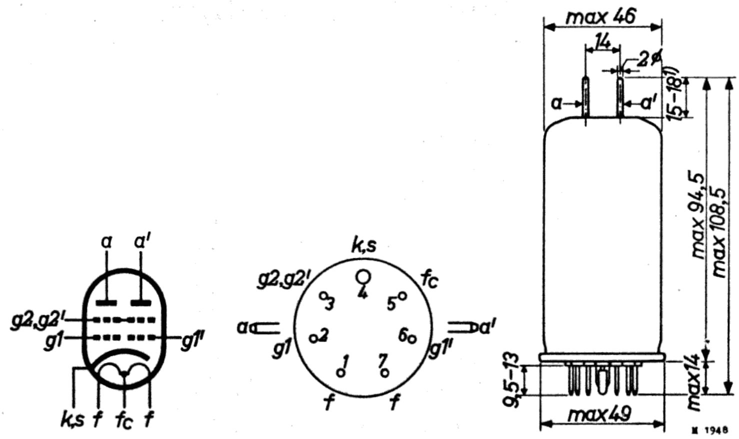

Fig.4. Socket connections and dimensional drawing (in mm) of the QQE 06/40.

Table of obtainable power

C.C.S. = Continuous Commercial Service.
I.C.A.S. = Intermittent Commercial and Amateur Service.

Frequency	H.F. class C					
	telegraphy			anode and screen-grid modulation		
Mc/s	anode voltage (volts)	output power (watts) C.C.S.	output power (watts) I.C.A.S.	anode voltage (volts)	output power (watts) C.C.S.	output power (watts) I.C.A.S.
60				600	71	79
200	600	90				
250	750	85	96	600	64	71
430	520	66				
500	500	60				

frequency	H.F. class C frequency tripler			A.F. class B amplifier or modulator		
Mc/s	anode voltage (volts)	output power (watts) C.C.S.	output power (watts) I.C.A.S.	anode voltage (volts)	output power (watts) C.C.S.	output power (watts) I.C.A.S.
50/150	500	20		600	86	
	400	18		450	60	
75/225	400	12		300	37	

Limiting values and operating conditions

H.F. CLASS C TELEGRAPHY C.C.S.

LIMITING VALUES (absolute limits)

Frequency	max.	250 Mc/s	500 Mc/s
Anode voltage	max.	750 V	600 V
Anode input power	max.	2x60 W	2x50 W
Anode dissipation	max.	2x20 W	
Anode current	max.	2x 110 mA	
Screen-grid voltage	max.	300 V	
Screen-grid dissipation	max.	2x3.5 W	
Control grid voltage	max.	-175 V	
Control grid current	max.	2x5 mA	
Resistance between control grid and cathode	max.	50 kΩ	
Voltage between cathode and heater	max.	100 V	

OPERATING CONDITIONS (two sections in push-pull)

	C.C.S.				
Frequency	200	250	430	500	Mc/s
Anode voltage	600	750	520	500	V
Control grid bias	-80	-80	-80		V
Common control grid bias resistor				20	kΩ
Screen-grid voltage	250	250	250	250	V
Anode current	2x 100	2x80	2x100	2x100	mA
Control grid current	2x2.5	2x1.5	2x2.8	2x3	mA
Screen-grid current	16	17	18	20	mA
Peak grid-to-grid driving voltage	200	250			V
Screen-grid dissipation	4	4.25	4.5	5	W
Anode input power	2x60	2x60	2x52	2x50	W
Anode dissipation	2x15	2x17.5	2x19	2x20	W
Tube output	90	85	66	60	W
Tube efficiency	75	71	64	60	%

H.F. CLASS C TELEGRAPHY I.C.A.S.

LIMITING VALUES (absolute limits)

Frequency	max.	250 Mc/s	500 Mc/s
Anode voltage	max.	750 V	600 V
Anode input power	max.	2x75 W	2x60 W
Anode dissipation	max.	2x22.5 W	
Anode current	max.	2x120 mA	
Screen-grid voltage	max.	300 V	
Screen-grid dissipation	max.	2x4 W	
Control grid voltage	max.	-175 V	
Control grid current	max.	2x5 mA	
Resistance between control grid and cathode	max.	50 kΩ	
Voltage between cathode and heater	max.	100 V	

OPERATING CONDITIONS (two systems in push-pull)

Frequency	250 Mc/s
Anode voltage	750 V
Control grid voltage	-80 V
Screen-grid voltage	250 V
Anode current	2x90 mA
Control grid current	2x1.7 mA
Screen-grid current	14 mA
Peak grid-to-grid driving voltage	260 V
Screen-grid dissipation	3.5 W
Anode input power	2x67.5 W
Anode dissipation	2x19.5 W
Tube output	96 W
Tube efficiency	71 %

H.F. CLASS C ANODE AND SCREEN GRID MODULATION
(two systems in push-pull)

LIMITING VALUES (absolute limits)

		C.C.S.		I.C.A.S.		
Frequency	max.	250	500	250	500	Mc/s
Anode voltage	max.	600	480	600	480	V
Anode input power	max.	2x45	2x33.5	2x50	2x40	W
Anode dissipation	max.	2x14		2x15		W
Anode current	max.	2x92		2x100		mA
Screen grid voltage	max.	300		300		V
Screen grid dissipation	max.	2x3.5[1])		2x4[1])		W
Screen grid dissipation	max.	2x2.3[2])		2x2.6[2])		W
Control grid voltage	max.	-175		-175		V
Control grid current	max.	2x5		2x5		mA
Resistance between control grid and cathode	max.	50[3])		50[3])		kΩ
Resistance between control grid and cathode	max.	25[4])		25[4])		kΩ
Voltage between cathode and heater	max.	100		100		V

1) Screen grid modulated via a choke.
2) For all other modulation methods.
3) Per section.
4) Per tube.

OPERATING CONDITIONS (two systems in push-pull)

	C.C.S.		I.C.A.S.		
Frequency	60	250	60	250	Mc/s
Anode voltage	600	600	600	600	V
Screen grid voltage	250	250	250	250	V
Control grid bias	-80	-80	-80	-80	V
Anode current	2x75	2x75	2x83	2x83	mA
Screen grid current	20	18	16	16	mA
Control grid current	2x3.8	2x1.6	2x4	2x1.7	mA
Peak grid-to-grid driving voltage	105	130	105	130	V
Screen grid dissipation	5	4.5	4	4	W
Anode input power	2x45	2x45	2x50	2x50	W
Anode dissipation	2x9.5	2x13	2x10.5	2x14.5	W
Tube output	71	64	79	71	W
Tube efficiency	79	71	79	71	%
Modulation factor	1	1	1	1	
Peak screen grid voltage	90	90	90	90	V
Modulation power	45	45	50	50	W

H.F. CLASS C FREQUENCY TRIPLER (two sections in push-pull)

LIMITING VALUES (absolute limits)

Frequency	max.	250 Mc/s	500 Mc/s
Anode voltage	max.	750 V	600 V
Anode input power	max.	2x60 W	2x50 W
Anode dissipation	max.	2x20 W	
Anode current	max.	2x110 mA	
Screen grid voltage	mac.	300 V	
Screen grid dissipation	max.	2x3.5 W	
Control grid voltage	max.	-175 V	
Control grid current	max.	2x5 mA	
Resistance between control grid and cathode	max.	50 kΩ	
Voltage between cathode and heater	max.	100 V	

OPERATING CONDITIONS

Wavelength	6/2	6/2	1.8/0.6	m
Anode voltage	500	400	400	V
Control grid bias	-150	-150	-175	V
Screen grid voltage	250	250	220	V
Anode current	2x60	2x73	2x70	mA
Screen grid current	2x3	2x2.5	2x2.5	mA
Peak grid-to-grid voltage	360	360		V
Control grid dissipation	2x0.6	2x0.5	2x4	W
Screen grid dissipation	2.5	4	1.1	W
Anode input power	2x30	2x29	2x28	W
Useful output power in load	20	18	16	W
Efficiency	33	31	28	%

PULSE MODULATOR

LIMITING VALUES (absolute limits)

Anode voltage	max.	7 kV
Peak anode voltage [1]	max.	8 kV
Anode dissipation	max.	2x7.5 W
Anode input power	max.	2x30 W
Screen grid voltage [2]	max.	850 V
Peak anode current (pulse duration max. 1.2 µsec)	max.	5 A
Peak anode current (pulse duration max. 0.2 µsec)	max.	6 A
Pulse repetition rate	max.	1250 c/s
Duty cycle	max.	0.0015
Peak screen grid current	max.	2x1 A
Screen grid dissipation	max.	2x1.5 W
Control grid voltage	max.	-200 V
Peak control grid voltage	max.	450 V
Peak control grid current	max.	2x1 A
Control grid dissipation	max.	2x0.5 W
Voltage between cathode and heater	max.	100 V
Pulse duration	max.	1.2 µsec

OPERATING CONDITIONS

Anode voltage	7	7	kV
Screen grid voltage	850	650	V
Control grid bias	-200	-200	V
Peak control grid voltage	450	450	V
Load resistance	400	1000	Ω
Peak anode current	5	6	A
Pulse duration	1.2	0.13	µsec
Pulse repetition rate	1250	500	c/s
Duty cycle	0.0015	0.000065	
Time of rise		0.01	sec

A.F. CLASS B AMPLIFIER OR MODULATOR 1
(without grid grid current)

LIMITING VALUES

Anode voltage	max.	600 V
Anode input power	max.	2x60 W
Anode dissipation	max.	2x20 W
Anode current	max.	2x110 mA
Screen grid voltage	max.	300 V
Screen grid disspation	max.	2x3.5 W
Resistance between grid and cathode	max.	50 kΩ
Voltage between cathode and heater	max.	100 V

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1) Due to transients.

2) The tube should be protected by sufficient d.c. resistance in the supply circuits of the anode, the screen grid and the control grid, so that in the case of short circuits the current is limited to 0.5 A in each circuit.

OPERATING CONDITIONS

Anode voltage	600		450		300		V
Control grid voltage	-27.5		-27.5		-26		V
Screen grid voltage	250		250		250		V
Anode-to-anode load resistance	12.5		10		6.5		kΩ
Peak grid-to-grid driving voltage	0	55	0	55	0	52	V
Anode current	2x20	2x62	2x20	2x58	2x20	2x56	mA
Screen grid current	0.9	23	1.4	27	2.2	28	mA
Screen grid dissipation	0.2	5.8	0.4	6.7	0.6	7.0	W
Anode input power	2x12	2x37	2x9.0	2x26	2x6.0	2x16.8	W
Anode dissipation	2x12	2x12	2x9.0	2x8.5	2x6.0	2x5.6	W
Output power	0	50	0	35	0	22.5	W
Total distortion		2.4		3.1		2.9	%
Efficiency		67.5		67.5		67	%

A.F. CLASS B AMPLIFIER OR MODULATOR 2 (with grid current)

LIMITING VALUES

Anode voltage	max.	600	V
Anode input power	max.	2x60	W
Anode dissipation	max.	2x20	W
Anode current	max.	2x110	mA
Screen grid voltage	max.	300	V
Screen grid dissipation	max.	2x3.5	W
Control grid current	max.	2x5	mA
Resistance between grid and cathode	max.	50	kΩ
Voltage between cathode and heater	max.	100	V

OPERATING CONDITIONS

Anode voltage	600		450		300		V
Control grid bias	-25		-25		-25		V
Screen grid voltage	250		250		250		V
Anode-to-anode load resistance	8.0		6.0		4.0		kΩ
Peak grid-to-grid driving voltage	0	78	0	76	0	75	V
Anode current	2x25	2x100	2x25	2x97	2x25	2x94	mA
Control grid current	0	2x2.6	0	2x2.6	0	2x2.6	mA
Screen grid current	1.2	26	1.9	28	2.8	28	mA
Control grid dissipation	0	2x0.1	0	2x0.1	0	2x0.1	W
Screen grid dissipation	0.3	6.5	0.5	7.0	0.7	7.0	W
Anode input power	2x15	2x60	2x11.2	2x43.5	2x7.5	2x28.2	W
Anode dissipation	2x15	2x17	2x11.2	2x13.5	2x7.5	2x9.7	W
Output power	0	86	0	60	0	37	W
Total distortion		5		5		5	%
Efficiency		71.5		69		65.5	%

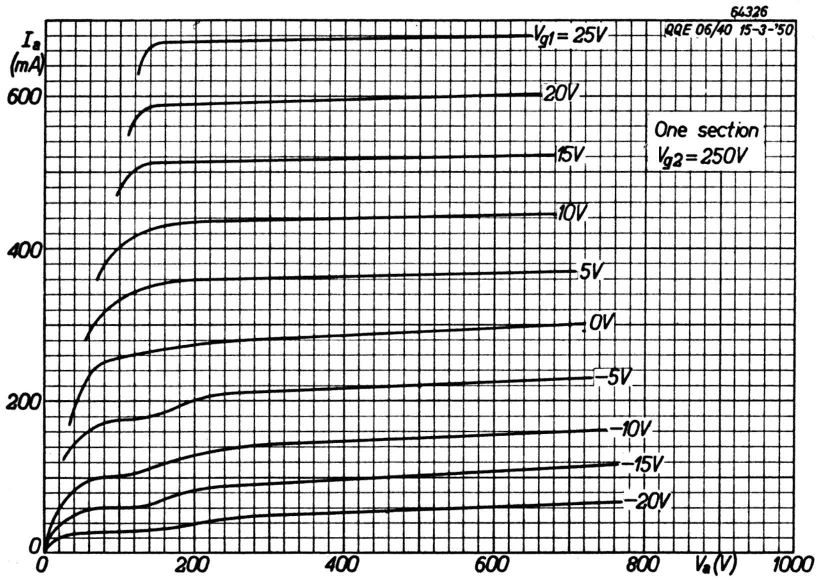


Fig.5. Anode current I_a as a function of the anode voltage V_a at a screen-grid voltage V_{g2} of 250 V with the control-grid voltage as parameter for each section of the QQE 06/40.

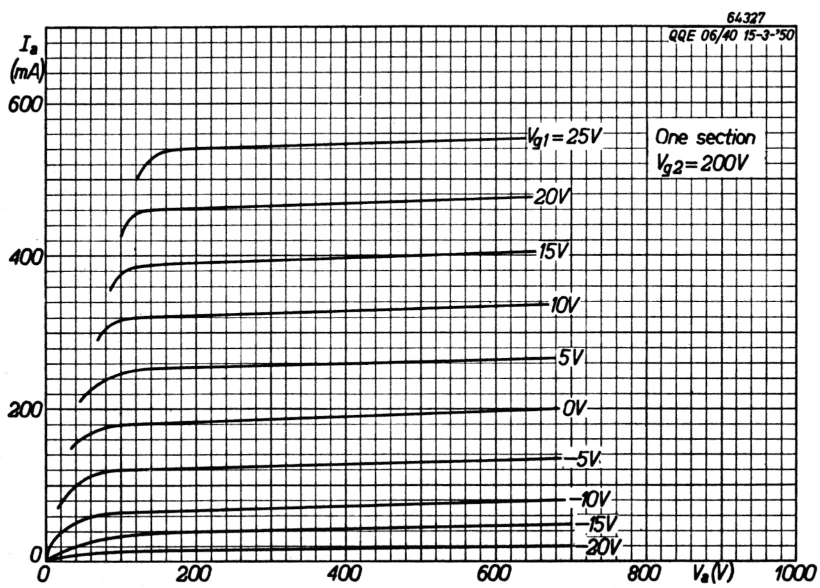


Fig.6. As Fig.5, but at a screen-grid voltage V_{g2} of 200 V.

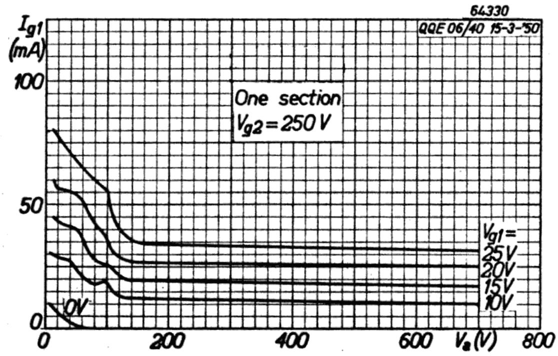


Fig.7. Control-grid current I_{g1} as a function of the anode voltage V_a with the control grid voltage V_{g1} as parameter, at a screen-grid voltage V_{g2} of 250 V.

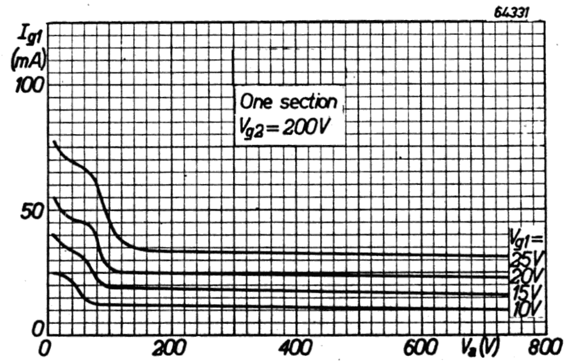


Fig.8. As Fig.7, but at a screen-grid voltage V_{g2} of 200 V.

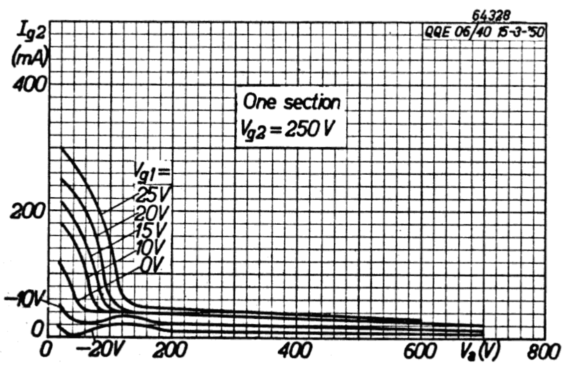


Fig.9. Screen grid current I_{g2} as a function of the anode voltage V_a with the control-grid voltage V_{g1} as parameter, at a screen-grid voltage V_{g2} of 250 V.

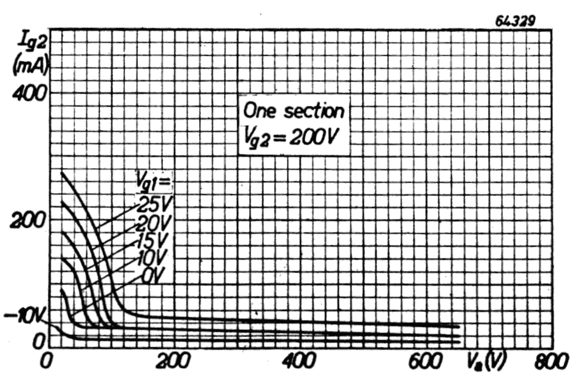
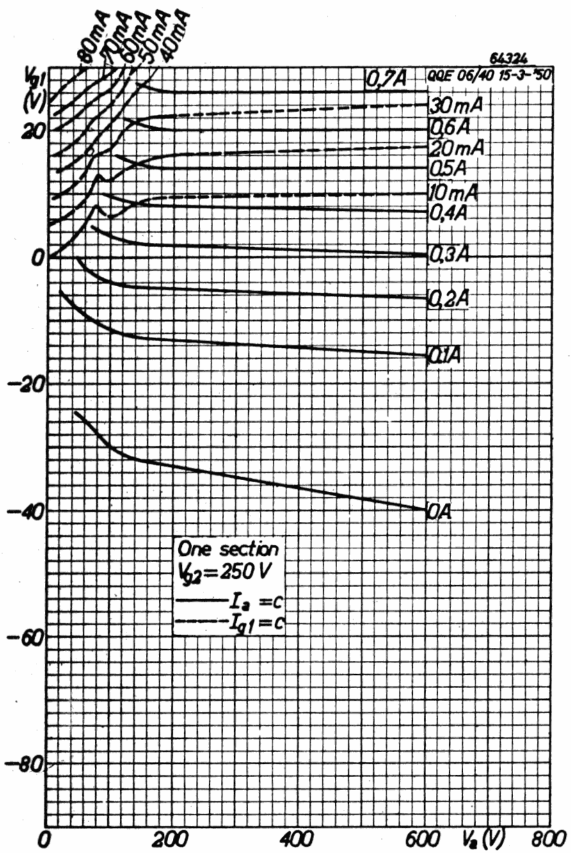
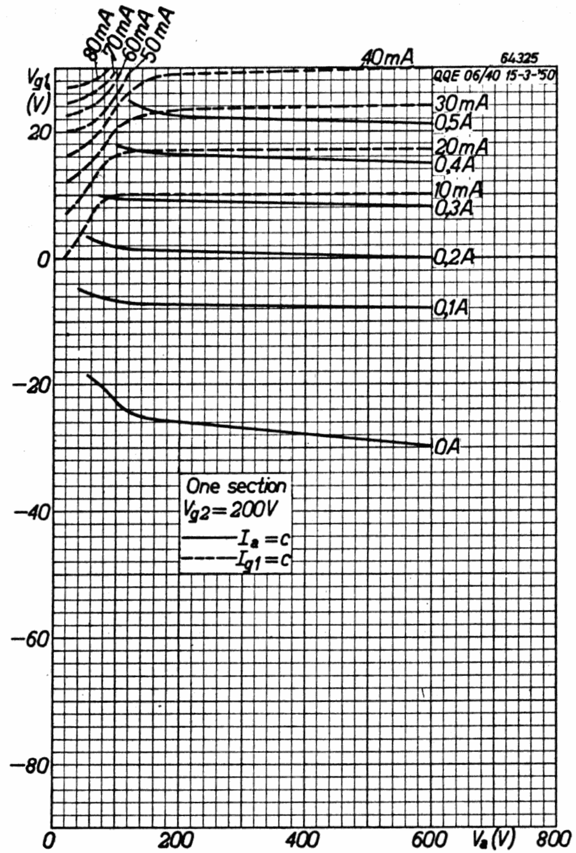


Fig.10. As Fig.9, but at a screen-grid voltage V_{g2} of 200 V.





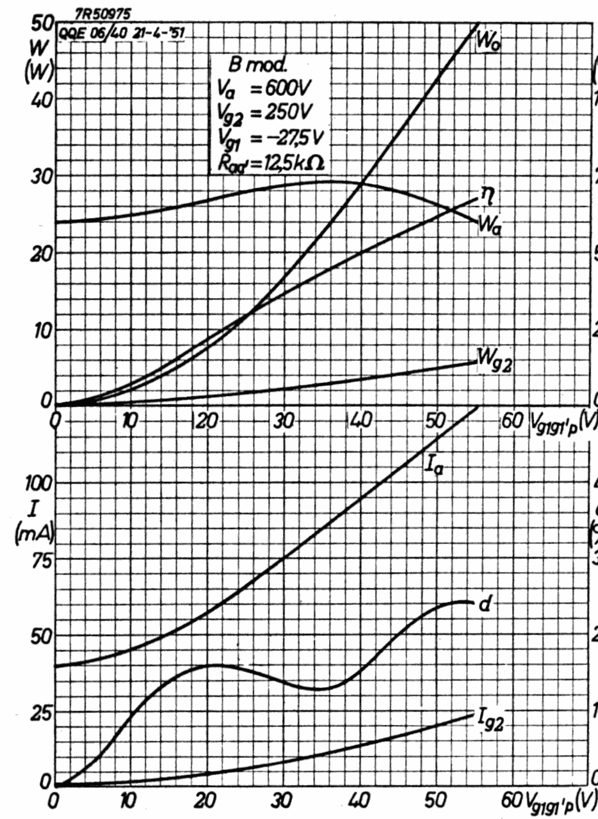
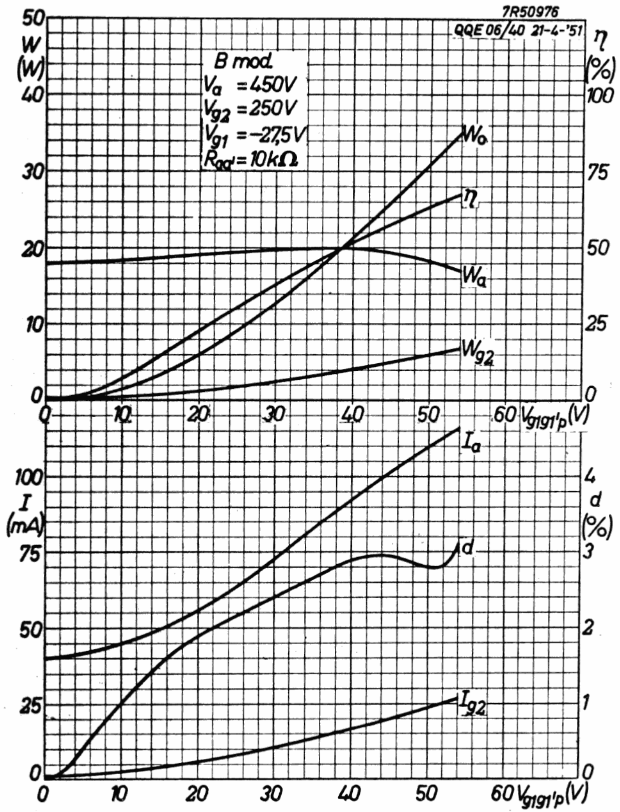
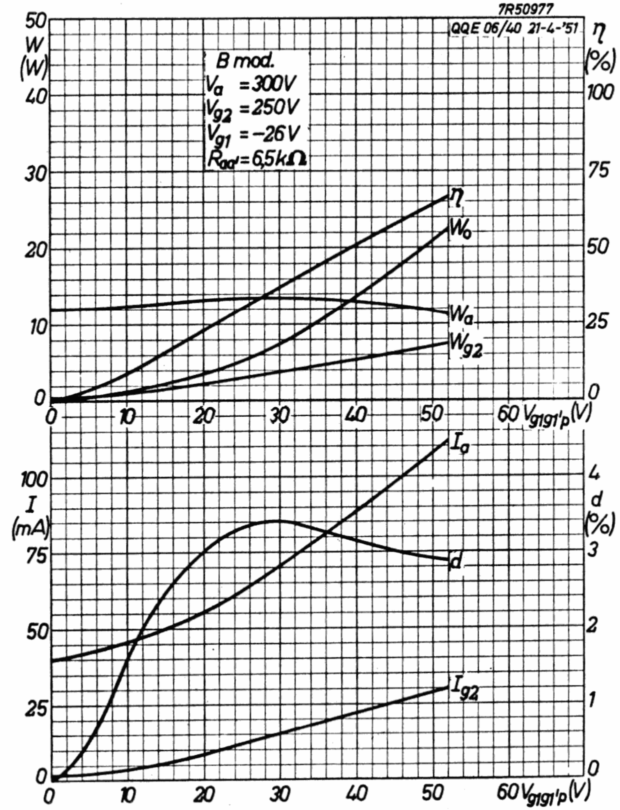


Fig.11. *(left)* Constant current characteristics of the QQE 06/40 at a screen-grid voltage of 250 V.

Fig.12. *(middle)* As Fig.11, but at a screen-grid voltage of 200 V.

Fig.13. *(right)* Output power W_o, anode dissipation W_a, efficiency η, screen-grid dissipation W_{g2}, anode current I_a, screen-grid current I_{g2} and total distortion d as functions of the peak-to-peak grid drive voltage $V_{g1g1'p}$ for the two sections of a QQE 06/40 in an A.F. amplifier or modulator push-pull class B circuit without grid current at an anode voltage V_a of 600 V, a screen-grid voltage V_{g2} of 250 V, and a control-grid bias of -27.5 V, the anode-to-anode load resistance $R_{aa'}$ being 12.5 kΩ.





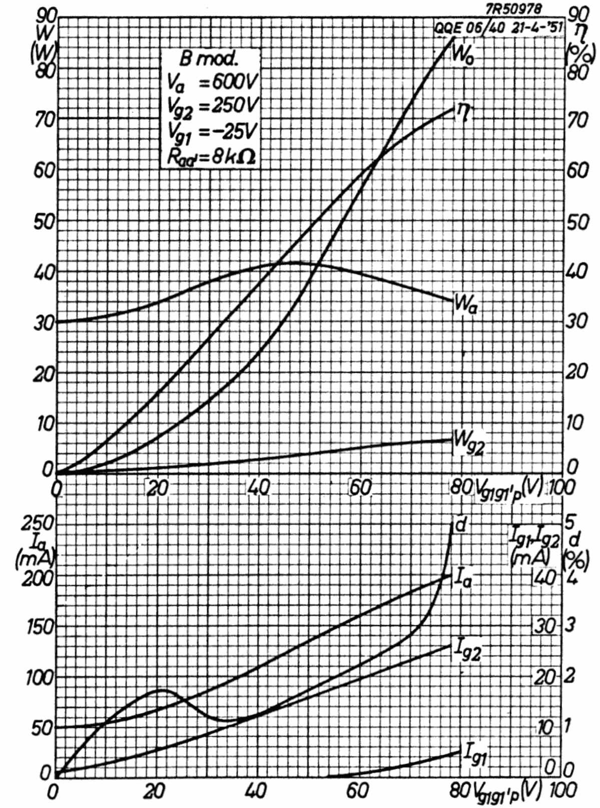
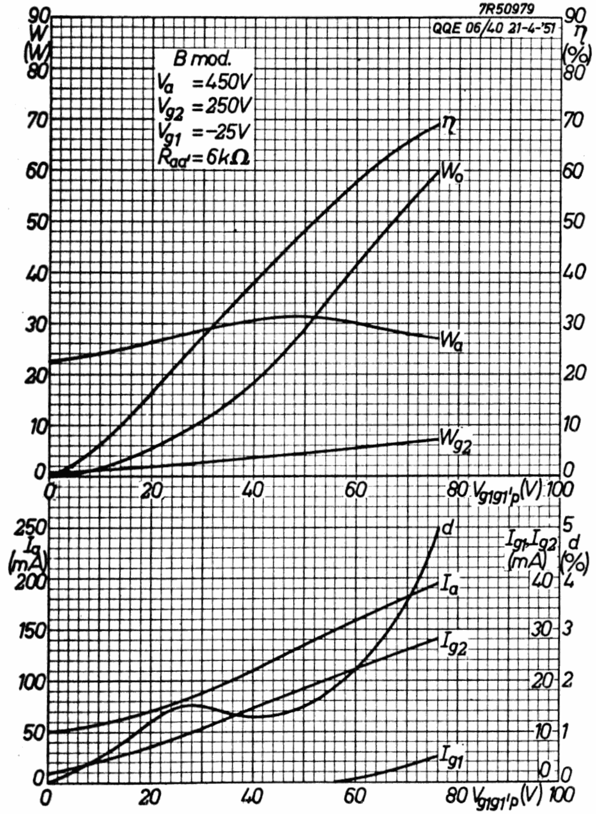
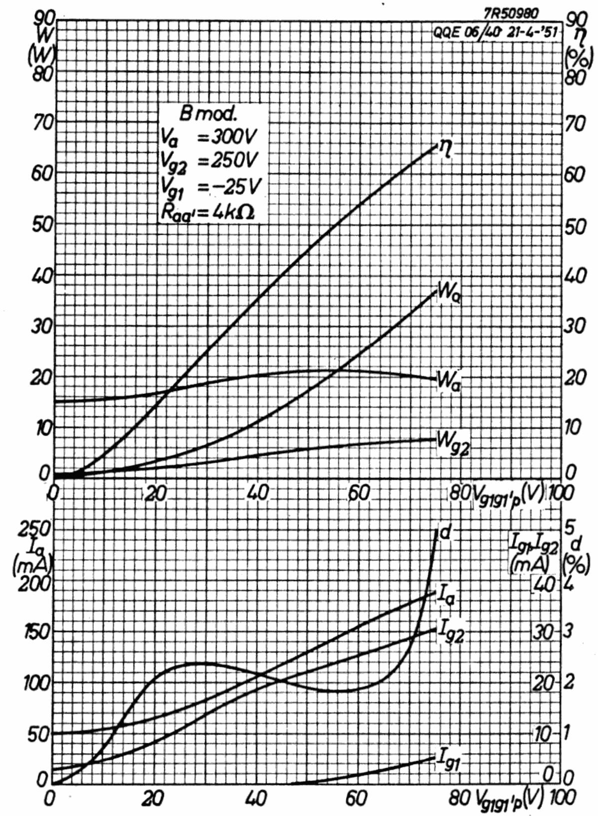


Fig.14. (*left*) As Fig.13, but for the following operating conditions: Anode voltage V_a = 450 V, screen-grid voltage V_{g2} = 250 V, control-grid bias V_{g1} = -27.5 V and an anode-to-anode load resistance R_{aa}' = 10 kΩ.

Fig.15. (*middle*) As Fig.13, but at an anode voltage V_a of 300 V a screen-grid voltage V_{g2} of 250 V, a control-grid bias V_{g1} of -26 V and an anode-to-anode load resistance R_{aa}' of 6.5 kΩ.

Fig.16. (*right*) Curves showing the performance of the QQE 06/40 as an A.F. amplifier or modulator push-pull class B amplifier with grid current. The output power W_o, anode dissipation W_a, screen-grid dissipation V_{g2}, efficiency η, anode current I_a, screen-grid current I_{g2}, control-grid current I_{g1} and total distortion d are plotted as functions of the peak-to-peak grid drive voltage $V_{g1g1'p}$ at an anode voltage V_a of 600 V, a screen-grid voltage V_{g2} of 250 V, a control-grid bias V_{g1} of -25 V and an anode-to-anode load resistance R_{aa}' of 8 kΩ.





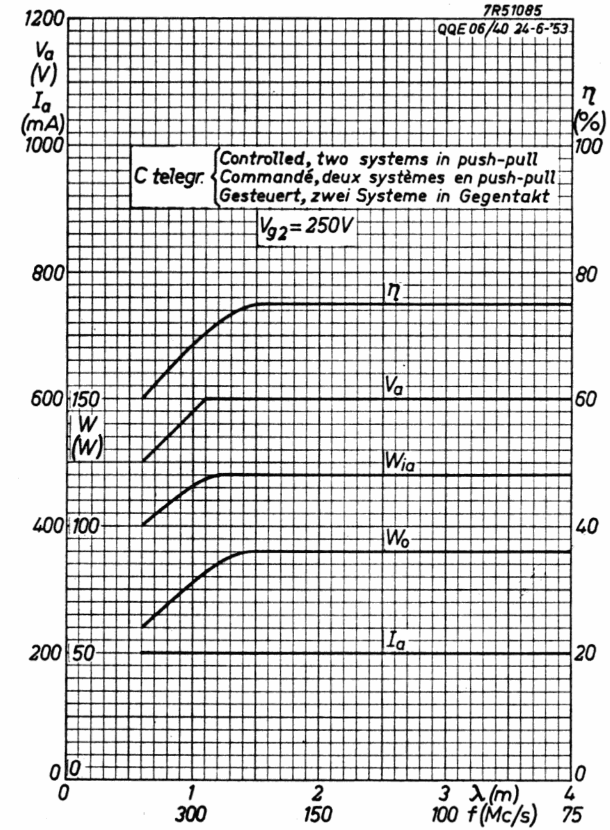


Fig.17. (*left*) As Fig.16. but at an anode voltage V_a = 450 V, screen-grid voltage V_{g2} = 250 V, control-grid bias V_{g1} = -25 V and anode-to anode load resistance R_{aa}' = 6 kΩ.

Fig.18. (*middle*) As Fig.16. but at an anode voltage V_a = 300 V, screen-grid voltage V_{g2} = 250 V, control-grid bias V_{g1} = -25 V and anode-to-anode load resistance R_{aa}' = 4 kΩ.

Fig.19. (*right*) Derating curves of the permissible anode voltage V_a and the corresponding anode supply power W_{ia}, the power output W_o, the efficiency η and the anode current I_a as functions of the frequency for two sections of the QQE 06/40 for push-pull class C telegraphy conditions.

Operational notes

Limiting values

The limiting values given in the technical data are absolute maxima, which implies that they may never be exceeded, neither by variations in supply voltage or in load, nor by variations caused by the normal tolerances of the components used in the assembly of the transmitter. Therefore, in order not to exceed the absolute limiting values, the equipment designer has the responsibility of determining design centre values, that are below the absolute limiting values given in the tables.

Bulb and seal temperatures

The maximum values for the bulb and seal temperatures given are also absolute maxima and should be observed in the same manner as the other limiting values. Temperature measurements should be made with the tube operating in the completely assembled transmitter, with all the shields and covers in place, delivering maximum output under the highest ambient temperature conditions and during the longest duty cycle for which the transmitter is designed.

The temperature may be measured by means of temperature-sensitive paint such as Tempilaq, made by the Tempil Corporation, 11 W. 25th Street, New York 10 N.Y.

When the QQE 06/40 is operated at frequencies higher than 150 Mc/s, it may be necessary to direct a low velocity air flow on the bulb and the anode seals.

Operation at frequency higher than 250 Mc/s

When the QQE 06/40 is operated at frequencies higher than 250 Mc/s, the anode voltage and the anode input power should be reduced in accordance with the technical data and the graphs of Fig. 19. It should be noted that the anode input power that can be applied to the tube at any given frequency should be chosen in accordance with the circuit efficiency, so that the limiting value at that frequency will not be exceeded.

Adjustments

When adjustments are made to a transmitter, or when a new circuit is tested, it is advisable to reduce the anode and screen-grid voltages to prevent overload. A protective device, such as a fuse or an over-current relay should be used, not only to protect the anodes but also the screen grid against overloads. The relays or fuses should cut out the anode and screen-grid voltages when the corresponding currents happen to reach values slightly higher than normal.

Screening

When the QQE 06/40 is used in H.F. circuits, screening is required for stable operation. Screening can be easily attained by mounting the tube socket about 22 mm below a hole in the chassis (see Fig. 20), so that, when the tube is inserted in the socket, the internal screening will be in the same plane as the chassis. The grid circuits are then made below the chassis, and the anode circuits above it. When the tube is mounted horizontally, a similar method can be used, with the tube protruding through the hole in the screen between two

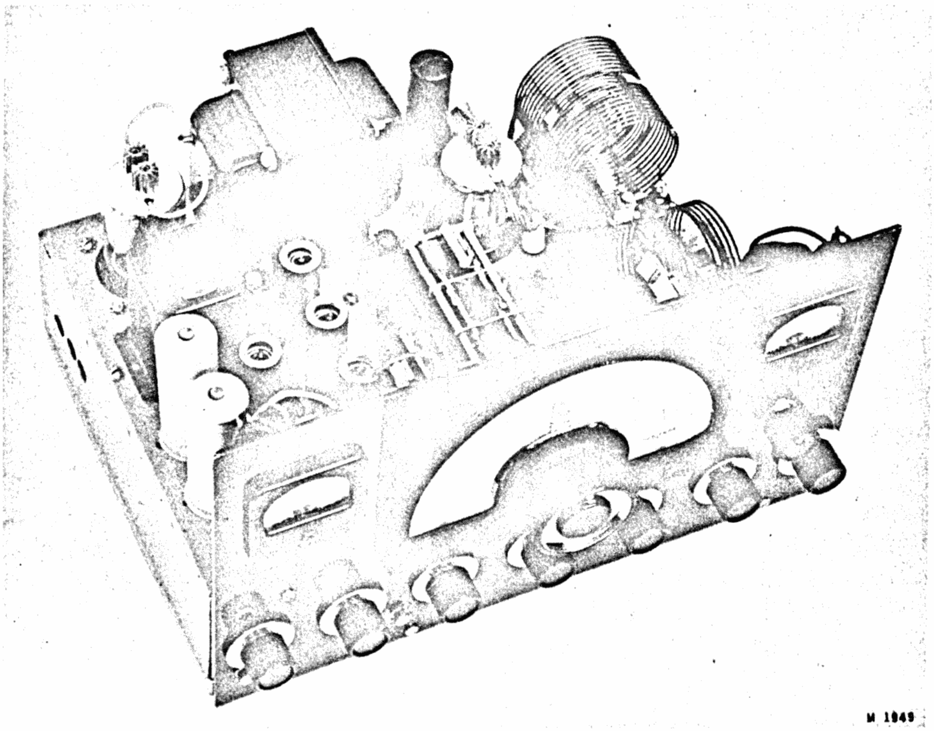


Fig.20. Amateur transmitter with a QQE 06/40 in the power stage and in the class *B* modulator. The sockets of the double tetrodes are mounted 22 mm below the chassis so that good screening is obtained.

compartments and the grid circuit being mounted in the one, and the anode circuit in the other compartment (see Fig. 21). The arrangement described provides a very effective screening between the control-grid circuit and the anode circuit.

Mounting

The connections to the anode pins should be sufficiently flexible to allow for mechanical tolerances and also for thermal expansion and other movements of the anode circuit, without subjecting the anode seals to any strain.

The connectors should facilitate heat conduction and not give

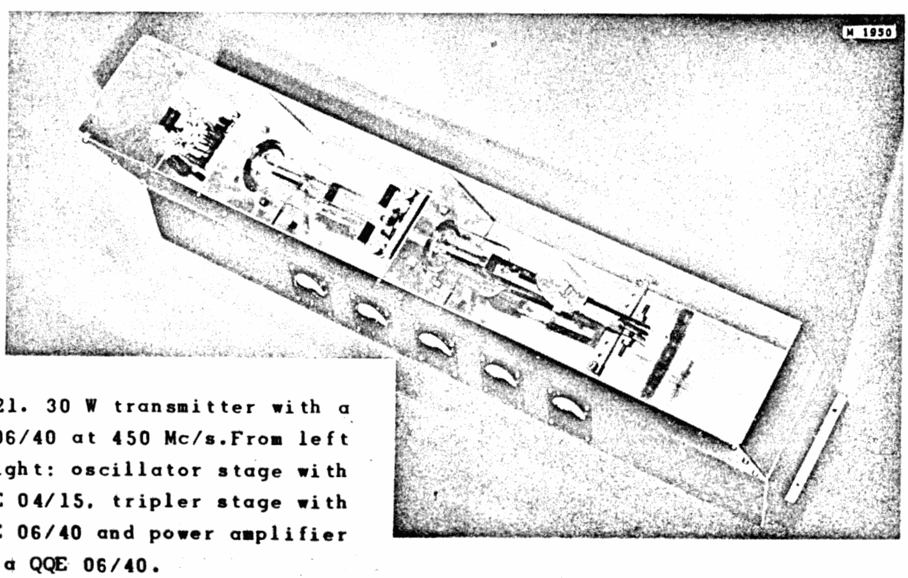


Fig.21. 30 W transmitter with a QQE 06/40 at 450 Mc/s. From left to right: oscillator stage with a QQE 04/15, tripler stage with a QQE 06/40 and power amplifier with a QQE 06/40.

rise to losses caused by poor contacts. They should never be soldered directly to the anode connecting pins.

Circuitry

The cathode should preferably be connected to one of the heater contacts. When the design prevents the heater contact to be connected directly to the cathode, the r.m.s. value of the heater-to-cathode voltage must be kept below the maximum value given in the tube data (usually 100 V).

The use of choke coils should be confined to a minimum. Choke coils in the screen-grid or cathode connections may give rise to parasitic oscillations. Usually the screen grid may be fed in series with a 150 ohm stopper resistor, whereas the cathode is preferably connected directly to earth.

In a push-pull circuit the centre tap of the anode coil should preferably be connected to the H.T. source via an unbypassed choke coil. If this choke were bypassed to earth, a slight asymmetry would result in part of the R.F. power in the anode circuit being lost due to its flowing off to earth via the bypass capacitor.

One of the heater contacts may be connected directly to earth, and the other via a capacitor. Much depends, however, on the circuit lay-out, and the above hints should, therefore, be considered as general indications. Sound and reliable equipment can be designed with the QQE 06/40 along other lines.

Particular care should be bestowed on the screen-grid voltage and supply. When the screen-grid is fed from a separate source, the anode voltage should be applied prior to, or simultaneously with the screen-grid voltage. With voltage applied to the screen grid only, the screen-grid current would render the screen-grid dissipation excessive, even when some protective control-grid bias is applied. When the screen-grid voltage is obtained from a voltage divider or through a dropping resistor from the anode supply, it is recommended to provide the voltage divider with an adjustable tapping or to use an adjustable series resistor so that the anode currents of individual tubes can be set to the required input, and variations within the tube tolerances can be compensated.

The screen-grid current is a very sensitive indication of the load in the anode circuit. When the amplifier operates without load, the screen-grid current may rise to a value which will damage the tube. When the QQE 06/40 is tuned under no-load conditions, care should therefore be taken that the screen-grid voltage is reduced so that the screen-grid input power will not exceed the limiting value.

The driver stage for a QQE 06/40 used in class C telegraphy or telephony service or as a tripler, should have an adequate output power for allowing a wide range of adjustments and to provide for the losses in the control-grid circuits. This is particularly important when the tube is operated at the higher frequencies, where the circuit and radiation losses, and also those due to transit time effects, become quite considerable.

A 30 WATT TRANSMITTER AT 450 Mc s

The double tetrode QQE 06/40 is very suitable for designing high-efficiency transmitters for radio communications over short distances at frequencies up to 500 Mc/s. To illustrate the possibilities the QQE 06/40 offers in this field, a short description is given of a simple experimental set-up consisting of an oscillator stage, a frequency tripler and a power stage. It is not meant to give full particulars of a complete transmitter, but merely directives for the electrical design of this type of equipment.

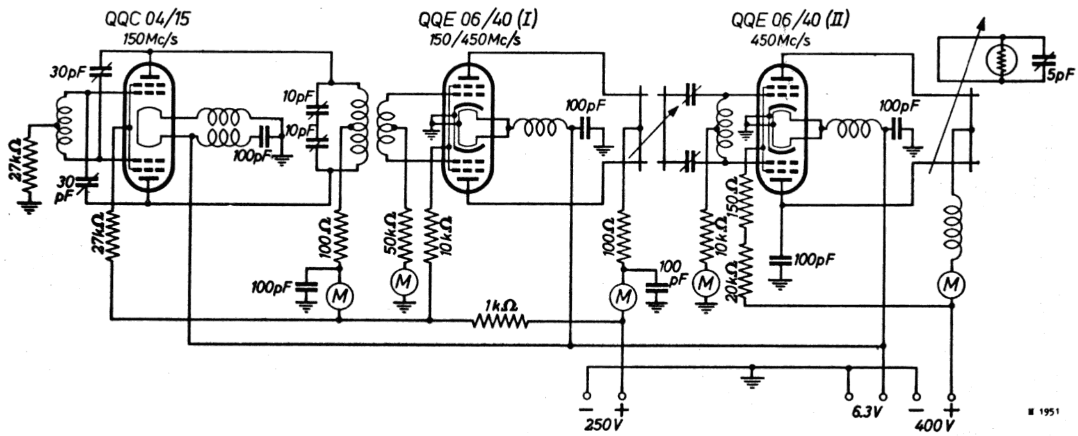


Fig.22. Circuit diagram of the 30 W transmitter with QQE 06/40 double tetrodes in the frequency tripler stage and in the power stage.

CIRCUIT DESCRIPTION

Fig. 22 shows the circuit of the transmitter the experimental set-up of which was depicted in Fig. 21. The sequence of the three stages in the circuit diagram corresponds to that of the three compartments shown in the photograph.

The oscillator stage is equipped with the smaller double tetrode type QQC 04/15, operating at 150 Mc/s. It is coupled by means of a conventional tuned R.F. transformer to the frequency tripler stage, equipped with a QQE 06/40 in a push-pull frequency tripler circuit. The anode circuit of this QQE 06/40 (I) is coupled to the power stage equipped with a second QQE 06/40 (II) via inductively coupled, tuned transmission lines, which can be seen in the centre compartment of Fig. 21. In the frequency tripler the frequency of the oscillator is raised to 450 Mc/s.

The power stage operates as a straight push-pull R.F. amplifier and delivers a useful output power of 30 W to a very simple output circuit. In this example the load consists of an incandescent lamp, inductively coupled to the tuned transmission lines in the anode circuit of the output tube. The tripler is required to deliver a power of about 8 W to drive the output stage. The tripler requires a driving power of about 5 W, which is provided by the oscillator.

Interstage coupling

The choice of the coupling between the frequency tripler and the output stage is governed by the consideration that the resonant frequency of the input of the QQE 06/40, with the control-grid pins interconnected with the shortest wire possible, is 300 Mc/s. At higher frequencies capacitors should therefore be connected in series with the control grids; these capacitors are most effectively mounted on the grid connections of the tube socket.

When the stages are inductively coupled, as is the case in this circuit, this method has the advantage that no d.c. connections to the tuned transmission lines are required. The bias of the output stage is applied via a centre-tapped choke.

Output circuits

Connections to the anode pins of the QQE 06/40 are preferably made by means of two clips type 40623 (Fig. 23), especially at frequencies up to 300 Mc/s, where flexible connections are usually applied. These clips increase the surface of the anode connections, and thus contribute towards effective cooling of the anode pins.

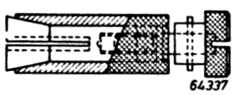


Fig.23. Anode clip type 40623.

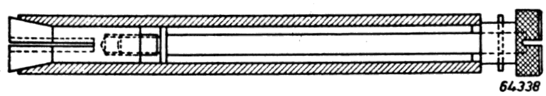


Fig.24. Example of elongated anode clip for use with tuned transmission lines.

At frequencies higher than 300 Mc/s, where tuned transmission lines with the least possible discontinuities are to be preferred, the clips can be used in conjunction with copper tubes with an internal diameter of 5 mm and an external diameter of 8 mm. The length is determined by the desired frequency, and an accordingly elongated fixing screw should be used. A drawing of such an elongated clip is given in Fig. 24; the use of this clip in the output circuits of the tripler can be seen in Fig. 22.

Tuning of the transmission lines is effected by a bridge sliding over the copper tubes of the elongated anode clips. A sketch of such a bridge is given in Fig. 25. In order to minimise the losses, it is advisible to have the transmission lines and the sliding bridge silver-plated.

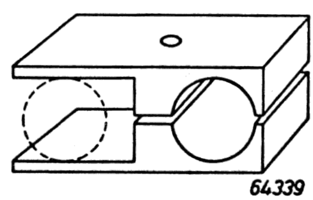


Fig.25. Sketch of sliding bridge.

VOLTAGES AND CURRENTS

The voltages and currents measured on the experimental set-up are given below. The currents are given of both sections together.

QQE 04/15 oscillator

Supply voltage	V_b	=	250	V
Anode voltage	V_a	=	180	V
Anode current	I_a	=	60	mA
Screen-grid voltage	V_{g2}	=	125	V
Screen-grid current	I_{g2}	=	2	mA

QQE 06/40 (I) frequency tripler

Supply voltage	V_b	=	250	V
Anode voltage	V_a	=	250	V
Anode current	I_a	=	80	mA
Screen-grid voltage	V_a	=	150	V
Screen-grid current	I_{g2}	=	3	mA
Control-grid current	I_{g1}	=	3	mA

QQE 06/40 (II) power amplifier

Supply voltage	V_b	=	400	V
Anode voltage	V_a	=	400	V
Anode current	I_a	=	180	mA
Screen-grid voltage	V_{g2}	=	200	V
Screen-grid current	I_{g2}	=	10	mA
Control-grid voltage	V_{g1}	=	-50	V
Control-grid current	I_{g1}	=	5	mA

A BROAD-BAND AMPLIFIER FOR OSCILLOSCOPES

The amplifier described has a bandwidth of about 50 Mc/s and is intended to be used as an amplifier for the vertical deflection in cathode-ray tubes with symmetrical, electrostatic deflection (for this purpose cathode-ray tubes should be used with the deflection plates connected to terminals on the bulb and not to the base, the capacitances of the latter tubes being too high for UHF work). The amplifier has a sensitivity of 1 V/cm, when cathode-ray tubes of normal sensitivity are used. The response curve is 6 dB down at 50 Mc/s; with pulses of 0.01 μs the overshoot is 5%.

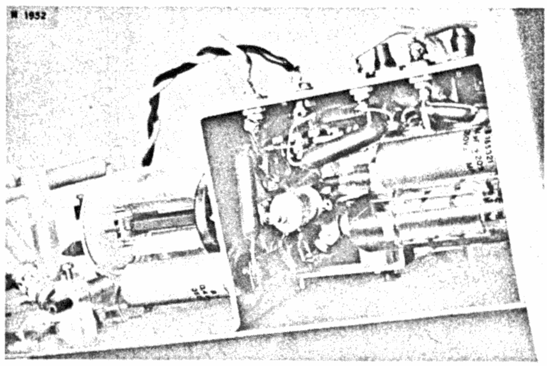


Fig.26. Broad-band amplifier with a QQE 06/40 for oscilloscopes.

CIRCUIT DESCRIPTION

A QQE 06/40 is used under entirely different conditions than customary in transmitters: the anode voltage is low and the cathode current is raised almost to the limiting value. Under these conditions the mutual conductance is considerably higher than the value given in the tube data, which results in a relatively high gain.

The QQE 06/40 is not only used as a push-pull output tube, but operates at the same time as a phase splitter. When the phase splitting is obtained in the final stage, a considerable amount of parts and components can be saved, and the circuit becomes relatively simple.

Fig. 27 gives a simplified circuit diagram of such an output stage. The resistors R_1 and R_2 have the same value, so that one half of the input signal is applied between cathode and grid of the first tube section, the other half of the signal being applied to the cathode. The grid of the second section of the QQE 06/40 is earthed, so that phase splitting is obtained, the control-grid voltages of the tube sections being in counter-phase. The value of the resistors R_1 and R_2 is low, viz. 120 Ω. For this purpose resistors of 220 Ω and 270 Ω of 1 W power rating are used in parallel; R_1 and R_2 should be made equal within 1%.

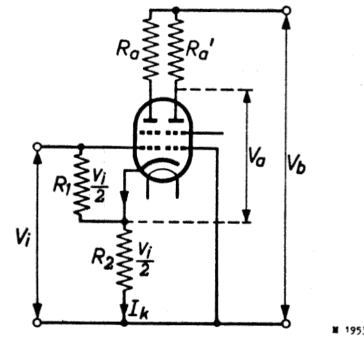


Fig.27. Simplified diagram of the output stage.

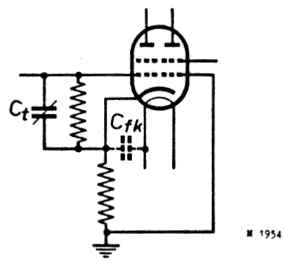


Fig.28. The heater-to-cathode capacitance C_{fk} is balanced by a trimmer of 3-30 pk (C_t) across R_1.

The cathode resistor R_2 is shunted by the heater-to-cathode capacitance C_{fk} (see Fig. 28); to prevent unbalance at the higher frequencies, the grid resistor R_1 is therefore shunted by a trimmer C_t of 3 to 30 pF, which should be adjusted with an H.F. signal applied to the input.

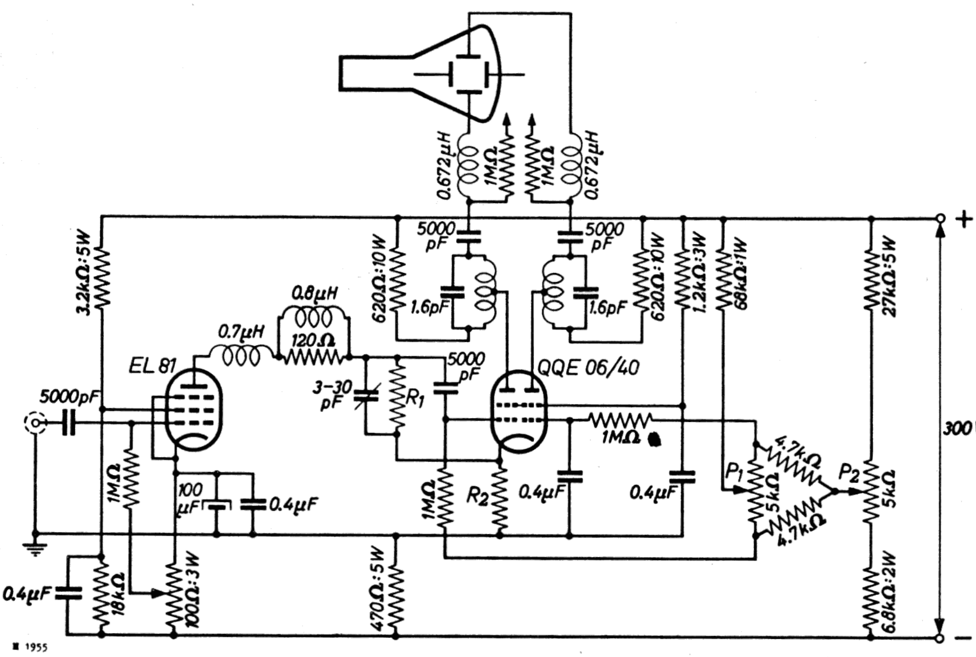


Fig.29. Circuit diagram of a broad-band oscilloscope amplifier with QQE 06/40 in the output stage.

In the circuit of Figs. 27 and 28, the control-grid bias cannot be adjusted. In the complete circuit of Fig. 29 it can be seen how the control grid of the first tube section is coupled to the top of R_1 via a capacitor of 5000 pF, whilst the grid of the second section is earthed via a capacitor of 0.4 µF. Grid resistors of 1 MΩ are used and connected to both ends of the potentiometer P_1 by means of which the anode currents can be balanced; the potentiometer P_2 is used for adjusting the correct grid bias.

The anode resistors of the QQE 06/40 are 620Ω with 5% tolerance, the power rating being 10 W. Various networks are used throughout the amplifier to compensate the falling-off in the frequency response at the high-frequency end. Special attention is drawn to the coils used in the anode circuit of the QQE 06/40. The coils have an inductance of 1.09 μH at either side of the centre tap which is connected to the anode; the complete coil is tuned by means of a 1.6 pF capacitor. The supply is fed to one end of the coil and the output voltage is taken off at the other. It is beyond the scope of this documentation to explain these compensating networks, full particulars of which are given in a recent paper published in Philips Research Reports*).

The pre-stage is equipped with the television line-output pentode type EL 81. This tube is also used with a low supply voltage and a high cathode current to obtain optimum mutual conductance and hence a sufficient gain with load resistors of low value.

The anode circuit of the EL 81 is very peculiar. The grid resistor R_1 of the QQE 06/40 also serves as an anode load resistor of the preceding EL 81, the supply voltage of the latter tube being obtained from the voltage drop across the cathode resistor of the QQE 06/40 (R_2) in series with a resistor of 470 Ω connected to the negative line of the high-tension supply unit. The cathode resistor of the EL 81 is also connected to the negative supply line. The cathode resistor of the QQE 06/40 is, however, connected directly to the chassis, the cathode of the EL 81 being connected to the chassis via a capacitor. The input signal on the grid of the latter tube can thus be applied between grid and earth, whilst the H.T. supply is floating. The screen grid of the EL 81 is connected to a tap on the bleeder resistor across the supply voltage, which consists of a 3.2 kΩ, 5 W resistor and an 18 kΩ, 2 W resistor. The screen-grid voltage is about 150 V.

VOLTAGES AND CURRENTS

The voltages and currents measured are given below. The voltages are given with respect to the negative supply line.

Pre-amplifier EL 81

Anode voltage	V_a	=	55	V
Anode current	I_a	=	132	mA
Screen-grid voltage	V_{g2}	=	162	V
Screen-grid current	I_{g2}	=	31	mA
Cathode voltage	V_k	=	16	V
Control-grid voltage	V_{g1}	=	5	V

Output tube QQE 06/40

Anode voltage (each anode)	V_a	=	229	V
Anode current (each anode)	I_a	=	106	mA
Screen-grid voltage	V_{g2}	=	247	V
Screen-grid current	I_{g2}	=	40	mA
Control-grid voltage (each system)	V_{g1}	=	68	V
Cathode voltage	V_k	=	71	V

*) G.Thirup, Design of low-pass amplifiers for fast transients, Philips Research Reports Vol. 10, No. 3, 1955.