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Data handbook

Electronic components and materials

Electron tubes

Part 2 April 1980

Transmitting tubes for communications

ELECTRON TUBES

PART 2 - APRIL 1980

TRANSMITTING TUBES FOR COMMUNICATIONS

SEE ALSO PART 1

RATING SYSTEM

(in accordance with IEC Publication 134)

ABSOLUTE MAXIMUM RATING SYSTEM

Absolute maximum ratings are limiting values of operating and environmental conditions applicable to any electronic device of a specified type as defined by its published data, which should not be exceeded under the worst probable conditions.

These values are chosen by the device manufacturer to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the device under consideration and of all other electronic devices in the equipment.

The equipment manufacturer should design so that, initially and throughout life, no absolute maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply variation, equipment component variation, equipment control adjustment, load variations, signal variation, environmental conditions, and variations in characteristics of the device under consideration and of all other electronic devices in the equipment.

DATA HANDBOOK SYSTEM

Our Data Handbook System is a comprehensive source of information on electronic components, sub-assemblies and materials; it is made up of three series of handbooks each comprising several parts.

ELECTRON TUBES	BLUE
SEMICONDUCTORS AND INTEGRATED CIRCUITS	RED
COMPONENTS AND MATERIALS	GREEN

The several parts contain all pertinent data available at the time of publication, and each is revised and reissued periodically.

Where ratings or specifications differ from those published in the preceding edition they are pointed out by arrows. Where application information is given it is advisory and does not form part of the product specification.

If you need confirmation that the published data about any of our products are the latest available, please contact our representative. He is at your service and will be glad to answer your inquiries.

ELECTRON TUBES (BLUE SERIES)

Starting in 1980, new part numbers and corresponding codes are being introduced. The former code of the preceding issue is given in brackets under the new code.

Part 1	February 1980	T1 02-80 (ET1a 12-75)	**Tubes for r.f. heating**
Part 2	April 1980	T2 04-80 (ET1b 08-77)	**Transmitting tubes for communications**
Part 2a	November 1977	ET2a 11-77	**Microwave tubes** Communication magnetrons, magnetrons for microwave heating, klystrons, travelling-wave tubes, diodes, triodes T-R switches
Part 2b	May 1978	ET2b 05-78	**Microwave semiconductors and components** Gunn, Impatt and noise diodes, mixer and detector diodes, backward diodes, varactor diodes, Gunn oscillators, sub-assemblies, circulators and isolators
Part 3	January 1975	ET3 01-75	**Special Quality tubes, miscellaneous devices**
Part 4	March 1975	ET4 03-75	**Receiving tubes**
Part 5a	October 1979	ET5a 10-79	**Cathode-ray tubes** Instrument tubes, monitor and display tubes, C.R. tubes for special applications
Part 5b	December 1978	ET5b 12-78	**Camera tubes and accessories, image intensifiers**
Part 6	January 1977	ET6 01-77	**Products for nuclear technology** Channel electron multipliers, neutron tubes, Geiger-Müller tubes
Part 7a	March 1977	ET7a 03-77	**Gas-filled tubes** Thyratrons, industrial rectifying tubes, ignitrons, high-voltage rectifying tubes
Part 7b	May 1979	ET7b 05-79	**Gas-filled tubes** Segment indicator tubes, indicator tubes, switching diodes, dry reed contact units
Part 8	July 1979	ET8 07-79	**Picture tubes and components** Colour TV picture tubes, black and white TV picture tubes, monitor tubes, components for colour television, components for black and white television.
Part 9	March 1978	ET9 03-78	**Photomultiplier tubes; phototubes**

SEMICONDUCTORS AND INTEGRATED CIRCUITS (RED SERIES)

Starting in 1980, new part numbers and corresponding codes are being introduced. The former code of the preceding issue is given in brackets under the new code.

Part 1a	August 1978	SC1a 08-78	**Rectifier diodes, thyristors, triacs** Rectifier diodes, voltage regulator diodes (> 1,5 W), transient suppressor diodes, rectifier stacks, thyristors, triacs
Part 1	March 1980	S1 03-80 (SC1b 05-77)	**Diodes** Small-signal germanium diodes, small-signal silicon diodes, special diodes, voltage regulator diodes (< 1,5 W), voltage reference diodes, tuner diodes, rectifier diodes
Part 2	June 1979	SC2 06-79	**Low-frequency power transistors**
Part 3	January 1978	SC3 01-78	**High-frequency, switching and field-effect transistors ***
Part 3	April 1980	S3 04-80 (SC2 11-77, partly) (SC3 01-78, partly)	**Small-signal transistors**
Part 4a	December 1978	SC4a 12-78	**Transmitting transistors and modules**
Part 4b	September 1978	SC4b 09-78	**Devices for optoelectronics** Photosensitive diodes and transistors, light-emitting diodes, photocouplers, infrared sensitive devices, photoconductive devices
Part 4c	July 1978	SC4c 07-78	**Discrete semiconductors for hybrid thick and thin-film circuits**
Part 5a	November 1976	SC5a 11-76	**Professional analogue integrated circuits**
Part 5b	March 1977	SC5b 03-77	**Consumer integrated circuits** Radio, audio, television
Part 6	October 1977	SC6 10-77	**Digital integrated circuits** LOCMOS HE4000B family
Part 6b	August 1979	SC6b 08-79	**ICs for digital systems in radio and television receivers**
Signetics integrated circuits			Bipolar and MOS memories 1979 Bipolar and MOS microprocessors 1978 Analogue circuits 1979 Logic - TTL 1978

*Field-effect transistors and wideband transistors will be transferred to S5 and SC3c respectively. The old book SC3 01-78 should be kept until then. The old book SC2 11-77 is now obsolete.

COMPONENTS AND MATERIALS (GREEN SERIES)

Starting in 1980, new part numbers and corresponding codes are being introduced.
The former code of the preceding issue is given in brackets under the new code.

Part 1	July 1979	CM1 07-79	**Assemblies for industrial use** PLC modules, high noise immunity logic FZ/30 series, NORbits 60-series, 61-series, 90-series, input devices, hybrid integrated circuits, peripheral devices
Part 3a	September 1978	CM3a 09-78	**FM tuners, television tuners, surface acoustic wave filters**
Part 3b	October 1978	CM3b 10-78	**Loudspeakers**
Part 4a	November 1978	CM4a 11-78	**Soft Ferrites** Ferrites for radio, audio and television, beads and chokes, Ferroxcube potcores and square cores, Ferroxcube transformer cores
Part 4b	February 1979	CM4b 02-79	**Piezoelectric ceramics, permanent magnet materials**
Part 6	April 1977	CM6 04-77	**Electric motors and accessories** Small synchronous motors, stepper motors, miniature direct current motors
Part 7	September 1971	CM7 09-71	**Circuit blocks** Circuit blocks 100 kHz-series, circuit blocks 1-series, circuit blocks 10-series, circuit blocks for ferrite core memory drive
Part 7a	January 1979	CM7a 01-79	**Assemblies** Circuit blocks 40-series and CSA70 (L), counter modules 50-series, input/output devices
Part 8	June 1979	CM8 06-79	**Variable mains transformers**
Part 9	August 1979	CM9 08-79	**Piezoelectric quartz devices** Quartz crystal units, temperature compensated crystal oscillators
Part 10	April 1978	CM10 04-78	**Connectors**
Part 11	December 1979	CM11 12-79	**Non-linear resistors** Voltage dependent resistors (VDR), light dependant resistors (LDR), negative temperature coefficient thermistors (NTC), positive temperature coefficient thermistors (PTC)
Part 12	November 1979	CM12 11-79	**Variable resistors and test switches**
Part 13	December 1979	CM13 12-79	**Fixed resistors**
Part 14	April 1980	C14 04-80 (CM2b 02-78)	**Electrolytic and solid capacitors**
Part 15	May 1980	C15 05-80 (CM2b 02-78)	**Film capacitors, ceramic capacitors, variable capacitors**

TRANSMITTING TUBES FOR COMMUNICATION
TUBES FOR R.F. HEATING
LIST OF SYMBOLS

a	Anode
B	Bandwidth; magnetic flux density
bp	Beam plates
C_a	Capacitance between anode and all other electrodes
C_{af}	Capacitance between anode and filament (all other electrodes being earthed)
C_{ag}	Capacitance between anode and grid (all other electrodes being earthed)
C_{ak}	Capacitance between anode and cathode (all other electrodes being earthed)
C_{gf}	Capacitance between grid and filament (all other electrodes being earthed)
C_{g1g2}	Capacitance between these two grids (all other electrodes being earthed)
C_{gk}	Capacitance between grid and cathode (all other electrodes being earthed)
C_i	Input capacitance
C_n	Neutralizing capacitance
C_o	Output capacitance
d	Harmonic distortion factor
d_n	n-th order intermodulation products
d_{tot}	Total harmonic distortion
f	Filament or heater; frequency
f_c	Filament or heater centre tap
f(k)	Filament (and cathode) r.f. connection
g	Grid
G	Power gain
h	Height above sea level
I_a	D.C. anode current
i.c.	Tube pin which must not be connected externally
I_f	Filament or heater current
I_g	D.C. grid current
I_k	D.C. cathode current
IMP	Inter modulation products
I_p	Peak value of a current
k	Cathode
m	Modulation factor
p	Pressure
p_i	Pressure drop of cooling air or cooling water
q	Rate of flow of cooling air or cooling water
R_a	Anode output a.c. resistance
R_{aa}	Anode to anode a.c. resistance
R_{fo}	Filament or heater resistance in cold condition
R_g	External grid resistor

R_k	External cathode resistor
R_{th}	Thermal resistance
s	Internal shield
S	Transconductance
t	Temperature
T	Duration
t_a	Temperature of anode body
t_{amb}	Ambient temperature
t_{bulb}	Bulb temperature
t_{env}	Envelope temperature
t_i	Inlet temperature of cooling air or cooling water
T_p	Pulse duration
t_o	Outlet temperature of cooling air or cooling water
t_{pin}	Pin temperature
t_s	Seal temperature
T_w	Waiting time (time which has to elapse between switching on the filament or heater voltage and switching on of the other voltages)
V_a	D.C. anode voltage
$V_{a\sim}$	Amplitude anode a.c. voltage
V_f	Filament or heater voltage
V_g	D.C. grid voltage
$V_{g\sim}$	Amplitude grid a.c. voltage
V_{kf}	Voltage between cathode and heater
V_p	Peak value of a voltage
V_{rms}	Root mean square value of a voltage
V_{tr}	Secondary transformer voltage
W_a	Anode dissipation
W_{dr}	Driving power
W_g	Grid dissipation
W_i	Input power
W_ℓ	Output power in the load
W_{mod}	Modulation power
W_o	Anode output power
W_{oPEP}	Peak envelope output power
W_{osc}	Oscillator output power
W_{Rg}	Grid resistor dissipation
δ	Duty factor
η	Efficiency
η_a	Anode efficiency
η_{osc}	Oscillator efficiency
λ	Wavelength
μ	Amplification factor
μ_{g2g1}	Amplification factor of grid 2 with respect to grid 1.

GENERAL OPERATIONAL RECOMMENDATIONS TRANSMITTING TUBES FOR COMMUNICATIONS TUBES FOR R.F. HEATING

1 PREFACE

1.1 In this handbook, data and curves are given for transmitting tubes for communications and tubes for r.f. heating.

1.2 The tubes are classified as follows:

D = **Design type.** Recommended for equipment design; production quantities available at date of publication.

C = **Current type.** No longer recommended for equipment design; available for equipment production and for use in existing equipment.

M = **Maintenance type.** No longer recommended for equipment production; available for maintenance of existing equipment.

O = **Obsolescent type.** Available until present stocks are exhausted.

Obsolescent types of which all stocks are exhausted are called **obsolete**; any data still published on these types is for reference purposes only.

The status of all types is given in a type survey at the end of the general section, together with data in condensed form. Full details are given of design and current types, divided into chapters as mentioned on the title page.

1.3 The characteristic data is general and independent of specific applications. This data, such as filament/heater current, amplification factor, transconductance and capacitances is given for a typical tube.

2 CHARACTERISTIC DATA

2.1 Inter-electrode capacitances

The published values of capacitances are average values measured on the cold tube with no operating voltages; individual deviations may however occur. The definitions of the capacitance symbols are given in the appropriate list in IEC publication 100.

2.2 Amplification factor μ and transconductance S

The published values are average values and individual deviations may occur. The conditions at which the values have been measured are stated.

2.3 Accessories

Proper functioning of the tubes can be guaranteed only if accessories (sockets, cooling devices etc.) have been supplied, or approved, by the tube manufacturer.

3 FILAMENT/HEATER SUPPLY

3.1 General

The published value of filament/heater voltage is that which should be present at the tube terminals. Filaments fed with direct current should have their supply polarity reversed at regular intervals (say monthly) to ensure uniform wear of the filament with consequent longer life. Reduction of filament/heater voltage is sometimes recommended to compensate for heating by back-bombardment at high frequencies; see the relevant data sheets. Special precautions must be taken when operating the filaments/heaters of transmitting tubes in series and the manufacturer should be consulted before doing so.

3.2 Pure tungsten cathodes (filaments)

The published value of filament voltage is the maximum voltage required for a new tube to supply the rated output power. A lower voltage, giving longer life, will often suffice and every tube with a pure tungsten cathode is supplied together with a list stating the saturation current at various filament voltages. Thus, knowing the required emission current, the most suitable filament voltage may be selected. Alternatively the filament voltage may be adjusted until the required output power, or maximum permissible signal, is reached and further adjusted after modulation is applied in order to obtain peak output power.

Regular adjustment (say monthly) will be necessary to maintain the required conditions and, towards the end of tube life, the filament voltage may be raised above the nominal. To compensate for mains supply fluctuations, automatic or manual control of the filament voltage should be used, especially when operating at nominal, or higher than nominal, filament voltage.

3.3 Thoriated tungsten cathodes (filaments)

To achieve satisfactory life, the filament voltage should be maintained within +1% and −3% of the published value. Excessive deviation over a long period from these limits will be harmful. Occasional temporary deviations should not exceed ±5% and +5% to −10% for tubes for industrial purposes, unless otherwise specified. If greater deviations occur a stabilized mains supply is recommended.

3.4 Quick heating cathodes (filaments)

In general, tubes with quick heating cathodes should have their filaments only in parallel. When a sinusoidal voltage is used for heating the filament, the frequency must not be in the range 200 Hz to 5000 Hz. In addition, if a non-sinusoidal voltage from a d.c./a.c. converter is used, the r.m.s. value should be adjusted to the published value of filament voltage.

If required, the heating time may be further reduced by applying a higher value for a short time. The manufacturer should be consulted before doing so.

3.5 Indirectly heated oxide coated cathodes

To achieve satisfactory life, the heater voltage should be maintained within +1% and −3% of the published value. Excessive deviation over a long period from these limits will be harmful. Occasional temporary deviations should not exceed ±10%. In order to avoid heater cathode r.f. damage, the heater to cathode insulation and the heater itself should be decoupled for r.f.

3.6 Switching on the filament

Switching on at full filament voltage is permissible unless a maximum switch-on value of filament current is stated in the data sheet. For the published values of maximum permissible filament current during switch-on, refer to the absolute maximum of the instantaneous value under worst case conditions.

3.7 By-passing the filament

Tubes with directly heated cathodes must have the filament terminals at the same r.f. potential. For this purpose it is usual to connect a capacitor which has low reactance with respect to the operating frequency, close to and between the filament terminals. As an added safety precaution, it should be ensured that the resonance of this capacitor together with the inductance of the filament structure, falls well below the operating frequency.

3.8 Switching on electrode voltages

Unless stated otherwise (e.g. cathode heating time T_h), simultaneous switching on of filament, control grid, anode and screen grid voltages is permissible for tubes with an internal anode. Tubes with an external anode should in general not have their positive voltages applied until the cathode has reached its operating temperature. This can be checked by monitoring the filament current.

3.9 Effective cathode

If both filament limbs are marked 'f' in the data sheets, the filament may be regarded as being symmetrical in its function as cathode. If such a filament is fed with d.c. the anode return lead should be connected to the negative end of the filament. All other decoupling and circuit returns must then also be connected to this point.

If the filament is fed with a.c., the anode return lead should be connected to the centre-tap of the filament transformer or to a tapped resistor shunted across the filament. The filament decoupling will then be symmetrical with regard to this point and all other circuit returns must also be made to this point.

If one filament limb is marked 'f' and the other 'f(k)', only the one marked 'f(k)' may be used as the circuit cathode. If such a filament is fed with d.c., the negative side of the filament supply should be connected to this point.

For either d.c. or a.c. filament supply, the anode supply, as well as decoupling and other circuit returns, must be connected to 'f(k)' only.

4 INITIAL OPERATION OF TUBE

4.1 Switching on the heater voltage

Ensure that any necessary cooling system is operative.
Sections 3.6 and 3.8 are applicable. The grid bias may be applied simultaneously.

4.2 Conditioning a tube

Conditioning is recommended for new tubes, after transit and after a period of storage. It is carried out by running the filament/heater only for at least 15 minutes before energizing the other electrodes, see also section 5.6.
Industrial tubes with anode voltages above 5 kV should also be operated for approximately 15 minutes at reduced anode voltage before applying full input ($V_a \times I_a$).
Television triodes and tetrodes may be operated for 15 minutes with the specified anode current in a no-signal condition. This treatment will remove any traces of gases which could cause premature failure of the tube.

4.3 Application of screen grid voltage to tetrodes

The screen grid voltage, V_{g2}, should be applied only when the anode voltage is present. If the anode voltage is removed, a safety circuit in the anode supply should cause the simultaneous removal of drive and screen grid voltages. If high voltage transients are present, it may be necessary to protect the cathode and control grid from arcing by means of a spark gap or protection diode across the relevant electrodes.

5 LIMITING VALUES

5.1 Notation

Limiting values are the maximum or minimum permissible values of the parameters listed. These limits are given either for all operating conditions together, or for an individual application.
The limiting values are applicable up to the maximum frequency stated. When operating at higher frequencies the limiting values must be decreased in accordance with the published figures or curves.

5.2 Derating of limiting values

If no limiting values have been published for a specific application, the derating factors listed in the following table must be applied. The values for class C telegraphy have been expressed as unity; the limiting values for other applications have been expressed as a factor of this unity.
A rectified 3-phase supply with or without filtering is equivalent to a d.c. supply.
The derating factors are determined by the physical limits of the tube and contain no safety margins. Where mains voltage fluctuations occur, further derating must be applied (see section 5.4). The nature of operation, e.g. industrial applications of heating generators, may necessitate further safety derating.

Wo = tungsten filament Th = thoriated tungsten filament

		V_a	I_a	I_g	W_{ia}	W_a	W_{g2}
R.F. class C telegraphy		1	1	1	1	1	1
Anode mod.	Th Wo	0.8 0.8	0.833 0.5	1 1	0.67 0.4	0.67 0.4	0.67 0.4
R.F. class B	Th Wo	1 1	0.833 0.5	1 1	0.833 0.5	1 1	0.67 0.5
A.F. class B		1	1	1	1	1	1
A.F. class AB		1	1	1	1	1	1
A.F. class A		1	1		W_a	1	1
Self-rectifying oscillator	Th Wo	1.13 1.13	0.53 0.32	0.53 0.32	0.665 0.4	1 1	
Two-phase half-wave without filter	Th Wo	0.9 0.9	0.89 0.6	0.89 0.6	1 1	1 1	

5.3 Rating system

The limiting values should be used in accordance with the 'Absolute maximum rating system' as defined by IEC publication 134.

5.4 Absolute maximum rating system

Absolute maximum ratings are limiting values of operating and environmental conditions applicable to any electronic device of a specified type as defined by its published data, which should not be exceeded under the worst probable conditions.
These values are chosen by the device manufacturer to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the device under consideration and of all other electronic devices in the equipment.
The equipment manufacturer should design so that, initially and throughout life, no absolute maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply voltage variation, equipment component variation, equipment control adjustment, load variations, signal variation, environmental conditions, and variations in characteristics of the device under consideration and of all other electronic devices in the equipment.

5.5 Limiting values

Each limiting value should be regarded independently of other values; under no circumstance is any limiting value to be exceeded (e.g. if the anode voltage is decreased to a value lower than its limiting value, it is not permissible to exceed the limiting value of anode current or anode dissipation).

5.6 Electrode voltages

The voltages (V_a, V_{g1}, V_{g2} etc.) listed under limiting values should not be exceeded even with a cold tube. Special attention should be paid to this point when a screen grid is supplied via a series resistor.
When designing equipment to be operated from an unstabilized mains supply, the maximum mains voltage which occurs determines the nominal operating voltages of the tube. These nominal voltages must be lower than the limiting values. Should the tube and thus the voltage supply, be temporarily under a lower load, these voltages may rise and these increased values, occurring at the highest mains voltage, determine the nominal operating voltages.
The limiting values of voltage are d.c. values. If an a.c. or an unsmoothed d.c. supply is used, the limiting values must be decreased in accordance with the derating factors shown in the table (section 5.2.).

5.7 Anode dissipation

The limiting value of the anode dissipation, W_a, should not be exceeded when fluctuations in the mains supply voltage occur, or when grid drive fails. To prevent damage to the tube in the latter case, adequate fixed bias or a quick action relay in the anode lead should be provided. When forced-air or water cooling is sufficient only for an anode dissipation smaller than the absolute maximum, the smaller value must be regarded as the limiting value.

5.8 Anode input power

Usually the data sheets show the limiting value of input power W_{ia} to be smaller than the product of limiting values of anode voltage and anode current; the latter two limits should not therefore occur simultaneously.
In practice, the input power W_{ia} is not always the product of the d.c. values of I_a and V_a. For pulsating supply voltages the form factor should be taken into account.

5.9 Screen grid dissipation, W_{g2}

The screen grid dissipation is the product of screen grid voltage and current. The screen grid should be protected against failure of anode voltage, see also section 4.3.

5.10 Control grid dissipation

The control grid dissipation W_g or W_{g1} can be approximated by subtracting the power supplied to the grid bias source ($-V_g \times I_g$) from the grid driving power (approx. 0.95 x $V_{gp} \times I_g$). When an a.c. or unsmoothed d.c. voltage supply is used, the form factor should be taken into account, see table in section 5.2 with the necessary derating factors.

5.11 Grid resistor

The maximum value of grid resistor, R_g max. (when published) should not be exceeded. This value is the maximum d.c. resistance in the grid circuit. A higher value may cause instability.

6 OPERATING CONDITIONS

6.1 General

In the published data, operating conditions for various applications have been given, stating the maximum frequency at which the conditions apply. If it is required to operate a tube at higher frequencies, the manufacturer should be consulted. The published values of operating conditions are average values derived from measurements made on a number of tubes of the same type, operating at optimum conditions.
Thus, small deviations from the published value may occur if measurements are made on an individual tube. However, some of the measured values of voltage or current must be adjusted to give the published figure. For example, the published value of output power is an average value which can be reached in practice by adjusting the r.f. or a.f. input voltage V_{gp}, when the published value of output power is not obtained at the nominal value of V_{gp}. When designing a multi-stage transmitter it is good practice to leave a margin in the output power and input voltage to allow for adjustments similar to that just described.
The published output power W_o of transmitting tubes is the tube's output, which may be determined by subtracting the anode dissipation W_a from the anode input W_{ia}. When a tube is used in a common grid circuit (grounded grid), the published value of the output power includes the power transferred from the driver.
Unless otherwise stated, losses in the anode circuit and coupling losses are not taken into account. The quoted grid input power is assumed to be 0.95 x the product of the average grid current I_g and the positive amplitude of the grid voltage $V_{g\sim}$. Losses in the grid circuit and the bleeder are sometimes accounted for by stating the required driver output power.
At high frequencies where reduced ratings have to be applied, the required driving power will often be considerably higher than the grid input power, due to circuit losses.

6.2 R.F. class C telegraphy and F.M. telephony

A class C amplifier or oscillator is one in which the grid bias is appreciably greater than the cut-off voltage so that current flows for less than one half of each cycle of the alternating grid voltage. Working to the published operating conditions will ensure good output power and efficiency.
If a grid resistor is used for obtaining automatic bias, care must be taken that the anode current does not become too high if the r.f. driving power should fail. A safety device in the anode or screen grid lead should be incorporated for this purpose.

6.3 R.F. class C anode and screen grid modulation

In an r.f. class C anode modulated stage the anode voltage is modulated with a.f. and at 100% modulation the voltage is varied from zero to twice the d.c. value. With tetrodes or pentodes the screen grid voltage may also be modulated. The average values of grid bias and r.f. driving voltage remain constant during modulation. With 100% modulation the average anode dissipation is 1.5 times the value without modulation and this is taken into account, although the published limiting value of anode dissipation refers to the unmodulated power.

6.4 R.F. class B telephony

A class B amplifier is one in which the grid is biased to the cut-off voltage so that the anode current flows for approximately one half of each cycle of the alternating grid voltage. The published data for r.f. class B telephony has been determined experimentally to give a linear modulation characteristic.

6.5 R.F. class AB SSB amplifier

The given operating conditions are obtained from measurements made in a circuit without feedback and with constant screen grid voltage. They show the best compromise between output power and linearity. Linearity is measured with a two-tone test signal in which both tones have equal amplitude and are 1 kHz apart in frequency. The amplitudes of the distortion products d_3 and d_5 are in dB referred to the amplitude of either of the two equal tones. The published values of d_3 and d_5 are the worst encountered at any driving level and occur usually slightly below full output power. Distortion products of orders other than d_3 and d_5 are, in general, negligible. If the amplitudes of the distortion products are referred to the peak envelope amplitude, the figures for d_3 and d_5 are improved by 6 dB.

6.6 A.F. class B push-pull amplifier

With this method of amplification, the anode dissipation is dependent on the input signal voltage, so that maximum anode dissipation is obtained when the signal is about 60% of the value at full drive. When this is not present continuously, as is the case with broadcast and telephony services, it is permissible for the limiting value of anode dissipation to be exceeded by 10%.
To suppress even harmonics, separate controllable grid bias for each tube, or a balancing circuit, should be incorporated. This data is purely arbitrary, i.e. the same output can be obtained with less modulation of the anode current (with smaller load resistance and lower peak grid current) although the efficiency would be lower. The requirements of the complete a.f. amplifier determine the choice of operation.

6.7 V.H.F and U.H.F. broadband conditions

The operating conditions for TV vision amplifiers, sound amplifiers and transposers (combined amplification of vision and sound) are compiled from measurements in tunable amplifiers which are available as accessories for the tubes concerned. These conditions generally show the nominal amplifier output (with v.s.w.r. of the load 1.1 max.) and a guaranteed linearity performance as differential phase, differential gain, l.f. linearity and intermodulation products as obtained in a 3-tone test.

6.8 Industrial operating conditions

With a single phase mains supply, smoothing will sometimes be omitted as is normal in a three phase mains supply. Operating conditions and derating factors are given for this kind of operation (section 5.2.). It must be ensured that no limiting values are exceeded because of fluctuations in the mains supply or by tolerances in other components. The published value of W_o is the actual tube output power. The output power of a self-oscillating circuit W_{osc} is obtained by subtracting the grid dissipation W_g and the losses in the grid resistor W_{Rg} from the output power W_o. The power in the load W_l is obtained by subtracting the losses in the output circuit from W_{osc}. A favourable load output characteristic may be obtained by automatically controlling the grid voltage and current, depending on the matching. A non-linear device e.g. a tungsten lamp **or a PTC thermistor may be used to perform this function adequately and help to prevent overloading the grid.**
With **self-oscillating** circuits, the frequency must be held within the available frequency band. This may be done by having large circuit capacitance, small stable self inductance, undercritical inductive coupling with the output circuit, electrostatic screening between oscillator and output circuit, etc.
If the frequency of an industrial generator is restricted to a very narrow band, crystal controlled driver stages may have to be used. It will then, however, be difficult to maintain a good match between tube and load over the whole of the processing cycle. Greater safety margins will have to be set for the tube, with the tube output very dependent on variations in the load. Special measures, such as automatic tuning and/or load matching, may have to be taken.
For smaller tubes in industrial applications, operating conditions have been given for an anode supply from a single phase full-wave rectifier, a three phase half-wave rectifier (which is nearly equivalent

6.8 Industrial operating conditions (continued)

to d.c.) and with raw a.c. In the latter case the output is about 0.6 times that obtained with d.c. and the peak inverse voltage is equal to the full anode voltage. With a single-phase, full-wave rectified anode voltage the useful output is nearly equal to that with a d.c. supply.

6.9 Intermittent service

When data concerning intermittent service is published, it is conditional that, although the cathode may be heated continuously, the on-period is no more than 5 minutes and that the off-period is equally long or longer.

7 COOLING

7.1 Temperature limits

The maximum temperatures given in the data should be heeded and operating temperatures should be kept well below these values in the interest of tube life. Surface (envelope) temperatures may be checked with the help of suitable thermocouples, thermocrayons, thermopaints or stick-on markers.

7.2 Cooling of the tube header

In order to maintain all parts of the tube header, i.e. contact surfaces and ceramic to metal or glass to metal seals, at temperatures below the limits given in the data, it may be necessary, depending on the surroundings and ambient temperatures, to provide some extra cooling even at low frequencies. At frequencies above 4 MHz such extra cooling becomes mandatory for all types. For this purpose an axial air stream is preferred since this will ensure a more even temperature around the circumference of the individual electrodes. This will already be assisted by also ensuring an even distribution of the high frequency currents around the seals.

7.2.1 Forced air cooled tubes

The anode cooler air will in most cases also effectively cool the seals, provided it is directed in such a way that the seals are not protected from this air stream.

7.2.2 Water cooled tubes

Unless environmental conditions make it necessary, additional cooling of the seals will be mandatory only at frequencies above 4 MHz. If some of the cooling water can be branched off, this may also serve as coolant through pipes that are in good thermal contact with the respective connectors. Such pipes are already integral with the filament connectors of industrial types YD1192 to YD1432. Their use with a reliable water flow is strongly recommended.

7.3 Minimum coolant quantities

When determining the minimum coolant flow through the cooler, account must be taken of the maximum inlet temperature and the maximum anode dissipation that may occur under the prevailing circumstances.

7.3.1 Minimum forced air flow

The temperature, dissipation and flow relationships are given in the published data, tables and curves. The temperature rise of the cooling air may be found from the following formula:

$$\Delta T = \frac{50 \times W_{tot}}{Q}$$

where Q = air flow in m^3/min

W_{tot} = anode + grid + filament dissipation in kW

ΔT = temperature rise in K

This formula holds for an ambient temperature of 20 °C at sea level. Whenever the ambient conditions (temperature, altitude) are beyond those shown in the published data, the tube supplier must be consulted.

7 **COOLING** (continued)

7.3.2 *Minimum cooling water flow*

The amount of cooling water required is given in the published data. The temperature rise of the cooling water may be found from the following formula:

$$\Delta T = \frac{14.4 \times W_{tot}}{Q}$$

where Q = water flow in litres/min

W_{tot} = anode + grid + filament dissipation in kW

ΔT = temperature rise in K

7.4 **Natural cooling**

This is applicable only to internal anode glass envelope tubes with a maximum anode dissipation of up to about 1 kW. A chimney around and extending above the tube will assist natural convection. For operation at higher frequencies additional cooling of the electrode pins, the tube socket and the bulb is often required. Temperature checks may be carried out as noted in section 7.1.

7.5 **Forced air cooling**

When using air as a cooling medium the intake must be properly filtered to prevent blockage of the anode radiator. All electrical supplies to the tube should be interlocked with a flow sensor in the exhaust stream. Temperature checks may be carried out as noted in section 7.1.

7.6 **Water cooling**

The direction of water flow, indicated by arrows near the water inlets and outlets of the tube are for when the tube is mounted 'anode down'. When reversing the position of the tube, i.e. 'anode up', the direction of flow should also be reversed. Re-circulating systems are preferred, since, apart from saving water, they help to ensure a high standard of purity.
Some of the requirements for satisfactory cooling water are that it should not be corrosive or deposit scale, should not contain insoluble material that might cause blockages and should have a high electrical resistance to prevent electrolysis. Its mineral content and electrical conductivity should therefore be periodically checked, especially when it is not drawn from a circulating system.
A non-corrosive water should be low in chlorides, oxygen and carbon dioxide.
Scale formation may be avoided by maintaining a low amount of silica and bicarbonates, especially calcium bicarbonate. No exact figures can be given for impurities as they are interdependent.
The cooling water must also be free from all traces of greasy substances since a small amount may form a dangerous heat barrier on the anode cooler, causing excessive anode temperatures despite an apparently adequate water flow. These greasy or oily films may be removed by repeated flushing of the cooling channels with a domestic liquid detergent or slightly soapy water to which a small quantity of industrial alcohol and 33% ammonia has been added (approx. 10 cc/l of each).
The cleaning process should be completed by repeated flushing with demineralized water. The cause of such greasy deposits will usually be found elsewhere in the cooling system as the result of, for example, leaky pump glands. After the necessary repairs have been carried out, the whole system must be cleaned in a similar manner to prevent deposits forming again. The cooling water system must be interlocked with all electrical supplies to the tube. As an added safeguard, the interlocks should be activated if the water outlet temperature exceeds the indicated upper limit.
To prevent the tube from running dry in the event of minor leakages in the system, the reservoir should always be above the level of the tube.

8 **CHECKING PROTECTION OF THE TUBE**

To verify the operation of the safety circuits noted in section **4.3**, as well as safeguarding against high and possibly destructive currents resulting from excessive transients, the following functional check is recommended.
With the tube removed, the anode supply lines (anode - cathode) are shorted at the tube position with a copper wire that is of a specified diameter for the tube type used (see table below) and has a length of approx. 2.5 cm per kV of applied anode potential. If this test wire does not fuse upon application of the full high tension, the speed of the safety circuit is adequate to protect the tube.

Industrial tubes	test wire diameter, mm
YD1150/52	0.12
YD1160/61/62	0.12
TB4/1500	0.14
TB5/2500	0.14
TB6/14	0.23
TB6/4000	0.14
TB6/6000	0.18
TB7/8000	0.14
TB7/9000	0.14
TB12/25	0.11
TB12/38	0.23
TB12/40	0.12
TB12/100	0.23
YD1140/41	0.15
YD1170 to YD1177	0.20
YD1180 to YD1187	0.20
YD1192 to YD1197	0.20
YD1202	0.25
YD1212	**0.30**
YD1342	**0.32**
YD1432	**0.32**
Tubes for communications	
QB5/3500	0.25
QBL3.5/2000	0.11
YL1420	0.17
YL1430	0.17
YL1440	0.11
YL1470	0.17
YL1520	0.17
YL1530	0.17
YL1540	0.12
YL1560	0.11
YL1590	0.11

9 CONNECTORS

9.1 Clean contact surface

Attention must be paid to a good fit on a clean contact surface of all electrode connectors as well as an even r.f. current distribution around their circumference.

9.2 Fastening the filament connector on industrial tubes

To ensure good seating of the filament connectors on industrial tubes, care should be taken that they are not crooked and that the applied clamping force is within the specified limits.
In the following table the minimum and maximum torque values are given for the different tubes concerned and the corresponding connector at room temperature.

Tube type	Cap dia. mm	Bolt size	Connector type	Min. torque Ncm	Max. torque Ncm
YD1170/77	25	M6	40692A	400	600
YD1180/87	32	M6	40708A	500	700
YD1190/97	42	M6	40705A	600	700
YD1202 YD1212 YD1342 YD1432	54	M8	40695A	800	1000

After the system has been warmed up and cooled down several times, it is advisable to check the bolts for correct tightness and if necessary re-tighten to the correct value.

10 STORAGE AND MAINTENANCE

10.1 General

Whenever possible, the tubes should be transported and stored in their original packing in an upright position. If the tubes are to be stored in an unpacked condition they should be kept in a dry room placed in an upright position in a rack that is not subject to excessive vibration and does not exert any mechanical stress on other parts of the tube except those that normally serve for the support of the tube, e.g. the anode cooler or the anode mounting flange.
If a tube is stored for an extended period it should be subjected to the conditioning schedule outlined in section 4.2.
Care should be taken that the glass or ceramic parts of a tube are kept clean and do not contact metallic objects since a scratch on glass may initiate a fracture and metal rubbed against ceramic may leave a metallic trace that can lead to surface arcing when high tension is applied to the tube. Soiled glass parts may be cleaned with conventional non-abrasive window cleaning agents and thoroughly rinsed and dried afterwards. Soiled ceramic parts are best cleaned with domestic cleaning powders applied with a moistened tooth brush. A final thorough rinse with clean water is essential to remove all traces of the cleaning powder and the loosened dirt.

10.2 Cleaning integrally water cooled tubes

If the water cooling channels or the helix of a tube become partially blocked (reduced flow and increased back pressure) by floating particles, these can be removed with compressed air or high pressure water, taking care that the water outlet of the tube is open to air and the maximum applied inlet pressure does not exceed 50 Pa. If the impurities adhere to the cooling channel walls or are of a sedimentary nature the cleaning will have to be assisted by a solvent. In the majority of cases these will be calcium deposits. They may be removed by flushing the tube, if necessary repeatedly, with a 5 to 10% solution of hydrochloric acid or 15% citric acid. This procedure should be followed by thoroughly rinsing with distilled or demineralized water.

SURVEY

Type	status	cooling	W_o kW	V_f V	I_f A	V_a kV	I_a A	V_a max kV	Wa max kW		h x dia max mm
TAW12/20	M	W	42	21,5	80	12	2,7	12	18		631 x 163
TB25/300	C	N	0,7	6,3	5,4	2,5	0,356	2,5	0,135		132 x 62
TB25/400	C	N	0,7	6,3	5,8	2,5	0,356	3	0,15		132 x 62
TB3/750	C	N	1,55	5	14,1	4	0,54	4	0,35		151 x 87
TB4/1250	C	N	2,29	10	9,9	4	0,736	4	0,45		213 x 118
TBH6/6000	C	WH	6,9	12,6	33	6	1,5	6	6		219 x 130
TBH7/8000	C	FA	6	12,6	33	6	1,5	7	6		219 x 130
TBL2/500	C	FA	0,67	3,4	19	2,5	0,38	2,7	0,5		83 x 41,5
TBL6/20	M	FA	17	6,3	154	6	4,8	5,5	10		277 x 169,5
TBL6/6000	C	FA	9	12,6	33	5	3,8	5	5		195 x 122,6
TBL7/8000	C	FA	20	12,6	33	7	4	7,2	6		195 x 122,6
TBL12/40	C	FA	19,2	8	130	10	3,2	13	15		404 x 225
TBL12/100	O	FA	202	17,5	196	10	5	15	45		660 x 286
TBW6/6000	C	W	9	12,6	33	5	3,8	5	5		190 x 70,5
TBW7/8000	C	W	20	12,6	33	7	4	7,2	6		190 x 70,5
TBW12/100	O	W	202	17,5	196	12	24	15	50		620 x 240

COOLING: FA = forced air; N = natural; W = water; WH = water (helix); V = vapour; H = heatsink

Type	status	cooling	W_o kW	V_f V	I_f A	V_a kV	I_a A	V_a max kV	W_a max kW		h x dia max mm
YD1001	C	FA	78	12,6	12,6	12	9,5	12	35		380 x 300
YD1002	C	V	78	12,6	12,6	12	9,5	12	60		380 x 218
YD1050	M	FA	0,026	6,0	1,05	0,5	0,125	1	0,1		67 x 32
YD1051	M	FA	0,03	6,0	1,05	0,5	0,1	1	0,1		67 x 32
YD1130	C	N	1,31	5	14,1	3	0,666	3	0,4		151,5 x 87
YD1140	M	FA	106	17,5	196	10	16	15	100		620 x 240
YD1141	M	FA	106	17,5	196	10	16	15	45		660 x 286
YD1270	D	FA	0,025	6,3	1,2	1,5	0,12	1,7	0,2		88,6 x 50,5
YD1300	D	FA	0,025	5	2	1,7	0,17	2	0,3		55,2 x 45,4
YD1302	D	FA	0,035	5	2	1,7	0,17	2	0,325		64,2 x 54,1
YD1303	D	FA	0,025	5	2	1,2	0,15	2	0,15		55,2 x 68,1
YD1304	D	FA	0,055	5	22	1,8	0,18	2	0,325		64,2 x 54,1
YD1330	C	FA	0,22	6,3	5,3	3	0,42	3,5	1,8		106 x 71
YD1333	C	FA	0,11	6,3	5,3	2	0,25	3,5	0,9		88,5 x 71
YD1334	D	FA	0,11	6,3	5,3	2,5	0,25	3,5	1,8		96,5 x 96
YD1335	D	FA	0,55	6,3	5,3	3,5	0,25	3,8	1,9		96,5 x 96
YD1336	D	FA	0,22	6,3	5,3	3	0,42	3,5	1,8		96,5 x 96
2C39BA	M	FA	0,024	6,0	1,05	0,6	0,1	1	0,1		67 x 32
5876	M	N	0,005	6,3	0,135	0,25	0,025	0,3	0,006		52 x 20
5893	M	N	0,008	6,3	0,28	0,2	0,025	0,33	0,007		52 x 20
6263	M	N	0,013	6,3	0,28	0,2	0,027	0,4	0,013		60 x 26
6264	M	N	0,013	6,3	0,28	0,2	0,018	0,4	0,013		60 x 26
7289	M	FA	0,024	6,0	1,05	0,6	0,095	1	0,1		67 x 32
8108	M	N	0,0018	6,3	0,75	0,18	0,03	0,3	0,0125		60 x 33
EC55	M	N	0,003	6,3	0,4	0,25	0,02	0,35	0,01		62 x 23
EC157	M	N	0,0018	6,3	0,75	0,18	0,03	0,30	0,0125		60 x 33
EC158	M	N	0,0053	6,3	0,9	0,18	0,06	0,30	0,03		60 x 33

SURVEY

Type	status	cooling	W_o W	V_f V	I_f A	V_a kV	V_{g2} V	I_a mA	V_a max kV	W_a max W	h x dia max mm
QB2/250	O	N	275	10	5	2	400	180	2	100	191 x 66
QB3/200	C	N	270	6	3,5	1,8	250	220	3	65	111 x 60,5
QB3/300	C	N	550	5	6,5	2,5	350	302	3	125	130,8 x 62
QB3/300GA	C	N	550	5	6,5	2,5	350	302	3	125	144 x 69,1
QB35/750	C	N	1000	5	14,1	4	500	310	4	250	151,8 x 87
QB3,5/750GA	C	N	1000	5	14,1	4	500	310	4	250	151,8 x 87
QB4/1100	C	N	1100	5	14,1	4	500	350	4	400	151,8 x 87
QB4/1100GA	C	N	1100	5	14,1	4	500	350	4	400	161 x 87
QB5/1750	C	N	1760	10	9,9	5	600	440	5	500	209 x 118
QB5/2000	C	N	2400	7,5	22,6	5	600	600	5,5	800	248 x 153
QBL3,5/2000	C	FA	2100	3,6	58	4,3	600	850	4,5	1500	215 x 89
QBL4/800	C	FA	930	5	13,5	4	500	315	4	500	120 x 67
QBL5/3500	C	FA	4100	6,3	32,5	5	800	1100	5	3000	169 x 97
QBW5/3500	C	W	4100	6,3	32,5	5	800	1100	5	3000	160 x 70,5
QC05/35	O	N	65	1,6	3,2	0,6	180	150	0,65	25	97 x 44
QE05/40	M	N	50	6,3	1,25	0,6	180	112	0,60	20	97 x 44
QE05/40F	M	N	50	12,6	0,625	0,6	180	112	0,60	20	96 x 44
QE05/40H	M	N	50	26,5	0,3	0,6	180	112	0,60	20	97 x 44
QE05/40K	M	N	50	13,5	0,585	0,6	180	112	0,60	20	96,8 x 42,1
QE08/200	C	N	290	6,3	3,9	1	250	385	1,1	100	150 x 72
QE08/200H	C	N	290	26,5	0,85	1	250	385	1,1	100	150 x 72
QEL1/150	C	FA	370	6	2,6	2	250	250	2	250	62,7 x 41,7
QEL1/150H	C	FA	370	26,5	0,58	2	250	250	2	250	62,7 x 41,7
QEL2/200	M	FA	105	6	2,6	0,5	250	200	2	250	62,7 x 41,7
QEL2/275	C	FA	390	6	2,6	2	250	250	2	250	62,7 x 41,7
QEL2/275H	C	FA	390	26,5	0,58	2	250	250	2	250	62,7 x 41,7
QQC03/14	O	N	11	3,15	1,65	0,25	250	0,045	0,3	7	77,8 x 22
QQC04/15	O	N	26	3	1,6	0,6	200	0,06	0,6	12	90 x 32
QQE02/5	M	N	5	6,3	0,6	0,18	180	0,055	0,18	6	66,7 x 22
QQE03/12	M	N	12	6,3	0,82	0,3	175	0,075	0,3	10	78 x 22
QQE03/20	M	N	48	6,3	1,3	0,6	250	0,1	0,6	20	85,5 x 46
QQE03/32	M	N	48	6,3	1,3	0,6	250	0,1	0,6	20	85,5 x 46
QQE04/5	M	N	4	6,3	0,6	0,25	160	0,27	0,4	16	63 x 44,5
QQE04/20	M	N	26	6,3	1,6	0,75	200	0,048	0,75	15	84 x 51
QQE06/40	M	N	90	6,3	1,8	0,6	250	0,2	0,75	40	108,5 x 46

COOLING: FA = forced air; N = natural; W = water; WH = water (helix); V = vapour; H = heatsink

SURVEY

Type	status	cooling	W_o kW	V_f V	I_f A	V_a kV	V_{g2} V	I_a mA	V_a max kV	W_a max W	h x dia max mm
YL1010	C	W	5,5	10	200	10	800	7400	10	2 kW	306,5 x 140
YL1011	C	FA	5,5	10	200	10	800	7400	10	2 kW	321,5 x 215
YL1012	C	V	5,5	10	200	10	800	7400	10	2 kW	315 x 218
YL1020	M	N	0,013	1,6	4	0,3	250	40	0,5	7	86 x 46
YL1030	M	N	0,032	2,1	4,5	0,4	250	75	0,6	14	92 x 46
YL1060	M	N	0,085	6,3	1,8	0,75	250	90	0,8	21	103 x 44,6
YL1070	C	N	0,158	6,3	1,8	1	250	40	0,85	30	103,8 x 44,6
YL1071	C	H	0,158	13,25	0,866	1	250	40	0,85	30	103,8 x 44,6
YL1091	C	V	3,2	20	345	11	1500	4400	12	150 kW	532 x 315
YL1100	M	FA	0,045	26,5	0,52	0,7	250	130	0,8	75	49,6 x 32,2
YL1101	M	FA	0,045	6,3	2,1	0,7	250	130	0,8	75	49,6 x 32,2
YL1110	M	FA	0,6	6,3	7,85	2	400	500	2	400	61 x 53,1
YL1120	C	FA	5,1	12,6	14,5	5	700	700	5,5	4 kW	202 x 159
YL1130	M	N	0,013	1,1	2,9	0,275	170	42,5	0,3	4	72,9 x 22
YL1150	C	N	0,2	6,3	1,9	0,6	250	520	0,75	75	125,5 x 51
YL1181	C	FA	5,5	5	64	3	600	1000	6	4 kW	178 x 100
YL1182	C	V	5,5	5	64	3	600	1000	6	4 kW	178 x 122
YL1190	M	N	0,026	1,1	4,2	0,35	132	70	0,4	8	73,9 x 30,2
YL1210	M	N	0,012	6,75	0,72	0,3	175	37,5	0,3	5	78 x 22
YL1220	M	N	0,006	6,75	0,56	0,18	180	27,5	0,25	3	66,7 x 22
YL1240	M	N	0,021	6,75	0,8	0,4	180	45	0,4	7,5	82,7 x 30,1
YL1250	M	N	0,052	6,75	1,2	0,55	235	136	0,55	25	59 x 44,5
YL1290	C	N	0,29	19	2,3	1	250	385	1,1	100	150 x 72
YL1340	C	FA	0,77	6	3,2	2,2	400	580	2,5	350	62,6 x 41,7
YL1341	C	FA	0,77	26,5	0,73	2,2	400	580	2,5	350	62,6 x 41,7
YL1360	M	N	0,007	13,5	0,28	0,25	160	35	0,4	8	63 x 44,5
YL1370	M	N	0,042	6,3	1,125	0,475	165	125	0,48	18	96 x 44
YL1371	M	N	0,042	12,6	0,562	0,475	165	125	0,48	18	96 x 44
YL1372	M	N	0,042	26,5	0,3	0,475	165	125	0,48	18	96 x 44
YL1420	D	FA	11	6,3	120	7	600	2300	8,5	6 kW	174 x 125,1
YL1430	D	FA	18	8	120	8	700	3500	9,5	12 kW	211 x 164,2
YL1440	D	FA	2,4	4,2	53	3	600	980	4	1500	125 x 63
YL1460	C	N	1,1	5	14,1	4	500	350	4	400	151,5 x 100
YL1461	C	N	1,1	5	14,1	4	500	350	4	400	151,5 x 100
YL1470	D	FA	11	6,3	120	7	600	2300	8,5	8 kW	174 x 125,1
YL1520	D	FA	25	11,5	120	8,5	700	4600	9,5	18 kW	225 x 164,2
YL1530	D	FA	35	7,5	180	10	900	2400	12	30 kW	264 x 215
YL1531	D	W	35	7,5	180	10	900	2400	12	30 kW	340 x 160,5
YL1540	D	FA	2,2	4,2	53	3	700	500	4,2	2 kW	122 x 63
YL1560	D	FA	5,5	5	130	2	700	6000	6	7 kW	153 x 120,3
YL1590	D	FA	1,1	3,9	52	1	700	2000	4	2 kW	62,7 x 41,7
7609	C	FA	0,58	26,5	0,57	2	250	200	2	250	62,7 x 41,7
8621	C	FA	0,436	25,6	0,56	0,5	250	200	2	250	62,7 x 41,7

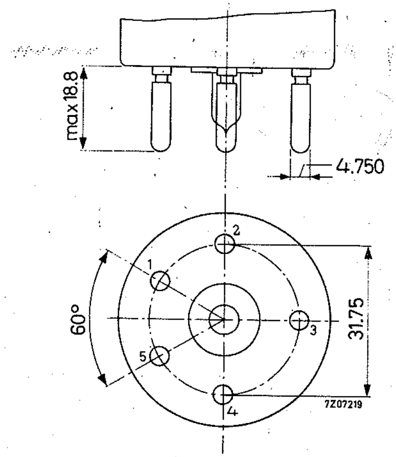
COOLING: FA = forced air; N = natural; W = water; WH = water (helix); V = vapour; H = heatsink

SURVEY

COOLING: forced air

type	band	output power kW	carrier frequency range MHz	power gain dB	tube used	dimensions in mm
Vision						
40771*	IV + V	0,5	470 to 860	15,0	YD1335/YD1336	627 x 239 x 182
40782V*	IV + V	0,6	470 to 860	15,4	YL1590	657 x 190 x 280
40776	III	1,1	170 to 230	20,0	YL1540	618 x 355 x 412
40755	I	1,2	55,25 to 67,25	11,5	YL1440	537 x 343 x 370
	I	1,5	77,25 to 83,25	12,0	YL1440	537 x 343 x 370
40743	III	1,55	170 to 250	14,1	YL1440	673 x 368 x 358
40783*	IV + V	5,5	470 to 860	16,5	YL1560	745 x 490 x 286
40757	I	6,25	55,25 to 67,25	12,0	YL1420	712 x 530 x 569
	I	6,25	77,25 to 83,25	12,7	YL1420	712 x 530 x 569
40745	III	8,6	170 to 230	13,8	YL1420	620 x 610 x 420
40747	III	18,4	170 to 230	14,0	YL1430	620 x 610 x 420
40759	I	13,2	55,25 to 67,25	12,5	YL1430	712 x 530 x 569
	I	13,2	77,25 to 83,25	13,0	YL1430	712 x 530 x 569
	I	20	55,25 to 67,25	13,4	YL1520	700 x 500 x 500
	I	20	77,25 to 83,25	13,8	YL1520	700 x 500 x 500
40768	III	27,5	170 to 230	14,5	YL1520	647 x 680 x 490
Sound						
40782S*	IV + V	1,1	470 to 860	16,4	YL1590	637 x 190 x 220
40778*	II	2,2	88 to 108	22,5	YL1540	330 x 300 x 300
40777	III	2,2	170 to 230	22,5	YL1540	618 x 355 x 412
40756	I	2,4	53 to 88	14,1	YL1440	537 x 343 x 370
40744	III	2,4	170 to 260	14,1	YL1440	673 x 368 x 358
40758	I	10,5	53 to 88	15,0	YL1420	712 x 530 x 569
40746	III	10,5	170 to 230	15,0	YL1420	620 x 610 x 420
40775	II	10,5	88 to 108	22	YL1470	393 x 400 x 632
40760	I	12	53 to 88	15,1	YL1430	712 x 530 x 569
40748	III	13	170 to 230	15,2	YL1430	620 x 610 x 420
40769*	III	25	170 to 230	14,9	YL1520	647 x 680 x 490
Vision and sound						
40770*	IV + V	0,025	470 to 860	20	YD1300	482 x 246 x 88
	IV + V	0,035	470 to 860	20	YD1302	482 x 246 x 88
	IV + V	0,055	470 to 860	19	YD1304	482 x 246 x 88
40771*	IV + V	0,11	470 to 860	16,5	YD1334	525 x 340 x 148
	IV + V	0,22	470 to 860	16,5	YD1336	525 x 340 x 148
40782V*	IV + V	0,22	470 to 860	15,6	YL1590	657 x 190 x 280
40743	III	0,55	175 to 250	14,8	YL1440	673 x 368 x 358
40783*	IV + V	2,2	470 to 860	16,5	YL1560	745 x 490 x 286
40745	III	2,5	175 to 225	14,8	YL1420	620 x 610 x 420
40747	III	7	175 to 225	15,0	YL1430	620 x 610 x 420
40748	III	10,5	175 to 225	16,2	YL1520	647 x 680 x 490

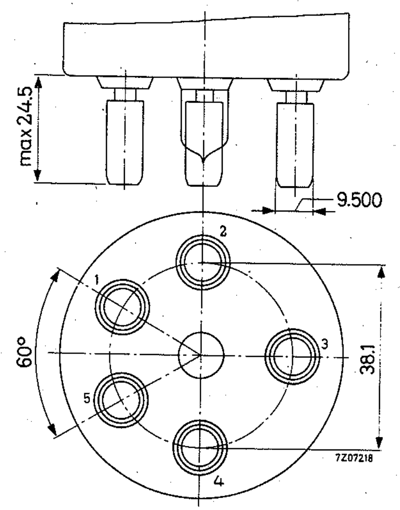
* Data available on request.



Giant 5-pin base
(IEC 67-I-21c)

Types: QB 3/300
QB 3,5/750
QB 4/1100

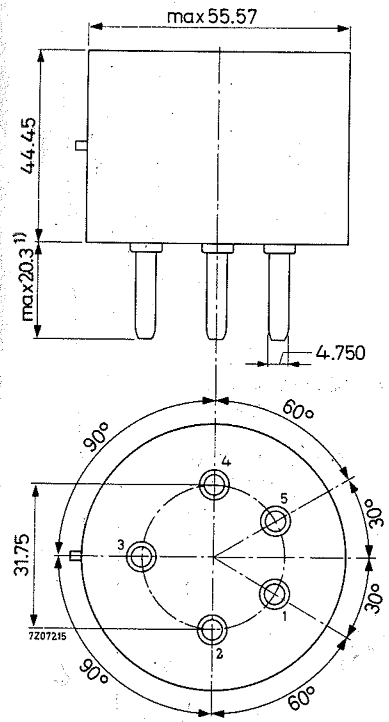
Fig. 1.



Super Giant 5-pin base
(IEC 67-I-22a)

Types: QB 5/1700
QB 5/2000

Fig. 2.

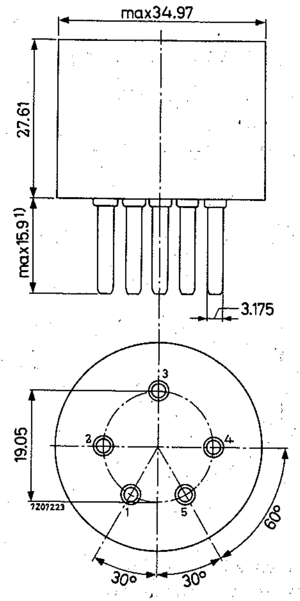


1) Including solder

Fig. 3.

Medium shell Giant 5-pin base
with bayonet
(IEC 67-I-21a)

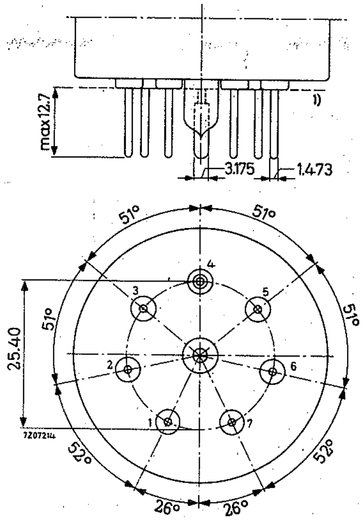
Types: QB 3/300 GA
QB 3,5/750 GA
QB 4/1100 GA



1) Including solder

Fig. 4.

Medium 5-pin base
(IEC 67-I-4a)



1) The reference line is established by the seating plane of the base and is determined by the three highest bosses.

Fig. 5.

Septar 7-pin base
(IEC 67-I-20a)

Types: PE 1/100
QB 3/200

R.F. POWER TRIODE

QUICK REFERENCE DATA									
λ (m)	Freq. (MHz)	C telegr.		C osc.		B teleph.		C_a mod.	
		V_a (V)	W_o (W)	V_a (V)	W_o (W)	V_a (V)	W_o (W)	V_a (V)	W_o (W)
4	75	2500 2000 1500 1000	390 295 210 126			2500 2000 1500	65 64 59	2000 1500 1000	204 153 95
2	150			2500 2000	376 282				
1.5	200			2000	198				

HEATING: direct; filament thoriated tungsten

Filament voltage	V_f	=	6.3	V
Filament current	I_f	=	5.4	A

CAPACITANCES

Anode to all other elements except grid	C_a	=	0.1	pF
Grid to all other elements except anode	C_g	=	4.3	pF
Anode to grid	C_{ag}	=	5.2	pF

TYPICAL CHARACTERISTICS

Amplification factor	μ	=	25	
Mutual conductance	S (I_a = 44 mA)	=	2.8	mA/V

COOLING: radiation/low-velocity air flow

It is necessary to direct a low-velocity air flow to the bottom and the top seal if the tube is used at or near the limiting values at frequencies above 50 MHz .

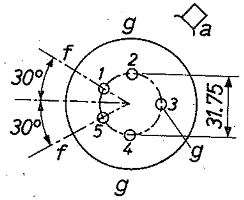
LIMITING VALUES (Absolute limits)

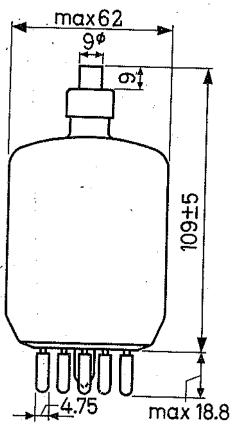
Anode voltage	V_a	= max.	2500	V
Anode dissipation	W_a	= max.	135	W [1])
Grid dissipation	W_g	= max.	16	W
Grid circuit resistance with fixed grid bias	R_g	= max.	0.1	MΩ
Grid circuit resistance with automatic grid bias	R_g	= max.	0.2	MΩ
Cathode current	I_k	= max.	250	mA
Peak cathode current	I_{kp}	= max.	1.6	A
Temperature of anode seal		= max.	220	°C
Bottom temperature		= max.	180	°C

MECHANICAL DATA

Dimensions in mm

Base	: giant 5p
Anode connector	: 40712
Socket	: 2422 512 01001
Socket with grounded grid connections:	40215/01
Net mass	: 110 g





Mounting position: vertical with base up or down

[1]) Anode red hot, temperature = 850 °C

OPERATING CONDITIONS R.F. CLASS C TELEGRAPHY

Wavelength	λ	=	4	4	4	4	m
Anode voltage	V_a	=	2500	2000	1500	1000	V
Grid voltage	V_g	=	-200	-150	-110	-80	V
Anode current	I_a	=	205	205	205	205	mA
Grid current	I_g	=	40	40	40	40	mA
Peak grid A.C. voltage	V_{gp}	=	390	340	300	260	V
Grid input power	W_{ig}	=	14	13	11	10	W
Anode input power	W_{ia}	=	512	410	308	205	W
Anode dissipation	W_a	=	122	115	98	79	W
Output power	W_o	=	390	295	210	126	W
Efficiency	η	=	76	72	68	61.5	%

OPERATING CONDITIONS R.F. CLASS B TELEPHONY

Wavelength	λ	=	4	4	4	m
Anode voltage	V_a	=	2500	2000	1500	V
Grid voltage	V_g	=	-87	-67	-45	V
Anode current	I_a	=	77	97	120	mA
Peak grid A.C. voltage	V_{gp}	=	100	100	100	V
Anode input power	W_{ia}	=	193	194	180	W
Anode dissipation	W_a	=	128	130	121	W
Output power	W_o	=	65	64	59	W
Efficiency	η	=	34	33	33	%
Modulation depth	m	=	100	100	100	%
Grid current	I_g	=	20	28	52	mA
Grid input power	W_{ig}	=	3.6	5.1	9.4	W

OPERATING CONDITIONS R.F. CLASS C ANODE MODULATION; two tubes

Wavelength	λ	=	4	4	4	m
Anode voltage	V_a	=	2000	1500	1000	V
Grid voltage	V_g	=	−225	−180	−130	V
Anode current	I_a	=	255	255	255	mA
Grid current	I_g	=	80	80	80	mA
Peak grid A.C. voltage	V_{gp}	=	415	370	320	V
Grid input power	W_{ig}	=	30	27	23	W
Anode input power	W_{ia}	=	510	382	255	W
Anode dissipation	W_a	=	102	76	65	W
Output power	W_o	=	408	306	190	W
Efficiency	η	=	80	80	74.5	%
Modulation depth	m	=	100	100	100	%
Modulation power	W_{mod}	=	255	191	126	W

OPERATING CONDITIONS AS R.F. CLASS C OSCILLATOR; two tubes

Wavelength	λ	=	2	2	1.5	m
Anode voltage	V_a	=	2500	2000	2000	V
Anode current	I_a	=	410	410	346	mA
Grid current	I_g	=	80	80	80	mA
Grid resistor	R_g	=	2500	1875	1875	Ω
Anode input power	W_{ia}	=	1025	820	692	W
Anode dissipation	W_a	=	245	230	270	W
Grid input power	W_{ig}	=	28	26	26	W
Output power	W_o	=	752	564	396	W
Efficiency	η	=	73	69	57	%

TB2.5/300

OPERATING CONDITIONS AS R.F. CLASS C OSCILLATOR for high frequency heating and diathermy generators

A. With anode voltage from single-phase full-wave rectifier without filter

Wavelength	λ	=	7.3	m
Anode voltage	V_a	=	2000	V [1])
Anode current	I_a	=	170	mA
Grid current	I_g	=	34	mA
Grid resistor	R_g	=	3750	Ω
Anode input power	W_{ia}	=	420	W
Anode dissipation	W_a	=	120	W
Grid input power	W_{ig}	=	10	W
Output power	W_o	=	290	W
Efficiency	η	=	69	%

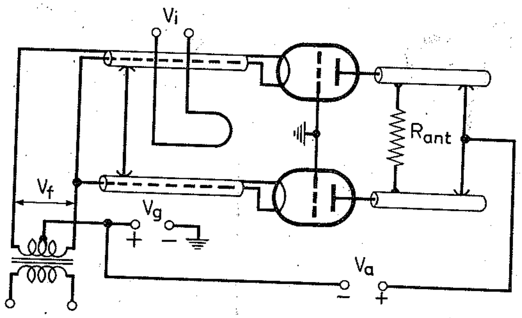
B. With anode and grid alternating voltage. Phase-shift of 180^o between V_a and V_g

Wavelength	λ	=	7.3	m
Anode voltage	V_a	=	2500	V_{RMS}
Anode current	I_a	=	90	mA
Grid current	I_g	=	20	mA
Grid resistor	R_g	=	1700	Ω
Grid voltage	V_g	=	85	V_{RMS}
Anode input power	W_{ia}	=	255	W
Anode dissipation	W_a	=	85	W
Output power	W_o	=	170	W
Efficiency	η	=	67	%

[1]) Mean value

OPERATING CONDITIONS R.F. CLASS C TELEGRAPHY

grounded grid, two tubes



Wavelength	λ	=	3	3	3	3	m
Anode voltage	V_a	=	2500	2000	1500	1000	V
Grid voltage	V_g	=	−200	−150	−110	−80	V
Anode current	I_a	=	410	410	410	410	mA
Grid current	I_g	=	80	80	80	80	mA
Peak grid A.C. voltage	V_{gp}	=	390	340	300	260	V
Grid input power	W_{ig}	=	158	136	118	100	W
Anode input power	W_{ia}	=	1025	820	615	410	W
Anode dissipation	W_a	=	245	230	195	158	W
Output power	W_o	=	780+130	590+110	420+96	252+80	W[1]
Efficiency	η	=	76	72	68	61.5	%[2]

1) Power transferred from driving stage included

2) Pure tube efficiency

A.F. CLASS B AMPLIFIER AND MODULATOR

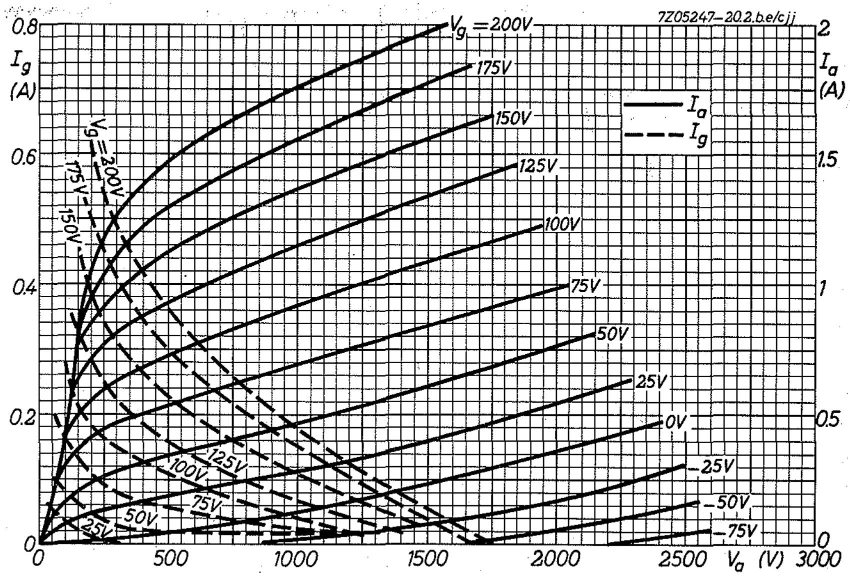
LIMITING VALUES (Absolute limits)

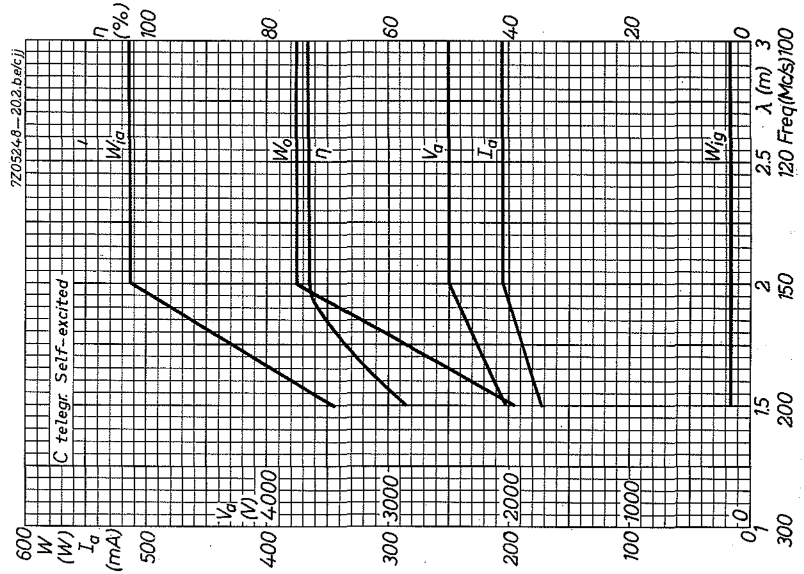
Anode voltage	V_a	=	max.	2500	V
Anode dissipation	W_a	=	max.	135	W
Grid dissipation	W_g	=	max.	16	W
Cathode current	I_k	=	max.	250	mA
Peak cathode current	I_{kp}	=	max.	1.6	A

OPERATING CONDITIONS, two tubes

Anode voltage	V_a	=	2500		2000		V
Grid voltage	V_g	=	−86		−65		V
Load resistance	$R_{aa\sim}$	=	18.2		12.0		kΩ
Peak grid to grid voltage	V_{ggp}	=	0	412	0	394	V
Anode current	I_a	=	2x30	2x178	2x30	2x208	mA
Grid current	I_g	=	0	2x42	0	2x42	mA
Grid input power	W_{ig}	=	0	2x7.8	0	2x7.3	W
Anode input power	W_{ia}	=	2x75	2x445	2x60	2x416	W
Anode dissipation	W_a	=	2x75	2x95	2x60	2x101	W
Output power	W_o	=	0	700	0	630	W
Total harmonic distortion	d_{tot}	=	−	5.0	−	3.7	%
Efficiency	η	=	−	78.5	−	76	%

Anode voltage	V_a	=	1500		1000		V
Grid voltage	V_g	=	−46		−23		V
Load resistance	$R_{aa\sim}$	=	8.5		5.0		kΩ
Peak grid to grid voltage	V_{ggp}	=	0	340	0	295	V
Anode current	I_a	=	2x30	2x210	2x30	2x210	mA
Grid current	I_g	=	0	2x40	0	2x40	mA
Grid input power	W_{ig}	=	0	2x6.1	0	2x5.4	W
Anode input power	W_{ia}	=	2x45	2x315	2x30	2x210	W
Anode dissipation	W_a	=	2x45	2x90	2x30	2x73	W
Output power	W_o	=	0	450	0	274	W
Total harmonic distortion	d_{tot}	=	−	2.9	−	2.2	%
Efficiency	η	=	−	71.5	−	65	%





R.F. POWER TRIODE

QUICK REFERENCE DATA

λ (m)	Freq. (MHz)	C telegr. V_a (V)	C telegr. W_o (W)	C grounded grid V_a (V)	C grounded grid W_o (W)	B teleph. V_a (V)	B teleph. W_o (W)	C_a mod. V_a (V)	C_a mod. W_o (W)
2	150	2500	390			2500	65		
		2000	295			2000	64	2000	205
		1500	210			1500	59	1500	154
		1000	126					1000	96
3	100			2500	910				
				2000	700				
				1500	516				
				1000	332				

λ (m)	Freq. (MHz)	C osc. industrial V_a ⎓ (V)	C osc. industrial W_o (W)	C osc. industrial V_a ∼ (V)	C osc. industrial W_o (W)	B mod. two tubes V_a (V)	B mod. two tubes W_o (W)
6	50	2000	290	2500	170	2500	700
						1000	274

HEATING: direct; filament thoriated tungsten

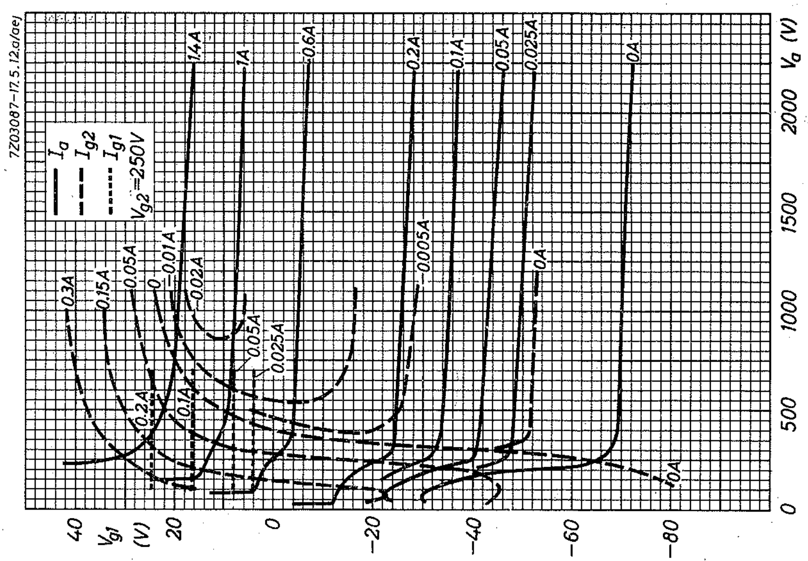
Filament voltage	V_f	=	6.3	V
Filament current	I_f	=	5.8	A

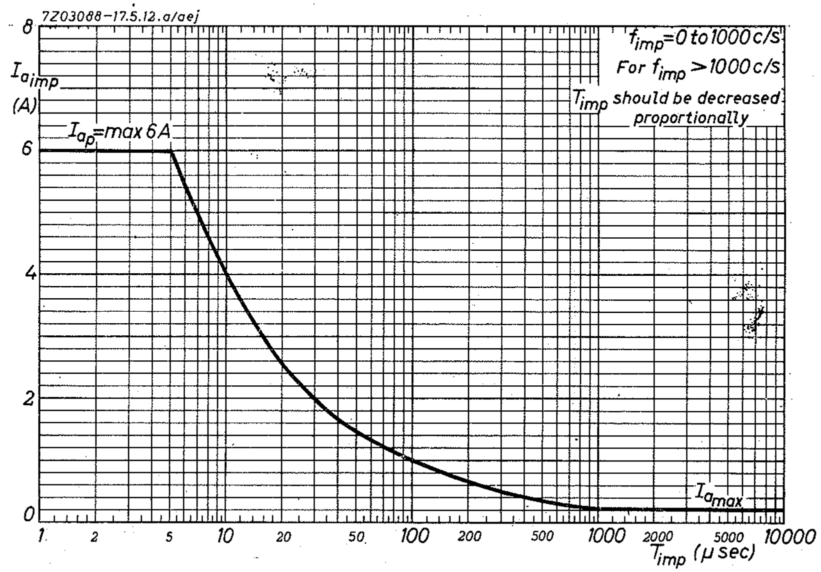
CAPACITANCES

Anode to all other elements except grid	C_a	=	0.1	pF
Grid to all other elements except anode	C_g	=	4.9	pF
Anode to grid	C_{ag}	=	5.0	pF

TYPICAL CHARACTERISTICS

Anode voltage	V_a	=	2500	V
Anode current	I_a	=	60	mA
Amplification factor	μ	=	25	
Mutual conductance	S	=	2.8	mA/V


7Z03087-17.5.12.c/aej
I_a
I_{g2}
I_{g1}
V_{g2}=250V
V_a (V)
V_{g1} (V)
0
500
1000
1500
2000
40
20
0
−20
−40
−60
−80


7Z03088-17.5.12.a/aej
$I_{a_{imp}}$ (A)
f_{imp}=0 to 1000 c/s
For f_{imp} >1000 c/s
T_{imp} should be decreased proportionally
I_{ap}=max 6A
$I_{a_{max}}$
T_{imp} (μ sec)
0
2
4
6
8
1
2
5
10
20
50
100
200
500
1000
2000
5000
10000

R.F. POWER TETRODES

R.F. power tetrodes in coaxial metal-ceramic construction intended for use as v.h.f. amplifier and s.s.b. amplifier. The YL1010 is water cooled. The YL1011 is air cooled. The YL1012 is vapour cooled.

QUICK REFERENCE DATA

R.F. class-AB amplifier, single-sideband				
Frequency	f	30	30	MHz
Anode voltage	V_a	8	10	kV
Output power (P.E.P.)	W_o	30	33	kW
R.F. class-C telegraphy, F.M. telephony				
Frequency	f		220	MHz
Anode voltage	V_a		5,5	kV
Output power	W_o		25	kW
R.F. class-C anode and screen grid modulation				
Frequency	f		30	MHz
Anode voltage	V_a		10	kV
Output power	W_o		55	kW

HEATING: direct, thoriated tungsten filament

Filament voltage	V_f	9	V
Filament current	I_f	200	A

CAPACITANCES

Anode to all except grid 1	$C_{a(g1)}$	42	pF
Grid 1 to all except anode	$C_{g1(a)}$	260	pF
Anode to grid 1	C_{ag1}	1,5	pF

TYPICAL CHARACTERISTICS

Anode voltage	V_a	3	kV
Grid 2 voltage	V_{g2}	1,2	kV
Anode current	I_a	2,5	A
Transconductance	S	65	mA/V
Amplification factor	μ_{g2g1}	6,6	

TEMPERATURE LIMITS AND COOLING

YL1010

Absolute maximum envelope and seal temperature	t_{env}	max	220 °C
Absolute maximum water inlet temperature	t_i	max	50 °C
Required quantity of water	see cooling curves Fig.1, Fig.2		

For temperatures between 20 °C and 50 °C the required quantity of water can be found by linear interpolation.

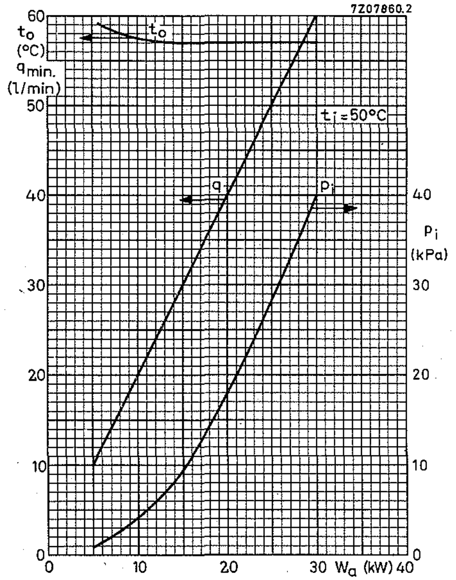


Fig.1.

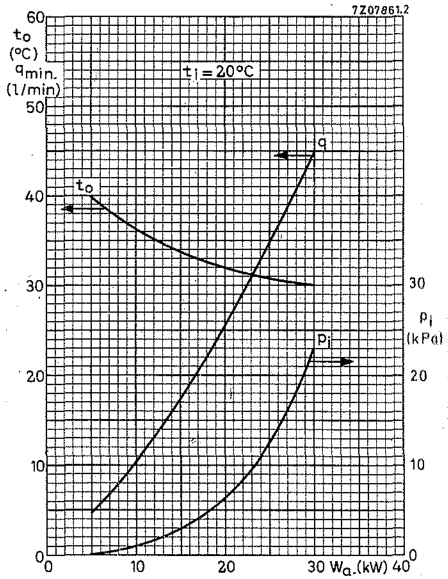


Fig.2.

YL1010
YL1011
YL1012

YL1011

Absolute maximum envelope and seal temperature	t_{env}	max.	220 °C
Required quantity of air, at t_i = 25 °C	see cooling curve below		

At t_i = 35 °C; q_{min} is 15% higher
At t_i = 45 °C; q_{min} is 35% higher

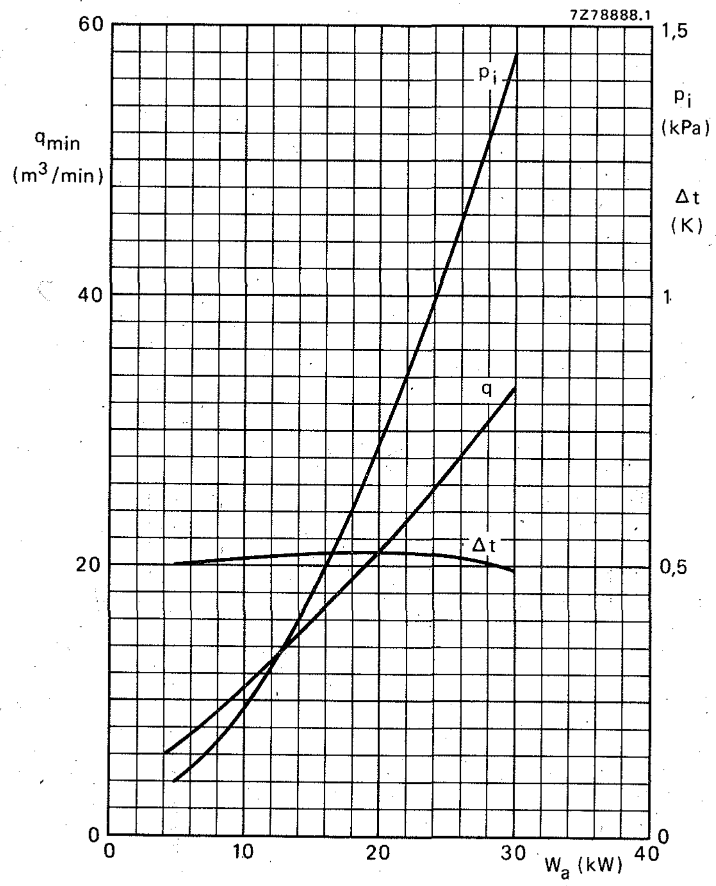


Fig. 3.

YL1012

Absolute maximum envelope and seal temperature	t_{env}	max.	220 °C

MECHANICAL DATA

Dimensions in mm

YL1010

Net mass: ≈ 7 kg

Mounting position: Vertical with anode down.

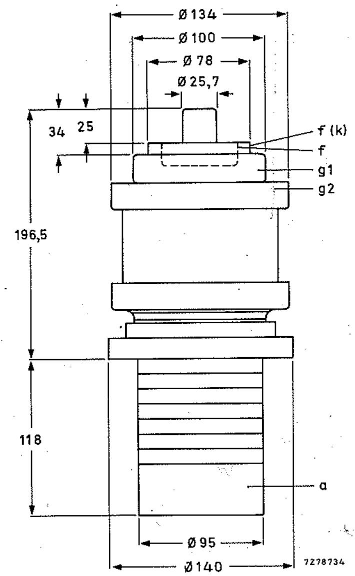


Fig. 4.

ACCESSORIES

Water-jacket	type K732
Inner filament connector	type 40725
Outer filament connector	type 40726
Grid 1 connector	type 40727
Grid 2 connector	type 40728

YL1011

Net mass: ≈ 13,5 kg

Mounting position: Vertical with anode down

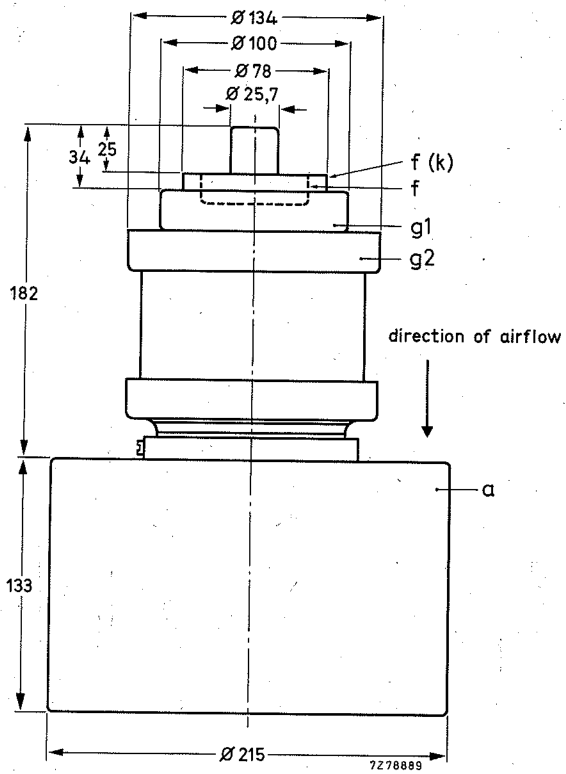


Fig. 5.

ACCESSORIES

Insulating pedestal	type 40729
Inner filament connector	type 40725
Outer filament connector	type 40726
Grid 1 connector	type 40727
Grid 2 connector	type 40728

YL1012

Net mass: ≈ 14,7 kg

Mounting position: Vertical with anode down

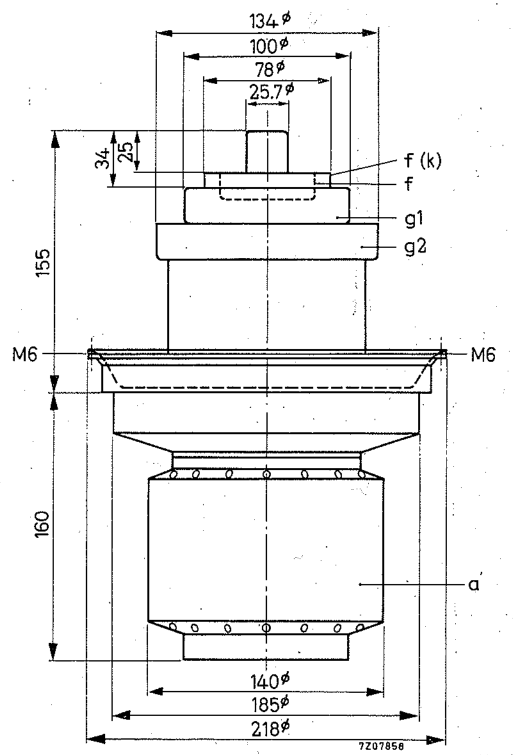


Fig. 6.

ACCESSORIES

Vapour jacket	type K728
Inner filament connector	type 40725
Outer filament connector	type 40726
Grid 1 connector	type 40727
Grid 2 connector	type 40728

R.F. CLASS-AB LINEAR AMPLIFIER, SINGLE-SIDEBAND, suppressed carrier

LIMITING VALUES (Absolute maximum rating system)

Frequency	f	up to	30	MHz
Anode voltage	V_a	max	12	kV
Grid 2 voltage	V_{g2}	max	1,4	kV
Grid 1 voltage	$-V_{g1}$	max	350	V
Anode current	I_a	max	10	A
Anode input power	W_{ia}	max	72	kW
Anode dissipation YL1010, YL1011	W_a	max	30	kW
Anode dissipation YL1012	W_a	max	45	kW
Grid 2 dissipation	W_{g2}	max	600	W
Grid 1 dissipation	W_{g1}	max	300	W

OPERATING CONDITIONS

Frequency	f		30		MHz
Anode voltage	V_a		8		kV
Grid 2 voltage	V_{g2}		1,2		kV
Grid 1 voltage	V_{g1}		−175		V *
		zero signal	single tone	double tone	
Grid 1 driving voltage, peak	V_{g1p}	0	175	175	V
Anode current	I_a	2	5,9	3,8	A
Grid 2 current	I_{g2}	0	250	100	mA
Grid 1 current	I_{g1}	0	0	0	mA
Anode input power	W_{ia}	16	47,2	30,4	kW
Anode dissipation	W_a	16	17,2	15,4	kW
Grid 2 dissipation	W_{g2}	0	300	120	W
Output power (P.E.P.)	W_o	0	30	30	kW
Efficiency	η		63,5	49	%
Intermodulation distortion					
3rd order	d_3			−36	dB **
5th order	d_5			−44	dB **

Notes see next page.

Frequency	f		30		MHz
Anode voltage	V_a		10		kV
Grid 2 voltage	V_{g2}		1,2		kV
Grid 1 voltage	V_{g1}		–185		V *
		zero signal	single tone	double tone	
Grid 1 driving voltage, peak	V_{g1p}	0	185	185	V
Anode current	I_a	2	5,2	3,3	A
Grid 2 current	I_{g2}	0	250	80	mA
Grid 1 current	I_{g1}	0	0	0	mA
Anode input power	W_{ia}	20	52	33	kW
Anode dissipation	W_a	20	19	16,5	kW
Grid 2 dissipation	W_{g2}	0	300	96	W
Output power (P.E.P.)	W_o	0	33	33	kW
Efficiency	η		63	50	%
Intermodulation distortion					
3rd order	d_3			–36	dB **
5th order	d_5			–44	dB **

* Adjust to give the zero signal anode current.
** Maximum values encountered at any level of drive voltage up to full drive referred to the amplitude of either of the two equal tones at that level.

R.F. CLASS-C TELEGRAPHY OR F.M. TELEPHONY, grounded grid

LIMITING VALUES (Absolute maximum rating system)

Frequency	f	up to	220	MHz
Anode voltage	V_a	max	6	kV
Grid 2 voltage	V_{g2}	max	1	kV
Grid 1 voltage	$-V_{g1}$	max	250	V
Anode current	I_a	max	10	A
Anode input power	W_{ia}	max	72	kW
Anode dissipation YL1010, YL1011	W_a	max	30	kW
Anode dissipation YL1012	W_a	max	45	kW
Grid 2 dissipation	W_{g2}	max	300	W
Grid 1 dissipation	W_{g1}	max	200	W

OPERATING CONDITIONS

Frequency	f	220	MHz
Anode voltage	V_a	5,5	kV
Grid 2 voltage	V_{g2}	800	V
Grid 1 voltage	V_{g1}	–200	V
Anode current	I_a	7	A
Grid 2 current	I_{g2}	250	mA
Grid 1 current	I_{g1}	150	mA
Driver output power	W_{dr}	2	kW
Anode input power	W_{ia}	38,5	kW
Anode dissipation	W_a	9	kW
Output power in load	W_ℓ	25	kW *
Efficiency	η	77	%

* Feed-through power included. Measured in a circuit having an efficiency of approx. 85%.

R.F. CLASS-C ANODE AND SCREEN GRID MODULATION (carrier conditions)

LIMITING VALUES (Absolute maximum rating system)

Frequency	f	up to	30 MHz
Anode voltage	V_a	max	10,5 kV
Anode input power	W_{ia}	max	74 kW
Anode dissipation YL1010, YL1011	W_a	max	30 kW
Anode dissipation YL1012	W_a	max	45 kW
Anode current	I_a	max	8,5 A
Grid 2 voltage	V_{g2}	max	900 V
Grid 2 dissipation	W_{g2}	max	600 W
Grid 1 voltage	$-V_{g1}$	max	500 V
Grid 1 dissipation	W_{g1}	max	300 W

OPERATING CONDITIONS

Frequency	f	30 MHz
Anode voltage	V_a	10 kV
Grid 2 voltage	V_{g2}	800 V
Grid 1 voltage	V_{g1}	−340 V
Grid 1 resistor	R_{g1}	300 Ω
Anode current	I_a	6,9 A
Grid 2 current	I_{g2}	500 mA
Grid 1 current	I_{g1}	360 mA
Driver output power	W_{dr}	200 W
Anode input power	W_{ia}	69 kW
Anode dissipation	W_a	14 kW
Output power	W_o	55 kW
Efficiency	η	80 %
Modulation depth	m	100 %
Modulation power	W_{mod}	35 kW
Grid 2 voltage, peak	V_{g2p}	700 V

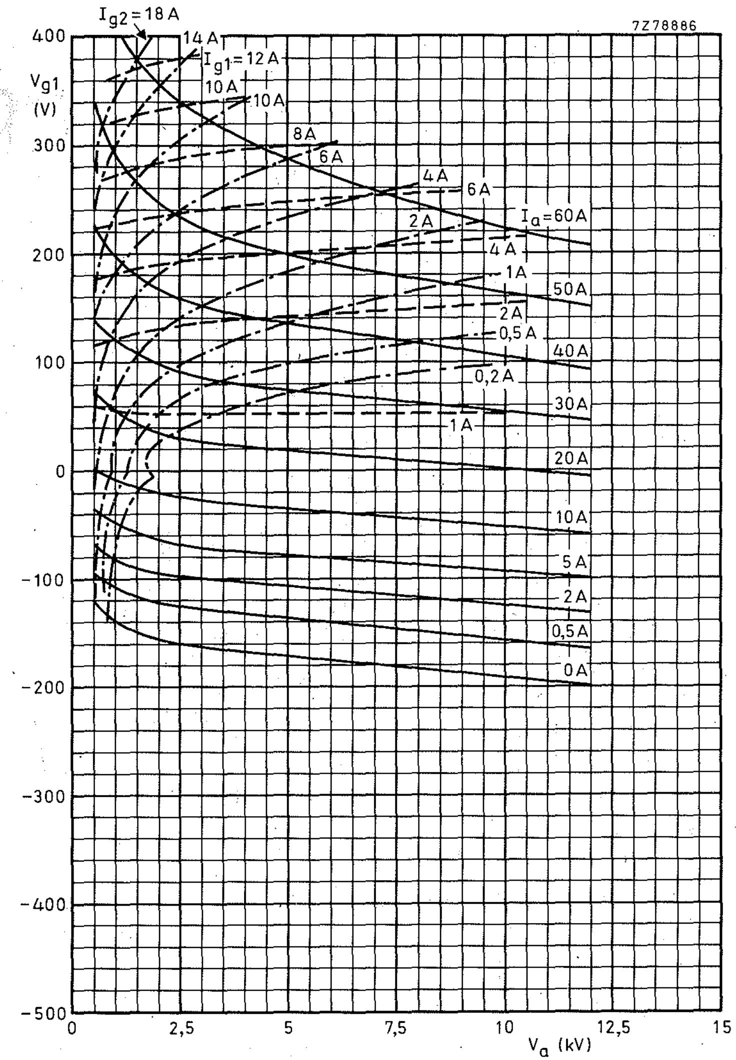


Fig. 7.

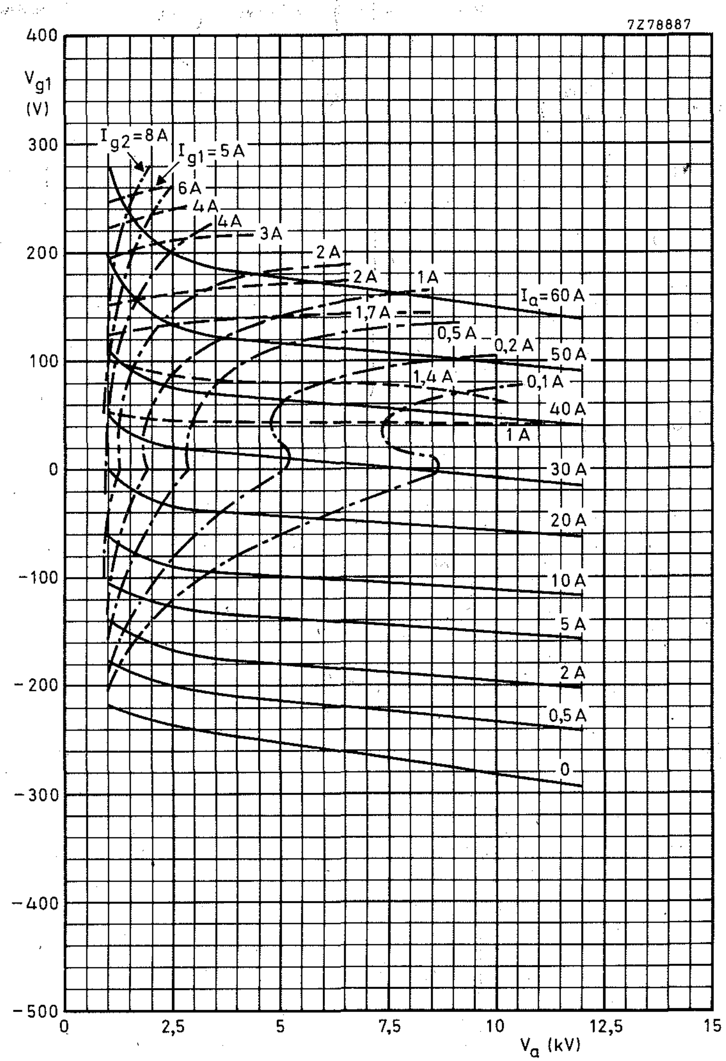


Fig. 8.

R.F. DOUBLE TETRODE

QUICK REFERENCE DATA								
Freq. (MHz)	C telegr.				C_{ag_2} mod.			
	C.C.S.		I.C.A.S.		C.C.S.		I.C.A.S.	
	V_a (V)	W_ℓ [1]) (W)	V_a (V)	W_ℓ [1]) (W)	V_a (V)	W_ℓ [1]) (W)	V_a (V)	W_ℓ [1]) (W)
175	900	132	1000	163	750	85	800	107

HEATING: indirect by A.C. or D.C. Cathode oxide coated

Heater voltage	V_f	=	6.3 V	12.6 V
Heater current	I_f	=	1.8 A	0.9 A
Pins			5-(1+7)	1-7

CAPACITANCES (each system, the elements of the other system being earthed)

Anode to all other elements except grid No.1	C_a	=	3.2 pF
Grid No.1 to all other elements except anode	C_{g_1}	=	10.5 pF
Anode to grid No.1	C_{ag_1}	<	0.09 pF

For internal neutralization (C_n, C_n') please refer to the electrode connections

TYPICAL CHARACTERISTICS (each system)

Anode current	I_a	=	30 mA
Mutual conductance	S	=	4.5 mA/V
Amplification factor	$\mu_{g_2g_1}$	=	8.2

[1]) Useful power in the load