PHILIPS

Data handbook

Electronic components and materials

# Electron tubes

Book T3 1986

# High-power klystrons

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- fundamental research
- leading technologies
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- quality

ADEK

# HIGH-POWER KLYSTRONS

# DATA HANDBOOK SYSTEM

Our Data Handbook System comprises more than 60 books with specifications on electronic components, subassemblies and materials. It is made up of four series of handbooks:

| | |
|---|---|
| ELECTRON TUBES | BLUE |
| SEMICONDUCTORS | RED |
| INTEGRATED CIRCUITS | PURPLE |
| COMPONENTS AND MATERIALS | GREEN |

The contents of each series are listed on pages iv to viii.

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

When ratings or specifications differ from those published in the preceding edition they are indicated with arrows in the page margin. Where application information is given it is advisory and does not form part of the product specification.

Condensed data on the preferred products of Philips Electronic Components and Materials Division is given in our Preferred Type Range catalogue (issued annually).

Information on current Data Handbooks and on how to obtain a subscription for future issues is available from any of the Organizations listed on the back cover.
Product specialists are at your service and enquiries will be answered promptly.

# ELECTRON TUBES (BLUE SERIES)

The blue series of data handbooks comprises:

**T1** **Tubes for r.f. heating**

**T2a** **Transmitting tubes for communications, glass types**

**T2b** **Transmitting tubes for communications, ceramic types**

**T3** **Klystrons**

**T4** **Magnetrons for microwave heating**

**T5** **Cathode-ray tubes**
Instrument tubes, monitor and display tubes, C.R. tubes for special applications

**T6** **Geiger-Müller tubes**

**T8** **Colour display systems**
Colour TV picture tubes, colour data graphic display tube assemblies, deflection units

**T9** **Photo and electron multipliers**

**T10** **Plumbicon camera tubes and accessories**

**T11** **Microwave semiconductors and components**

**T12** **Vidicon and Newvicon camera tubes**

**T13** **Image intensifiers and infrared detectors**

**T15** **Dry reed switches**

**T16** **Monochrome tubes and deflection units**
Black and white TV picture tubes, monochrome data graphic display tubes, deflection units

# SEMICONDUCTORS (RED SERIES)

The red series of data handbooks comprises:

**S1** **Diodes**
Small-signal silicon diodes, voltage regulator diodes (< 1,5 W), voltage reference diodes, tuner diodes, rectifier diodes

**S2a** **Power diodes**

**S2b** **Thyristors and triacs**

**S3** **Small-signal transistors**

**S4a** **Low-frequency power transistors and hybrid modules**

**S4b** **High-voltage and switching power transistors**

**S5** **Field-effect transistors**

**S6** **R.F. power transistors and modules**

**S7** **Surface mounted semiconductors**

**S8a** **Light-emitting diodes**

**S8b** **Devices for optoelectronics**
Optocouplers, photosensitive diodes and transistors, infrared light-emitting diodes and infrared sensitive devices, laser and fibre-optic components

**S9** **Power MOS transistors**

**S10** **Wideband transistors and wideband hybrid IC modules**

**S11** **Microwave transistors**

**S12** **Surface acoustic wave devices**

**S13** **Semiconductor sensors**

# INTEGRATED CIRCUITS (PURPLE SERIES)

The purple series of data handbooks comprises:

| EXISTING SERIES | | Superseded by: |
|---|---|---|
| **IC1** | **Bipolar ICs for radio and audio equipment** | IC01N |
| **IC2** | **Bipolar ICs for video equipment** | IC02Na and IC02Nb |
| **IC3** | **ICs for digital systems in radio, audio and video equipment** | IC01N, IC02Na and IC02Nb |
| **IC4** | **Digital integrated circuits**<br>CMOS HE4000B family | |
| **IC5** | **Digital integrated circuits – ECL**<br>ECL10 000 (GX family), ECL100 000 (HX family), dedicated designs | IC08N |
| **IC6** | **Professional analogue integrated circuits** | IC03N and Supplement to IC11N |
| **IC7** | **Signetics bipolar memories** | |
| **IC8** | **Signetics analogue circuits** | IC11N |
| **IC9** | **Signetics TTL logic** | IC09N and IC15N |
| **IC10** | **Signetics Integrated Fuse Logic (IFL)** | IC13N |
| **IC11** | **Microprocessors, microcomputers and peripheral circuitry** | IC14N |

## NEW SERIES

| | | |
|---|---|---|
| **IC01N** | **Radio, audio and associated systems**<br>Bipolar, MOS | (published 1985) |
| **IC02Na** | **Video and associated systems**<br>Bipolar, MOS<br>Types MAB8031AH to TDA1524A | (published 1985) |
| **IC02Nb** | **Video and associated systems**<br>Bipolar, MOS<br>Types TDA2501 to TEA1002 | (published 1985) |
| **IC03N** | **Integrated circuits for telephony** | (published 1985) |
| **IC04N** | **HE4000B logic family**<br>CMOS | |
| **IC05N** | **HE4000B logic family – incased ICs**<br>CMOS | (published 1984) |
| **IC06N*** | **High-speed CMOS; PC74HC/HCT/HCU**<br>Logic family | (published 1986) |
| **IC07N** | **High-speed CMOS; PC54/74HC/HCT/HCU – uncased ICs**<br>Logic family | |
| **IC08N** | **ECL 10K and 100K logic families** | (published 1984) |
| **IC09N** | **TTL logic series** | (published 1984) |
| **IC10N** | **Memories**<br>MOS, TTL, ECL | |
| **IC11N** | **Linear LSI** | (published 1985) |
| **Supplement to IC11N** | **Linear LSI** | (published 1986) |
| **IC12N** | **Semi-custom gate arrays & cell libraries**<br>ISL, ECL, CMOS | |
| **IC13N** | **Semi-custom**<br>Integrated Fuse Logic | (published 1985) |
| **IC14N** | **Microprocessors, microcontrollers & peripherals**<br>Bipolar, MOS | (published 1985) |
| **IC15N** | **FAST TTL logic series** | (published 1984) |

**Note**

Books available in the new series are shown with their date of publication.

* Supersedes the IC06N 1985 edition and the Supplement to IC06N issued Autumn 1985.

# COMPONENTS AND MATERIALS (GREEN SERIES)

The green series of data handbooks comprises:

**C1** **Programmable controller modules**
PLC modules, PC20 modules

**C2** **Television tuners, coaxial aerial input assemblies, surface acoustic wave filters**

**C3** **Loudspeakers**

**C4** **Ferroxcube potcores, square cores and cross cores**

**C5** **Ferroxcube for power, audio/video and accelerators**

**C6** **Synchronous motors and gearboxes**

**C7** **Variable capacitors**

**C8** **Variable mains transformers**

**C9** **Piezoelectric quartz devices**

**C10** **Connectors**

**C11** **Varistors, thermistors and sensors**

**C12** **Potentiometers, encoders and switches**

**C13** **Fixed resistors**

**C14** **Electrolytic and solid capacitors**

**C15** **Ceramic capacitors**

**C16** **Permanent magnet materials**

**C17** **Stepping motors and associated electronics**

**C18** **Direct current motors**

**C19** **Piezoelectric ceramics**

**C20** **Wire-wound components for TVs and monitors**

**C21*** **Assemblies for industrial use**
HNIL FZ/30 series, NORbits 60-, 61-, 90-series, input devices

**C22** **Film capacitors**

* To be issued shortly.

## U.H.F. POWER KLYSTRONS

| type | status | cooling | output power, peak sync. kW | frequency range MHz |
|---|---|---|---|---|
| YK1001 | M | FA | 11 | 470 to 860 |
| YK1002 | M | W, FA | 11 | 470 to 860 |
| YK1151 | M | FA | 25 | 470 to 860 |
| YK1190 | M | V/VC/W | 45 | 470 to 610 |
| YK1191 | M | V/VC/W | 45 | 590 to 720 |
| YK1192 | M | V/VC/W | 45 | 710 to 860 |
| YK1198 | M | V/VC/W, FA | 60 c.w. | 600 to 800 |
| YK1220 | C | V/VC/W, FA | 16.5 | 470 to 860 |
| YK1223 | P | V/VC/W, FA | 16.5 | 470 to 860 |
| YK1230 | C | V/VC/W, FA | 27 | 470 to 860 |
| YK1233 | P | V/VC/W, FA | 27 | 470 to 860 |
| YK1263 | P | V/VC/W, FA | 58 | 470 to 810 |
| YK1265 | P | V/VC/W, FA | 64 | 470 to 810 |
| YK1295 | C | V/VC/W, FA | 58 | 470 to 610 |
| YK1296 | C | V/VC/W, FA | 58 | 590 to 720 |
| YK1297 | C | V/VC/W, FA | 58 | 710 to 860 |

## HIGH-POWER KLYSTRONS

| type | status | cooling | output power | | centre frequency MHz |
|---|---|---|---|---|---|
| | | | c.w. kW | pulse kW | |
| YK1240 | P | W | – | 330 | 1300 |
| YK1250 | P | W | 400 | – | 999.3 |
| YK1300 | P | W | 600 | – | 499.7 |
| YK1301 | P | W | 800 | – | 499.7 |
| YK1302 | P | V,FA | 800 | – | 508.6 |
| YK1303* | P | V,FA | 1000 | – | 508.6 |
| YK1305 | P | W | 350 | – | 499.7 |
| YK1350 | P | W | 1000 | – | 352.21 |

## PULSED POWER KLYSTRONS

| type | status | cooling | output power kW | gain dB | frequency MHz |
|---|---|---|---|---|---|
| YK1110 | C | W | 6000 | 30 | 2998 ± 5 |
| YK1510 | P | W | 20000 | 44 | S-band |
| YK1511 | P | W | 20000 | 44 | S-band |
| YK1512 | P | W | 20000 | 44 | S-band |
| YK1600 | N | W | 35000 | 53 | 2998.5 |

## S.H.F. POWER KLYSTRONS

| type | status | cooling | output power kW | gain dB | frequency range MHz |
|---|---|---|---|---|---|
| YK1210 | C | FA | 1.15 | 50 | 11800 to 12200 |

COOLING: FA = forced air; W = water; V = vapour; VC = vapour condensation.

* Data available on request.

## CLASSIFICATION

The devices are classified as follows:

N = **New type.** Recommended for new equipment design. Data sheets contain advance information and specifications are subject to change without notice.

P = **Preferred 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.

# GENERAL

# LIST OF SYMBOLS

**1. Symbols denoting electrodes and electrode connections**

| | |
|---|---|
| Anode | a |
| Accelerator electrode | acc |
| Collector electrode | coll |
| Filament or heater | f |
| Filament or heater tap | $f_c$ |
| Grid | g |
| Tube pin which must not be connected externally | i.c. |
| Cathode | k |
| Resonator | res |
| Helical electrode | x |

**2. Symbols denoting voltages**

**Remarks**

a. In the case of indirectly heated tubes the voltages on the various electrodes are with respect to the cathode; in the case of directly heated, d.c. fed tubes, with respect to the negative side of the filament; and in the case of directly heated, a.c. fed tubes, with respect to the electrical centre of the filament, unless otherwise stated.

b. The symbols quoted below represent the average values of the voltages concerned, unless otherwise stated.

| | |
|---|---|
| Anode voltage | $V_a$ |
| Anode voltage in cut-off or in cold condition | $V_{ao}$ |
| Accelerator voltage | $V_{acc}$ |
| Supply voltage of tube electrodes | $V_b$ |
| Collector voltage | $V_{coll}$ |
| Filament or heater voltage | $V_f$ |
| Filament or heater starting voltage | $V_{fo}$ |
| Voltage between focusing electrode and cathode | $V_{foc}$ |
| Grid voltage | $V_g$ |
| A.C. input voltage | $V_i$ |
| Inverse voltage | $V_{inv}$ |
| Voltage between cathode and heater | $V_{kf}$ |
| A.C. output voltage | $V_o$ |
| Peak value of a voltage | $V_p$ |
| Resonator voltage | $V_{res}$ |
| Voltage on helical electrode | $V_x$ |

### 3. Symbols denoting currents

**Remarks**

a. The positive electrical current is directed opposite to the direction of the electron current.

b. The symbols quoted below represent the average values of the currents concerned, unless otherwise stated.

| | |
|---|---|
| Anode current | $I_a$ |
| Accelerator current | $I_{acc}$ |
| Collector current | $I_{coll}$ |
| Filament or heater current | $I_f$ |
| Filament or heater starting current | $I_{fo}$ |
| Peak filament or heater starting current | $I_{fp}$, $I_{fsurge}$ |
| Grid current | $I_g$ |
| Cathode current | $I_k$ |
| Peak value of a current | $I_p$ |
| Resonator current | $I_{res}$ |
| Current to helical electrode | $I_x$ |

### 4. Symbols denoting powers

| | |
|---|---|
| Anode dissipation | $W_a$ |
| Collector dissipation | $W_{coll}$ |
| A.C. driving power | $W_{dr}$ |
| Grid dissipation | $W_g$ |
| Input power | $W_i$ |
| D.C. anode supply power | $W_{ia}$ |
| Peak input power | $W_{ip}$ |
| Output power | $W_o$ |
| Peak output power | $W_{op}$ |
| Resonator dissipation | $W_{res}$ |

### 5. Symbols denoting capacitances

Measured on the cold tubes.

| | |
|---|---|
| Capacitance between anode and all other elements except control grid | $C_a$ |
| Capacitance between anode and grid (all other elements being earthed) | $C_{ag}$ |
| Capacitance between anode and cathode (all other elements being earthed) | $C_{ak}$ |
| Capacitance between a grid and all other elements except anode | $C_g$ |
| Capacitance between a grid and cathode (all other elements being earthed) | $C_{gk}$ |

**6. Symbols denoting resistances**

| | |
|---|---|
| External a.c. resistance in anode lead or matching resistance | $R_a$ |
| Filament or heater resistance in cold condition | $R_{fo}$ |
| External resistance in a grid lead | $R_g$ |
| Internal resistance of a tube | $R_i$ |
| External resistance in a cathode lead | $R_k$ |
| External resistance between cathode and heater | $R_{kf}$ |

**7. Symbols denoting various quantities**

| | |
|---|---|
| Bandwidth | B |
| Noise factor | F |
| Frequency | f |
| Pulse repetition rate | $f_{imp}$ |
| Power gain | |
| Magnetic field strength | H |
| Height above sea level | h |
| Pressure drop of cooling air or cooling water | $\Delta p$ |
| Required air flow or water flow for cooling | q |
| Transconductance | S |
| Temperature of anode or anode block | $T_a$ |
| Ambient temperature | $T_{amb}$ |
| Averaging time of current or voltage | $t_{av}$ |
| Inlet temperature of cooling air or cooling water | $T_i$ |
| Pulse duration | $t_{imp}$ |
| Outlet temperature of cooling air or cooling water | $T_o$ |
| Time of rise of voltage | $t_{rv}$ |
| Cathode preheating time, also called waiting time; the minimum period of time during which the heater or filament voltage should be applied before the application of electrode voltages | $t_w$ |
| Rate of rise of voltage | $\frac{dV_a}{dt}$, $\frac{\Delta V}{\Delta t_{rv}}$ |
| Voltage standing-wave ratio | VSWR |
| Reflection coefficient | $\sigma$ |
| Duty factor | $\delta$ |
| Efficiency | $\eta$ |
| Wavelength | $\lambda$ |
| Amplification factor | $\mu$ |
| Temperature, relative | $\theta$ |

# TUBES FOR MICROWAVE EQUIPMENT
# DEFINITIONS

B — Bandwidth.

$\Delta f/\Delta T$ — The temperature coefficient $\Delta f/\Delta T$ is the change of frequency with temperature.

$f_{imp}$ — Pulse repetition rate.

$\Delta f_p$ — The pulling figure $\Delta f_p$ is the difference between the maximum and minimum frequencies, reached when the phase angle of the load with a VSWR of 1,5 is varied from $0^o$ to $360^o$.

H — Magnetic field strength.

$t_{imp}$ — The pulse duration $t_{imp}$ is defined as the time interval between the two points on the current pulse at which the current is 70% of the smooth peak current (see Fig.1).

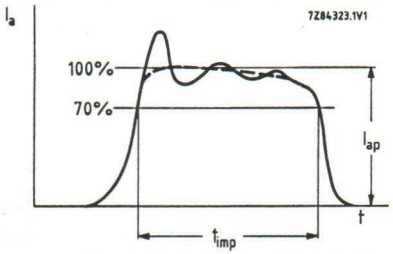



Fig. 1 Current pulse.

The smooth peak is the maximum value of a smooth curve through the average of the fluctuation over the top portion of the pulse.

$t_{rv}$ — The time of rise of voltage $t_{rv}$ is defined as the time interval between points of 10 and 90 per cent of the smooth peak value measured on the leading edge of the voltage pulse.

$T_a$ — Temperature of anode or anode block.

VSWR — The voltage standing-wave ratio in a waveguide is the ratio of the amplitude in the electrical field at a voltage maximum to that at an adjacent minimum.

$dV_a/dt$ or $\Delta V_a/\Delta t_{rv}$ — Unless otherwise stated the rate of rise of voltage $dV_a/dt$ is defined by the steepest tangent to the leading edge of the voltage pulse above 80% of the smooth peak value (see Fig. 2).

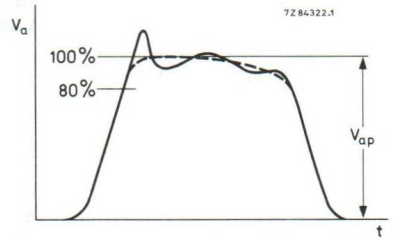



Fig. 2 Voltage pulse.

$\delta$ — The duty factor $\delta$ is the ratio of the pulse duration to the time between corresponding points of two successive pulses.

# RECTANGULAR WAVEGUIDE DATA AND DESIGNATIONS

| FREQUENCY RANGE $TE_{10}$ - mode 153-IEC* GHz | WAVEGUIDE DESIGNATION 153-IEC* | BRITISH STAND. | RETMA | JAN RG- /U brass | JAN RG- /U alum. | BAND PREFIX | WAVEGUIDE Inner cross-section 153-IEC* Width mm | Height mm | Tolerance on width and height ± | WAVEGUIDE Outer cross-section 153-IEC* Width mm | Height mm | Tolerance on width and height ± | ATTENUATION in dB/m for copper waveguide 153-IEC* Frequency GHz | Theoretical value | Maximum value | Theoretical C. W. power rating** lowest to highest frequency MW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.14 — 1.73 | R 14 | WG 6 | WR 650 | 69 | 103 | L | 165.10 | 82.55 | 0.33 | 169.16 | 86.61 | 0.20 | 1.36 | 0.00522 | 0.007 | 12.0 —17.0 |
| 1.45 — 2.20 | R 18 | WG 7 | WR 510 | — | — | D | 129.54 | 64.77 | 0.26 | 133.60 | 68.83 | 0.20 | 1.74 | 0.00749 | 0.010 | 7.5 —11.0 |
| 1.72 — 2.61 | R 22 | WG 8 | WR 430 | 104 | 105 | — | 109.22 | 54.61 | 0.22 | 113.28 | 58.67 | 0.20 | 2.06 | 0.00970 | 0.013 | 5.2 — 7.5 |
| 2.17 — 3.30 | R 26 | WG 9A | WR 340 | 112 | 113 | — | 86.36 | 43.18 | 0.17 | 90.42 | 47.24 | 0.17 | 2.61 | 0.0138 | 0.018 | 3.4 — 4.8 |
| 2.60 — 3.95 | R 32 | WG 10 | WR 284 | 48 | 75 | S | 72.14 | 34.04 | 0.14 | 76.20 | 38.10 | 0.14 | 3.12 | 0.0189 | 0.025 | 2.2 — 3.2 |
| 3.22 — 4.90 | R 40 | WG 11A | WR 229 | — | — | A | 58.17 | 29.083 | 0.12 | 61.42 | 32.33 | 0.12 | 3.87 | 0.0249 | 0.032 | 1.6 — 2.2 |
| 3.94 — 5.99 | R 48 | WG 12 | WR 187 | 49 | 95 | G | 47.55 | 22.149 | 0.095 | 50.80 | 25.40 | 0.095 | 4.73 | 0.0355 | 0.046 | 0.94 — 1.32 |
| 4.64 — 7.05 | R 58 | WG 13 | WR 159 | — | — | C | 40.39 | 20.193 | 0.081 | 43.64 | 23.44 | 0.081 | 5.57 | 0.0431 | 0.056 | 0.79 — 1.0 |
| 5.38 — 8.17 | R 70 | WG 14 | WR 137 | 50 | 106 | J | 34.85 | 15.799 | 0.070 | 38.10 | 19.05 | 0.070 | 6.46 | 0.0576 | 0.075 | 0.56 — 0.71 |
| 6.57 — 9.99 | R 84 | WG 15 | WR 112 | 51 | 68 | H | 28.499 | 12.624 | 0.057 | 31.75 | 15.88 | 0.057 | 7.89 | 0.0794 | 0.103 | 0.35 — 0.46 |
| 7.00 — 11.00 | — | — | WR 102 | — | 320 | T | 25.90 | 12.95 | 0.125 | 29.16 | 16.21 | 0.125 | — | — | — | 0.33 — 0.43 |
| 8.2 — 12.5 | R 100 | WG 16 | WR 90 | 52 | 67 | X | 22.860 | 10.160 | 0.046 | 25.40 | 12.70 | 0.05 | 9.84 | 0.110 | 0.143 | 0.20 — 0.29 |
| 9.84 — 15.0 | R 120 | WG 17 | WR 75 | — | — | M | 19.050 | 9.525 | 0.038 | 21.59 | 12.06 | 0.05 | 11.8 | 0.133 | — | 0.17 — 0.23 |
| 11.9 — 18.0 | R 140 | WG 18 | WR 62 | 91 | — | P | 15.799 | 7.899 | 0.031 | 17.83 | 9.93 | 0.05 | 14.2 | 0.176 | — | 0.12 — 0.16 |
| 14.5 — 22.0 | R 180 | WG 19 | WR 51 | — | — | — | 12.954 | 6.477 | 0.026 | 14.99 | 8.51 | 0.05 | 17.4 | 0.238 | — | 0.080 — 0.107 |
| 17.6 — 26.7 | R 220 | WG 20 | WR 42 | 53 | 121 | — | 10.668 | 4.318 | 0.021 | 12.70 | 6.35 | 0.05 | 21.1 | 0.370 | — | 0.043 — 0.058 |
| 21.7 — 33.0 | R 260 | WG 21 | WR 34 | — | — | — | 8.636 | 4.318 | 0.020 | 10.67 | 6.35 | 0.05 | 26.1 | 0.435 | — | 0.034 — 0.048 |
| 26.4 — 40.0 | R 320 | WG 22 | WR 28 | — | — | — | 7.112 | 3.556 | 0.020 | 9.14 | 5.59 | 0.05 | 31.6 | 0.583 | — | 0.022 — 0.031 |
| 32.9 — 50.1 | R 400 | WG 23 | WR 22 | — | — | — | 5.690 | 2.845 | 0.020 | 7.72 | 4.88 | 0.05 | 39.5 | 0.815 | — | 0.014 — 0.020 |
| 39.2 — 59.6 | R 500 | WG 24 | WR 19 | — | — | — | 4.775 | 2.388 | 0.020 | 6.81 | 4.42 | 0.05 | 47.1 | 1.060 | — | 0.011 — 0.015 |
| 49.8 — 75.8 | R 620 | WG 25 | WR 15 | — | — | — | 3.759 | 1.880 | 0.020 | 5.79 | 3.91 | 0.05 | 59.9 | 1.52 | — | 0.0063 — 0.0090 |
| 60.5 — 91.9 | R 740 | WG 26 | WR 12 | — | — | — | 3.099 | 1.549 | 0.020 | 5.13 | 3.58 | 0.05 | 72.6 | 2.03 | — | 0.0042 — 0.0060 |
| 73.8 —112.0 | R 900 | WG 27 | WR 10 | — | — | — | 2.540 | 1.270 | 0.020 | 4.57 | 3.30 | 0.05 | 88.6 | 2.74 | — | 0.0030 — 0.0041 |
| 92.2 —140.0 | R 1200 | WG 28 | WR 8 | — | — | — | 2.032 | 1.016 | 0.020 | 4.06 | 3.05 | 0.05 | 111.0 | 3.82 | — | 0.0018 — 0.0026 |
| 114.0 —173.0 | R 1400 | WG 29 | WR 7 | — | — | — | 1.651 | 0.826 | — | — | — | — | 136.3 | 5.21 | — | 0.0012 — 0.0017 |

* IEC Recommendations are obtainable from :
Central Office of the International Electrotechnical Commission
1, rue de Varembé
GENEVA, Switzerland

** based on breakdown of air of 15,000 volts per cm (safety factor of approx. 2 at sea level)

# FLANGE DESIGNATIONS

| FOR WAVEGUIDE 153 - IEC* | FLANGE DESIGNATION | | | | | |
|---|---|---|---|---|---|---|
| | PLAIN FLANGE | | | CHOKE FLANGE | | |
| | 154 - IEC | JAN UG /U | | 154 - IEC | JAN UG /U | |
| | | Brass | Aluminium | | Brass | Aluminium |
| R 14 | PDR 14 | 417A | 418A | | | |
| R 18 | PDR 18 | | | | | |
| R 22 | PDR 22 | 435A | 437A | | | |
| R 26 | PDR 26 | 553 | 554 | | | |
| R 32 | UER 32 PDR 32<br>PAR 32 UAR 32 | 53 | 584 | CAR 32 | 54A | 585A |
| R 40 | UER 40 PDR 40 | | | | | |
| R 48 | PAR 48 PDR 48<br>UAR 48 UER 48 | 149A | 407 | CAR 48 | 148C | 406B |
| R 58 | PAR 58 PDR 58<br>UAR 58 UER 58 | | | CAR 58 | | |
| R 70 | PAR 70 PDR 70<br>UAR 70 UER 70 | 344 | 441 | CAR 70 | 343B | 440B |
| R 84 | PBR 84 PDR 84<br>UBR 84 UER 84 | 51 | 138 | CBR 84 | 52B | 137B |
| R 100 | PBR 100 PDR 100<br>UBR 100 UER 100 | 39 | 135 | CBR 100 | 40B | 136B |
| R 120 | | | | | | |
| R 140 | PBR 140 UBR 140 | 419 | | CBR 140 | 541A | |
| R 180 | | | | | | |
| R 220 | PBR 220 UBR 220<br>PCR 220 | 595 | 597 | CBR 220 | 596A | 598A |
| R 260 | PCR 260 | | | | | |
| R 320 | PBR 320 PCR 320<br>UBR 320 | 599 | | CBR 320 | 600A | |
| R 400 | PCR 400 | 383 | | | | |
| R 500 | PCR 500 PAR 500 | | | | | |
| R 620 | PCR 620 PFR 620 | 385 | | | | |
| R 740 | PCR 740 PFR 740 | 387 | | | | |
| R 900 | PCR 900 PFR 900 | | | | | |
| R 1200 | PCR1200 PFR 1200 | | | | | |

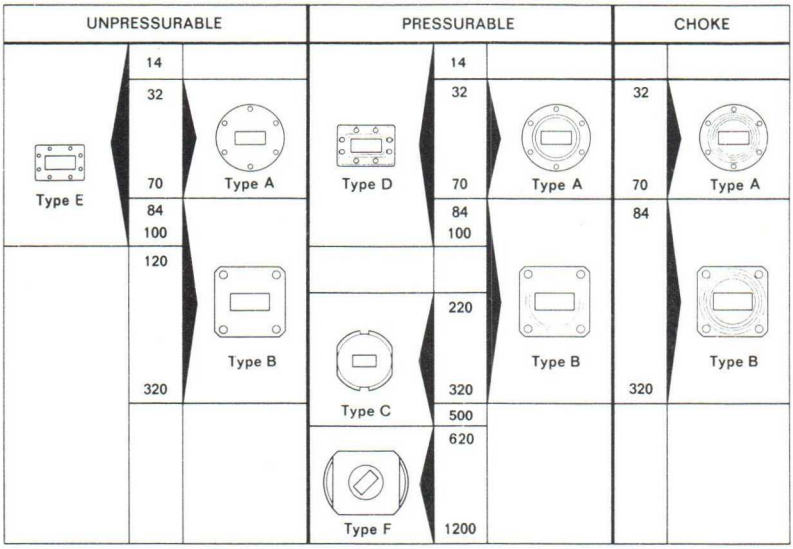
## IEC

Waveguide flanges covered by IEC recommendation shall be indicated by a reference number comprising the following information:

a. the number of the present IEC publication.
b. the letter "IEC".
c. a dash.
d. a letter relating to the basic construction of the flange

P = pressurable
C = choke, pressurizable
U = unpressurizable

e. a letter for the type according to the drawing. Flanges with the same letter and of the same waveguide size can be mated.
f. the letter and number of the waveguide for which the flange is designed.




* IEC Recommendations are obtainable from :

Central Office of the
International Electrotechnical Commission
1, rue de Varembé
GENEVA, Switzerland

# GENERAL OPERATIONAL RECOMMENDATIONS
# KLYSTRONS

## 1. GENERAL

### 1.1 Data

The characteristic data, operational data, capacitance values and curves apply to an average tube which is characteristic of the type of tube in question.

### 1.2 Reference point of the electrode voltages

If not otherwise stated the electrode voltages are given with respect to the cathode.

### 1.3 Operational data

The operational data stated in the data sheets do not relate to any fixed setting instructions. They should rather be regarded as recommendations for the effective use of the tube. On account of the tolerances prevailing, deviations from the settings stated may occur.

It is also possible to use other settings, for which purpose the graphs can be used for finding the operational data, or for which purpose interpolation between the settings stated can be performed. If one wishes to deviate from the settings recommended in the data sheets, one should take great care not to exceed the permissible limiting values. If appreciable deviations occur, the manufacturer should be consulted.

A general rule for multi-cavity klystrons is that the accelerator electrode voltage and/or the focusing electrode voltage must be adjusted so that the cathode current stated will flow.

### 1.4 D.C. connections

At all times there should be a d.c. connection between each electrode and the cathode. If necessary, limiting values have been stated for the resistance of these connections.

### 1.5 Mounting and removal

The instructions relating to each type of tube can be found in the data sheets and the "Instructions for operation and maintenance".
The mounting and removal should be effected with extreme care to avoid damage to the tube. This also applies to rejected tubes, where claims are made under guarantee.

Ferromagnetic parts must not be used in the vicinity of klystrons equipped with a permanent magnet, as this might have a detrimental effect on the operation of the klystron. If necessary, the ceramic insulators and windows must be carefully cleaned, as dirt may damage the klystron on account of local overheating. Naturally the flange of the output cavity must also be thoroughly cleaned so as to prevent arcing.

The "Instructions for operation and maintenance" should in all cases be followed.

### 1.6 Accessories

Perfect operation of the tubes can only be guaranteed if use is made of the accessories which the manufacturer designed for the tube.

### 1.7 Supply leads

The supply leads to the connections and terminals must be of such a quality that no mechanical stresses, due to differences in temperature or other causes, can occur.

### 1.8 Danger of radiation

In general the absorption in the tissues of the body, and hence the danger, is the greater the shorter the wavelength of the h.f. radiation for equal output. The output of klystrons may be so high that injuries (in particular of the eye) can be inflicted.

Klystrons operated at a high voltage (exceeding 16 kV) may, moreover, emit X-rays of appreciable intensity, which call for protection of the operators.

## 2. LIMITING VALUES

### 2.1 Absolute limiting values

In all cases the limiting values stated are absolute maximum or minimum values. They apply either to all settings or to the various modes of operation. The values stated should in no case be exceeded, neither on account of mains voltage fluctuations and load variations, nor on account of production tolerances in the various building elements (resistors, capacitors, etc.) and tubes, or as a result of meter tolerances when setting the voltages and currents.

Every limiting value should be regarded as the permissible absolute maximum independent of other values. It is not permitted to exceed one limiting value because another is not reached. For instance, one should not allow the limiting value of the collector current to be surpassed while reducing the collector voltage below the permissible limiting value.

If in special cases it should be necessary to exceed a specific limiting value, it is advisable to consult the tube manufacturer, as otherwise no claims can be made.

### 2.2 Protective circuit

To prevent the limiting values of voltages, currents, outputs and temperatures from being exceeded, fast-operating protective circuits must be provided.

### 2.3 Drift current

The limiting value indicated for the drift current is an arithmetical mean value.

## 3. NOTES ON OPERATION

### 3.1 Operational data and variations

When developing electrical equipment the spread in the tube data must be taken into account; if necessary, the tube tolerances can be applied for.

With respect to the spread in the operational data and the average values stated in the data sheets it is recommended that a certain margin be allowed for in the output and input powers when designing equipment intended for series production.

### 3.2 Input power, required driving power

In the data sheets the power stated is the input power $W_{dr}$ fed to the input cavity and measured between the circulator and this cavity with a 50-ohm resistor serving as a substitute for the load presented by the cavity.

### 3.3 Output power

As a general principle the effective output power is stated.

### 3.4 Sequence of application of the electrode voltages

With multi-cavity klystrons the electrode voltages must be connected in the order given in the operating instructions.

### 3.5 Drift current

When the klystron is driven by an a.m. signal (for instance a video signal), the drift current fluctuates with the modulation. Consequently, the power supply unit must be designed so as to be suitable for the peak values occurring, which may be appreciably higher than the arithmetical mean values stated.

## 4. HEATING

### 4.1 Type of current

Klystrons can be heated by means of either standard alternating current or direct current. At other frequencies the tube manufacturer should be consulted.

### 4.2 Adjusting the heater voltage

The heater voltage generally governs the adjustment of the heating, while the heater current may deviate from its nominal value within fixed tolerances. The heater voltage should be maintained as accurately as possible. For measuring the heater voltage a r.m.s. voltmeter is required. This meter must be directly connected to the filament terminals of the tube and have an inaccuracy $< 1{,}5\%$ in the voltage range concerned. The indicated measuring value should lie in the uppermost third of the scale.

### 4.3 Switching on the heater current

If the data sheet does not contain special data concerning the heater current during switch-on, the tube may be switched on at full heater voltage.

If maximum values are stated for the heater current during switch-on, they relate to the absolute maximum instantaneous value under unfavourable conditions. In the case of a.c. supply this value will occur if the tube is switched on at the maximum amplitude of the highest mains voltage. It is possible to calculate the maximum current during switch-on if the cold resistance and the relationship between the heater current and the heater voltage is known. In practice a heater transformer more or less acting as a leakage transformer is mostly used for limiting the starting current, or a choke coil or resistor is connected in series with the primary of the heater transformer. This choke coil or resistor can be short-circuited by a relay whose action is delayed by about 15 seconds. By means of a calibrated oscilloscope it can be checked whether the starting current remains within the permissible limits; the supply lead may, if necessary, be used as measuring resistance.

## 5. COOLING

### 5.1 Forced-air cooling

It is essential that the faces of tubes that are to be cooled by an air-blast should be hit as evenly as possible by the air stream, so as to prevent large differences in temperature which may give rise to mechanical stresses. In many cases (in particular with the large types of tubes) an additional air stream must be directed to the metal-to-ceramic seals. The cooling air is usually supplied from a fan via an insulating duct. This air should be filtered, so that all impurities and moisture are removed; in addition to this the radiator must be cleaned at regular intervals. The data concerning the cooling can be found in the data sheets. The cooling must be switched on together with the heating. After the klystron has been switched off cooling air must be supplied for some time; this period depends on the size of the tube and the load. If the cooling of whatever part of the tube is interrupted or if the quantity of cooling air is too small, the collector voltage and the heating must be switched off automatically.

### 5.2 Water cooling

With water-cooled klystrons the cooling equipment is rigidly attached to the tube. If the equipment should be live, the cooling water must be supplied through insulating pipes, of sufficient length.

The water cooling and air cooling for other parts of the tube must be switched on together with the heating. The cooling-water circuit must be arranged so that the water always enters at the bottom, no matter how the tube is mounted. If the pumps should be out of operation, the water jacket(s) of the tube must always be full. In that case after-cooling may in general be done away with.

In many cases the metal-to-glass or metal-to-ceramic seals require additional cooling by a low-velocity air flow. If the cooling-water supply or additional air cooling should fail, the collector voltage and heating must immediately be switched off. Further cooling data can be found in the data sheets.

The specific resistance of the cooling water must be minimum 20 kΩ·cm, the temporary hardness must be maximum 6 German degrees of hardness. In principle distilled water should be used in the circulation cooler; to reduce the corrosive effect of the distilled water about 700 mg of 24% hydrazin hydrate and 700 mg sodium silicate must be added per litre. The pH-value should range from 7 to 9.

If frost is to be expected, a standard glycol based antifreeze for cars, like Glysantin should be added.

### 5.3 Vapour cooling

The conversion of water of 100 °C to steam of 100 °C requires an energy of 2256 kJ/ℓ.
This energy is extracted from the collector which by this means is cooled very effectively.

The cooling system may be designed as a closed circuit where the steam is ducted upwards or downwards to the applied heat exchanger. Due to a strong deposit of minerals during the continued variation of the aggregate state, the use of distilled water is absolutely necessary. When commencing operation a multiple change of the complete cooling water is recommended to dispose deteriorations of the systems.

The loss of coolant during operation is very low (1 ℓ per week approx).

It is obvious, that a vapour cooling system is advantageous only in stationary assemblies and for high dissipation levels. This, however, yields another advantage of vapour cooling. The energy, generated in the heat exchanger, can be used very effectively i. e. for heating purposes.

## 6. STORAGE

Klystrons may only be stored in their original packing and according to the instructions, so as to avoid damage. For fitting, the tubes must be removed from the packing and directly inserted into the support. In all cases the "Instructions for operation and maintenance" must be adhered to.

In the case of prolonged storage the vacuum of high-power klystrons should be checked at intervals of about three months and improved if necessary, both being possible with the aid of the built-in getter ion pump and a suitable power supply/test unit. During this operation the heater supply should preferably be turned on slowly.

# 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.

# HIGH-POWER KLYSTRONS

# U.H.F. POWER KLYSTRONS

Power amplifier klystrons in metal-ceramic construction for the frequency band 470 MHz to 860 MHz designed for four external resonant cavities, beam focusing by means of permanent magnets, continuously operating getter-ion pump and operation with a depressed collector potential. These klystrons are intended for use as u.h.f. power amplifier in vision and/or sound transmitters for the TV bands IV and V.

## QUICK REFERENCE DATA

| | |
|---|---|
| Frequency range | 470 to 860 MHz |
| Power output | 11 kW |
| Power gain | 30 dB |
| Cooling | |
| YK1001: air-cooled drift tubes and air-cooled collector | |
| YK1002: air-cooled drift tubes and water-cooled collector | |

This data must be read in conjunction with GENERAL OPERATIONAL RECOMMENDATIONS for KLYSTRONS.

**HEATING**: indirect by a.c. or d.c.

| | | | |
|---|---|---|---|
| Cathode | | dispenser type | |
| Heater voltage | $V_f$ | 7.5 to 8.0 | V |

During operation the applied heater voltage should not fluctuate more than ± 3%. It is advised to operate the klystron at 8 to 8.5 V (including mains fluctuations) during the first 300 hours. The heater voltage should then be reduced to 7.5 to 8.0 V.

| | | | |
|---|---|---|---|
| Heater current | $I_f$ | 32 ($\leqslant$ 36) | A |

The heater current should never exceed a peak value of 80 A when applying an a.c. heater voltage or 65 A when applying a d.c. heater voltage.

| | | | |
|---|---|---|---|
| Cold heater resistance | $R_{fo}$ | 28 | mΩ |
| Waiting time | $t_w$ min. | 180 | s |

**GETTER-ION PUMP POWER SUPPLY**

| | | | |
|---|---|---|---|
| Pump voltage, unloaded (cathode reference) | | 4.0 | kV |
| Internal resistance | approx. | 300 | kΩ |

## MECHANICAL DATA

Dimensions in mm

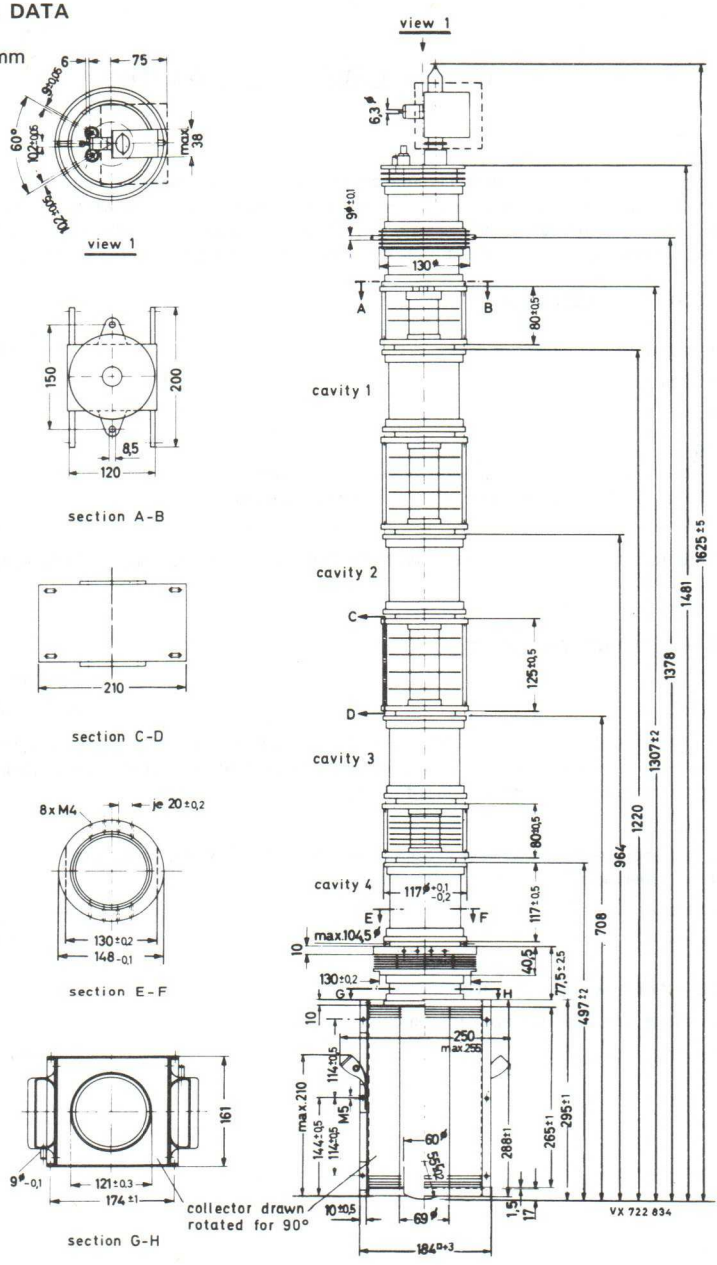



Fig. 1.

## MECHANICAL DATA

Dimensions in mm

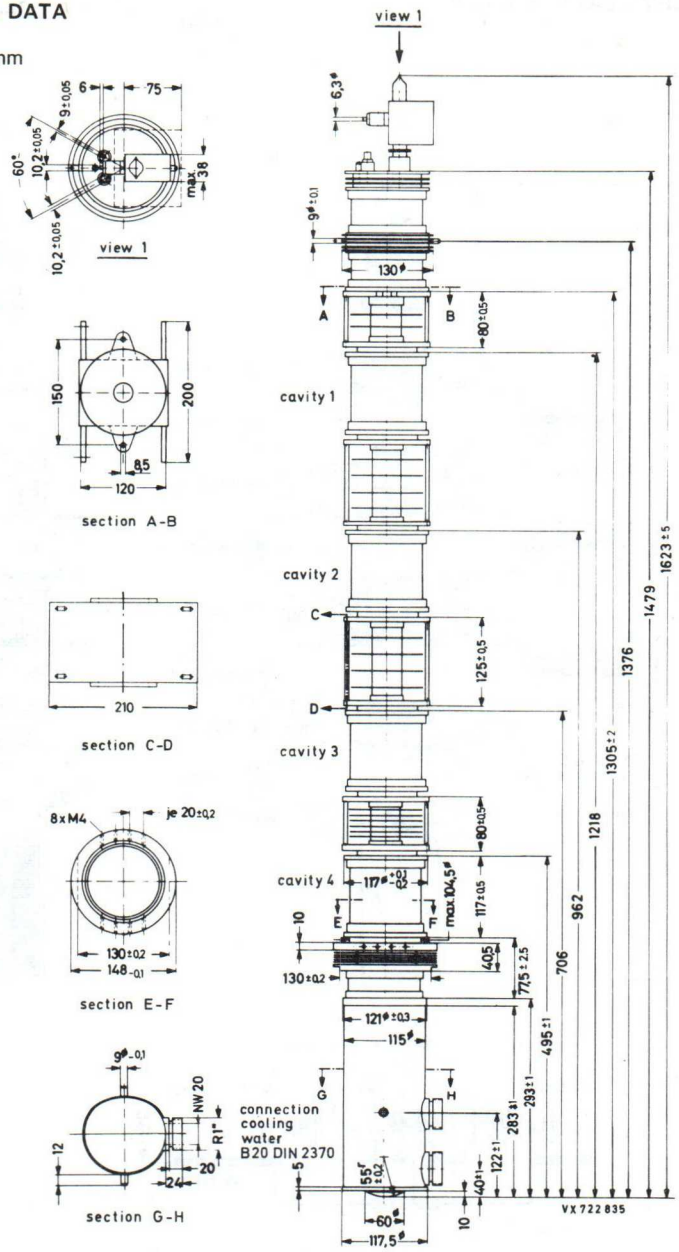



Fig. 2.

**MECHANICAL DATA** (continued)

Dimensions in mm

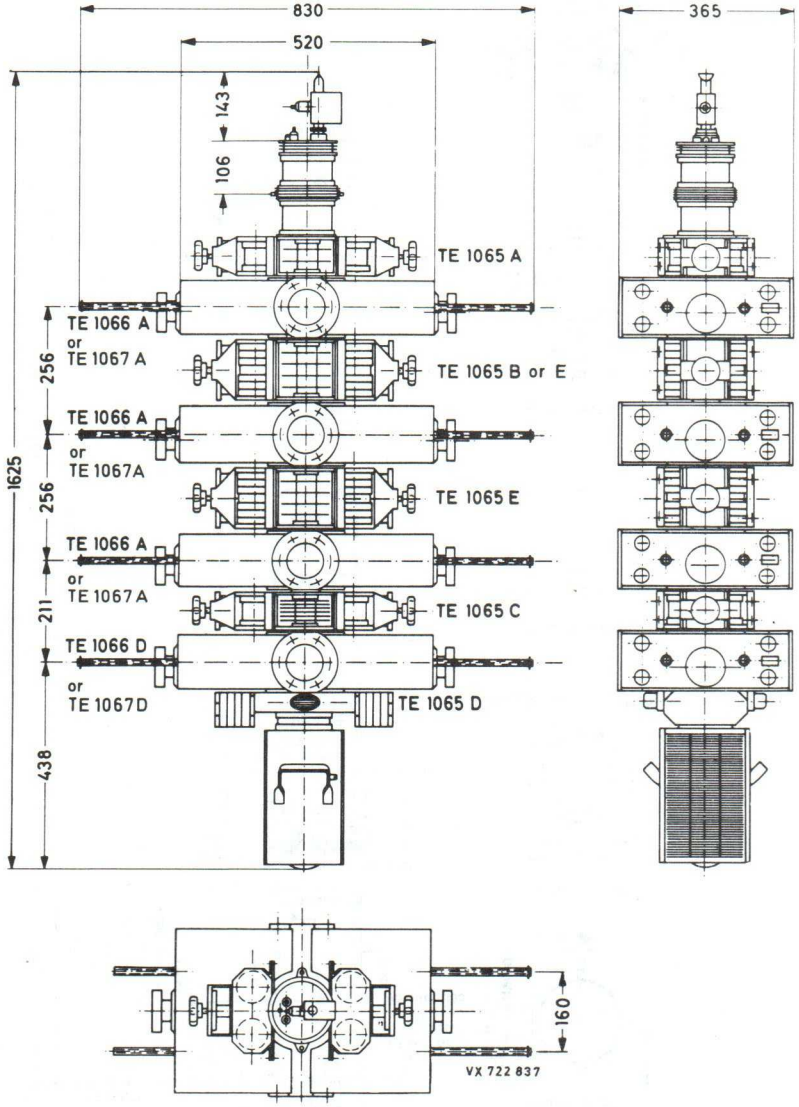



Fig. 3.

## COOLING

Except collector, applicable up to an air-inlet temperature $T_j$ of 40 °C and an altitude of 2500 m (values refer to air inlet).

| | |
|---|---|
| Cathode base | air, q = approx. 0.5 $m^3$/min |
| Accelerating electrode | air, q = approx. 0.5 $m^3$/min |
| Drift tubes 1, 2 and 3 | air, q = approx. 1.0 $m^3$/min each |
| Drift tube 4 | air, q = approx. 1.5 $m^3$/min |
| Drift tube 5 | forced air, q = approx. 1.5 $m^3$/min ($\Delta p$ = 900 Pa = 9 mbar) |
| Cavity TE1066D or TE1067D | forced air, q = approx. 2.0 $m^3$/min ($\Delta p$ = 900 Pa = 9 mbar) |
| Collector YK1001 | forced air, see cooling curves Figs 5, 6 and 7 |
| Collector YK1002 | water, see cooling curves Figs 9 and 10 |

## MOUNTING

Vertical, cathode up. In order to prevent distortion of the magnetic focusing field ferromagnetic material should not be used within a radius of 35 cm from the tube axis. All connections should be free from strain.

## MASS (net)

| | |
|---|---|
| YK1001 | approx. 55 kg |
| YK1002 | approx. 45 kg |
| Total mass of accessories | approx. 125 kg |

## PRODUCT SAFETY

*1. X-radiation*

Correct operation of the tube can be guaranteed only if a set of accessories, approved by the tube manufacturer, is used.

The operating tube generates X-rays which can penetrate the ceramic parts of the tube envelope. In order to reduce the radiation at any accessible points to an officially acceptable, non-dangerous level the tube must be shielded and any possible radiation path blocked by at least 1 mm of brass or an equivalent depth of non-magnetic X-ray absorbing material. The proper use of accessories will provide the necessary shielding.

*2. R.F. radiation*

R.F. power may be emitted through apertures other than the normal output coupling (for example r.f. leaks). This r.f. power may be sufficiently intense to cause danger to the human body, particularly to the eyes. Such radiation may be increased if the tube is functioning incorrectly.

## ACCESSORIES

| | |
|---|---|
| Heater connector | type 40649 |
| Heater/cathode connector | type 40649 |
| Focusing electrode connector | type 40634 |
| Accelerating electrode connector | type 40634 |
| Collector connector | type 40634 |
| Getter ion pump connector | type 55351 |
| Magnet unit for ion pump | type TE1053 |
| Set of five pairs of focusing magnets | type TE1065 (2xA, 2xB, 2xC, 2xD, 2xE)* |
| Set of four cavities for 470 MHz to 790 MHz | type TE1066 (3xA, 1xD) |
| or | |
| Set of four cavities for 700 MHz to 860 MHz | type TE1067 (3xA, 1xD) |
| 2 magnet field adaptor plates for collector (YK1001 only)** | type TE1073 |
| Recommended circulators (optional) | |
| 470 to 600 MHz | 2722 162 01551 (T100/IV-N) |
| 600 to 800 MHz | 2722 162 01561 (T100/V-N) |
| 790 to 1000 MHz | 2722 162 03261 (T100/V-3-N) |

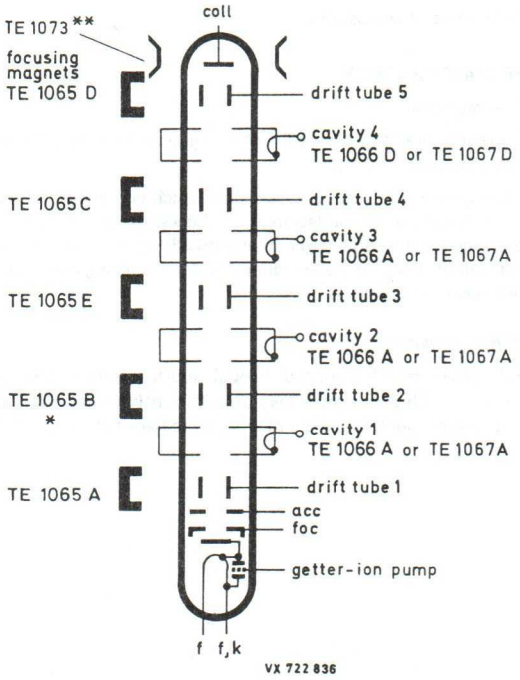



Fig. 4.

* If the klystron is used under TV transposer conditions replace 2xB by 2xE.

** Operation for vision and sound transmitter without depressed collector voltage.

**LIMITING VALUES** (Absolute maximum rating system)

| | | | |
|---|---|---|---|
| Heater voltage | max. | 8.5 | V |
| Cathode voltage | max. | −22 | kV |
| Cathode voltage at zero current | max. | −25 | kV |
| Depressed collector voltage | max. | 7 | kV |
| | min. | 0.5 | kV |
| Cathode current | max. | 2.3 | A |
| Accelerating electrode voltage | max. | −25 | kV |
| Series resistance in accelerating electrode circuit | max. | 20 | kΩ |
| | min. | 10 | kΩ |
| Negative focusing electrode voltage* | max. | 700 | V |
| | min. | 100 | V |
| Drift tube current** | | | |
| Collector dissipation | max. | 40 | kW |
| Load VSWR | max. | 1.5 | (14 dB) |
| Pump voltage | max. | 4.5 | kV |
| Pump current (see Fig. 8.) | max. | 15 | mA |
| Temperature of | | | |
| cathode base and accelerating electrode | max. | 125 | °C |
| drift tubes 1, 2 and 3 | max. | 80 | °C |
| drift tubes 4 and 5 | max. | 150 | °C |
| resonator 4 | max. | 125 | °C |
| collector seal YK1001 | max. | 200 | °C |
| Collector body YK1001▲ | max. | 300 | °C |
| outlet cooling water YK1002 | max. | 75 | °C |
| inlet cooling air | max. | 40 | °C |

* The power supply must be preloaded with min. 10 mA at 500 V.

* For limiting values of various operating conditions see next page and Fig. 11.

▲ In safeguard this temperature limit the air outlet temperature should be measured in at least two places; one 50 mm and one 150 mm from the upper collector plate and 50 mm from the cooling fins; the cooling data of collector are minimum values.

**MAXIMUM VALUES** of drift tube current

| | | | |
|---|---|---|---|
| For vision transmitter without level dependent cut-out threshold | | | |
| without depressed collector voltage | max. | 80 | mA |
| with depressed collector voltage | max. | 130 | mA |
| For vision transmitter with level dependent cut-out threshold | | | |
| without depressed collector voltage for 0 to 7 kW output power, peak sync. | max. | 40 | mA |
| with depressed collector voltage for 0 to 7 kW output power, peak sync. | max. | 60 | mA |
| without depressed collector voltage for full output power | max. | 100 | mA |
| with depressed collector voltage for full output power | max. | 200 | mA |
| For vision and sound transmitter fed from the same power supply and without level dependent cut-out threshold | | | |
| without depressed collector voltage | max. | 100 | mA |
| with depressed collector voltage | max. | 160 | mA |
| For vision and sound transmitter fed from the same power supply and with level dependent cut-out threshold | | | |
| without depressed collector voltage for 0 to 7 kW output power, peak sync. | max. | 60 | mA |
| with depressed collector voltage for 0 to 7 kW output power, peak sync. | max. | 80 | mA |
| without depressed collector voltage for full output power | max. | 120 | mA |
| with depressed collector voltage for full output power | max. | 250 | mA |

## TYPICAL OPERATING CONDITIONS

**As 11 kW vision transmitter** (CCIR-G standard) in the frequency range 470 MHz to 790 MHz

| | | without depressed collector voltage | with depressed collector voltage | | notes |
|---|---|---|---|---|---|
| Cathode voltage | | −18.0 | −13.5 | kV | 3 |
| Depressed collector voltage | | −0.5 | −5.0 | kV | |
| Accelerating electrode voltage | | 0 | 0 | V | 4 |
| Neg. focusing voltage | ≈ | 400 | 400 | V | 5 |
| Drift tube current, static | ≈ | 25 | 30 | mA | |
| black level | ≈ | 40 | 80 | mA | 6 |
| Cathode current | | 1.9 | 1.9 | A | |
| Output power, peak sync. | | 11 | 11 | kW | |
| Drive power see Fig. 12. | | | | | |
| Linearity without compensation | ≈ | 80 | 80 | % | 7 |
| Sync. compression | ⩽ | 45/25 | 45/25 | | 8 |
| V.S.B. suppression | ⩽ | −20 | −20 | dB | 9 |
| Noise with reference to black level | ⩽ | −46 | −46 | dB | 10 |
| Differential gain | ≈ | 5 | 5 | deg | 11 |

**As 2.2 kW and 4.4 kW TV sound amplifier**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Cathode voltage | | −18.0 | −18.0 | −13.5 | −13.5 | kV | 3 |
| Depressed collector voltage | | −0.5 | −0.5 | −5.0 | −5.0 | kV | |
| Accelerating electrode voltage | | −7.5 | −5.5 | −7.5 | −5.5 | kV | 4 |
| Neg. focusing voltage | ≈ | 400 | 400 | 400 | 400 | V | 5 |
| Drift tube current | ≈ | 40 | 50 | 50 | 70 | mA | 6 |
| Cathode current | | 0.7 | 1.0 | 0.7 | 1.0 | A | |
| Output power | | 2.2 | 4.4 | 2.2 | 4.4 | kW | |
| Drive power | ⩽ | 0.5 | 0.5 | 0.5 | 0.5 | W | |

**As 2.1 kW amplifier for television transposer service**

| | | | | |
|---|---|---|---|---|
| Cathode voltage | | −15 | kV | 3 |
| Depressed collector voltage | | 5.0 | kV | |
| Neg. focusing voltage | ≈ | 400 | V | 5 |
| Drift tube current | ≈ | 60 | mA | 6 |
| Cathode current | | 2.2 | A | |
| Output power, peak sync. | | 2.1 | kW | |
| Drive power see Fig. 12 | | | | |
| Intermodulation products | ⩽ | −51 | dB | 12 |

**Notes**

1. With the appropriate focusing magnets TE1065, cavities TE1066 and a circulator between the driver and input cavity.
   A precorrection of the level dependent frequency response up to 2 dB must be provided.
2. In case of failure the beam voltage must be switched off and made to drop below 5% of its nominal value within 500 ms of the failure.
3. Fluctuations of the beam voltage up to ± 3% will not damage the tube; to meet the signal-transfer quality requirements the nominal beam voltage should not vary more than ± 1%.
4. It is recommended that this voltage be obtained from a voltage divider between cathode and ground, which should carry a quiescent current of minimum 3 mA.
5. The focusing electrode voltage should be adjustable from 100 V to 500 V; a setting range from 100 V to 700 V is recommended.
6. At black level, to be focused for minimum drift tube current. If necessary to obtain the required signal-transfer quality, a deviation of maximum 10% from this minimum current is permitted. The limiting value, see Fig. 11, must however, not be exceeded.
7. Measured with a sawtooth voltage with amplitude between 17 and 75% of the peak sync value, on which is superimposed a 4.43 MHz sinewave with a 10% peak-to-peak value.
8. Calculated from $(1-V_{black}/V_{sync})_{in} / (1-V_{black}/V_{sync})_{out}$.
9. Measured with 10 to 75% modulation without compensation; V.S.B. filter between driving stage and klystron.
10. Produced by the klystron itself; without hum from power supplies.
11. Without compensation.
12. Without compensation, see German Bundespost 176 Pfl 2 or ARD-Pflichtenheft 5/2. Three-tone test method (vision carrier −8 dB, sound carrier −7 dB, sideband signal −16 dB with respect to peak sync = 0 dB).

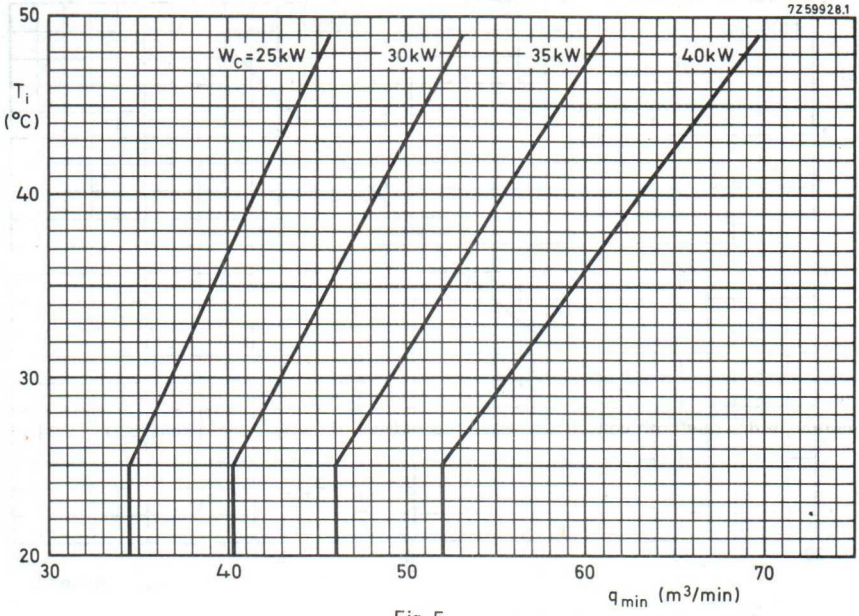

7Z59928.1
$W_C$=25kW
30kW
35kW
40kW
$T_i$ (°C)
50
40
30
20
30
40
50
60
70
$q_{min}$ ($m^3$/min)

Fig. 5.

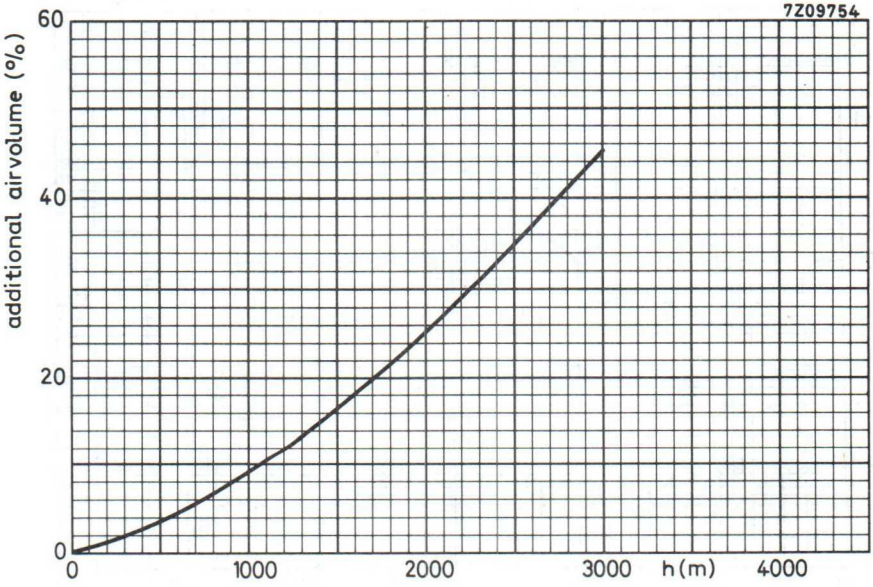

7Z09754
additional air volume (%)
60
40
20
0
0
1000
2000
3000
h (m)
4000

Fig. 6.

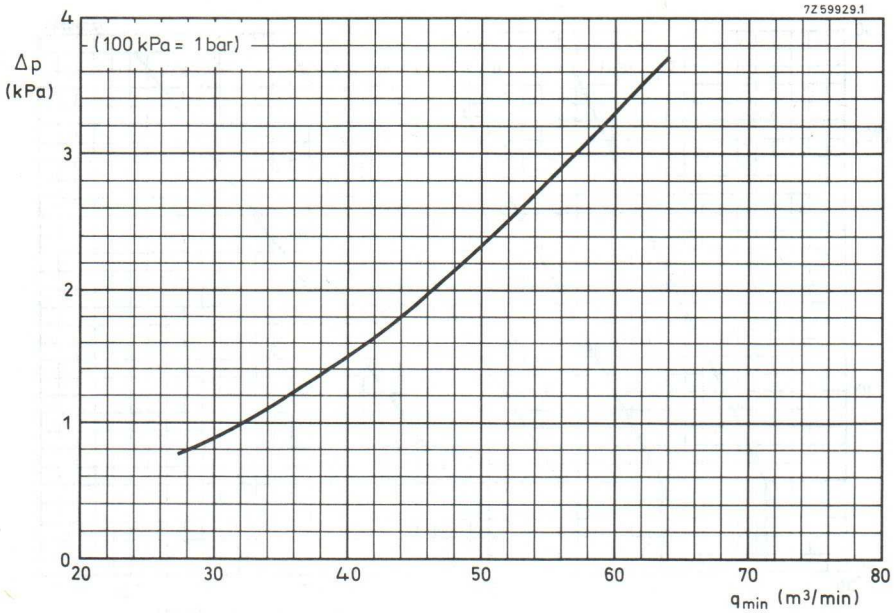



Fig. 7 Ratio of cooling air pressure to cooling air volume of YK1001.

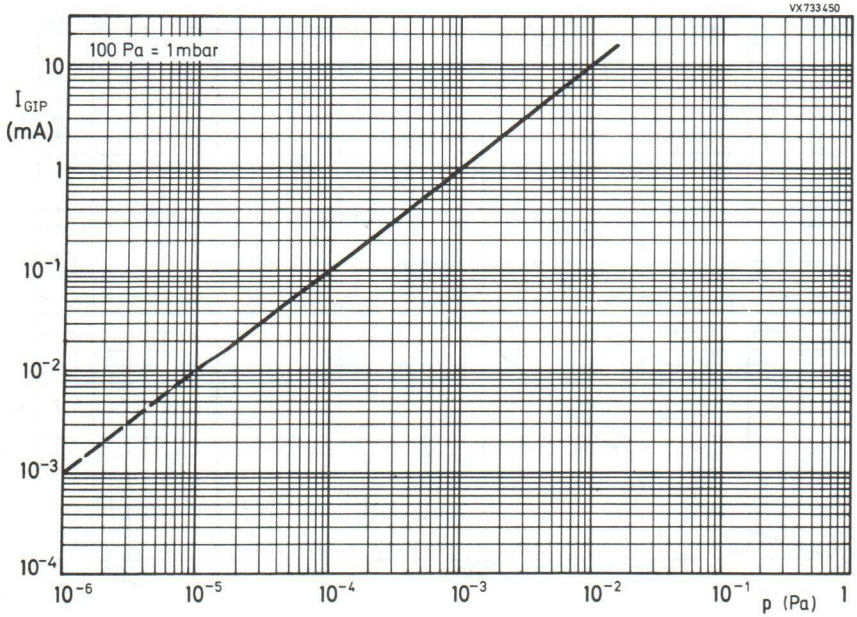



Fig. 8 Ratio of pump current to gas pressure in the klystron.

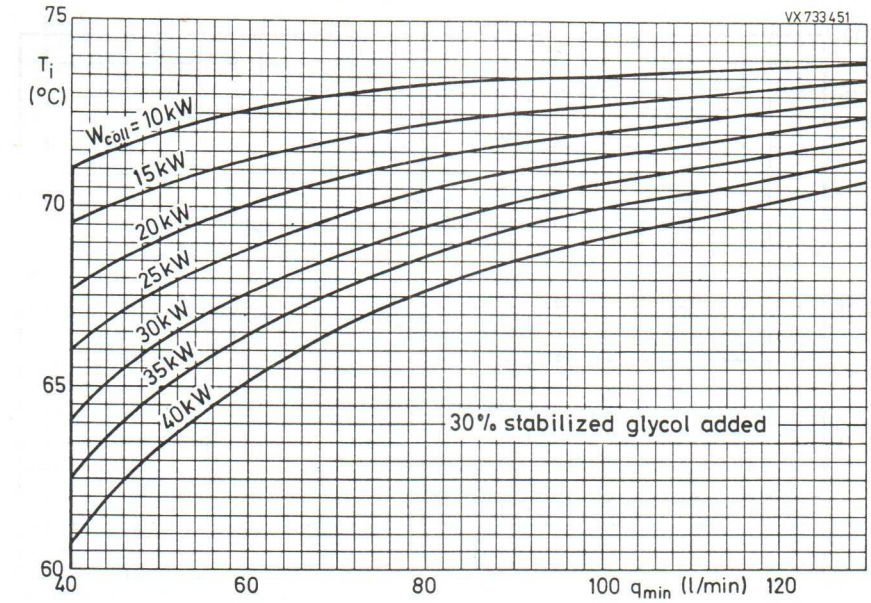



Fig. 9 Cooling curves for closed circuit cooling.

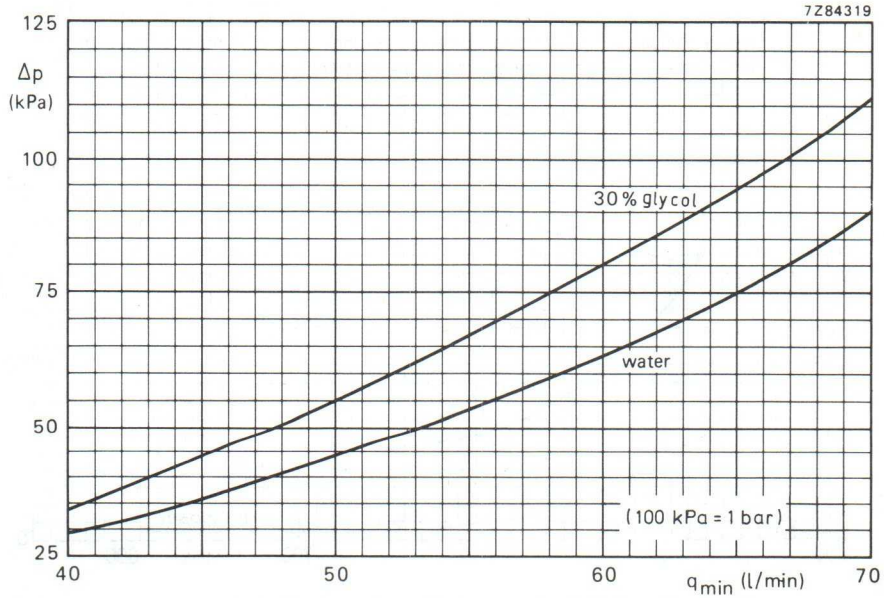



Fig. 10 Ratio of cooling water pressure to cooling water volume.

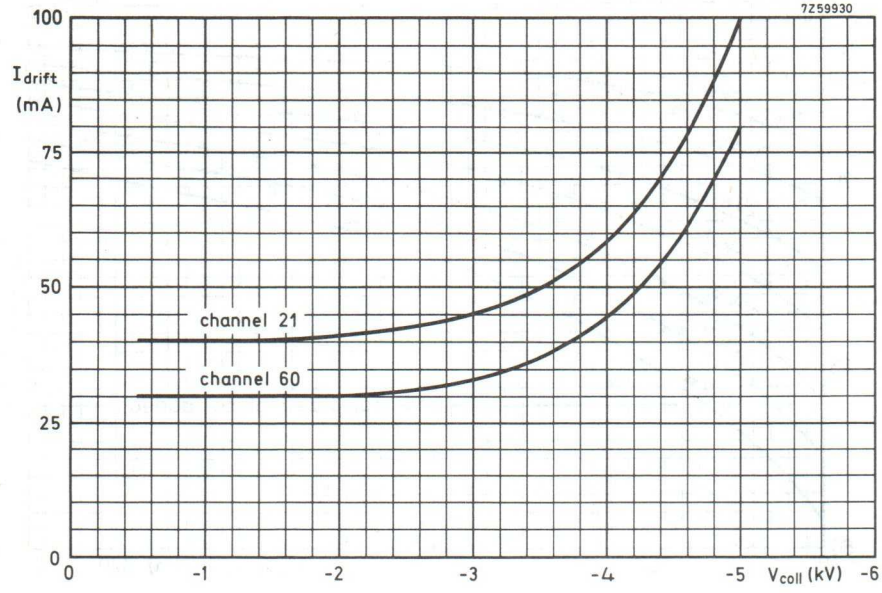

7Z59930
100
$I_{drift}$ (mA)
75
50
25
0
channel 21
channel 60
0
-1
-2
-3
-4
-5
$V_{coll}$ (kV)
-6

Fig. 11.

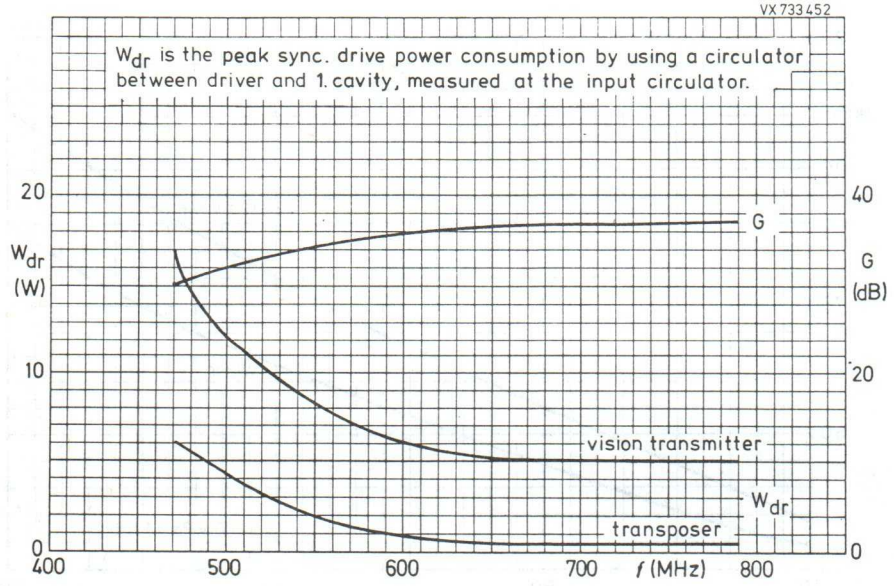

VX733452
$W_{dr}$ is the peak sync. drive power consumption by using a circulator between driver and 1. cavity, measured at the input circulator.
20
$W_{dr}$ (W)
10
0
40
G
G (dB)
20
0
vision transmitter
$W_{dr}$
transposer
400
500
600
700
f (MHz)
800

Fig. 12.

# PULSED POWER KLYSTRON

Fixed frequency pulsed power klystron in metal-ceramic construction for the range 2998 ± 5 MHz, with 3 internal cavities, electromagnetic focusing, continuously operating getter-ion pump, coaxial input connector and S-band output waveguide, water cooled, intended as amplifier in linear accelerators and similar applications.

## QUICK REFERENCE DATA

| | | |
|---|---|---|
| Frequency range | f | 2998 ± 5 MHz |
| The klystron is factory tuned to 2998 MHz but can delivered for any frequency within the range 2993 MHz to 3003 MHz. Other frequencies on request. | | |
| Peak power output | $W_{op}$ | 6 MW |
| Power gain | G | 30 dB |

This data must be read in conjunction with GENERAL OPERATIONAL RECOMMENDATIONS for KLYSTRONS.

**HEATING**: indirect by a.c. or d.c.

| | | |
|---|---|---|
| Cathode | | oxide coated |
| Heater voltage | $V_f$ | 3 to 4.6 V |
| Heater current, marked on each tube | $I_f$ | 70 to 82 A |
| The heater current should never exceed a peak value of 150 A when applying an a.c. heater voltage or 100 A when applying a d.c. heater voltage. | | |
| Cold heater resistance | $R_{fo}$ | 6 mΩ |
| Waiting time | $t_w$ min. | 45 min |

## GETTER-ION PUMP POWER SUPPLY

| | | |
|---|---|---|
| Pump voltage, unloaded | | 4 kV |
| Internal resistance | approx. | 300 kΩ |

**COOLING** (valid for a pulse repetition rate up to 50 p.p.s.)

| | | | |
|---|---|---|---|
| Drift tubes and focusing coils | q | min. | 4 l/min |
| | p | max. | 350 Pa * |
| Collector | q | min. | 7 l/min |
| | p | max. | 350 Pa * |

## ACCESSORIES

| | |
|---|---|
| Magnet and housing for getter-ion pump | type TE1053A and TE1053B |

**MASS** (net) approx. 110 kg

* 350 Pa = 3,5 mbar.

## MECHANICAL DATA

Dimensions in mm

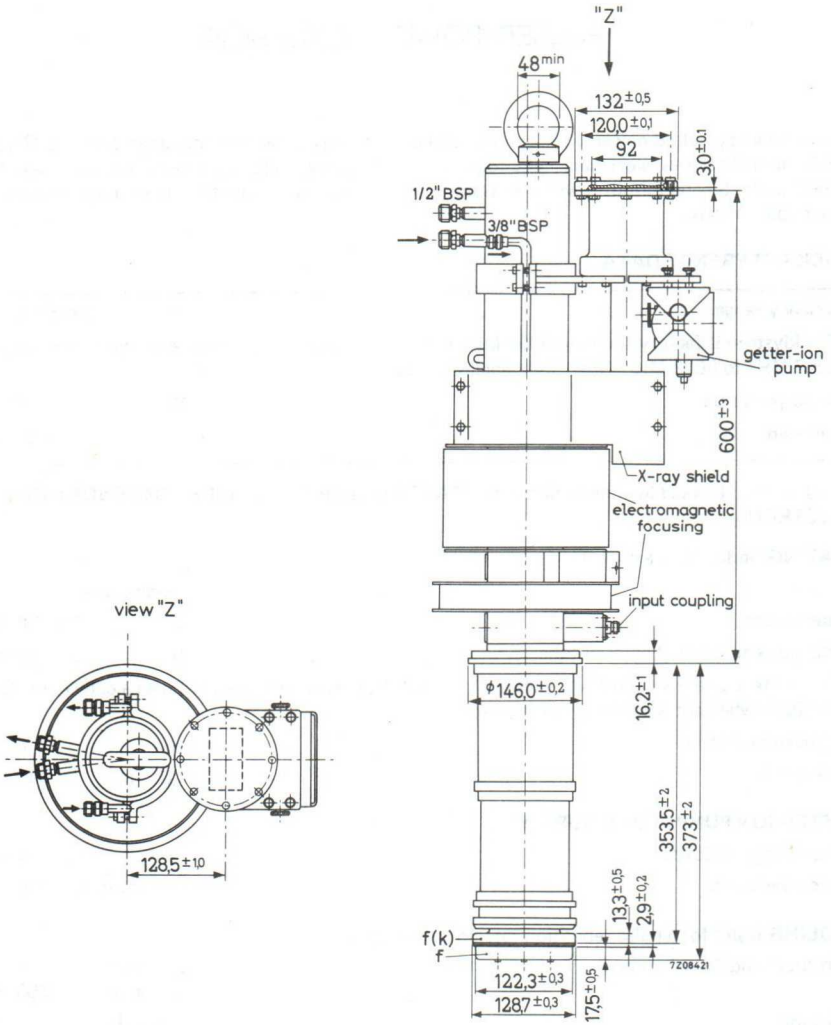



Fig. 1.

**MOUNTING** Vertical.

To be supported from mounting flange with cathode down. Although the collector and output cavity are provided with a lead shield, adequate additional shielding is required for protection against personal injury due to X-ray radiation.

**LIMITING VALUES** (Absolute maximum rating system) for pulsed operation.

| | | | notes |
|---|---|---|---|
| All voltages are specified with respect to ground. | | | |
| Cathode voltage, peak | max. | −220 kV | |
| Cathode current, peak | max. | 120 A | |
| Beam input power, peak | max. | 25 MW | |
| R.F. input power, peak | max. | 10 kW | |
| R.F. output power, peak | max. | 8 MW | |
| Pulse repetition rate | max. | 600 p.p.s. | |
| Pulse duration | max. | 3 μs | |
| Voltage standing-wave ratio of load | max. | 1.5 | |
| Focusing magnet voltage | max. | 50 V | |
| Focusing magnet current | max. | 32 A | |
| | min. | 24 A | |
| Pump voltage | max. | 4.5 kV | |
| Pump current | max. | 15 mA | |
| Water outlet temperature | max. | 75 °C | |

| **OPERATING CONDITIONS** | | notes |
|---|---|---|
| Frequency | 2998 MHz | 1 |
| Heater current | | 2 |
| Cathode voltage, peak | −210 kV | 3 |
| Cathode current, | | |
| peak | 100 A | |
| mean | 10 mA | |
| Focusing magnet voltage | 40 V | |
| Focusing magnet current | 29 A | 4 |
| Pulse repetition rate | 50 p.p.s. | 5 |
| Pulse duration | 2.2 μs | |
| R.F. input power | 5 kW | |
| R.F. output power, | | |
| peak | 6 MW | |
| mean | 0.66 kW | |

**Notes**

1. When the klystron has not been in operation for some time, conditioning might be required. This should be done by gradually increasing the cathode voltage until in each step stable operation is obtained. Stored tubes require pumping at intervals of approx. 3 months.
2. To be adjusted at the value marked on each tube.
3. For maintaining a minimum output power of 5 MW during life the cathode voltage may be increased to −215 kV.
4. To be adjusted for max. r.f. output power.
5. Data for operation at p.r.r. higher than 50 p.p.s. on request.

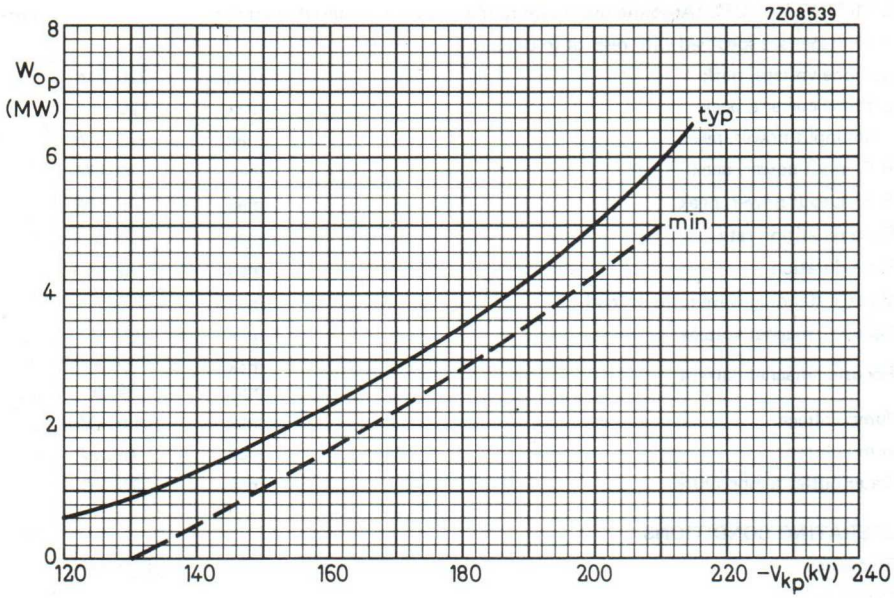

7Z08539
8
$W_{op}$
(MW)
6
4
2
0
typ
min
120
140
160
180
200
220
$-V_{kp}$(kV)
240

Fig. 2.

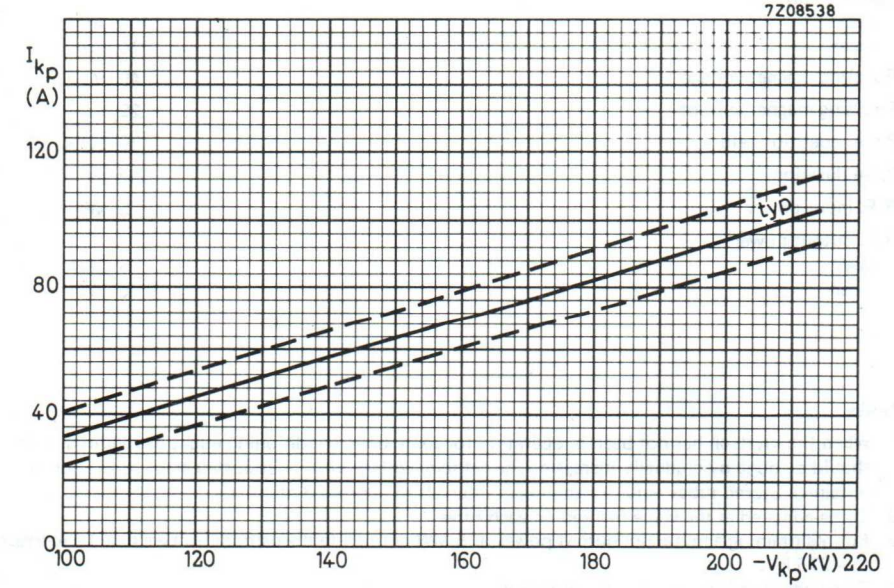

7Z08538
$I_{kp}$
(A)
120
80
40
0
typ
100
120
140
160
180
200
$-V_{kp}$(kV)
220

Fig. 3.

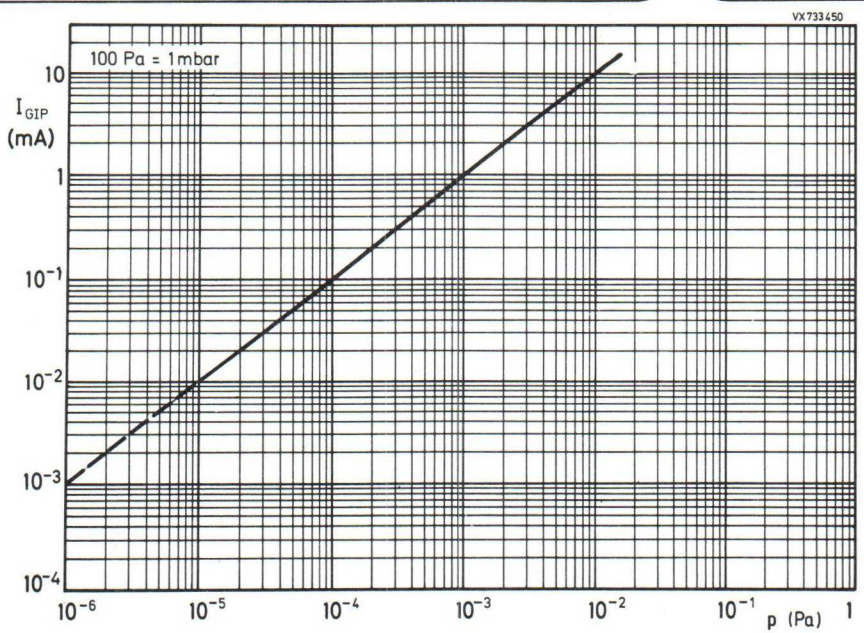



Fig. 4 Ratio of pump current to gas pressure in the klystron.

## PRODUCT SAFETY

*R.F. radiation*

R.F. power may be emitted not only through the normal output coupling but also through other apertures (for example, r.f. leaks). This r.f. power may be sufficiently intense to cause danger to the human body, particularly to the eyes. Such radiation may be increased if the tube is functioning incorrectly.

*X-radiation*

A highly dangerous intensity of X-rays may be emitted by tubes operating at voltages higher than approximately 5 kV. Adequate protection (X-ray shielding) for the operator is then necessary. The emission intensity of X-rays may correspond to a value of voltage much higher than that expected from the actual value applied to the tube.

Poor focusing may result in excessive X-radiation.

# U.H.F. POWER KLYSTRON

U.H.F. TV power klystron in metal-ceramic construction, with four external resonant cavities, integral permanent magnets, and incorporated getter-ion pump. The klystron is intended to be used with depressed collector voltage in 10 kW and 20 kW vision transmitters, in sound transmitters or in high-power transposers in the frequency range 470 to 860 MHz.

## QUICK REFERENCE DATA

| | |
|---|---|
| Frequency range | 470 to 860 MHz |
| Output power, peak sync | 25 kW |
| Cooling | forced air |

This data must be read in conjunction with GENERAL OPERATIONAL RECOMMENDATIONS for KLYSTRONS.

| **HEATING:** indirect by d.c. | | | | notes |
|---|---|---|---|---|
| Cathode | dispenser type | | | |
| Heater voltage | | | | |
| vision transmitter | $V_f$ | 7 | V | 1 |
| sound transmitter | $V_f$ | 6.5 | V | 1 |
| Heater current | $I_f \approx$ | 30 (26 to 34) | A | |
| Cold heater resistance | $R_{fo} \approx$ | 28 | mΩ | |
| Waiting time | | | | |
| a. Heater voltage 7 V | $t_w$ min. | 180 | s | 2 |
| b. Stand-by 6 V vision transmitter | $t_w$ | 0 | s | 2, 3 |
| c. Stand-by 5.5 to 6 V sound transmitter | $t_w$ | 0 | s | 2, 3 |

## FOCUSING

The integral temperature-compensated coaxial permanent magnets are pre-adjusted by the tube manufacturer.

## GETTER-ION PUMP SUPPLY

| | | |
|---|---|---|
| Pump voltage, no load condition | 4 | kV |
| Internal resistance | 300 | kΩ |

If it is between 3 kV and 4.5 kV, the collector to body voltage may be used as the pump supply voltage. In this case the pump anode must be connected to body (earth) via a 300 kΩ series resistor.

**Notes**

1. During operation the heater voltage should not fluctuate more than ± 3%.
2. The heater current should never exceed a peak value of 65 A.
3. Valid after a waiting time of at least 8 min; as soon as the beam voltage is switched on, the heater voltage must be increased to the nominal value.

## MECHANICAL DATA

Dimensions in mm

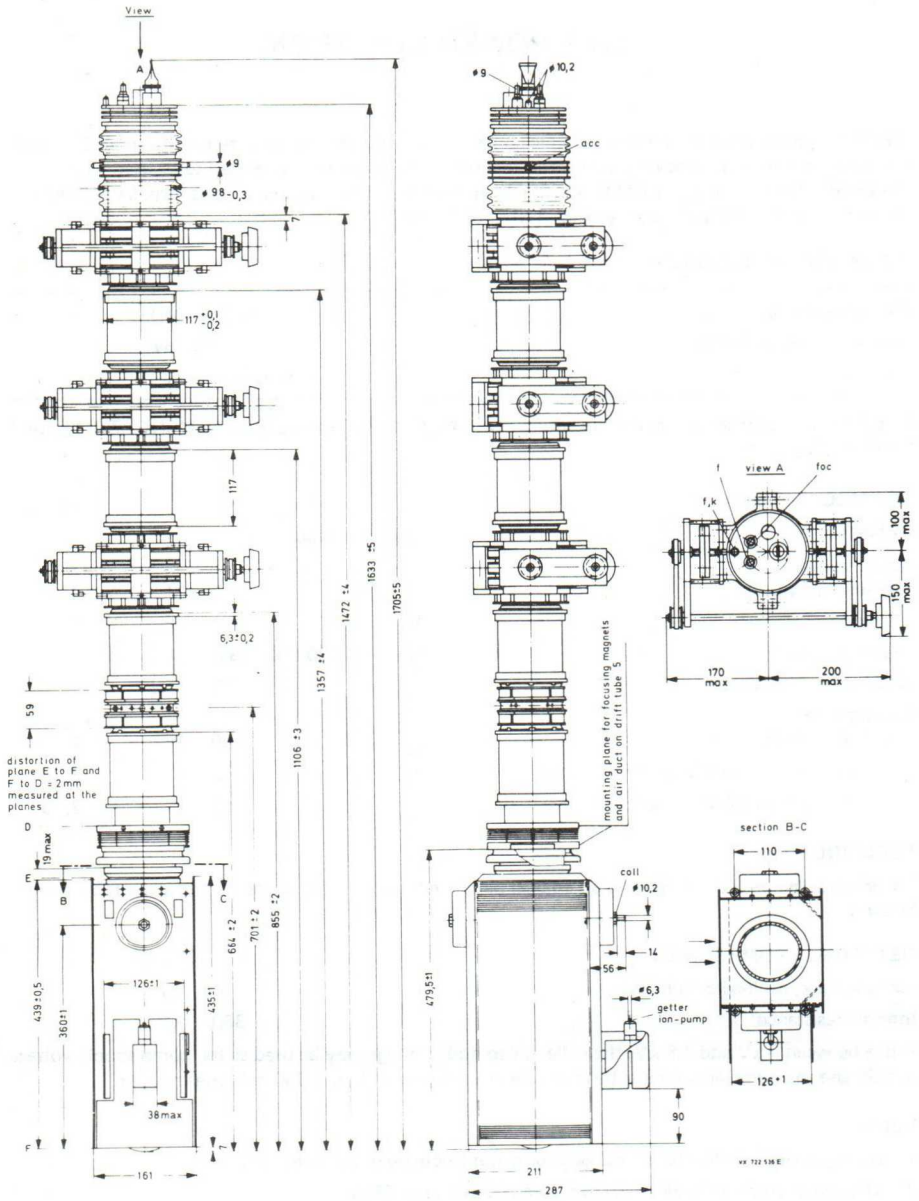



Fig. 1.

## MASS AND DIMENSIONS

Klystron

| | |
|---|---|
| net | approx. 100 kg |
| gross | approx. 200 kg |
| outline dimensions of packing (cm) | 205 x 79 x 66 |

## MOUNTING

Mounting position: vertical with collector down.
To remove the tube from the magnet frame a total free height of 2.5 m, excluding hoist, is required.

## COOLING

**Cooling data, using the trolley TE1081**

| | |
|---|---|
| Cathode socket, drift tubes, and cavities | forced air, approx. 5 $m^3$/min, $\Delta p$ = 800 Pa (8 mbar) |
| Collector (60 kW dissipation) | forced air, min 55 $m^3$/min. $\Delta p$ = 2100 Pa (21 mbar), see Figs 3, 4 and 5. |

## PRODUCT SAFETY

*1. X-radiation*

Correct operation of the tube can be guaranteed only if a set of accessories, approved by the tube manufacturer, is used.

The operating tube generates X-rays which can penetrate the ceramic parts of the tube envelope. In order to reduce the radiation at any accessible points to an officially acceptable, non-dangerous level the tube must be shielded and any possible radiation path blocked by at least 1 mm of brass or an equivalent depth of non-magnetic X-ray absorbing material. The proper use of accessories will provide the necessary shielding.

*2. R.F. radiation*

R.F. power may be emitted through apertures other than the normal output coupling (for example r.f. leaks). This r.f. power may be sufficiently intense to cause danger to the human body, particularly to the eyes. Such radiation may be increased if the tube is functioning incorrectly.

**Instruction manual**

For detailed mounting and tuning instructions see klystron instruction manual, delivered with each tube.

**MECHANICAL DATA** of the trolley TE1081 Dimension in mm

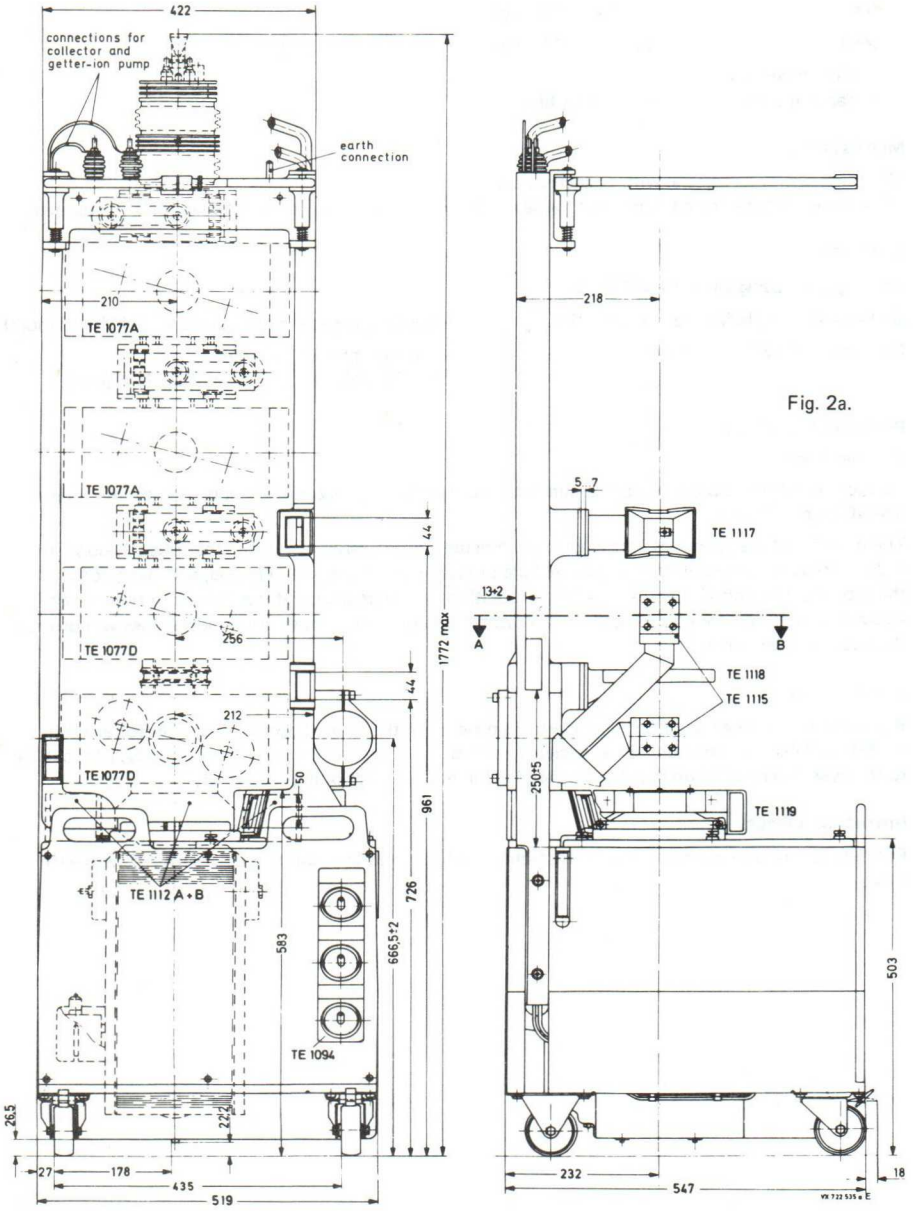



Fig. 2a.

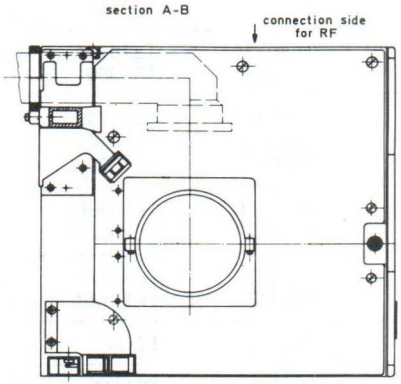
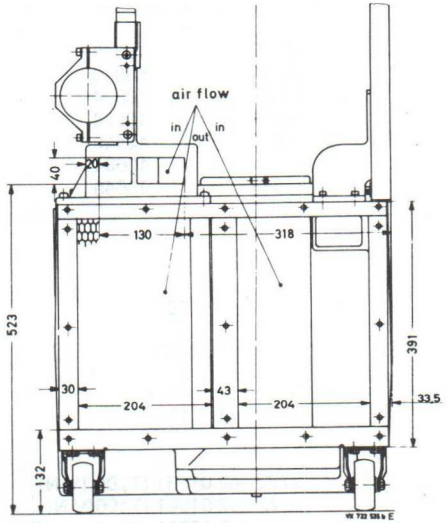

section A-B
connection side
for RF

Fig.2b.


air flow
in
out
in
40
20
130
318
523
391
30
204
43
204
33,5
132

## ACCESSORIES

| Frequency range (MHz)<br>Channel | 470 to 637<br>21 to 41 | 638 to 860<br>42 to 68 |
|---|---|---|
| Stub | TE1089 | TE1089 |
| Cavity 1<br>Input coupling device | TE1077A<br>TE1083 | TE1078A<br>TE1084 |
| Cavity 2<br>Load coupling device | TE1077A<br>TE1085 | TE1078A<br>TE1086 |
| Cavity 3<br>Load coupling device<br>Adaptor flange | TE1077D<br>TE1085<br>TE1090 | TE1078D<br>TE1086<br>TE1090 |
| Cavity 4<br>Output coupling device | TE1077D<br>TE1091A | TE1078D<br>TE1092A |
| Magnet<br>for drift tube 5 | TE1112A<br>TE1112B | TE1112A<br>TE1112B |
| Trolley | TE1081 | TE1081 |
| Air duct for cavities<br>Air duct for drift tube 3<br>Air duct for drift tube 4<br>Air duct for drift tube 5 | TE1115<br>TE1117<br>TE1118<br>TE1119 | TE1115<br>TE1117<br>TE1118<br>TE1119 |
| Magnet for getter-ion pump | TE1053A | TE1053A |
| Connectors<br>Heater<br>Heater/cathode<br>Focusing electrode<br>Accelerating electrode<br>Collector<br>Getter-ion pump<br>Earth | <br>40649<br>40649<br>40634<br>40634<br>40649<br>40634<br>40649 | <br>40649<br>40649<br>40634<br>40634<br>40649<br>40634<br>40649 |

**Special parts**

| | |
|---|---|
| Load coupling unit mating TE1077D (instead of TE1091A) | TE1087 |
| Load coupling unit mating TE1078D (instead of TE1092A) | TE1088 |
| Plug connection mating TE1091A and TE1092A | TE1091B |
| Lifting device | TE1113 |

| Recommended circulators (optional) | |
|---|---|
| 470 to 600 MHz | 2722 162 01551 (T100/IV-N) |
| 600 to 800 MHz | 2722 162 01561 (T100/V-N) |
| 790 to 1000 MHz | 2722 162 03261 (T100/V-3-N) |

**LIMITING VALUES** (Absolute maximum rating system)

| | min. | max. | notes |
|---|---|---|---|
| Heater voltage | | 8.5 V | |
| Ground to cathode voltage | | 28 kV | |
| Ground to the accelerator electrode voltage | 0 kV | 28 kV | |
| Ground to collector voltage | 0 kV | 5 kV | |
| Cathode to focusing electrode voltage | 100 V | 600 V | |
| Cathode current | | 4 A | |
| Accelerator electrode current | −0.2 mA | +1.5 mA | |
| Focusing electrode current | −0.2 mA | +3 mA | |
| Drift tube current | | | |
| static | | 60 mA | 4, 5 |
| dynamic | | 260 mA | 5 |
| Collector dissipation | | 65 kW | |
| Series resistor in accelerator electrode circuit | 10 kΩ | | |
| Return loss of load at operating frequency | 14 dB | | |
| Pump voltage, no load condition | 3.0 kV | 5.0 kV | |
| Pump current | | 15 mA | |
| Temperature of focusing magnets | | 70 °C | |
| Inlet temperature of cooling air | | 45 °C | |
| Outlet temperature of cooling air | | 110 °C | |

Notes

4. Static operation (operation without output power) in vision transmitters only with beam currents $< 2/3$ of given value allowed (see design considerations).
5. A drift tube current cut-out should be provided to protect the klystron. The cut-out should have an automatic action which depends on the drive level, see Figs 6 and 7.

## TYPICAL OPERATING CONDITIONS

**As 20 kW vision transmitter** in accordance with CCIR-G standard, with depressed collector voltage

| | | | | | notes |
|---|---|---|---|---|---|
| *Operating conditions* | | | | | 7 |
| Frequency range | 470 to 640 | 470 to 790 | 790 to 860 | MHz | |
| Channel | 21 to 41 | 21 to 60 | 61 to 68 | | |
| Collector to cathode voltage | 16.5 18 | 20.0 | 20.0 | kV | 8 |
| Cathode current | 3.6 3.3 | 3.0 | 3.1 | A | |
| Ground to collector voltage | 4.0 4.0 | 4.0 | 4.5 | kV | |
| Drift tube current (black level) | 120 100 | 70 | 70 | mA | |
| Ground to accelerator electrode voltage | 0 ≈ 3 | ≈ 6 | ≈ 6 | kV | |
| D.C. input power | 59 59 | 60 | 62 | kW | |
| Cathode to focusing electrode voltage | | 300 (100 to 600) | | V | 9 |

Drive power see Fig. 10.

*Performance*

| | min. | typ. | max. | | notes |
|---|---|---|---|---|---|
| Output power, peak sync | | 22 | | kW | 10 |
| Sync. compression | | | 40/25 | | 11 |
| V.S.B. suppression | 23 | 25 | | dB | 12 |
| Noise ratio, with reference to black level | 48 | > 50 | | dB | 13 |
| Linearity 10/75 | 0.75 | 0.8 | | | 14 |
| Differential gain (10/85 at 4.43 MHz) | 0.75 | 0.85 | | | 15 |
| Differential phase (10/85 at 4.43 MHz) | | +10/−3 | +15/−5 | deg | 15, 16 |
| Variation in response characteristic as a function of power level | | | | | |
| in the double-sideband region | | 0.25 | 0.5 | dB | 17 |
| in the single-sideband region | | 0.4 | 0.6 | dB | 18 |
| Ripple of response characteristic (white level 10/20) | | | 0.3 | dB | |
| Maximum output power | | 25 | | kW | 19 |
| Efficiency | | 37 | | % | |

**TYPICAL OPERATING CONDITIONS** (continued)

| | | | notes |
|---|---|---|---|
| **As 20 kW vision transmitter** in accordance with CCIR-G standard, without depressed collector voltage | | | 6 |
| *Operating conditions* | | | 7 |
| Frequency range | 470 to 860 | MHz | |
| Channel | 21 to 68 | | |
| Collector to cathode voltage | 19.5 to 23 | kV | 8 |
| Cathode current | 3.05 to 2.6 | A | |
| Ground to collector voltage | 0 | kV | |
| Drift tube current (black level) | 80 to 40 | mA | |
| Ground to accelerator electrode voltage | 1.5 to 6.5 | kV | |
| D.C. input power | 60 | kW | |
| Cathode to focusing electrode voltage | 300 (100 to 600) | V | 9 |
| Drive power see Fig. 10. | | | |

*Performance*

| | min. | typ. | max. | | notes |
|---|---|---|---|---|---|
| Output power, peak sync | | 22 | | kW | 10 |
| Sync. compression | | | 52/26 | | 11 |
| V.S.B. suppression | 23 | 25 | | dB | 12 |
| Noise ratio, with reference to black level | 48 | > 50 | | dB | 13 |
| Linearity 10/75 | 0.65 | 0.75 | | | 14 |
| Differential gain (10/85 at 4.43 MHz) | 0.65 | 0.75 | | | 15 |
| Differential phase (10/85 at 4.43 MHz) | | +12/–3 | +15/–5 | deg | 15, 16 |
| Variation in response characteristic as a function of power level | | | | | |
| in the double-sideband region | | 0.25 | 0.5 | dB | 17 |
| in the single-sideband region | | 0.4 | 0.6 | dB | 18 |
| Ripple of response characteristic (white level 10/20) | | | 0.3 | dB | |
| Maximum output power | 22 | 23 | | kW | 19 |
| Efficiency | | 37 | | % | |

**TYPICAL OPERATING CONDITIONS** (continued)

| | | | | | notes |
|---|---|---|---|---|---|
| **As 10 kW vision transmitter** in accordance with CCIR-G standard | | | | | 6 |
| *Operating conditions* | | | | | 7 |
| Frequency range | 470 to 640 | 470 to 790 | 790 to 860 | MHz | |
| Channel | 21 to 41 | 21 to 60 | 61 to 68 | | |
| Collector to cathode voltage | 15.0 | 16.0 | 16.0 | kV | 8 |
| Cathode current | 2.2 | 2.1 | 2.2 | A | |
| Ground to collector voltage | 4.0 | 4.0 | 4.5 | kV | |
| Drift tube current (black level) | 60 | 50 | 50 | mA | |
| Ground accelerator electrode voltage | ≈ 4.0 | ≈ 5.5 | ≈ 6.0 | kV | |
| D.C. input power | 33 | 33.5 | 35 | kW | |
| Cathode to focusing electrode voltage | | 300 (100 to 600) | | V | 9 |
| Drive power see Fig. 10. | | | | | |

| *Performance* | | | | | 10 |
|---|---|---|---|---|---|
| Output power, peak sync | | 11 | | kW | |
| | min. | typ. | max. | | |
| Sync. compression | | | 40/25 | | 11 |
| V.S.B. suppression | 23 | 25 | | dB | 12 |
| Noise ratio, with reference to black level | 48 | > 50 | | dB | 13 |
| Linearity 10/75 | 0.75 | 0.8 | | | 14 |
| Differential gain (10/85 at 4.43 MHz) | 0.75 | 0.85 | | | 15 |
| Differential phase (10/85 at 4.43 MHz) | | +10/–3 | +15/–5 | deg | 15, 16 |
| Variation in response characteristic as a function of power level | | | | | |
| in the double-sideband region | | 0.25 | 0.5 | dB | 17 |
| in the single-sideband region | | 0.4 | 0.6 | dB | 18 |
| Ripple of response characteristic (white level 10/20) | | | 0.3 | dB | |
| Maximum output power | | 12.5 | | kW | 19 |
| Efficiency | | 33 | | % | |

**TYPICAL OPERATING CONDITIONS** (continued) notes

**As sound transmitter** in accordance with the CCIR-G standard (one carrier operation) 6

R.F. setting

| | |
|---|---|
| Cavity 4 | on sound carrier frequency |
| Cavity 1 | on sound carrier frequency −0.5 MHz |
| Cavity 2 | on sound carrier frequency +0.5 MHz, |
| Cavity 3 | on sound carrier frequency min. +3 MHz, (load coupler and load are not necessary) |

Double-humped resonance curve slack $\leqslant -0.5$ dB

*Operation with high voltage collector to cathode*

with depressed collector voltage 7

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Frequency range | | 470 to 640 | | 470 to 790 | | 790 to 860 | | MHz | |
| Channel | | 21 to 41 | | 21 to 60 | | 61 to 68 | | | |
| Collector to cathode voltage | | 16.5 | 18 | 20.0 | | 20.0 | | kV | |
| Ground to collector voltage | | 4.0 | 4.0 | 4.0 | | 4.5 | | kV | |
| Cathode to focusing electrode voltage | | 100 to 600 | | 100 to 600 | | 100 to 600 | | V | |
| Driving power | $\leqslant$ | 0.5 | | 0.5 | | 0.5 | | W | |
| Ground to accelerator electrode voltage | $\approx$ | 10.5 | 12.5 | 14.0 | 16.0 | 14.5 | 16.5 | kV | |
| Cathode current | | 1.1 | 0.8 | 1.0 | 0.7 | 1.0 | 0.7 | A | 20 |
| Output power | | 4.4 | 2.2 | 4.4 | 2.2 | 4.4 | 2.2 | kW | |

without depressed collector voltage

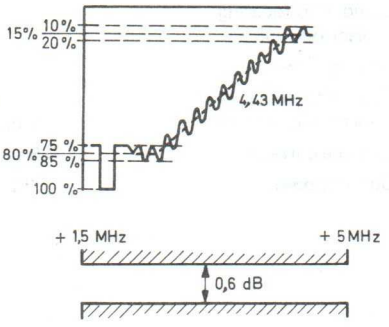
| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Frequency range | | | | 470 to 860 | | | | MHz | |
| Channels | | | | 21 to 68 | | | | | |
| Collector to cathode voltage | | | | 19.5 to 23 | | | | kV | |
| Ground to collector voltage | | | | 0 | | | | kV | |
| Cathode to focusing electrode voltage | | | | 100 to 600 | | | | V | |
| Driving power | | | | $\leqslant$ 1 | | | | W | |
| Ground to accelerator electrode voltage | | 11.5 to 15.5 | | | | 13 to 17 | | kV | |
| Cathode current | | 0.8 to 0.7 | | | | 0.6 to 0.5 | | A | 20 |
| Output power | | 2.2 | | | | 1.1 | | kW | |

**TYPICAL OPERATING CONDITIONS** (continued)

| | | | | | | | | notes |
|---|---|---|---|---|---|---|---|---|
| **As sound transmitter** (continued) | | | | | | | | 6 |
| *Operation with low voltage collector to cathode* | | | | | | | | 7 |
| with depressed collector voltage | | | | | | | | |
| Frequency range | 470 to 640 | | 470 to 790 | | 790 to 860 | | MHz | |
| Channel | 21 to 41 | | 21 to 60 | | 61 to 68 | | | |
| Collector to cathode voltage | 15.0 | | 16.0 | | 16.0 | | kV | |
| Ground to collector voltage | 4.0 | | 4.0 | | 4.5 | | kV | |
| Cathode to focusing electrode voltage | 100 to 600 | | 100 to 600 | | 100 to 600 | | V | |
| Driving power | ⩽ 0.5 | | ⩽ 0.5 | | ⩽ 0.5 | | W | |
| Ground to accelerator electrode voltage | ≈ 0.9 | ≈10.5 | ≈12.5 | ≈13.5 | ≈13.0 | ≈14.0 | kV | |
| Cathode current | 0.8 | 0.6 | 0.65 | 0.5 | 0.65 | 0.5 | A | 20 |
| Output power | 2.2 | 1.1 | 2.2 | 1.1 | 2.2 | 1.1 | kW | |

**Notes**

6. With stated accessories; in case of failure the beam voltage must be switched-off and made to drop below 5% of its nominal value within 500 ms of the failure.
7. For optimum performance one of these settings has to be chosen in accordance with the transmitter manual.
8. Fluctuations up to ± 3% will not damage the tube; to obtain a good signal transfer quality the beam voltage should not vary more than ± 1%.
9. To be adjusted for the specified cathode current.
10. The signal transfer quality is measured with matched load (VSWR ⩽ 1.05).
11. Calculated from $(1-V_{black}/V_{sync})_{in}/(1-V_{black}/V_{sync})_{out}$
12. Measured with 10 to 75% modulation without compensation; V.S.B. filter between driving stage and klystron.
13. Produced by the klystron itself; without hum from power supplies.
14. Measured with a staircase signal of 10 to 75% of the peak sync value.
15. Measured with a sawtooth voltage with an amplitude between 15 and 80% of the peak sync. value on which is superimposed a 4.43 MHz sinewave with a 10% peak to peak value.
16. Phase difference to burst signal.
17. With respect to ± 0.5 MHz about the carrier frequency.
18. With respect to specified tolerance range.
19. With increased driving power under the given operating conditions, without guarantee for signal transfer quality.
20. Cathode current adjusted by accelerating electrode voltage (coarse), and focusing electrode voltage (fine).



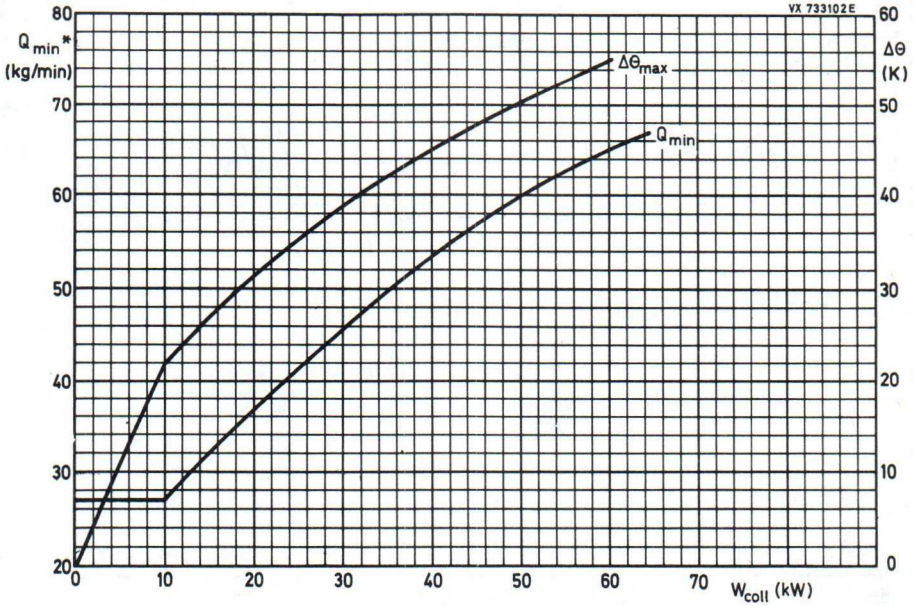



Fig. 3 Required quantity of cooling air $Q_{min}$ for the inlet temperature $T_i$ = 25 °C and relative temperature difference $\Delta\theta$ versus the collector dissipation $W_{coll}$.

* A normal cubic metre (at 1033 mbar, 15 °C) corresponds to 1.226 kg.

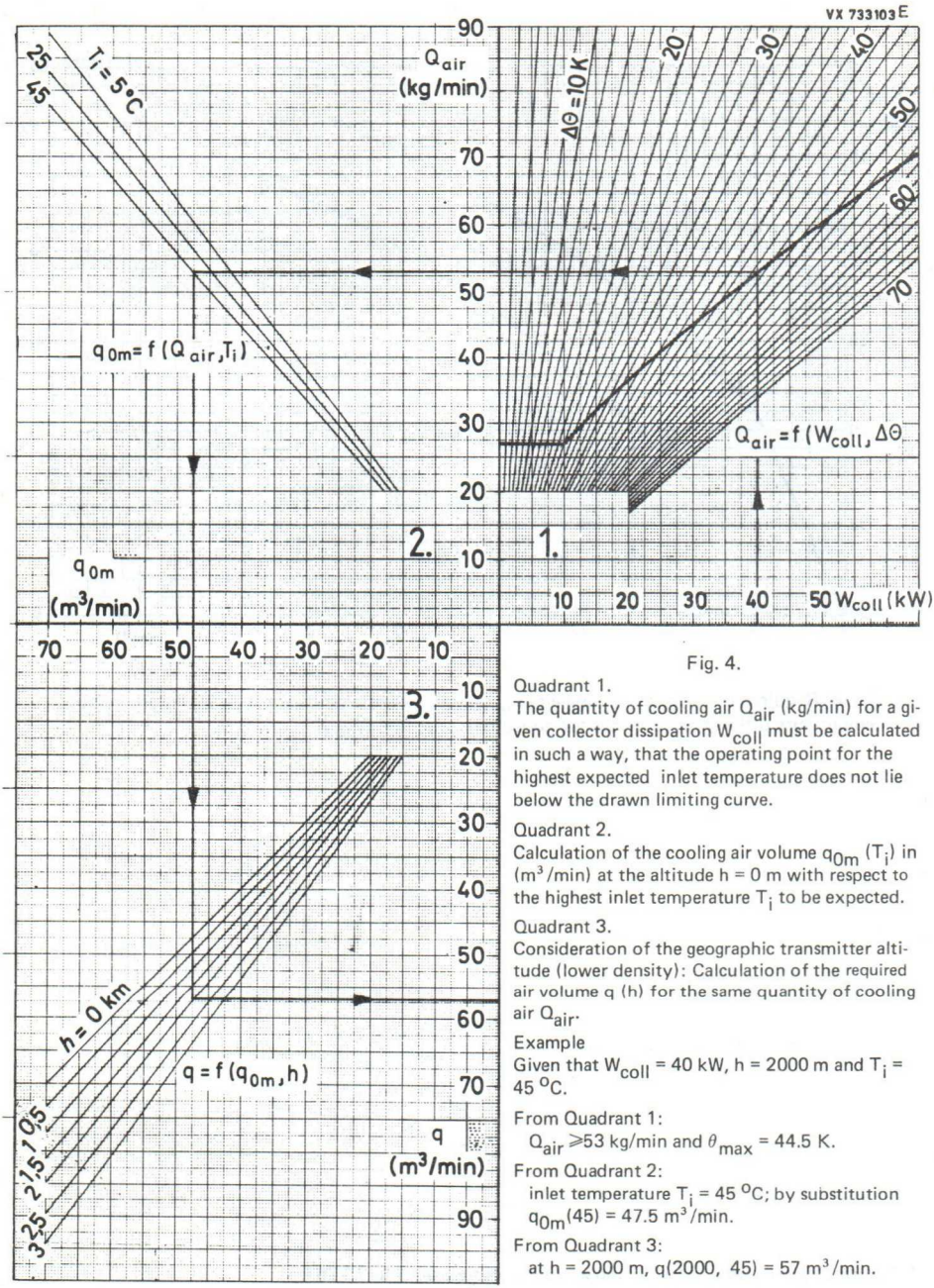



Fig. 4.

Quadrant 1.
The quantity of cooling air $Q_{air}$ (kg/min) for a given collector dissipation $W_{coll}$ must be calculated in such a way, that the operating point for the highest expected inlet temperature does not lie below the drawn limiting curve.

Quadrant 2.
Calculation of the cooling air volume $q_{0m}$ ($T_i$) in ($m^3$/min) at the altitude h = 0 m with respect to the highest inlet temperature $T_i$ to be expected.

Quadrant 3.
Consideration of the geographic transmitter altitude (lower density): Calculation of the required air volume q (h) for the same quantity of cooling air $Q_{air}$.

Example
Given that $W_{coll}$ = 40 kW, h = 2000 m and $T_i$ = 45 °C.

From Quadrant 1:
$Q_{air} \geqslant 53$ kg/min and $\theta_{max}$ = 44.5 K.

From Quadrant 2:
inlet temperature $T_i$ = 45 °C; by substitution $q_{0m}(45)$ = 47.5 $m^3$/min.

From Quadrant 3:
at h = 2000 m, q(2000, 45) = 57 $m^3$/min.

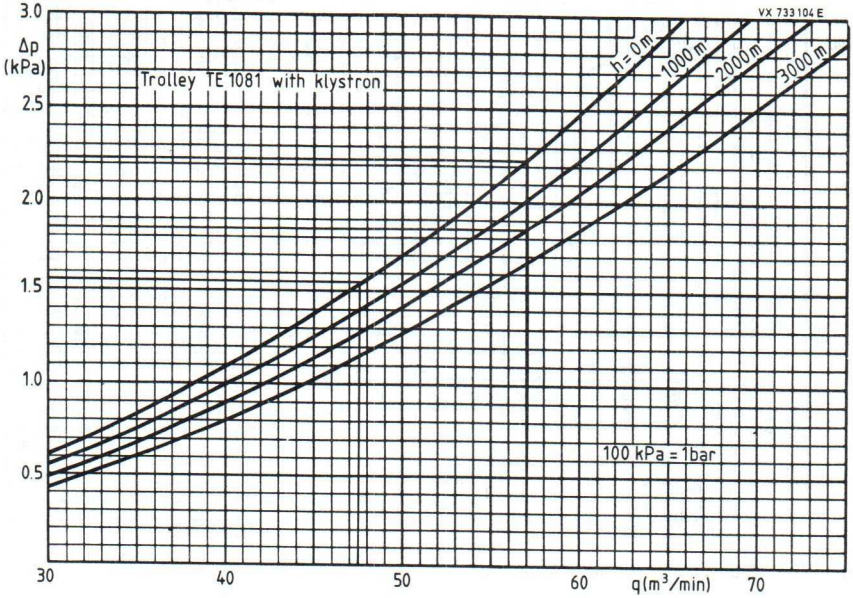



Fig. 5 Calculation of the pressure drop Δp between air inlet and air outlet at the trolley TE1081 as a function of cooling air volume q for selection of the correct blower.

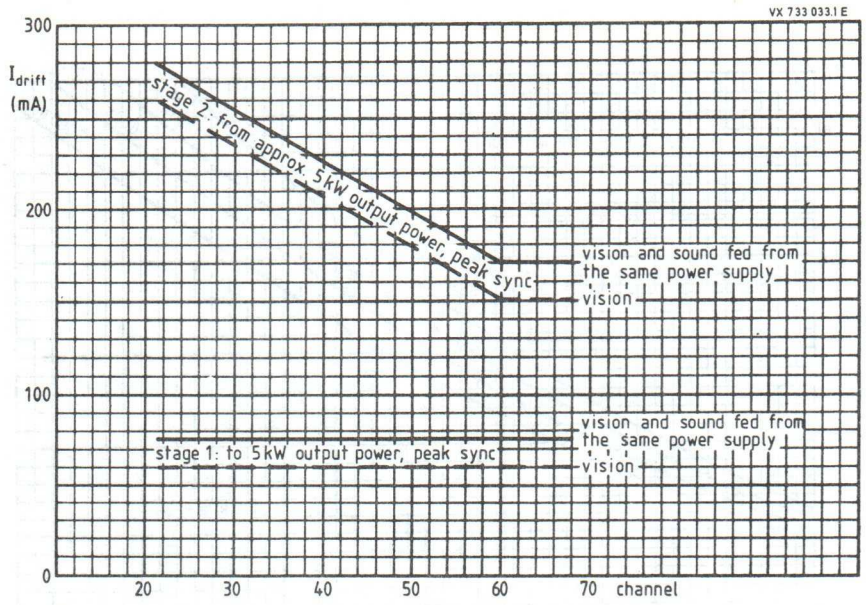



Fig. 6 Drift tube current cut-out at operation with depressed collector voltage for 20 kW transmitter.

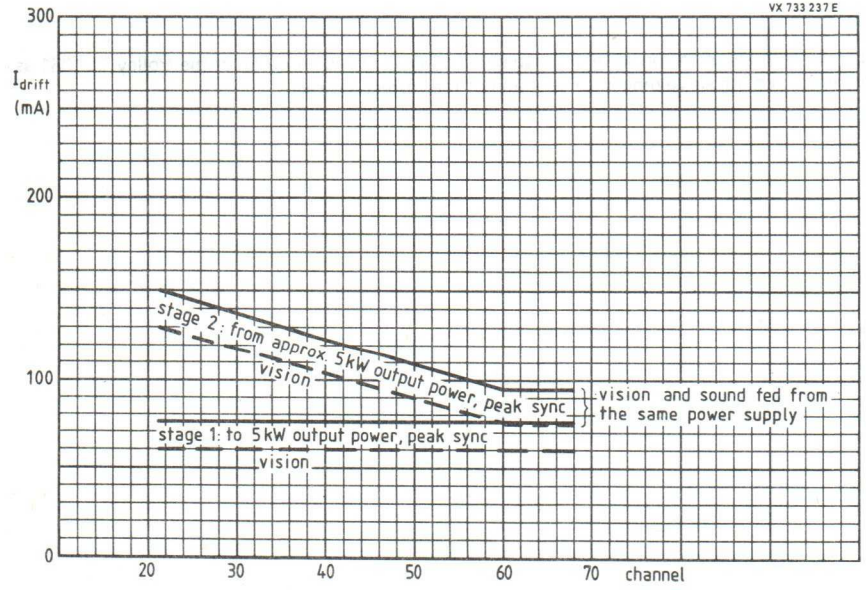



Fig. 7 Drift tube current cut-out at operation without depressed collector voltage for 20 kW transmitter.

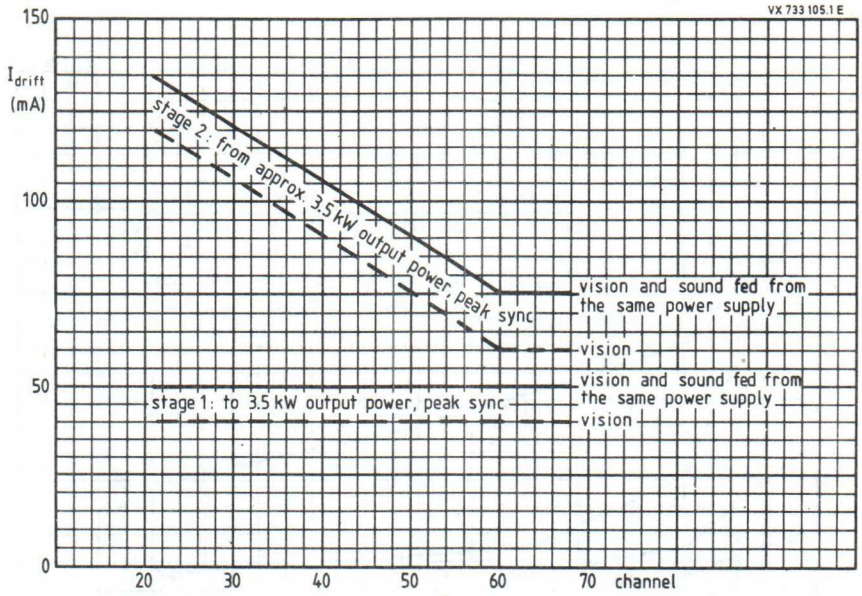



Fig. 8 Drift tube current cut-out at operation with depressed collector voltage for 10 kW transmitter.

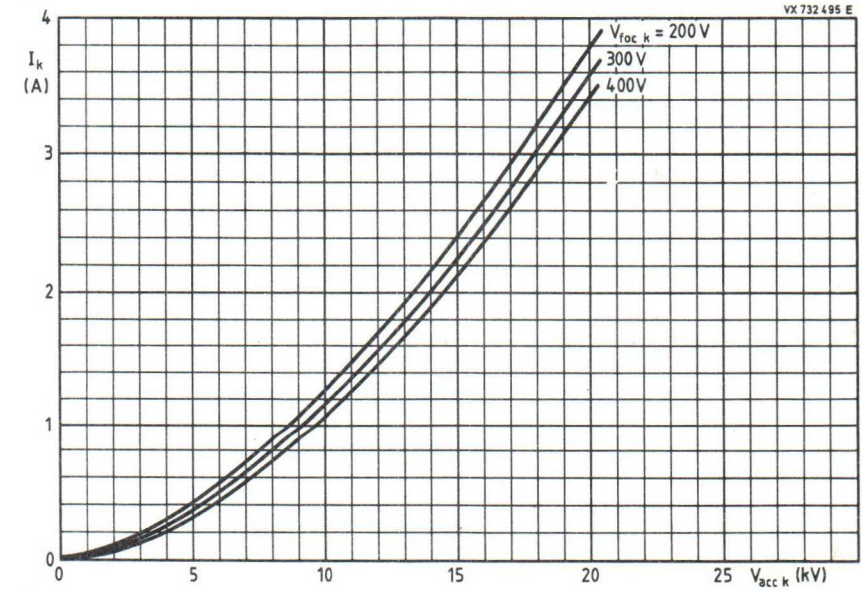



Fig. 9.

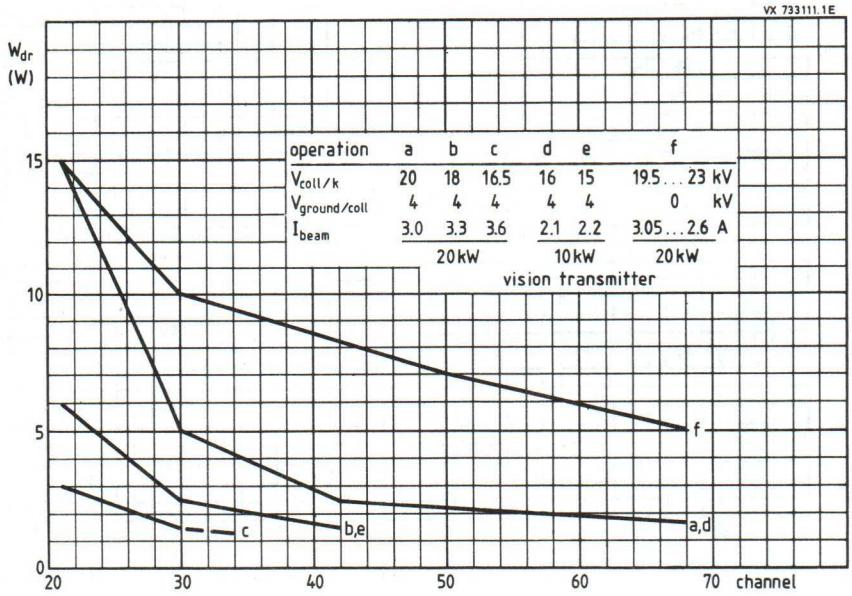



Fig. 10 Max. drive power in dependence on channel and operation mode.

## DESIGN CONSIDERATIONS FOR POWER SUPPLIES AND SAFETY CIRCUITS

### 1. Power supplies

| | Range [1] | | Internal resistance | Hum |
|---|---|---|---|---|
| Heater voltage | 6.5 to 8.0 V<br>(26 to 36 A) | | [2] | Corresponding to non-smoothed three-phase, full-wave rectifier |
| Cathode to focusing electrode voltage | 100 to 600 V<br>(−0.2 to +3 mA) | | | < 0.1% |
| Ground to collector voltage | 0 or 4.5/ 4.0/ 3,5 kV [3]<br>(500 mA mean, 1 A peak) | | 0 or<br>300 to 600 Ω | < 0.1% |
| Collector to [4] cathode voltage | Operation without depressed collector voltage | Operation with depressed collector voltage | | |
| 20 kW operation | 19.5 to 23 kV<br>(65 kW) | 16.5 kV<br>18.0 kV (65 kW)<br>20.0 kV | 300 to 600 Ω | < 0.1% |
| 10 kW operation | | 15.0 kV<br>16.0 kV (35 kW) | | |
| Ground to accelerator electrode voltage | see Fig. 9. | | | |
| Getter-ion pump to cathode voltage [5] | voltage, unloaded 3.5 to 4 kV<br>(load up to 15 mA) | | 300 kΩ | – – |

[1] Maximum allowable deviation from nominal or set values:
a) ±2% during adjustment, if the published performance is to be attained,
b) ±1% fluctuation of the set values during operation to maintain the performance,
c) during operation, deviations not exceeding ±3% of the set values will not damage the tube.

[2] The heater current should never exceed a peak value of 65 A.

[3] At operation with depressed collector voltage a capacitor of 0.5 μF must be installed near the collector connection of the klystron and the trolley between feed line and ground.

[4] An additional tap for approx. 500 V to the given voltages is recommended.

[5] Needed for operation without depressed collector voltage.

### 2. Safety circuits

The safety circuits must operate in any one of the following cases:

a) The cut-out threshold of the drift tube current is exceeded. Dependent on the peak output power this cut-out should operate in two stages, see Figs 6 and 7.

b) The set collector or cathode current is exceeded by more than 30 % (max. 400 mA).

c) The air volume for collector cooling falls below the initial value for a longer period (see data sheet by cooling).

d) The cooling air for drift tubes 3, 4 and 5, cavity 4, and cathode terminals fails (checked by a vane or equivalent device).

e) The set max. temperature on the contact thermometers of the klystron is exceeded.

Set temperatures of the probe assemblies are:

| | Probe 1 (top) | Probe 2 (middle) | Probe 3 (bottom) |
|---|---|---|---|
| 10 kW Vision | 80 °C | 80 °C | 80 °C |
| 10 kW Sound | 65 °C | 65 °C | 65 °C |
| 20 kW Vision | 90 °C | 110 °C | 110 °C |
| 20 kW Sound | 65 °C | 65 °C | 65 °C |

f) The return loss is lower 14 dB (VSWR $\geqslant$ 1.5).

g) The pump operating current exceeds 50 $\mu$A.

**3. Operation without output power**

Static operation (operation without output power) in vision transmitters is not allowed at beam currents $>$ 2/3 of the given value. Without driving signal the beam current must be reduced or the tube switched-off.

**4. Switching-on and switching-off procedures**

**a) Switching-on sequence:**

1. accelerating electrode at cathode potential,
2. cooling air,
3. ground to collector voltage,
4. heater voltage and cathode to focusing electrode voltage.

Steps 1 to 4 can be simultaneous.

5. waiting time,
6. collector to cathode voltage,
7. ground to accelerator electrode voltage.

**b) Switching-off sequence:**

1. accelerating electrode at cathode potential,
2. all other voltages and cooling simultaneously.

**c) Switching-off sequence when the safety circuits operate:**

1. accelerating electrode at cathode potential,
2. cathode-to-collector voltage.

For repeated switching-on (repeating): see a) 6 and 7.

In case of failure the following voltages must be switched-off and made to drop below 5% of their nominal value:

accelerating electrode-to-body voltage and cathode-to-collector voltage within 500 ms, collector-to-body voltage within 1 s.

It is recommended to start this drop 200 ms after occurrence of the failure.

**5. Waiting time after short interruptions of operation**

| Interruption of the heater voltage | Required waiting time { vision $V_f$ = 7 V; sound $V_f$ = 6.5 V } |
|---|---|
| 0 to 30 s | 0 s |
| 30 to 60 s | 30 s |
| 60 to 90 s | 60 s |
| > 90 s | 180 s |

**6. Focusing**

a) The tube is pre-focused by the tube manufacturer.

b) For final focusing see manual.

**7. Cooling**

a) The cooling of the cathode socket, accelerating electrode, drift tubes, and cavities must be monitored.

b) The air volume of the collector cooling and, dependent on it, the temperature distribution at the air outlet, must be monitored at minimum three points.

c) Also during stand-by the cathode socket must be cooled and the getter-ion pump kept in operation.

**8. Mounting**

a) The r.f. connectors for operation have the following dimensions:

| | |
|---|---|
| Stub | 7/16 |
| Input coupling device cavity 1 | 7/16 |
| Output coupling device cavities 2 and 3 | 7/16 |
| Output coupling device cavity 4 | 3 1/8'' |

b) Forces on klystron terminals max. 10 N. Bending moment max. 1 Nm.

c) The coaxial magnets must not be removed from the klystron.

d) In order to prevent distortion of the magnetic focusing field, ferromagnetic material should not be applied within a radius of 35 cm from the tube axis.
Using the trolley TE1081. No parts should be mounted on or within the trolley and ferromagnetic parts in the trolley are not allowed.

e) Magnetic stray fields, e.g. from transformers, coils, etc., must not exceed 50 $\mu$T (0.5 gauss) at the surface of the klystron.

f) It is recommended to use non-magnetic material for doors of cabinets containing output stages, if these doors must be closed after focusing.

**9. Storage and transport**

a) In cases of prolonged storage, each klystron must be checked for vacuum at least every 6 months and pumped if necessary.
It is recommended to check every 3 months (the heater voltage need not switched-on).

b) All klystrons are insured during delivery transportation.
Each tube must be inspected for damage within 7 days of delivery:
1. Visual inspection of pack and tube.
2. Vacuum inspection with the getter-ion pump (without heating), the pump current must decrease to less than 10 $\mu$A within 15 min.

# U.H.F. POWER KLYSTRONS

For u.h.f. band IV/V vision transmitters and sound transmitters.
Metal-ceramic construction, four external cavities, electromagnetic focusing and a high-stability dispenser type cathode.
Suitable for vapour, vapour-condensation or water cooling.

## QUICK REFERENCE DATA

| | | |
|---|---|---|
| Frequency range | | |
| YK1190 | 470 to 610 | MHz |
| YK1191 | 590 to 720 | MHz |
| YK1192 | 710 to 860 | MHz |
| Output power as vision transmitter | 40 | kW |
| Cooling | vapour, vapour condensation, or water | |

This data must be read in conjunction with GENERAL OPERATIONAL RECOMMENDATIONS for KLYSTRONS.

| **HEATING:** indirect by d.c. | | | | notes |
|---|---|---|---|---|
| Cathode | dispenser type | | | |
| Heater voltage | $V_f$ ≈ | 8.5 | V ± 3 % | |
| Heater current | $I_f$ ≈ | 22 to 27 | A | 1 |
| Cold heater resistance | $R_{fo}$ ≈ | 30 | mΩ | |
| Waiting time | | | | 2 |
| at $V_f$ = 8.5 V | $t_w$ min. | 300 | s | |
| at $V_f$ = 6.0 V (black heat) | $t_w$ min. | 0 | s | |

| **FOCUSING:** electromagnetic | | | |
|---|---|---|---|
| Focusing coil current | | 9 to 12 | A |
| Resistance of focusing coils | | | |
| cold (20 °C) | | 7.2 to 9.5 | Ω |
| operating at an ambient temperature of 20 °C | ⩽ | 11 | Ω |

**BEAM CONTROL**

The accelerator electrode voltage allows adjustment of the beam current between 0 and 100%.

| **GETTER-ION PUMP SUPPLY** | | | 3 |
|---|---|---|---|
| Pump voltage, no-load condition | | 3 to 4 | kV |
| Internal resistance of supply | | 300 | kΩ |

## MECHANICAL DATA YK1190

Dimensions in mm

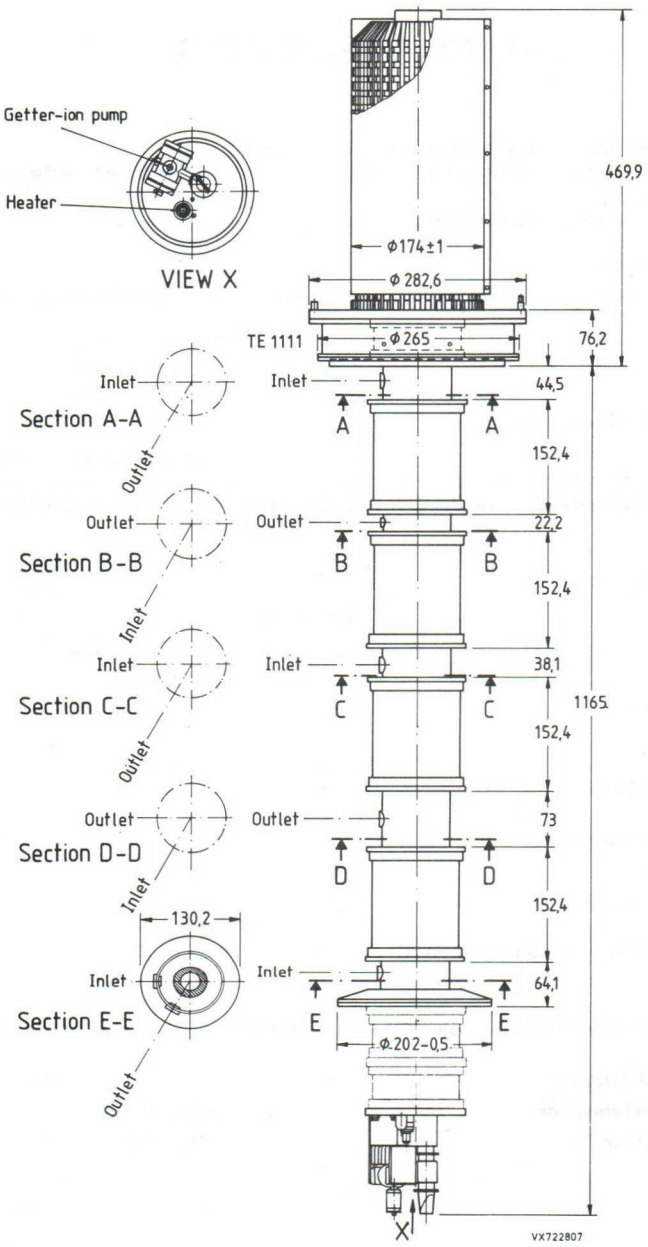



Fig. 1.

YK1191, YK1192

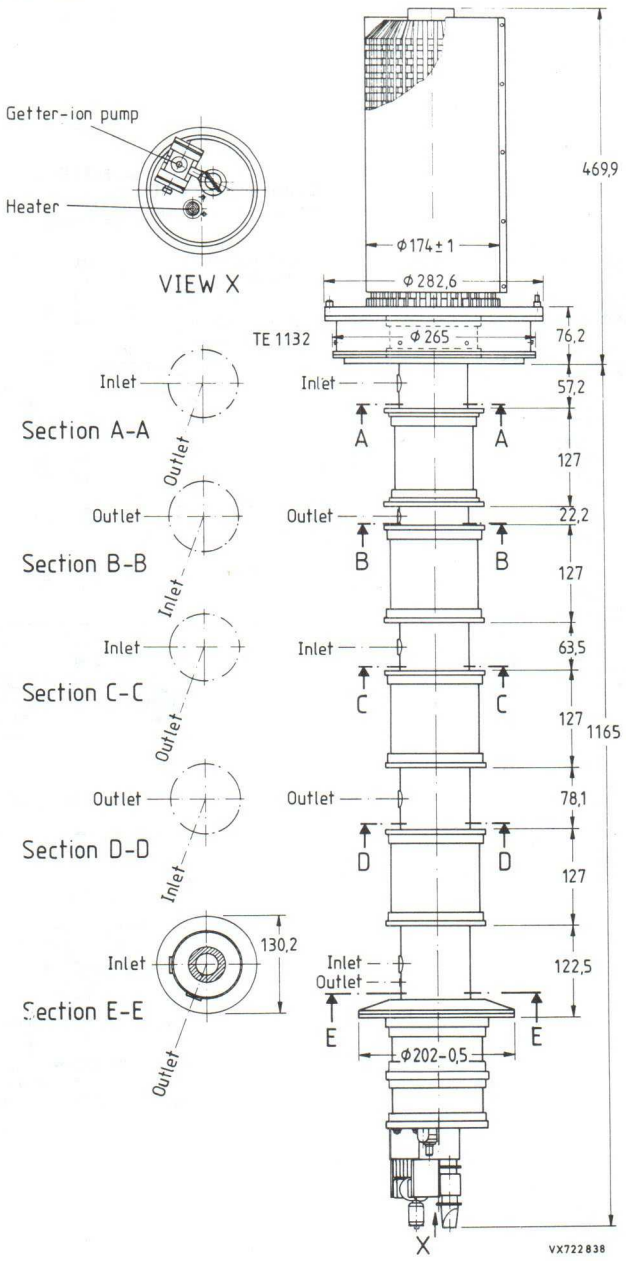



Fig. 2.

**Mechanical outlines of trolley**

Dimensions in mm

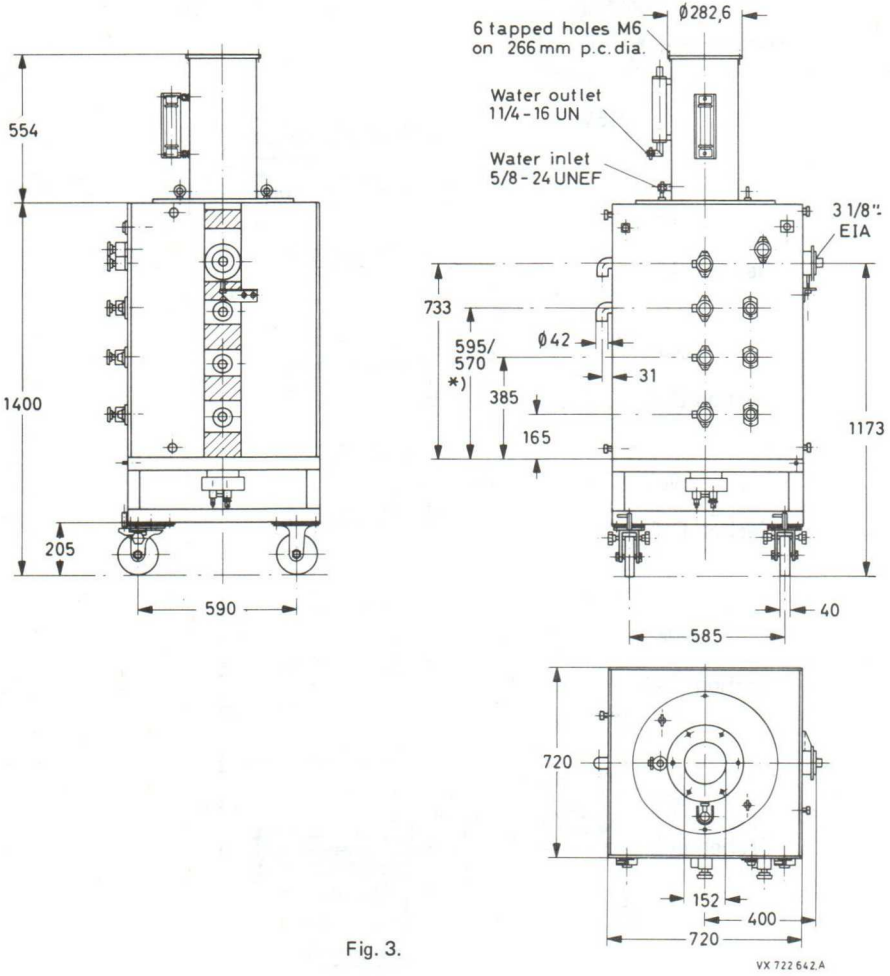



Fig. 3.

* YK 1190 = 570 mm.
YK 1191/92 = 595 mm.

## COOLING

| | |
|---|---|
| Cathode socket<br>accelerator electrode | air; $q \approx 0.15$ m$^3$/min, $T_i$ max. 40 °C |
| Collector | vapour (with boiler TE1110), note 4<br>volume of water converted to steam: 27 cm$^3$/min per kW collector dissipation resulting in 43 ℓ/min steam per kW collector dissipation<br>water or vapour condensation (with cooler TE1194) $q$ = 35 to 60 ℓ/min, $T_o$ max 80 °C, |
| Drift tubes | water; rate of flow to drift tubes and collector connected in series $q \approx 9$ ℓ/min, $T_i$ max. 80 °C, $\Delta p$ = 200 kPa (2 bar) |
| Cavities 3 and 4 | forced air; $q$ = 1.5 m$^3$/min, $\Delta p$ = 250 Pa (2.5 mbar) $T_i$ max. 45 °C |

## MASS AND DIMENSIONS

| | | | |
|---|---|---|---|
| Klystron | | | |
| net | approx. | 80 | kg |
| gross | approx. | 230 | kg |
| outline dimensions of packing (cm) | 205 x 75 x 65 | | |
| Cavities | approx. | 45 | kg |
| Magnet frame with coils | approx. | 885 | kg |

## MOUNTING

Mounting position: vertical with collector up.
To remove the tube from the magnet frame a total free height of 3.5 m, excluding hoist, is required.

## PRODUCT SAFETY

*1. X-radiation*

Correct operation of the tube can be guaranteed only if a set of accessories, approved by the tube manufacturer, is used.

The operating tube generates X-rays which can penetrate the ceramic parts of the tube envelope. In order to reduce the radiation at any accessible points to an officially acceptable, non-dangerous level the tube must be shielded and any possible radiation path blocked by at least 1 mm of brass or an equivalent depth of non-magnetic X-ray absorbing material. The proper use of accessories will provide the necessary shielding.

*2. R.F. radiation*

R.F. power may be emitted through apertures other than the normal output coupling (for example r.f. leaks). This r.f. power may be sufficiently intense to cause danger to the human body, particularly to the eyes. Such radiation may be increased if the tube is functioning incorrectly.

### Instruction manual

For detailed mounting and tuning instructions see klystron instruction manual, delivered with each tube.

**ACCESSORIES** (note 5)

Each tube is delivered with the following factory fitted accessories:

| | YK1190 | YK1191 | YK1192 |
|---|---|---|---|
| Collector radiation suppressor | TE1111 | TE1132 | TE1195 |
| Accelerator electrode ring | TE1141 | TE1141 | TE1141 |
| Cathode ring | TE1142 | TE1142 | TE1142 |
| | or TE1142B | or TE1142B | or TE1142B |
| Set of sealing rings | TE1147 | TE1147 | TE1147 |
| **A. Accessories to be ordered separately when replacing equivalent other brand types** | | | |
| Magnet flux ring | TE1138 | TE1138 | |
| Spark gap | TE1140 | TE1140 | |
| Set of connectors (heater, cathode, acc. electrode, getter-ion pump) | TE1146 | TE1146 | TE1146 |
| **B. Accessories required for first equipment** | | | |
| Magnet flux ring | TE1138 | TE1138 | TE1138 |
| Spark gap | TE1140 | TE1140 | TE1140 |
| Set of connectors (heater, cathode, acc. electrode, getter-ion pump) | TE1146 | TE1146 | TE1146 |
| Extension pipes for drift tubes | 6 x TE1133A<br>2 x TE1133B | 6 x TE1133A<br>2 x TE1133B | 6 x TE1133A<br>2 x TE1133B |
| Water interconnecting pipes between drift tubes | | | |
| $T_1$ - $T_2$ | TE1134A | TE1135A | TE1135A |
| $T_2$ - $T_3$ | TE1134B | TE1135B | TE1135B |
| $T_3$ - $T_4$ | TE1134C | TE1135C | TE1135C |
| $T_4$ - $T_5$ | TE1134D | TE1135D | TE1135D |
| Flexible water pipes | | | |
| between tube and boiler for vapour cooling | TE1145A | TE1145A | TE1145A |
| between frame and tube | TE1145B | TE1145B | TE1145B |
| tube outlet for water cooling | TE1145C | TE1145C | TE1145C |
| Boiler for vapour cooling | TE1110 | TE1110 | TE1110 |
| or | | | |
| Cooler for water cooling | TE1194 | TE1194 | TE1194 |
| Cavities | 3 x TE1121A<br>1 x TE1121D | 3 x TE1098A<br>1 x TE1098D | 3 x TE1191A<br>1 x TE1191B |
| Input coupler | TE1122A | TE1102 | TE1102 |
| Load coupler for cavities 2 and 3 | 2 x TE1122B | 2 x TE1102 | 2 x TE1102 |
| Blanking plates | 3 x TE1157 | 3 x TE1157 | 3 x TE1157 |
| Output coupler for cavity 4 | TE1123 | TE1105 | TE1196 |
| Arc detector | TE1107 | TE1107 | TE1107 |
| Magnet frame with coils | TE1108 | TE1108 | TE1108 |
| Tool set | TE1137 | TE1137 | TE1137 |

| ACCESSORIES (continued) | YK1290 | YK1291 | YK1292 |
|---|---|---|---|
| **C. Spare and optional parts** | | | |
| Collector radiation suppressor | TE1111 | TE1132 | TE1195 |
| Accelerator electrode ring | TE1141 | TE1141 | TE1141 |
| Cathode ring | TE1142 | TE1142 | TE1142 |
| | or TE1142B | or TE1142B | or TE1142B |
| Set of connectors (heater, cathode, acc. electrode, getter-ion pump) | TE1146 | TE1146 | TE1146 |
| Set of sealing rings | TE1147 | TE1147 | TE1147 |
| Water protection shield | TE1139 | TE1139 | TE1139 |
| Recommended circulators | | | |
| 470 to 600 MHz | 2722 162 01551 (T100/IV-N) | | |
| 600 to 800 MHz | 2722 162 01561 (T100/V-N) | | |
| 790 to 1000 MHz | 2722 162 03261 (T100/V-3-N) | | |

**LIMITING VALUES** (Absolute maximum rating system)

| | | | | |
|---|---|---|---|---|
| Heater voltage | max. | 9.5 | V | |
| Beam voltage | max. | 23 | kV | |
| Cold cathode voltage | max. | −27 | kV | |
| Beam current | max. | 7 | A | |
| Body current | max. | 150 | mA | |
| Accelerator electrode current | max. | 6 | mA | note 7 |
| Collector dissipation | max. | 150 | kW | |
| Load VSWR | max. | 1.5 | | |
| Temperature of tube envelope | max. | 175 | °C | |
| Static pressure in the cooling system | max. | 600 | kPa | (6 bar) note 6 |

## TYPICAL OPERATING CONDITIONS: YK1190/YK1191

**As 40 kW vision transmitter (CCIR-G standard)**

| | gain-tuned operation | efficiency-tuned operation (examples) | | | |
|---|---|---|---|---|---|
| Output power, peak sync. | 45 | 45 | 45 | kW | |
| Beam voltage | 22 | 20.5 | 22 | kV | |
| Beam current | 6.3 | 5.7 | 4.8 | A | |
| Accelerator to cathode voltage | 22 | 20.5 | 18 | kV | |
| Body current | | | | | |
| without drive | 15 | 15 | 15 | mA | |
| at 45 kW peak sync., black level | 30 | 40 | 40 | mA | |
| Focusing coil current | 10.5 | 10.5 | 10.0 | A | |
| Drive power, peak sync. | | | | | |
| YK1190 - channel 21 | 2 | 10 | 6 | W | note 9 |
| channel 38 | 1.5 | 7 | 4 | W | note 9 |
| YK1191 - channel 37 | 1.5 | 7 | 4 | W | note 9 |
| channel 51 | 1 | 5 | 3 | W | note 9 |
| Bandwidth at −1 dB points | 8 | 8 | 8 | MHz | note 10 |
| Differential gain | 80 | 75 | 70 | % | note 11 |
| Differential phase | 6 | 7 | 10 | deg | note 11 |
| Linearity | 70 | 65 | 60 | % | note 12 |
| Operating efficiency | 32 | 38.5 | 42.5 | % | |
| Saturation output power | 55 | 60 | 46.5 | kW | |
| Saturation efficiency | 40 | 43 | 44 | % | |

**As 4 kW/8 kW sound transmitter (CCIR-G standard)**

| | | | | | | |
|---|---|---|---|---|---|---|
| Output power | 4.5 | 9 | 4.5 | 9 | kW | |
| Beam voltage | 20.5 | 20.5 | 22 | 22 | kV | note 6 |
| Beam current | 1.25 | 1.5 | 1.15 | 1.4 | A | |
| Accelerator cathode voltage | ≈ 7.5 | ≈ 8.5 | ≈ 7 | ≈ 8 | kV | note 13 |
| Focusing coil current | 9 | | | | A | |
| Drive power | 1.5 | | | | W | note 9 |
| Bandwidth at −1 dB points | 1 | | | | MHz | |

## TYPICAL OPERATING CONDITIONS: YK1192

### As 40 kW vision transmitter (CCIR-G standard)

| | | | |
|---|---|---|---|
| Output power, peak sync. | 45 | kW | |
| Beam voltage | 23 | kV | note 6 |
| Beam current | 4.6 | A | note 8 |
| Accelerator to cathode voltage | 18 | kV | |
| Body current | | | |
| without drive | 15 | mA | |
| at 45 kW peak sync., black level | 40 | mA | |
| Focusing coil current | 10 | A | |
| Drive power, peak sync. | 2 | W | note 9 |
| Bandwidth at −1 dB points | 8 | MHz | note 10 |
| Differential gain | 70 | % | note 11 |
| Differential phase | 10 | deg | note 11 |
| Linearity | 60 | % | note 12 |
| Operating efficiency | 42.5 | % | |
| Saturation output power | 46.5 | kW | |
| Saturation efficiency | 44 | % | |

### As 4 kW/8 kW sound transmitter (CCIR-G standard)

| | | | | |
|---|---|---|---|---|
| Output power | 4.5 | 9 | kW | |
| Beam voltage | 23 | 23 | kV | note 6 |
| Beam current | 1.1 | 1.3 | A | |
| Accelerator to cathode voltage | ≈7 | ≈8 | kV | note 13 |
| Focusing coil current | 9 | | A | |
| Drive power | 1.5 | | W | note 9 |
| Bandwidth at −1 dB points | 1 | | MHz | |

**Notes**

1. When switching on the heater voltage, the heater current must never exceed a peak value of 65 A.
2. In case of a mains failure an interruption up to 30 s can be tolerated without new waiting time. After min. 10 minutes of stand-by heating time at 6 V (black heat), the beam current may be switched on; the heater voltage must be increased to its nominal value of 8.5 V simultaneously. Continuous black heat periods should not exceed two weeks and should be separated by similar periods of rest or full operation.
3. To ensure that the klystron is always ready for operation, operate the ion getter pump at least every 6 months (preferably every 3 months) during storage. For details see klystron instruction manual.
4. In order to avoid corrosion of the cooling system, coolant water must be pure and deionized (resistivity min. 100 kΩ·cm).
5. Correct operation of the tube can be guaranteed only if a set of accessories, approved by the tube manufacturer, is used. The operating tube generates X-rays which can penetrate the ceramic parts of the tube envelope. In order to reduce the radiation at any accessible points to an officially admissible, non-dangerous level the tube must be shielded and any possible radiation path must be blocked by at least 1 mm of brass or an equivalent portion of non-magnetic X-ray absorbing material. The proper use of our accessory parts will provide the necessary shielding.
6. Static pressure in the body-cooling system and in the water-cooling jacket TE1194.
7. The accelerator electrode voltage must not be positive with respect to the body (ground).
8. If the accelerator electrode is connected to the body (ground) via 10 kΩ resistor, the beam current is within ± 5% of the value given in the graph of Fig. 4.
9. The drive power is defined as the power delivered to a matched load.
10. Variation of the signal level between black and white at any sideband frequency may cause a reaction of the peak sync. level. Proper tube design limits this reaction to less than 0.5 dB.
11. Measured with a sawtooth signal from black level to peak white occuring at each line and superimposed colour subcarrier with a 10 % peak to peak amplitude.
12. Measured with a ten-step staircase signal from black level to peak with occuring at each line.
13. A voltage divider for adjusting the beam current should be dimensioned on the basis of an accelerator electrode current of max. 1.5 mA.

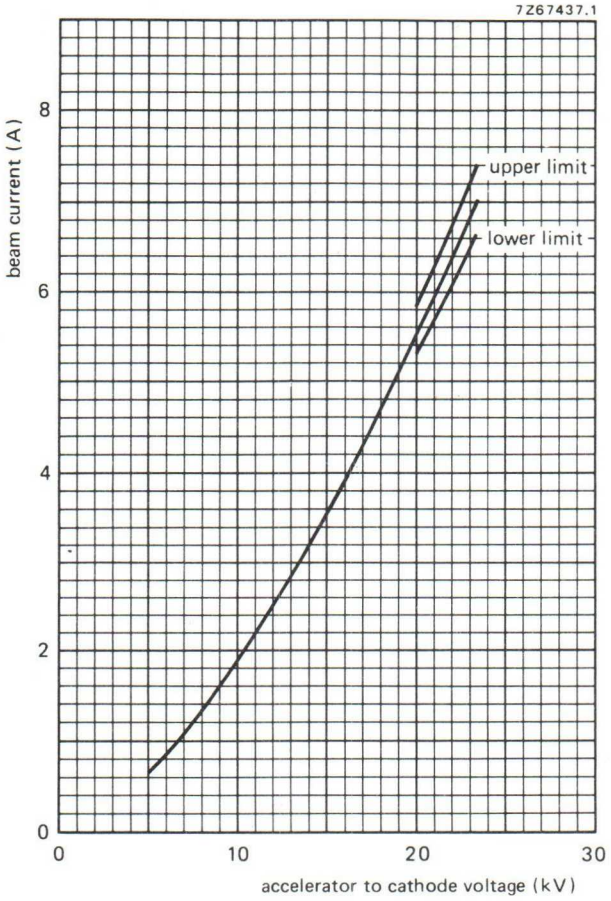

7Z67437.1
beam current (A)
8
6
4
2
0
upper limit
lower limit
0
10
20
30
accelerator to cathode voltage (kV)

Fig. 4.

# U.H.F. POWER KLYSTRON

Optionally vapour, vapour condensation, or water-cooled power klystron in metal-ceramic construction for 60 kW CW amplifiers. The tube has four external cavities, electromagnetic focusing and a high stability dispenser-type cathode.

## QUICK REFERENCE DATA

| | |
|---|---|
| Frequency range | 800 MHz |
| Cooling | vapour, vapour condensation, or water |

This data must be read in conjunction with GENERAL OPERATIONAL RECOMMENDATIONS for KLYSTRONS.

| **HEATING:** indirect by d.c. | | | | notes |
|---|---|---|---|---|
| Cathode | dispenser type | | | |
| Heater voltage | $V_f$ | ≈ | 8.5 V ±3 % | |
| Heater current | $I_f$ | ≈ | 22 to 27 A | 1 |
| Cold heater resistance | $R_{fo}$ | ≈ | 30 mΩ | |
| Waiting time | | | | 2 |
| at $V_f$ = 8.5 V | $t_w$ | min. | 300 s | |
| at $V_f$ = 6.0 V (black heat) | $t_w$ | min. | 0 s | |

| **FOCUSING:** electromagnetic | | | |
|---|---|---|---|
| Focusing coil current | | 9 to 12 | A |
| Resistance of focusing coils | | | |
| cold (20 °C) | | 7.2 to 9.5 | Ω |
| operating at an ambient temperature of 20 °C | ⩽ | 11 | Ω |

## BEAM CONTROL

The accelerator electrode voltage allows adjustment of the beam current between 0 and 100%.

| **GETTER-ION PUMP SUPPLY** | | | notes |
|---|---|---|---|
| Pump voltage, no-load condition | 3 to 4 | kV | 3 |
| Internal resistance of supply | 300 | kΩ | |

## MECHANICAL DATA

Dimensions in mm

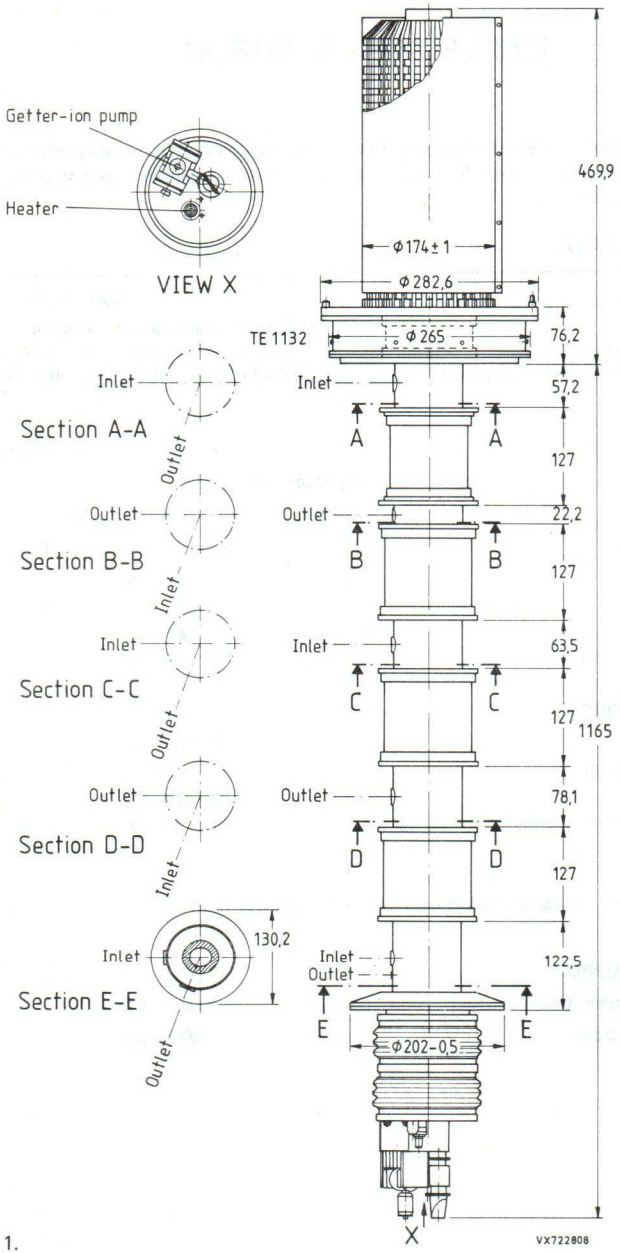



Fig. 1.

## Mechanical outlines of trolley

Dimensions in mm

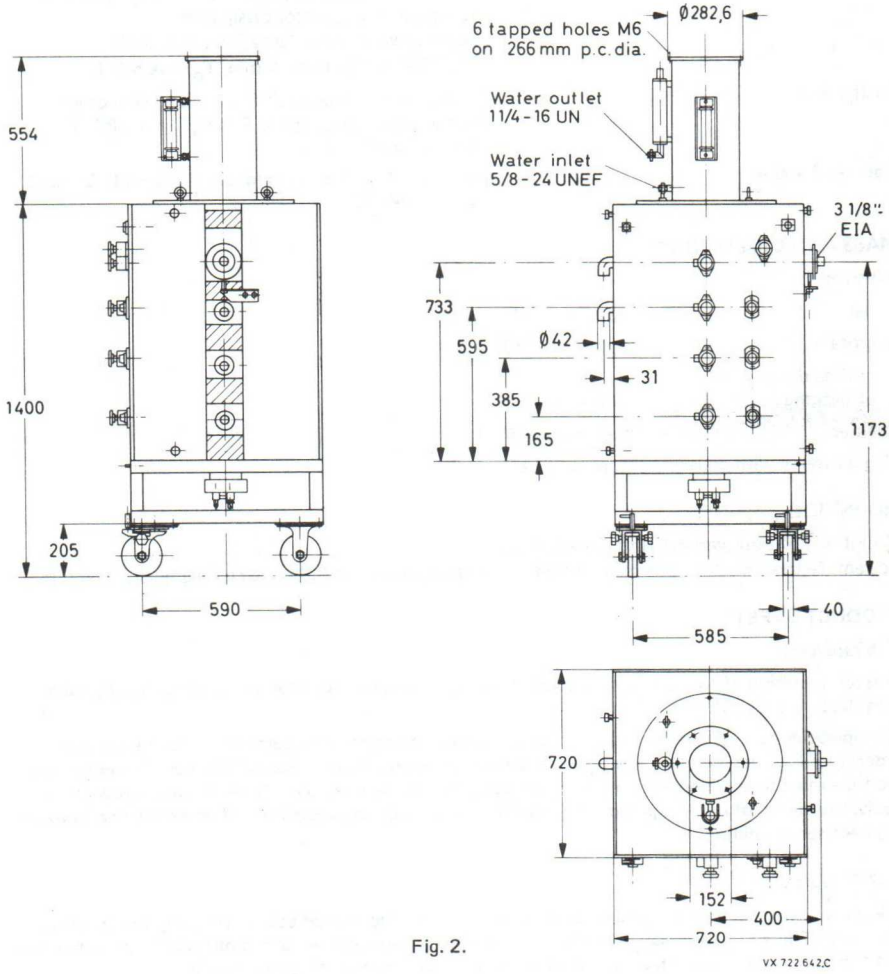



Fig. 2.

## COOLING

| | |
|---|---|
| Cathode socket accelerator electrode | air; $q \approx 0.15$ m$^3$/min, $T_i$ max. 40 °C |
| Collector | vapour (with boiler TE1110), note 4<br>volume of water converted to steam: 27 cm$^3$/min per kW collector dissipation resulting in 43 ℓ/min steam per kW collector dissipation<br>water or vapour condensation (with cooler TE1194) q = 35 to 60 ℓ/min, $T_o$ max 80 °C, |
| Drift tubes | water; rate of flow to drift tubes and collector connected in series $q \approx 9$ ℓ/min, $T_i$ max. 80 °C, $\Delta p$ = 200 kPa (2 bar) |
| Cavities 3 and 4 | forced air; q = 1.5 m$^3$/min, $\Delta p$ = 250 Pa (2.5 mbar) $T_i$ max. 45 °C |

## MASS AND DIMENSIONS

| | | | |
|---|---|---|---|
| Klystron | | | |
| net | approx. | 80 | kg |
| gross | approx. | 230 | kg |
| outline dimensions of packing (cm) | 205 x 75 x 65 | | |
| Cavities | approx. | 45 | kg |
| Magnet frame with coils | approx. | 885 | kg |

## MOUNTING

Mounting position: vertical with collector up.
To remove the tube from the magnet frame a total free height of 3.5 m, excluding hoist, is required.

## PRODUCT SAFETY

*1. X-radiation*

Correct operation of the tube can be guaranteed only if a set of accessories, approved by the tube manufacturer, is used.

The operating tube generates X-rays which can penetrate the ceramic parts of the tube envelope. In order to reduce the radiation at any accessible points to an officially acceptable, non-dangerous level the tube must be shielded and any possible radiation path blocked by at least 1 mm of brass or an equivalent depth of non-magnetic X-ray absorbing material. The proper use of accessories will provide the necessary shielding.

*2. R.F. radiation*

R.F. power may be emitted through apertures other than the normal output coupling (for example r.f. leaks). This r.f. power may be sufficiently intense to cause danger to the human body, particularly to the eyes. Such radiation may be increased if the tube is functioning incorrectly.

### Instruction manual

For detailed mounting and tuning instructions see klystron instruction manual, delivered with each tube.

## ACCESSORIES

| | | |
|---|---|---|
| Set of sealing rings | TE1147 | |
| Collector radiation suppressor | TE1195 | |
| Accelerator electrode ring | TE1141 | |
| Cathode ring | TE1142 | |
| Water interconnecting pipes between drift tubes | | |
| $T_1$ - $T_2$ | TE1135A | |
| $T_2$ - $T_3$ | TE1135B | |
| $T_3$ - $T_4$ | TE1135C | |
| $T_4$ - $T_5$ | TE1135D | |
| Extension pipes for drift tubes | 6 x TE1133A<br>2 x TE1133B | |
| Flexible water pipes | for vapour cooling | for water cooling |
| between tube and boiler | TE1145A | – |
| between frame and tube | TE1145B | TE1145B |
| tube outlet | – | TE1145C |
| Boiler for vapour cooling | TE1110 | – |
| or | | |
| Cooler for water cooling | – | TE1194 |
| Magnet flux ring | TE1138 | |
| Water protection shield | TE1139 | |
| Spark gap | TE1140 | |
| Set of connectors (heater, cathode, accelerator electrode, getter-ion pump) | TE1146 | |
| Cavities | 3 x TE1191A<br>1 x TE1191B | |
| Input coupler | TE1102 | |
| Load coupler for cavities 2 and 3 | 2 x TE1102 | |
| Blind flanges | 3 x TE1157 | |
| Output coupler for cavity 4 | TE1192 | |
| Arc detector | TE1107 | |
| Magnet frame with coils | TE1193 | |
| Tool set | TE1137 | |
| Recommended circulator | 2722 162 01561 (T100/V-N) | |

**LIMITING VALUES** (Absolute maximum rating system)

| | | | | |
|---|---|---|---|---|
| Heater voltage | max. | 9.5 | V | |
| Beam voltage | max. | 28 | kV | |
| Cold cathode voltage | max. | −30 | kV | |
| Beam current | max. | 7 | A | |
| Body current | max. | 60 | mA | |
| Accelerator electrode current | max. | 6 | mA | note 5 |
| Collector dissipation | max. | 150 | kW | |
| Load VSWR | max. | 1.5 | | |
| Temperature of envelope | max. | 175 | °C | |
| Static pressure in the body cooling system and in the water cooling jacket TE1194 | max. | 600 | kPa | (6 bar) |

**TYPICAL OPERATING CONDITIONS**

**As 60 kW CW amplifier**

| | | | | |
|---|---|---|---|---|
| Output power | | 60 | kW | |
| Beam voltage | | 27 | kV | |
| Beam current | | 4.9 | A | note 6 |
| Accelerator to cathode voltage | ≈ | 17 | kV | |
| Body current | | | | |
| without drive | | 10 | mA | |
| at 60 kW | | 20 | mA | |
| Focusing coil current | ≈ | 10 | A | |
| Drive power, at 800 MHz | ≈ | 2 | W | note 7 |
| Bandwidth at −1 dB points | ≈ | 5 | MHz | |
| Operating efficiency | = | 45 | % | |

**Notes**

1. When switching on the heater voltage, the heater current must never exceed a peak value of 65 A.
2. In case of a mains failure an interruption up to 30 s can be tolerated without new waiting time. After min. 10 minutes of stand-by heating time at 6 V (black heat), the beam current may be switched on; the heater voltage must be increased to its nominal value of 8.5 V simultaneously. Continuous black heat periods should not exceed two weeks and should be separated by similar periods of rest or full operation.
3. To ensure that the klystron is always ready for operation, operate the ion getter pump at least every 6 months (preferably every 3 months) during storage. For details see klystron instruction manual.
4. In order to avoid corrosion of the cooling system, coolant water must be pure and deionized (resistivity min. 100 kΩ·cm).
5. The accelerator electrode voltage must not be positive with respect to the body (ground).
6. If the accelerator electrode is connected to the body (ground) via 10 kΩ resistor, the beam current is within ± 5% of the value given in the graph of Fig. 3.
7. The drive power is defined as the power delivered to a matched load.

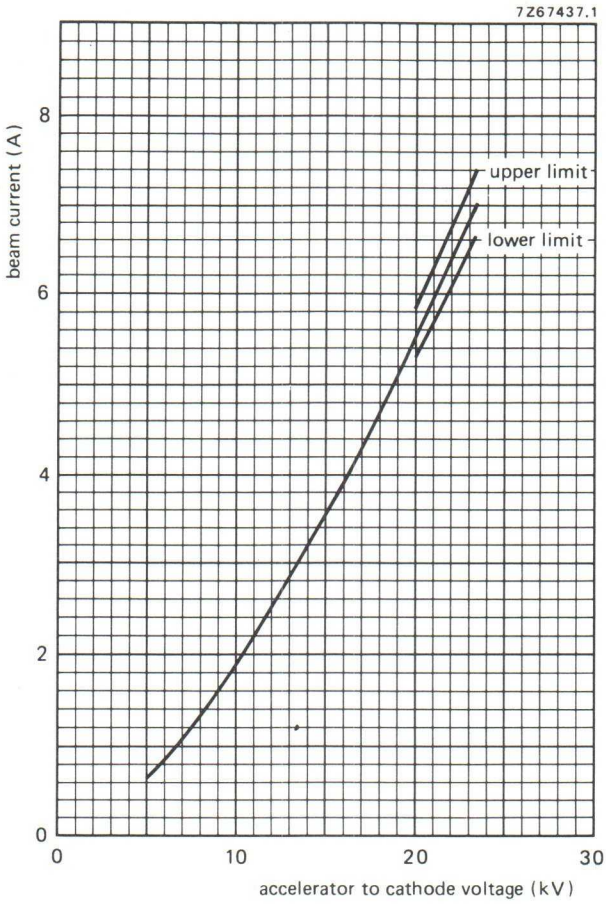

7Z67437.1
beam current (A)
8
6
4
2
0
upper limit
lower limit
0
10
20
30
accelerator to cathode voltage (kV)

Fig. 3.

# S.H.F. POWER KLYSTRON

Forced-air cooled power amplifier klystron in metal-ceramic construction for the frequency band of 11.8 to 12.2 GHz. The tube has internal resonant cavities, beam focusing by means of permanent magnets, and an integral getter-ion pump. The YK1210 is intended to be used in vision and sound transmitters, and transposers. It may be operated with or without depressed collector voltage.

## QUICK REFERENCE DATA

| | |
|---|---|
| Frequency range | 11.8 to 12.2 GHz |
| Output power as vision transmitter | 1.15 kW |
| Gain | 50 dB |
| Cooling | forced air |

This data must be read in conjunction with GENERAL OPERATIONAL RECOMMENDATIONS for KLYSTRONS.

## HEATING: indirect by d.c.

| | | |
|---|---|---|
| Cathode | dispenser type | |
| Heater voltage | $V_f$ | 5 to 6 V |
| Heater current | $I_f$ | 4 ($\leqslant$ 5) A |
| Heater peak starting current | $I_{fp}$ | max. 8 A |
| Cold heater resistance | $R_{fo}$ | $\approx$ 20 m$\Omega$ |
| Waiting time | $t_w$ | min. 120 s |

## COOLING

| | |
|---|---|
| Cathode socket and accelerating electrode | low-velocity air flow<br>0.5 m$^3$/min, 100 cm$^2$ |
| Body | forced air, $\approx$ 0.5 m$^3$/min<br>$\Delta p \leqslant$ 1000 kPa (10 bar) |
| Collector | forced air, $\approx$ 6 m$^3$/min<br>$\Delta p \leqslant$ 1000 kPa (10 bar) |

## GETTER-ION PUMP SUPPLY

| | |
|---|---|
| Pump voltage, no-load condition | 3 kV |
| Internal resistance of supply | 300 k$\Omega$ |

## MOUNTING

Vertical

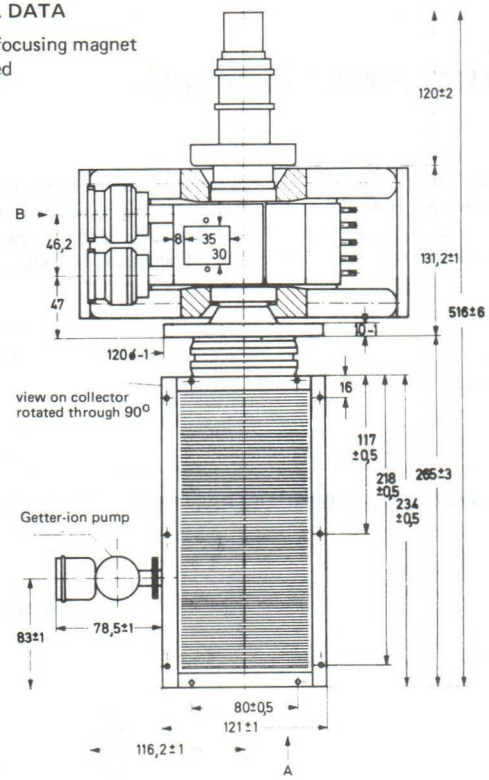
Forces on klystron terminals max 10 N. Bending moment max 10 Nm.

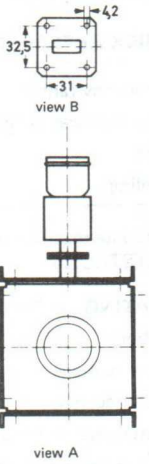
To maintain correct focusing, the magnetic system should not be closer than 150 mm to external ferromagnetic materials, and no closer than 300 mm to external magnets.

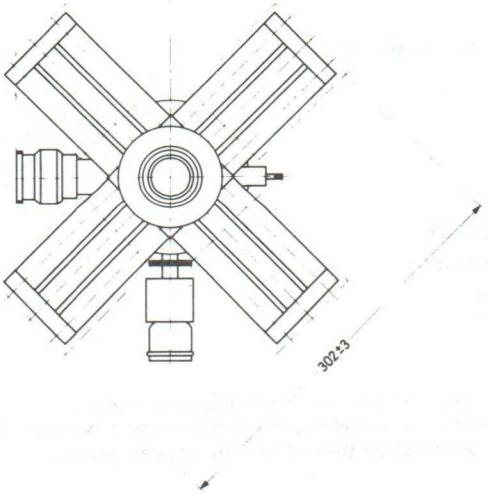
## MECHANICAL DATA

Mass: ≈ 30 kg focusing magnet included

Dimensions in mm



**LIMITING VALUES** (Absolute maximum rating system)

| | | |
|---|---|---|
| Collector to cathode voltage | max. | 15 kV |
| Body to collector voltage | max. | 4 kV |
| Body to accelerator voltage | max. | 15 kV |
| Accelerator to cathode voltage | max. | 10 kV |
| | min. | 7.5 kV |
| Cathode current | max. | 650 mA |
| Collector dissipation | max. | 7.5 kW |
| Drift tube current, static, set value | max. | 10 mA |
| **As vision transmitter at $W_{o\ sync}$ = 1 kW** | | |
| dynamic, without depressed collector voltage | max. | 30 mA |
| dynamic, with depressed collector voltage | max. | 60 mA |
| **as transposer at $W_{o\ sync}$ = 210 W** | | |
| dynamic, without depressed collector voltage | max. | 20 mA |
| dynamic, with depressed collector voltage | | |
| current cut-out region | | 20 to 50 mA |
| measuring range | max. | 60 mA |
| Getter-ion pump voltage | max. | 4 kV |
| | min. | 2.5 kV |
| Pump current | max. | 15 mA |
| Internal resistance of the pump supply | min. | 300 kΩ |
| Accelerator current | max. | −0.2 to +2 mA |
| Series resistor in accelerator circuit | min. | 10 kΩ |
| Temperature of focusing magnets | max. | 55 °C |
| Inlet temperature of cooling air | max. | 45 °C |
| | min. | 5 °C |

## TYPICAL OPERATION

| | | | |
|---|---|---|---|
| Frequency range | 11.8 to 12.2 | | GHz |
| Bandwidth (−1 dB) | ⩾ 12 | | MHz |
| Power gain | 50 (⩾ 49) | | dB |
| | without depressed collector voltage | with depressed collector voltage | |
| **As vision transmitter** | | | |
| Collector to cathode voltage | 10.5 | 8.5 | kV |
| Body to collector voltage | 0 | 2 | kV |
| Cathode current | 0.4 | 0.4 | A |
| Output power, sync | 1.15 | 1.15 | kW |
| **As sound transmitter** | | | |
| Collector to cathode voltage | 10.5 | 8.5 | kV |
| Body to collector voltage | 0 | 2 | kV |
| Cathode current | 0.4 | 0.4 | A |
| Output power | 1.05 | 1.05 | kW |
| **As transposer** ($W_0$ nom. 100 W) | | | |
| Collector to cathode voltage | 10.5 | 8.0 | kV |
| Body to collector voltage | 0 | 2.5 | kV |
| Cathode current | 0.4 | 0.4 | A |
| Output power, sync | 105 | 105 | W |
| Intermodulation products | ⩽ −57 | ⩽ −57 | dB |
| **As transposer** ($W_0$ nom. 200 W) | | | |
| Collector to cathode voltage | 12 | 9 | kV |
| Body to collector voltage | 0 | 3 | kV |
| Cathode current | 0.5 | 0.5 | A |
| Output power, sync | 210 | 210 | W |
| Intermodulation products | ⩽ −57 | ⩽ −57 | dB |

## GENERAL NOTES ON POWER SUPPLY DESIGN

| | range* | internal resistance | hum |
|---|---|---|---|
| Heater voltage | 4.5 to 6.5 V (max. 5 A) | The heater current should not exceed a value of 8 A when switching on the supply | Corresponding to non-smoothed three-phase bridge rectifier |
| Body to collector voltage | 0/2.0/2.5/3.0 kV 100 mA continuous 200 mA peak | $< 600\ \Omega$ | $< 0.1\%$ |
| Collector to cathode voltage** | 8.0/8.5/9.5 kV with depressed collector voltage 10.5/11.5 kV without depressed collector voltage | $< 600\ \Omega$ | $< 0.1\%$ |
| Body to accelerator voltage | Via potentiometer. Total resistance $\approx 5\ M\Omega$ and series resistor 10 $k\Omega$ (suitable for 15 kV) between accelerator electrode and tap. | | |

## PRODUCT SAFETY

*R.F. radiation*

R.F. power may be emitted not only through the normal output coupling but also through other apertures (for example, r.f. leaks). This r.f. power may be sufficiently intense to cause danger to the human body, particularly to the eyes. Such radiation may be increased if the tube is functioning incorrectly.

*X-radiation*

A highly dangerous intensity of X-rays may be emitted by tubes operating at voltages higher than approximately 5 kV. Adequate protection (X-ray shielding) for the operator is then necessary. The emisson intensity of X-rays may correspond to a value of voltage much higher than that expected from the actual value applied to the tube.

Poor focusing may result in excessive X-radiation.

* Maximum allowable deviation from nominal or set values:
a) ±2% during adjustment, if the published performance is to be attained.
b) ±1% fluctuation of the set values during operation to maintain the performance.

** It is recommended that additional taps be made ≈ 500 V above and below the indicated values.

# U.H.F. POWER KLYSTRONS

For u.h.f. band IV/V vision transmitters and sound transmitters.
Metal-ceramic construction, four external cavities, electromagnetic focusing and a high-stability dispenser type cathode.
Suitable for vapour, vapour-condensation or water cooling.
YK1223 comprising a non-intercepting annular beam control electrode (ABC) for low-voltage beam modulation.

## QUICK REFERENCE DATA

| | |
|---|---|
| Frequency range | 470 to 860 MHz |
| Output power as vision transmitter | 10 and 15 kW |
| Cooling | vapour, vapour condensation, or water |

This data must be read in conjunction with GENERAL OPERATIONAL RECOMMENDATIONS for KLYSTRONS.

| **HEATING:** indirect by d.c. | | | | | notes |
|---|---|---|---|---|---|
| Cathode | dispenser type | | | | |
| Heater voltage | $V_f$ | | 5.0 | V* | |
| Heater current | $I_f$ | ≈ | 19.5 to 22.5 | A | 1 |
| Cold heater resistance | $R_{fo}$ | ≈ | 25 | mΩ | |
| Waiting time | | | | | 2 |
| at $V_f$ = 5.0 V | $t_w$ | min. | 300 | s | |
| at $V_f$ = 4.3 to 4.5 V (black heat) | $t_w$ | min. | 0 | s | |

| **FOCUSING** | | | | |
|---|---|---|---|---|
| Focusing coil current | | | 8 to 11 | A |
| Resistance of focusing coils | | | | |
| cold (20 °C) | | | 7.2 to 9.5 | Ω |
| operating at an ambient temperature of 20 °C | | ⩽ | 11 | Ω |

**BEAM CONTROL** for YK1220 — 6, 7

The accelerator electrode voltage allows adjustment of the beam current between 0 and 100 %.

**BEAM CONTROL** for YK 1223 — 6, 7

The klystron comprises a non-intercepting annular beam control electrode (ABC) for low-voltage beam modulation. See Fig. 7.
Additionally the accelerator electrode voltage allows adjustment of the beam current between 0 and 100%.

| **GETTER-ION PUMP SUPPLY** | | | 3 |
|---|---|---|---|
| Pump voltage, no-load condition | 3 to 4 | kV | |
| Internal resistance of supply | 300 | kΩ | |

*During operation the heater voltage may not fluctuate more than +1 or −2 %.

## MECHANICAL DATA

Dimensions in mm

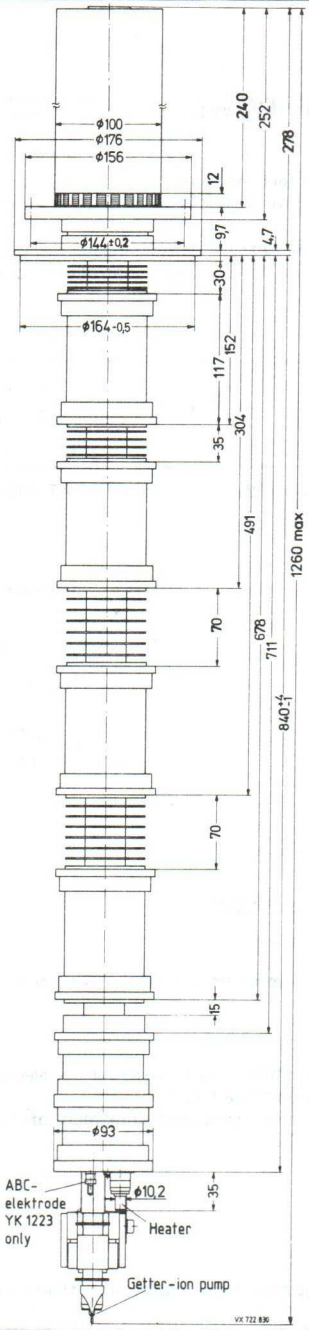



Fig. 1.

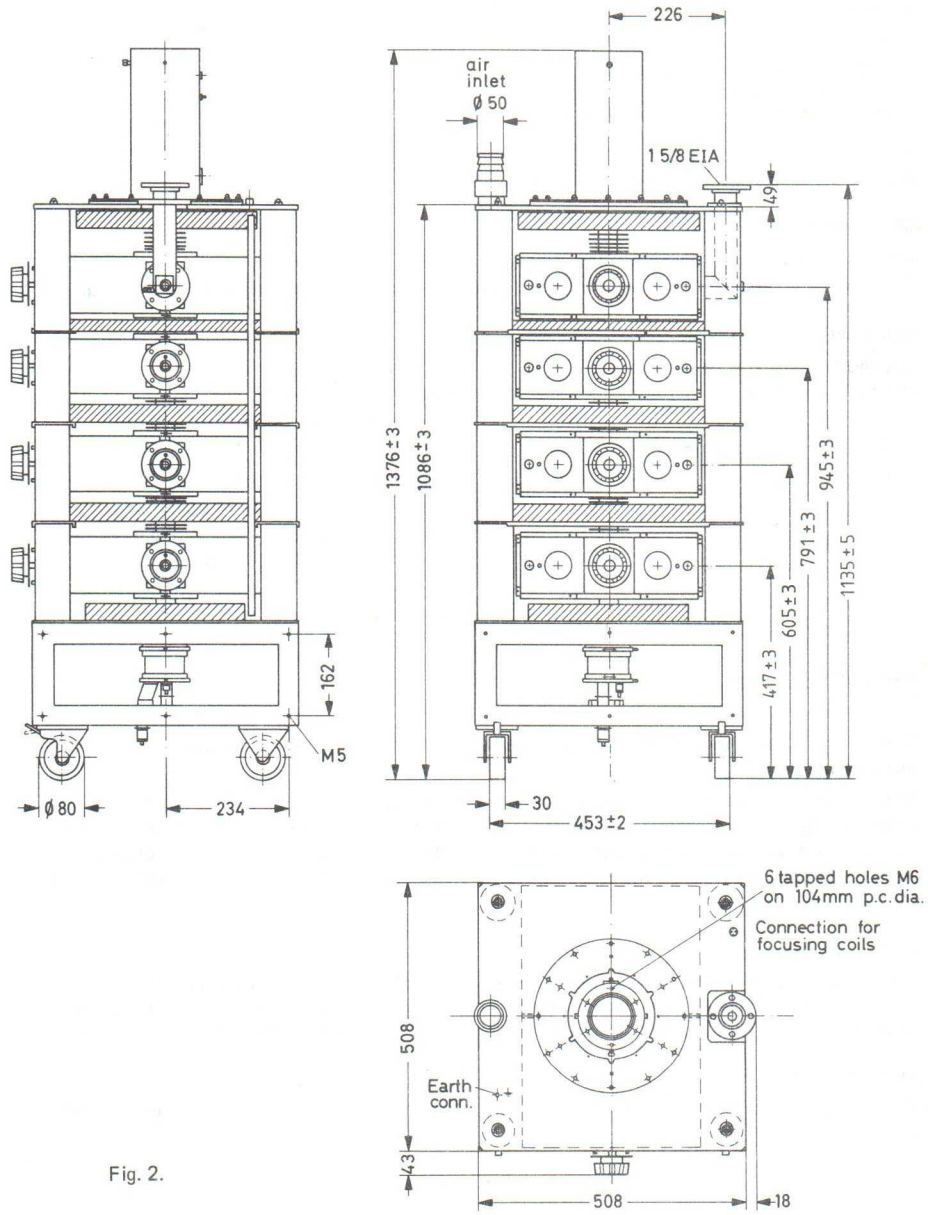

226
air inlet Ø 50
1 5/8 EIA
49
1376±3
1086±3
945±3
791±3
605±3
417±3
1135±5
162
M5
Ø 80
234
30
453±2
6 tapped holes M6 on 104mm p.c. dia.
Connection for focusing coils
508
Earth conn.
43
508
18
VX 722 585.4

Fig. 2.

## MASS AND DIMENSIONS

Klystron

| | |
|---|---|
| net | approx. 25 kg |
| gross | approx. 77 kg |
| outline dimensions of packing (cm) | 170 x 45 x 46 |
| Cavities | approx. 45 kg |
| Magnet frame with coils | approx. 220 kg |

## MOUNTING

Mounting position: vertical with collector up.
To remove the tube from the magnet frame a total free height of 2.5 m, excluding hoist, is required.

## COOLING

| | |
|---|---|
| Cavities 1, 2, 3 and 4, drift tubes 4 and 5 and cathode socket | forced air, $T_i$ max. 50 °C<br>$q \approx 1.2$ m³/min, $\Delta p = 350$ Pa (3.5 mbar) |
| Cathode socket only, during black heat | forced air, $T_i$ max. 50 °C, $q \approx 0.15$ m³/min |
| Collector | vapour with boiler TE1189C, note 4<br>volume of water converted to steam: 27 cm³/min per kW collector dissipation resulting in 43 ℓ/min steam per kW collector dissipation;<br>water or vapour condensation (with water jacket TE1189A) q = 7 to 18 ℓ/min, $T_o$ max. 90 °C, see Fig. 4. For 10 ℓ/min, $\Delta p = 16$ kPa (0.16 bar). |

## PRODUCT SAFETY

*1. X-radiation*

Correct operation of the tube can be guaranteed only if a set of accessories, approved by the tube manufacturer, is used.

The operating tube generates X-rays which can penetrate the ceramic parts of the tube envelope. In order to reduce the radiation at any accessible points to an officially acceptable, non-dangerous level the tube must be shielded and any possible radiation path blocked by at least 1 mm of brass or an equivalent depth of non-magnetic X-ray absorbing material. The proper use of accessories will provide the necessary shielding.

*2. R.F. radiation*

R.F. power may be emitted through apertures other than the normal output coupling (for example r.f. leaks). This r.f. power may be sufficiently intense to cause danger to the human body, particularly to the eyes. Such radiation may be increased if the tube is functioning incorrectly.

### Instruction manual

For detailed mounting and tuning instructions see klystron instruction manual, delivered with each tube.

## ACCESSORIES

Correct operation can be guaranteed only if approved accessories are used.

| | | | notes |
|---|---|---|---|
| Collector radiation suppressor | TE1182B | | |
| Spark gap | TE1183 | | |
| Set of connectors (heater, cathode, accelerator electrode, getter-ion pump) | TE1184 | | |
| Magnet frame with coils | TE1188 | | |
| | water cooling or vapour condensation cooling | vapour cooling | |
| Collector cooling jacket | TE1189A | TE1189C | |
| Temperature sensor | – | TE1199 | 11 |
| Tool set | TE1190 | | |
| Cavities | 4 x TE1185 | | |
| Inlet coupler and load coupler for cavities 2 and 3 | 3 x TE1186C | | 12 |
| Output coupler, 3 1/8 inch, 90°-elbow | TE1187C | | 13, 14 |
| Arc detector | TE1107B | | |
| Recommended circulators (optional) | | | |
| 470 to 600 MHz | 2722 162 01551 (T100/IV-N) | | |
| 600 to 800 MHz | 2722 162 01561 (T100/V-N) | | |
| 790 to 1000 MHz | 2722 162 03261 (T100/V-3-N) | | |

## LIMITING VALUES (Absolute maximum rating system)

| | | | | |
|---|---|---|---|---|
| Heater voltage | max. | 6.5 | V | |
| Beam voltage | max. | 21 | kV | |
| Cold cathode voltage | max. | –21 | kV | |
| Beam current | max. | 3 | A | |
| Body current | max. | 100 | mA | |
| Accelerator electrode current | max. | 5 | mA | 5 |
| Collector dissipation | max. | 42 | kW | |
| Load VSWR | max. | 1.5 | | |
| Temperature of tube envelope | max. | 175 | °C | |
| Static pressure in the cooling system TE1189A | max. | 600 | kPa | ( 6 bar) |
| Focusing coil current | max. | 11.5 | A | |
| ABC-electrode voltage with respect to cathode for YK1223 | max. | –1 | kV | |

## PERFORMANCE DATA

| of ABC-electrode for YK1223 | min. | typ. | max. | |
|---|---|---|---|---|
| Capacity | 70 | 75 | 85 | pF |
| D.C. current at –1000 V* | – | – | 0.5 | mA |

* The d.c. electrode current may rise up to max. 1 mA during life time. The applied modulator should be designed for an ABC-electrode current of at least 1 mA.

**TYPICAL OPERATING CONDITIONS** (modulation electrode YK1223 at cathode potential)

| **As 10 kW vision transmitter** | | | | | | | | notes |
|---|---|---|---|---|---|---|---|---|
| Standard CCIR: | G | I | G | I | G | I | | 10 |
| Channel | 21 | | 45 | | 68 | | | |
| Output power, peak sync. | 11 | | 11 | | 11 | | kW | |
| Beam voltage | 13 | 13.5 | 15 | 15 | 16 | 16 | kV | |
| Beam current | 1.95 | 2.05 | 1.55 | 1.55 | 1.5 | 1.5 | A | 6 |
| Accelerator to cathode voltage | ≈ 12 | ≈ 12.5 | ≈ 10 | ≈ 10 | ≈ 10 | ≈ 10 | kV | 7 |
| Body current | | | | | | | | |
| without drive | ≈ 10 | ≈ 10 | ≈ 7 | ≈ 7 | ≈ 7 | ≈ 7 | mA | |
| at black level | ≈ 50 | ≈ 50 | ≈ 35 | ≈ 35 | ≈ 30 | ≈ 30 | mA | |
| Focusing coil current | ≈ 10 | ≈ 10 | ≈ 9 | ≈ 9 | ≈ 9 | ≈ 9 | A | |
| Drive power, peak sync., max. | 10 | 15 | 6 | 10 | 4 | 8 | W | 8 |
| Operating efficiency | 43 | 40 | 47 | 47 | 45 | 45 | % | |
| Minimum efficiency | 42 | 40 | 46 | 44 | 44 | 43 | % | |

| **Sound transmitter** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Output power | 1.1 | | 2.2 | | 5.5 | kW | |
| Beam voltage | 13 | 16 | 13 | 16 | 18.5 | kV | |
| Beam current | 0.38 | 0.3 | 0.5 | 0.4 | 0.8 | A | 6 |
| Accelerator to cathode voltage | ≈ 3.5 | ≈ 3.0 | ≈ 4.5 | ≈ 3.5 | ≈ 6.0 | kV | 7 |
| Body current | ≈ 15 | | ≈ 15 | | ≈ 15 | mA | |
| Focusing coil current | ≈ 10 | | ≈ 10 | | ≈ 10 | A | 9 |
| Drive power, | | | | | | | |
| channel 21 | 4 | | 4 | | 4 | W | 8 |
| channel 45 | 2 | | 2 | | 2 | W | 8 |
| channel 68 | 1 | | 1 | | 1 | W | 8 |
| Bandwidth at −1 dB points | ⩾ 300 | | ⩾ 300 | | ⩾ 300 | kHz | |
| Operating efficiency | 22 | | 34 | | 37 | % | |

**As 15 kW vision transmitter**

| | | | | | | | | notes |
|---|---|---|---|---|---|---|---|---|
| Standard CCIR: | G | I | G | I | G | I | | 10 |
| Channel | 21 | | 45 | | 68 | | | |
| Output power, peak sync. | 16.5 | | 16.5 | | 16.5 | | | |
| Beam voltage | 16.5 | 15.5 | 17.5 | 17.5 | 19 | 19 | kV | |
| Beam current | 2.35 | 2.6 | 2.0 | 2.0 | 1.95 | 1.95 | A | 6 |
| Accelerator to cathode voltage | ≈ 13.5 | ≈ 14.5 | ≈ 12 | ≈ 12 | ≈ 12 | ≈ 12 | kV | 7 |
| Body current | | | | | | | | |
| without drive | ≈ 10 | ≈ 10 | ≈ 7 | ≈ 7 | ≈ 7 | ≈ 7 | mA | |
| at black level | ≈ 50 | ≈ 70 | ≈ 45 | ≈ 45 | ≈ 40 | ≈ 40 | mA | |
| Focusing coil current | ≈ 10 | ≈ 10 | ≈ 9 | ≈ 9 | ≈ 9 | ≈ 8 | A | |
| Drive power, peak sync. max. | 10 | 15 | 8 | 10 | 6 | 10 | W | 8 |
| Operating efficiency | 43 | 43 | 47 | 47 | 45 | 45 | % | |
| Minimum efficiency | 42 | 40 | 46 | 44 | 44 | 43 | % | |

**Sound transmitter**

| | | | | | | |
|---|---|---|---|---|---|---|
| Output power | 1.65 | | 3.3 | | kW | |
| Beam voltage | 15.5 | 19 | 15.5 | 19 | kV | |
| Beam current | 0.37 | 0.3 | 0.63 | 0.5 | A | 6 |
| Accelerator to cathode voltage | ≈ 3.5 | ≈ 3.0 | ≈ 5.0 | ≈ 4.5 | kV | 7 |
| Body current | ≈ 15 | | ≈ 15 | | mA | |
| Focusing coil current | ≈ 10 | | ≈ 10 | | A | 9 |
| Drive power, | | | | | | |
| channel 21 | 4 | | 4 | | W | 8 |
| channel 51 | 2 | | 2 | | W | 8 |
| channel 68 | 1 | | 1 | | W | 8 |
| Bandwidth at −1 dB points | ⩾300 | | ⩾300 | | kHz | |
| Operating efficiency | 29 | | 34 | | % | |

**Notes**

1. When switching on the heater voltage, the heater current must never exceed a peak value of 65 A.
2. In case of a mains failure an interruption up to 30 s can be tolerated without new waiting time. After min. 10 minutes of stand-by heating time at 4.3 to 4.5 V (black heat), the beam current may be switched on; the heater voltage must be increased to its nominal value of 5.0 V simultaneously. Continuous black heat periods should not exceed two weeks and should be separated by similar periods of rest or full operation.
3. To ensure that the klystron is always ready for operation, operate the ion getter pump at least every 6 months (preferably every 3 months) during storage. For details see klystron instruction manual.
4. In order to avoid corrosion of the cooling system, coolant water must be pure and deionized (resistivity min. 100 kΩ·cm).
5. The accelerator electrode voltage must not be positive with respect to the body (ground).
6. For cathode current versus accelerator-to-cathode voltage, see Fig. 5.
7. The accelerator electrode has to be connected to its supply (power supply or voltage divider) via a 10 kΩ resistor.
   For adjusting the cathode current a voltage divider should be dimensioned according to an accelerator electrode current of max. 1.5 mA.
8. The drive power is defined as the power delivered to a matched load.
9. Value is not critical. It may be set in accordance to the vision klystron focusing coil current. Operation of one vision and one sound klystron focusing units in series is admitted.
10. Standard CCIR-G: klystron tuned to frequency response according to the specification CCIR-G.
    Standard CCIR-I: klystron tuned to frequency response according Fig. 3.

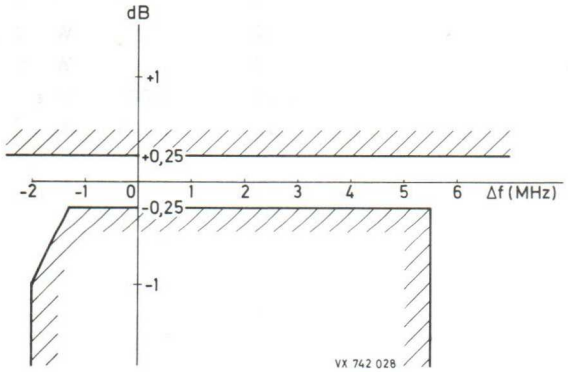



Fig. 3.

11. Optional.
12. Standard equipment is directly controlled on the side of trolley. In case of front panel control TE1186A is available instead of TE1186C.
13. Output coupler 1 5/8" (TE1187B for direct control, TE1187A for front panel control) is also available. Please contact manufacturer.
14. The output couplers comprise a standard loop. For several channels a modified loop is to be used. Please indicate channel when ordering.

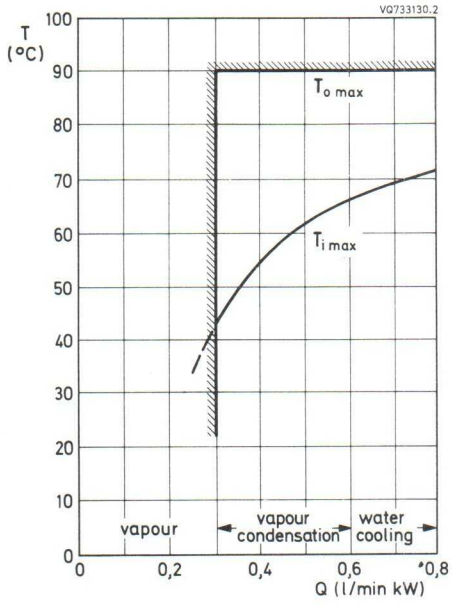



Fig. 4.

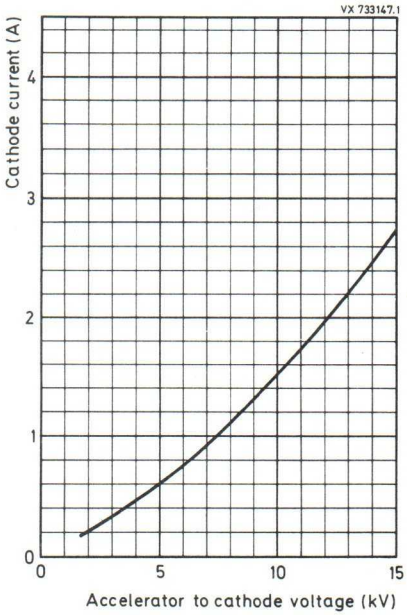



Fig. 5.

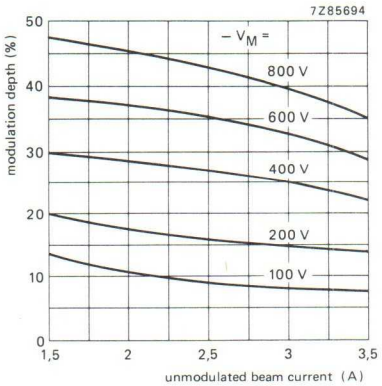



Fig. 6 ABC-operation for YK1223. Parameter: modulation voltage $-V_M$ (with respect to cathode).

# U.H.F. POWER KLYSTRONS

For u.h.f. band IV/V vision transmitters and sound transmitters.
Metal-ceramic construction, four external cavities, electromagnetic focusing and a high-stability dispenser type cathode.
Suitable for vapour, vapour-condensation or water cooling.
YK1233 comprising a non-intercepting annular beam control electrode (ABC) for low-voltage beam modulation.

## QUICK REFERENCE DATA

| | |
|---|---|
| Frequency range | 470 to 860 MHz |
| Output power as vision transmitter | 20, 25 and 30 kW |
| Cooling | vapour, vapour condensation, or water |

This data must be read in conjunction with GENERAL OPERATIONAL RECOMMENDATIONS for KLYSTRONS.

| **HEATING**, indirect by d.c. | | | | | notes |
|---|---|---|---|---|---|
| Cathode | dispenser type | | | | |
| Heater voltage | $V_f$ | | 5.0 | V* | |
| Heater current | $I_f$ | ≈ | 19.5 to 22.5 | A | 1 |
| Cold heater resistance | $R_{fo}$ | ≈ | 25 | mΩ | |
| Waiting time | | | | | 2 |
| at $V_f$ = 5.0 V | $t_w$ | min. | 300 | s | |
| at $V_f$ = 4.3 to 4.5 V (black heat) | $t_w$ | min. | 0 | s | |

| **FOCUSING** | | | | |
|---|---|---|---|---|
| Focusing coil current | | | 8 to 11 | A |
| Resistance of focusing coils | | | | |
| cold (20 °C) | | | 7.2 to 9.5 | Ω |
| operating at an ambient temperature of 20 °C | | ⩽ | 11 | Ω |

**BEAM CONTROL** for YK1230 — 6, 7

The accelerator electrode voltage allows adjustment of the beam current between 0 and 100 %.

**BEAM CONTROL** for YK1233 — 6, 7

The klystron comprises a non-intercepting annular beam control electrode (ABC) for low-voltage beam modulation. See Fig. 7.
Additionally the accelerator electrode voltage allows adjustment of the beam current between 0 and 100%.

| **GETTER-ION PUMP SUPPLY** | | | 3 |
|---|---|---|---|
| Pump voltage, no-load condition | 3 to 4 | kV | |
| Internal resistance of supply | 300 | kΩ | |

*During operation the heater voltage may not fluctuate more than ± 1 or −2 %.

## MECHANICAL DATA

Dimensions in mm

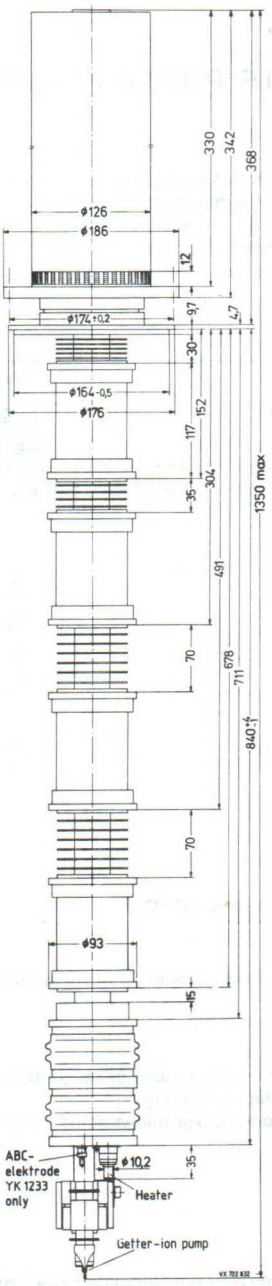



Fig. 1.

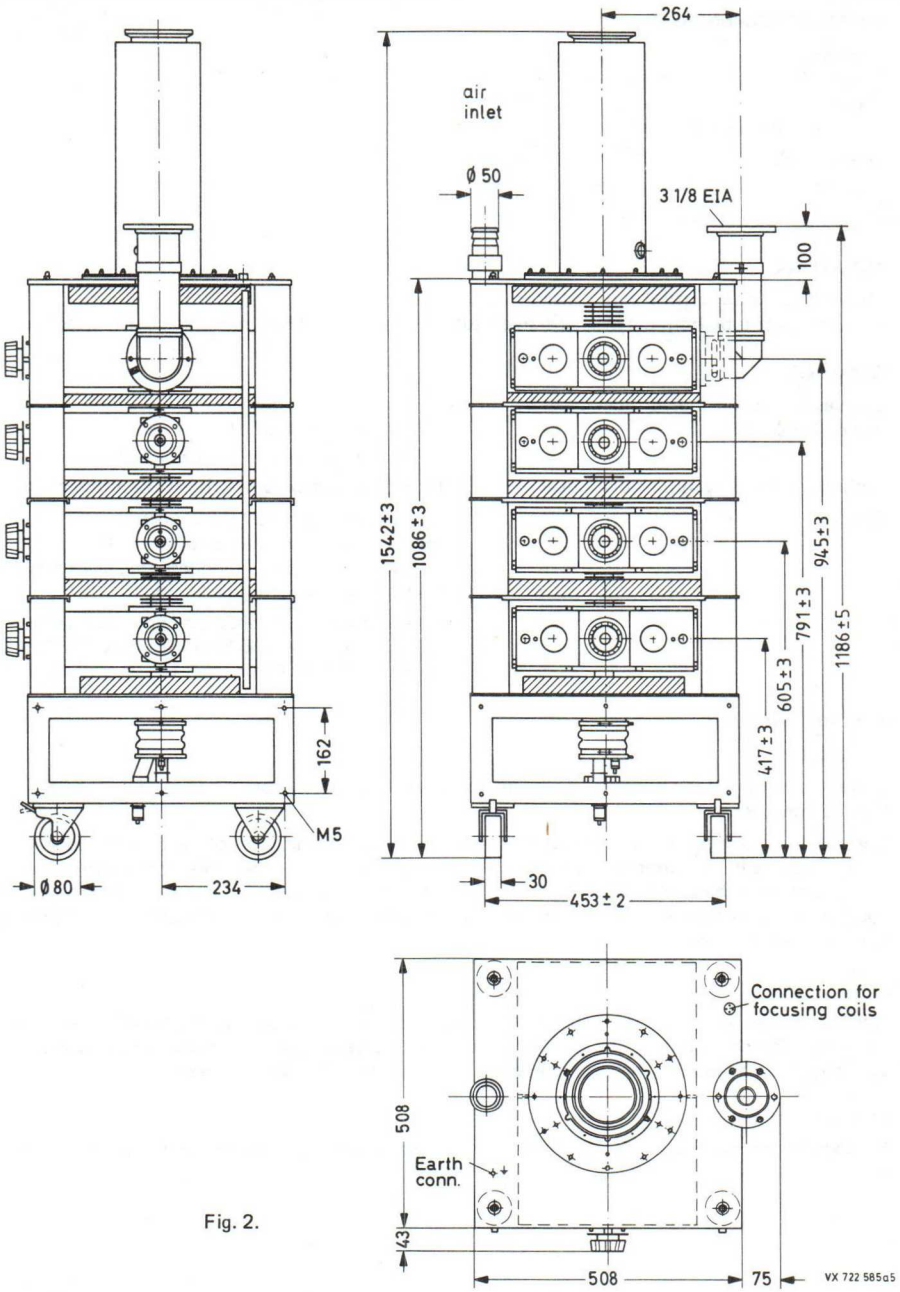

264
air
inlet
Ø 50
3 1/8 EIA
100
1542±3
1086±3
945±3
791±3
605±3
417±3
1186±5
162
M5
Ø 80
234
30
453±2
Connection for
focusing coils
508
Earth
conn.
43
508
75
VX 722 585a5

Fig. 2.

## MASS AND DIMENSIONS

| | | | |
|---|---|---|---|
| Klystron | | | |
| net | approx. | 40 | kg |
| gross | approx. | 90 | kg |
| outline dimensions of packing (cm) | 170 x 45 x 46 | | |
| Cavities | approx. | 45 | kg |
| Magnet frame with coils | approx. | 220 | kg |

## MOUNTING

Mounting position: vertical with collector up.
To remove the tube from the magnet frame a total free height of 2.5 m, excluding hoist, is required.

## COOLING

| | |
|---|---|
| Cavities 1, 2, 3 and 4, drift tubes 4 and 5 and cathode socket | forced air, $T_i$ max. 50 °C<br>$q \approx 1.2$ m³/min, $\Delta p = 350$ Pa (3.5 mbar) |
| Cathode socket only, during black heat | forced air, $T_i$ max. 50 °C, $q \approx 0{,}15$ m³/min |
| Collector | vapour with boiler TE1189D, note 4<br>volume of water converted to steam: 27 cm³/min per kW collector dissipation resulting in 43 ℓ/min steam per kW collector dissipation;<br>water or vapour condensation (with water jacket TE1189F) q = 16 to 36 ℓ/min, $T_o$ max 90 °C, see Fig. 4. For 10 ℓ/min, $\Delta p$ =16 kPa (0.16 bar). |

## PRODUCT SAFETY

*1. X-radiation*

Correct operation of the tube can be guaranteed only if a set of accessories, approved by the tube manufacturer, is used.

The operating tube generates X-rays which can penetrate the ceramic parts of the tube envelope. In order to reduce the radiation at any accessible points to an officially acceptable, non-dangerous level the tube must be shielded and any possible radiation path blocked by at least 1 mm of brass or an equivalent depth of non-magnetic X-ray absorbing material. The proper use of accessories will provide the necessary shielding.

*2. R.F. radiation*

R.F. power may be emitted through apertures other than the normal output coupling (for example r.f. leaks). This r.f. power may be sufficiently intense to cause danger to the human body, particularly to the eyes. Such radiation may be increased if the tube is functioning incorrectly.

**Instruction manual**

For detailed mounting and tuning instructions see klystron instruction manual, delivered with each tube.

## ACCESSORIES

| Correct operation can be guaranteed only if approved accessories are used. | | notes |
|---|---|---|
| Collector radiation suppressor | TE1182B | |
| Spark gap | TE1183 | |
| Set of connectors (heater, cathode, accelerator electrode, getter-ion pump) | TE1184 | |
| Magnet frame with coils | TE1188 | |

| | water cooling or vapour condensation cooling | vapour cooling | |
|---|---|---|---|
| Collector cooling jacket | TE1189F | TE1189D | |
| Temperature sensor | – | TE1199 | 11 |
| Tool set | TE1190 | | |
| Cavities | 4 x TE1185 | | |
| Inlet coupler and load coupler for cavities 2 and 3 | 3 x TE1186C | | 12 |
| Output coupler, 3 1/8 inch, 90° elbow | TE1187C | | 13 |
| Arc detector | TE1107B | | 14 |

Recommended circulators (optional)

| | |
|---|---|
| 470 to 600 MHz | 2722 162 01551 (T100/IV-N) |
| 600 to 800 MHz | 2722 162 01561 (T100/V-N) |
| 790 to 1000 MHz | 2722 162 03261 (T100/V-3-N) |

## LIMITING VALUES (Absolute maximum rating system)

| | | | |
|---|---|---|---|
| Heater voltage | max. 6.5 | V | |
| Beam voltage | max. 26 | kV | |
| Cold cathode voltage | max. –26 | kV | |
| Beam current | max. 3.8 | A | |
| Body current | max. 120 | mA | |
| Accelerator electrode current | max. 5 | mA | 5 |
| Collector dissipation | max. 70 | kW | |
| Load VSWR | max. 1.5 | | |
| Temperature of tube envelope | max. 175 | °C | |
| Static pressure in the cooling system TE1189F | max. 600 | kPa | (6 bar) |
| Focusing coil current | max. 11.5 | A | |
| ABC-electrode voltage with respect to cathode for YK1233 | max. –1 | kV | |

## PERFORMANCE DATA

| of ABC-electrode for YK1233 | min. | typ. | max. | |
|---|---|---|---|---|
| Capacity | 70 | 75 | 85 | pF |
| D.C. current at –1000 V* | – | – | 0.5 | mA |

* The d.c. electrode current may rise up to max. 1 mA during life time. The applied modulator should be designed for an ABC-electrode current of at least 1 mA.

**TYPICAL OPERATING CONDITIONS** (modulation electrode YK1233 at cathode potential)

| **As 20 kW vision transmitter** | | | | | notes |
|---|---|---|---|---|---|
| Standard CCIR-G | | | | | 9 |
| Channel | 21 | 45 | 68 | | |
| Output power, peak sync. | 22 | 22 | 22 | kW | |
| Beam voltage | 19.5 | 20 | 22 | kV | |
| Beam current | 2.7 | 2.45 | 2.2 | A | 6 |
| Accelerator to cathode voltage | ≈ 15 | ≈ 14 | ≈ 13 | kV | 7 |
| Body current | | | | | |
| without drive | ≈ 10 | ≈ 7 | ≈ 7 | mA | |
| at black level | ≈ 50 | ≈ 45 | ≈ 40 | mA | |
| Focusing coil current | ≈ 10 | ≈ 9 | ≈ 9 | A | |
| Drive power, peak sync. | 15 | 10 | 10 | W | 8 |
| Operating efficiency | 42 | 45 | 45 | % | |
| Minimum efficiency | 41 | 44 | 44 | % | |

| **Sound transmitter** | | | | | | |
|---|---|---|---|---|---|---|
| Output power | 2.2 | | 4.4 | | kW | |
| Beam voltage | 19.5 | 22 | 19.5 | 22 | kV | |
| Beam current | 0.4 | 0.35 | 0.6 | 0.55 | A | 6 |
| Accelerator to cathode voltage | ≈ 3.5 | ≈ 3.0 | ≈ 5.0 | ≈ 4.5 | kV | 7 |
| Body current | ≈ 15 | | ≈ 15 | | mA | |
| Focusing coil current | ≈ 10 | | ≈ 10 | | A | 9 |
| Drive power, | | | | | | |
| channel 21 | 4 | | 4 | | W | 8 |
| channel 45 | 2 | | 2 | | W | 8 |
| channel 68 | 1 | | 1 | | W | 8 |
| Bandwidth at −1 dB points | ⩾ 300 | | ⩾ 300 | | kHz | |
| Operating efficiency | 28 | | 37 | | % | |

**As 25 kW vision transmitter**

| | | | | | | | | notes |
|---|---|---|---|---|---|---|---|---|
| Standard CCIR: | G | I | G | I | G | I | | 10 |
| Channel | 21 | | 45 | | 68 | | | |
| Output power, peak sync. | 27 | | 27 | | 27 | | kW | |
| Beam voltage | 21 | 19 | 21.5 | 21.5 | 23.5 | 23.5 | kV | |
| Beam current | 3 | 3.45 | 2.8 | 2.8 | 2.5 | 2.55 | A | 6 |
| Accelerator to cathode voltage | ≈ 16 | ≈ 17.5 | ≈ 15 | ≈ 15 | ≈ 14 | ≈ 14 | kV | 7 |
| Body current | | | | | | | | |
| without drive | ≈ 10 | ≈ 10 | ≈ 7 | ≈ 7 | ≈ 7 | ≈ 7 | mA | |
| at black level | ≈ 60 | ≈ 80 | ≈ 50 | ≈ 50 | ≈ 45 | ≈ 50 | mA | |
| Focusing coil current | ≈ 10 | ≈ 10 | ≈ 9 | ≈ 9 | ≈ 9 | ≈ 9 | A | |
| Drive power, peak sync., max. | 15 | 25 | 10 | 20 | 10 | 20 | W | 8 |
| Operating efficiency | 42 | 41 | 45 | 45 | 46 | 45 | % | |
| Minimum efficiency | 41 | 40 | 44 | 44 | 44 | 43 | % | |

**Sound transmitter**

| | | | | | | |
|---|---|---|---|---|---|---|
| Output power | 2.7 | | 5.5 | | kW | |
| Beam voltage | 19 | 23.5 | 19 | 23.5 | kV | |
| Beam current | 0.47 | 0.38 | 0.7 | 0.55 | A | 6 |
| Accelerator to cathode voltage | ≈ 4.7 | ≈ 4.1 | ≈ 5.5 | ≈ 4.5 | kV | 7 |
| Body current | ≈15 | | ≈15 | | mA | |
| Focusing coil current | ≈ 8 | | ≈10 | | A | 9 |
| Drive power, | | | | | | |
| channel 21 | 4 | | 4 | | W | 8 |
| channel 45 | 2 | | 2 | | W | 8 |
| channel 68 | 1 | | 1 | | W | 8 |
| Bandwidth at −1 dB points | ⩾300 | | ⩾ 300 | | kHz | |
| Operating efficiency | 30 | | 41 | | % | |

**TYPICAL OPERATING CONDITIONS** (continued)

modulation electrode YK1233 at cathode potential

**As 30 kW vision transmitter**

| | | | | | | | | | | | notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Standard * | G | M | K | G | M | K | G | M | K | | 10 |
| Channel | 21 | 14 | 21 | 42 | 42 | 42 | 62 | 69 | 62 | | |
| Output power, peak sync. | 32 | 32 | 32 | | 32 | | | 32 | | kW | |
| Beam voltage | 23 | 23 | 21 | | 24 | | | 25 | | kV | |
| Beam current | 3.3 | 3.3 | 3.7 | | 2.95 | | | 2.85 | | A | 6 |
| Accelerator to cathode voltage | ≈ 17.5 | 17.5 | 18.5 | | 16.5 | | | 16 | | kV | 7 |
| Body current | | | | | | | | | | | |
| without drive | ≈ 10 | 10 | 10 | | 7 | | | 7 | | mA | |
| at black level | ≈ 50 | 50 | 50 | | 45 | | | 40 | | mA | |
| Focusing coil current | ≈ 9 | 9 | 10 | | 8 | | | 8 | | A | |
| Drive power, peak sync., max. | 25 | 25 | 25 | | 20 | | | 20 | | W | 8 |
| Operating efficiency | 42 | 42 | 41 | | 45 | | | 45 | | % | |
| Minimum efficiency | 41 | 41 | 40 | | 44 | | | 44 | | % | |

**Sound transmitter**

| | | | | | |
|---|---|---|---|---|---|
| Output power | | 3.3 | | kW | |
| Beam voltage | 23 | | 25 | kV | |
| Beam current | 0.42 | | 0.39 | A | 6 |
| Accelerator to cathode voltage | ≈ 4.5 | | ≈ 4.2 | kV | 7 |
| Body current | | ≈15 | | mA | |
| Focusing coil current | | ≈ 8 | | A | 9 |
| Drive power, | | | | | |
| Standard* M \| G,K | | | | | |
| channel 14 \| 21 | | 4 | | W | 8 |
| channel 42 \| 42 | | 2 | | W | 8 |
| channel 69 \| 62 | | 1 | | W | 8 |
| Bandwidth at −1 dB points | | ⩾300 | | kHz | |
| Operating efficiency | | 34 | | % | |

*Standards: CCIR-G, RTMA-M, RTMA-M* and CCIR-K.

Notes

1. When switching on the heater voltage, the heater current must never exceed a peak value of 65 A.
2. In case of a mains failure an interruption up to 30 s can be tolerated without new waiting time. After min. 10 minutes of stand-by heating time at 4.3 to 4.5 V (black heat), the beam current may be switched on; the heater voltage must be increased to its nominal value of 5.0 V simultaneously. Continuous black heat periods should not exceed two weeks and should be separated by similar periods of rest or full operation.
3. To ensure that the klystron is always ready for operation, operate the ion getter pump at least every 6 months (preferably every 3 months) during storage. For details see klystron instruction manual.
4. In order to avoid corrosion of the cooling system, coolant water must be pure and deionized (resistivity min. 100 kΩ·cm).
5. The accelerator electrode voltage must not be positive with respect to the body (ground).
6. For cathode current versus accelerator-to-cathode voltage, see Fig. 5.
7. The accelerator electrode has to be connected to its supply (power supply or voltage divider) via a 10 kΩ resistor.

   For adjusting the cathode current a voltage divider should be dimensioned according to an accelerator electrode current of max. 1.5 mA.
8. The drive power is defined as the power delivered to a matched load.
9. Value is not critical. It may be set in accordance to the vision klystron focusing coil current. Operation of one vision and one sound klystron focusing unit in series is admitted.
10. Standard CCIR-G: klystron tuned to frequency response according to the specification CCIR-G.
    Standard CCIR-I: klystron tuned to frequency response according Fig. 3.
    Standard CCIR-M: klystron tuned to frequency response according to the specification CCIR-M.

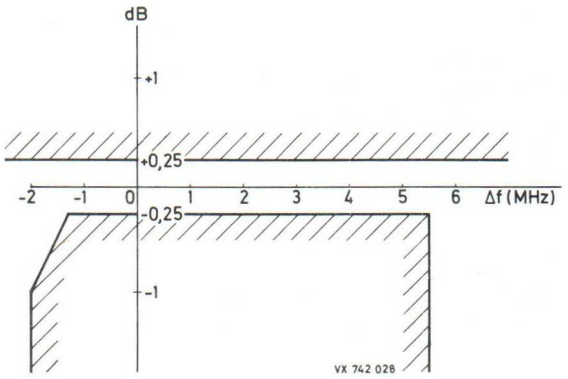



Fig. 3.

11. Optional.
12. Standard equipment is directly controlled on the side of trolley. In case of front panel control TE1186A is available instead of TE1186C.
13. The output couplers comprise a standard loop. For several channels a modified loop is to be used. Please indicate channel when ordering.
14. One arc detector for cavity 4 is required. For output power > 15 kW an additional arc detector for cavity 3 is recommended.

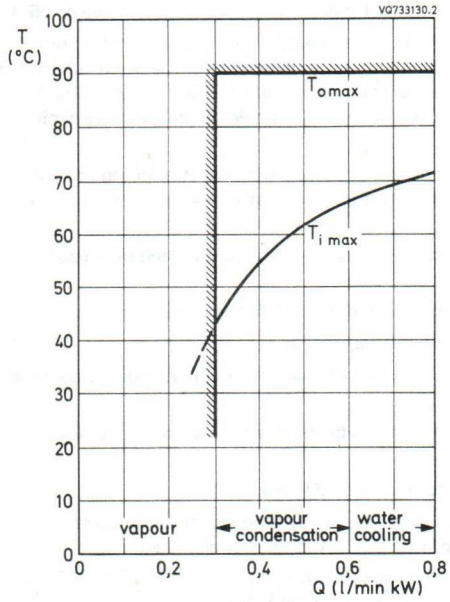



Fig. 4.

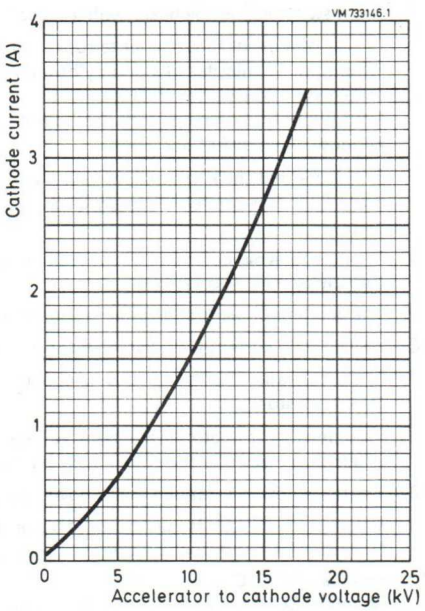



Fig. 5.

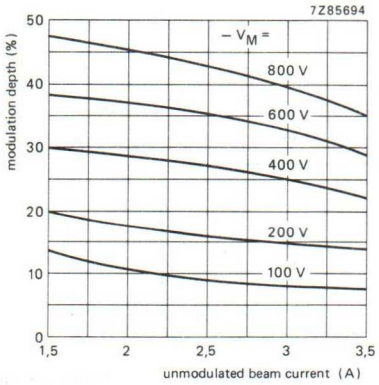



Fig. 6 ABC-operation for YK1233.
Parameter: modulation voltage $-V_M$ (with respect to cathode).

# HIGH-POWER KLYSTRONS

Fixed frequency, high-power klystron in metal-ceramic construction, for use in scientific and industrial applications. The tube has internal cavities, solenoid focusing, and a high stability dispenser-type cathode.

## QUICK REFERENCE DATA

| | | |
|---|---|---|
| Centre frequency (fixed tuned) | 1300 | MHz |
| Bandwidth | | note 1 |
| Pulse output power | 330 | kW |
| Cooling | | |
| collector | water | |
| body | air | |

This data must be read in conjunction with GENERAL OPERATIONAL RECOMMENDATIONS for KLYSTRONS.

**HEATING:** indirect by a.c.

Cathode: dispenser type

| | | min. | typ. | max. | | |
|---|---|---|---|---|---|---|
| Heater voltage | $V_f$ | 7 | 7.8 | 8.5 | V | note 2 |
| Heater current | $I_f$ | 31 | 32 | 33 | A | |
| Cold heater resistance | $R_{fo}$ | – | 30 | – | mΩ | |
| Waiting time | $t_w$ | 10 | 15 | – | minutes | |

**FOCUSING:** electromagnetic

| | | | | | |
|---|---|---|---|---|---|
| Solenoid current | 11 | 12 | 13 | A | |
| Solenoid voltage | – | – | 200 | V | |

**GETTER-ION PUMP SUPPLY**

| | | | | |
|---|---|---|---|---|
| Operating voltage | 3 | 4 | 5 | kV |
| Operating current | – | $5 \cdot 10^{-3}$ | 5 | mA |
| Internal resistance of power supply | – | 300 | – | kΩ |

**Notes**

1. Bandwidth, see Fig. 1.
   An input signal with an edge of 1 μs will be transmitted without discernable overshooting of the output signal.
2. Typical values are adjusted at the supplied heater transformer, which is mounted inside of the oil container (primary voltage 220 V).

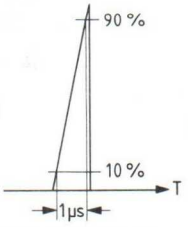



Fig. 1.

## MECHANICAL DATA

Dimensions in mm

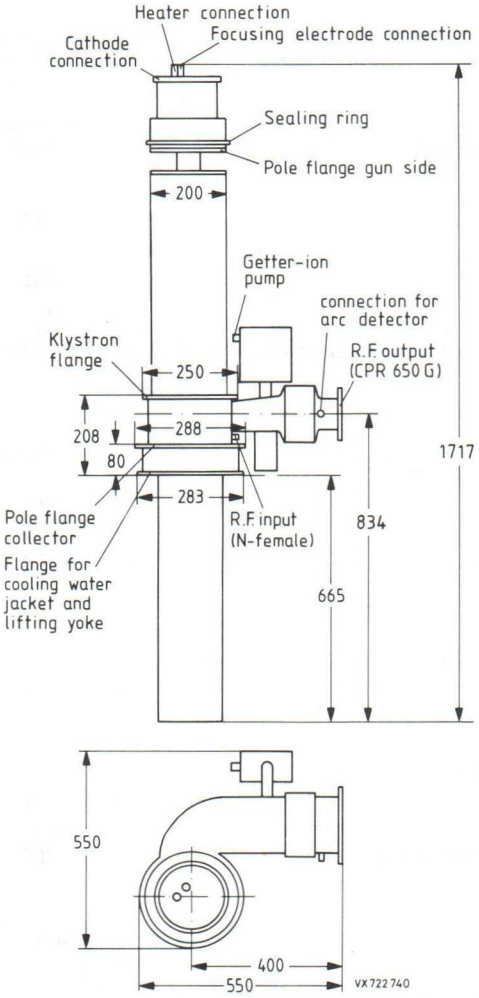



Fig. 2.

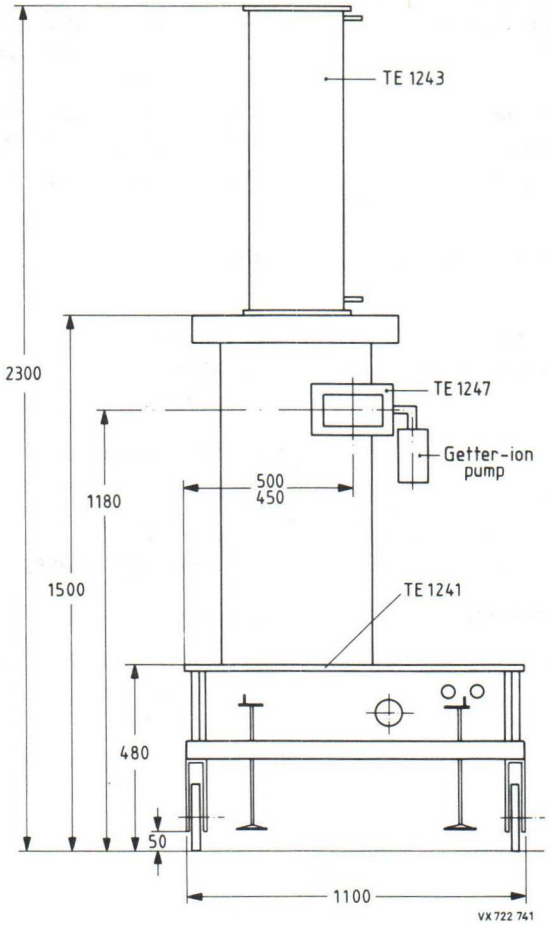



Fig. 3 Complete assembly consisting of tube, trolley, oil tank, focus mount, r.f. transition and operational lead shieldings.

## COOLING

| Cooling is achieved by demineralized water with 10 % stabilized glycol added | min. | typ. | max. | | |
|---|---|---|---|---|---|
| pressure in any cooling water circuit | – | – | 900 | kPa | (= 9 bar) |
| pressure drop | – | – | 100 | kPa | (= 1 bar) |
| Collector | | | | | |
| cooling water flow rate | 8 | 15 | 30 | ℓ/min | |
| inlet water temperature | +15 | +20 | +30 | °C | |
| outlet water temperature | +15 | +25 | +60 | °C | |

## MASS

Net mass of complete assembly 350 kg

## DIMENSIONS

Tube and mounting frame see drawings

Required ground clearance for lifting hoist min. 450 cm

Capability of hoist min. 250 kg

## MOUNTING

vertical, collector up

## R.F. CONNECTORS

Input N-type, female, 50 Ω

Output waveguide WR650 / CRP650G

**OIL CONTAINER**, contents approx. 70 ℓ

## ACCESSORIES

**A. Tube parts** (factory fitted)

The tube will be shipped without additional factory fitted parts.

**B. Operational parts for first equipment**

| | |
|---|---|
| Operational frame, consisting of trolley, oil container, heater transformer, di/dt sensor, focusing coil unit and cathode plug-connections | TE1241 |
| Collector water cooling jacket | TE1243 |
| Temperature sensors for water inlet, —outlet and collector | TE1245 |
| $30^{o}$ waveguide bend (H-plain) | TE1247 |
| Arc detector | TE1249 |

**C. Optional parts**

| | |
|---|---|
| H.V. cable with R3 plugs, length 6 m | TE1159 |
| H.V. dummy plug R3 | TE1161 |

**D. Parts for handling**

| | |
|---|---|
| Yoke for lifting klystron vertically | TE1251 |
| Lifting frame for storage and any movement of a burnt-out or spare klystron in any other position than vertical | TE1253 |

**LIMITING VALUES** (Absolute maximum rating system)

| | | | | |
|---|---|---|---|---|
| Heater voltage, a.c. | max. | 8.5 | V | |
| Heater current, a.c. | max. | 33 | A | note 1 |
| Cathode voltage to body | max. | −65 | kV | |
| Cathode current | max. | 12 | A | |
| Collector dissipation | max. | 650 | kW | note 2 |
| Pulse output power | max. | 330 | kW | |
| Pulse length | max. | 2 | s | |
| Ratio | max. | 1/100 | | |
| Load VSWR | max. | 1.2 | | |
| Input power, d.c. | max. | 650 | kW | |

**TYPICAL OPERATING CONDITIONS**

| | | | |
|---|---|---|---|
| **325 kW pulse output power** (VSWR < 1.1) | typ. | | |
| Cathode voltage | −60 | kV | |
| Cathode current | 11 | A | |
| Input power, d.c. | 600 | kW | |
| Collector dissipation | 330 | kW | |
| Efficiency | 50 | % | |
| Drive power | 27 | W | |
| Pulse length | 1.5 | s | |
| Ratio | 1/200 | | |

**PERFORMANCE DATA**

| | | |
|---|---|---|
| Phase shift to cathode current | < 20 | °/A |
| Phase shift to rel. cathode voltage | < 20 | °/% |
| R.F. output to rel. cathode voltage | < 0.3 | dB/% |
| Harmonic levels to fundamental | < 30 | dB |
| Signal-to-noise ratio | > 50 | dB |

**Notes**

1. When switching on the heater voltage, the heater current must never exceed a peak value of 40 A.
2. Maximum dissipation can be tolerated up to 0.5 s.

## INSTALLATION AND OPERATION REQUIREMENTS

### A. Required interlocks

1. Fast switch-off of the drive power within 10 ms has to be done if the arc detector and/or r.f. reflection indicator is activated. An arc detector must be provided at the output waveguide.
2. A fast switch-off of the beam supply has to be provided when one of the following situations occurs:
   a) the beam current increases rapidly,
   b) the solenoid current deviates by more than ±5% from the adjusted value,
   c) when the body current exceeds 500 mA.

   The switching sensors and the discharge facilities for the power supply must be designed so that a copper wire of 0.35 mm diameter, connected to the power supply instead of the klystron (length approx. 1 cm/kV), will not be destroyed, if the full operating voltage is switched on and applied to the wire.
3. The mains for the beam power supply has to be switched off within 100 ms when one of the following situations occur:
   a) the collector temperature monitor (with internal thermocouple) is activated (adjusted to maximum temperature),
   b) the monitored temperature differences between inlet and outlet in the collector and/or body cooling circuits are too high;

      max. values permitted: $\Delta\theta = 30$ K
   c) the beam current either exceeds the limiting value or increases by more than 30% or max. 2 A above the adjusted value,
   d) the water flow of the collector and body cooling circuit decreases below the required minimum value.

Restarting is not allowed within 10 s after any interruption.

### B. Switching-on and off sequence

Switching-on sequence

1. Getter-ion pump supply on.
2. Check that the pump current is $< 1$ mA.
3. Heater voltage supply on.
4. Wait for preheating time (min. 10 minutes).
5. Cooling of focusing.
6. Collector cooling supply on.
7. Solenoid current supply on.
8. R.F. drive on.
9. Beam voltage supply on.

Switching-off sequence

1. Beam voltage supply off.
2. All other supplies and cooling circuits off.

**C. Radiation dangers**

*R.F. radiation*

R.F. power may be emitted not only through the normal output coupling but also through other apertures (for example, r.f. leaks). This r.f. power may be sufficiently intense to cause danger to the human body, particularly to the eyes. Such radiation may be increased if the tube is functioning incorrectly.

*X-radiation*

A highly dangerous intensity of X-rays may be emitted by tubes operating at voltages higher than approximately 5 kV. Adequate protection (X-ray shielding) for the operator is then necessary. The emisson intensity of X-rays may correspond to a value of voltage much higher than that expected from the actual value applied to the tube.

Poor focusing may result in excessive X-radiation.

This tube and accessories are equipped with a lead shielding which under normal conditions reduces the radiation values below 0.75 mR/h, measured at a distance of 1 m from the tube assembly.

# CONTINUOUS-WAVE HIGH-POWER KLYSTRON

Water cooled, high efficiency, fixed frequency, continuous-wave high-power klystron in metal-ceramic construction, for use in scientific and industrial applications. The tube has internal cavities, solenoid focusing, beam control by accelerator anode and a high stability dispenser-type cathode.

## QUICK REFERENCE DATA

| | | |
|---|---|---|
| Centre frequency (fixed tuned) | 999.3 | MHz |
| Bandwidth at saturation (−1 dB points) | 4 | MHz |
| Output power | 400 | kW |
| Cooling | water | |

This data must be read in conjunction with GENERAL OPERATIONAL RECOMMENDATIONS for KLYSTRONS.

**HEATING:** indirect by a.c. or d.c.

Cathode: dispenser type

| | | min. | typ. | max. | | |
|---|---|---|---|---|---|---|
| Heater voltage | $V_f$ | 8.0 | 8.5 | 9.0 | V | |
| Heater current | $I_f$ | 24 | 26 | 28 | A | notes 1, 2 |
| Cold heater resistance | $R_{fo}$ | – | 30 | – | mΩ | |
| Waiting time | $t_w$ | 10 | – | – | minutes | |

**FOCUSING:** electromagnetic

| | | | | | |
|---|---|---|---|---|---|
| Solenoid current | – | – | 20 | A | |
| Solenoid voltage | – | – | 200 | V | |
| Solenoid resistance | – | 10 | – | Ω | |

**GETTER-ION PUMP SUPPLY**

| | | | | |
|---|---|---|---|---|
| Operating voltage | 3 | 3.3 | 4 | kV |
| Operating current | – | $10^{-3}$ | 80 | mA |
| Internal resistance of power supply | 25 | 300 | – | kΩ |

## MECHANICAL DATA

Dimensions in mm

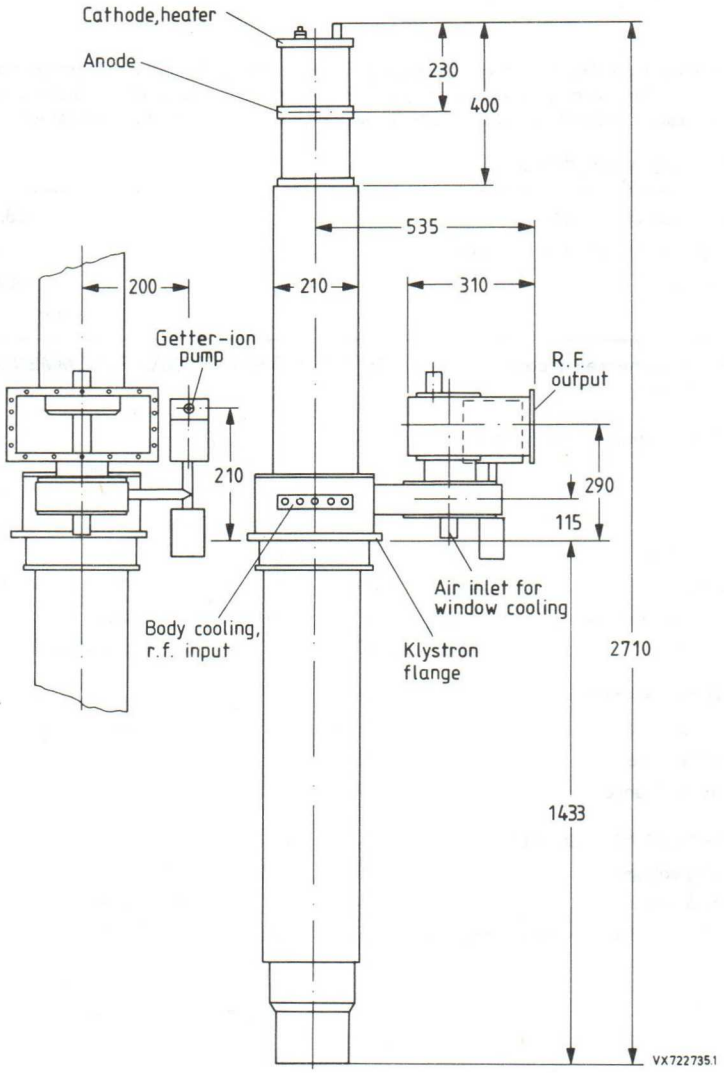



Fig. 1.

Tube mounted in the mounting frame with solenoid.

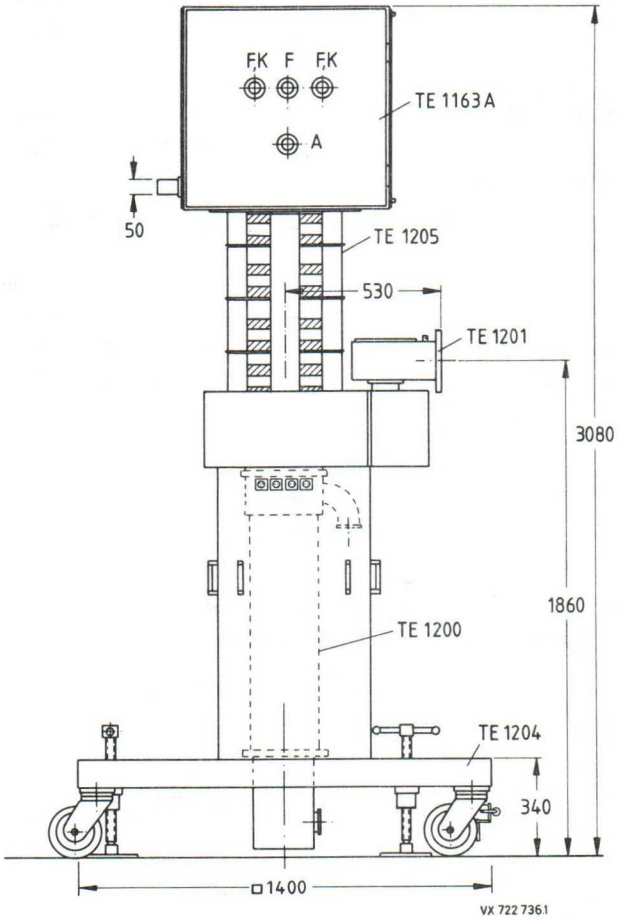



Fig. 2.

| COOLING | min. | typ. | max. | | |
|---|---|---|---|---|---|
| Collector | | | | | |
| demineralized or distilled water with 10% stabilized glycol added | 350 | 450 | 550 | ℓ/min | note 3 |
| pressure drop | – | 100 | – | kPa | (= 1 bar) |
| Body circuit I | | | | | |
| demineralized or distilled water with 10% stabilized glycol added | 5 | 7 | – | ℓ/min | note 3 |
| pressure drop | – | 300 | – | kPa | (= 3 bar) |
| Body circuit II | | | | | |
| demineralized or distilled water with 10% stabilized glycol added | 7 | 9 | – | ℓ/min | note 3 |
| pressure drop | – | 300 | – | kPa | (= 3 bar) |
| Cathode socket and accelerator anode | | | | | |
| air | 2 | – | – | $m^3$/min | |
| pressure drop | – | – | 500 | Pa | (= 5 mbar) |
| Output window | | | | | |
| air | – | 2 | – | $m^3$/min | |
| pressure drop | – | 2 | – | kPa | (= 20 mbar) |
| Inlet water temperature | – | – | +50 | °C | |
| Inlet air temperature | – | – | +45 | °C | |

**MASS**

| | | | |
|---|---|---|---|
| Net mass YK1250 | | 300 | kg |
| Mounting frame with solenoid | | 750 | kg |
| Capability of hoist | min. | 600 | kg |

**DIMENSIONS**

| | |
|---|---|
| Tube and mounting frame | see drawings |
| Required ground clearance for lifting hoist | min. 450 cm |

**MOUNTING** vertical, cathode up

**R.F. CONNECTORS**

| | |
|---|---|
| Input | N-type, female |
| Output | waveguide R9 (WR – 975) |

## ACCESSORIES

### A. Tube parts

| | | |
|---|---|---|
| Waveguide coupling iris (if required) | | note 4 |
| Magnet for getter-ion pump (factory fitted) | | |

### B. Operational parts for first equipment

| | | |
|---|---|---|
| Collector water cooling jacket | TE1200 | |
| Waveguide transition, R9 | TE1201 | note 5 |
| Anode ring | TE1202 | |
| Cathode ring | TE1203 | |
| H.V. connection unit with four R3 sockets | TE1163A | note 6 |
| Klystron trolley | TE1204 | |
| Focusing coil unit | TE1205 | |
| Connection cables | | |
| heater/cathode | 2 x TE1206A | |
| heater | 1 x TE1206B | |
| accelerator anode | 1 x TE1206C | |

### C. Parts for handling

note 7

| | |
|---|---|
| Yoke for lifting TE1205 and TE1163 | TE1208 |
| Yoke for lifting and turning a klystron from any position | TE1209 |
| Supporting frame for storage and any movement of burnt-out or spare klystrons in any position other than vertical | TE1210 |
| Trolley for transportation of a klystron in horizontal position without lifting gear | TE1211 |

**LIMITING VALUES** (Absolute maximum rating system)

| | | | | |
|---|---|---|---|---|
| Heater voltage<br>Heater current | } max. 10% above specified values | | | |
| Cathode voltage to body (ground) | max. | −61 | kV | |
| Cold cathode voltage to body (ground) | max. | −65 | kV | |
| Cathode current | max. | 12 | A | |
| Accelerator anode voltage to cathode | max. | 41 | kV | note 8 |
| Cold accelerator anode voltage to cathode | max. | 45 | kV | |
| Accelerator anode current | max. | 10 | mA | |
| Collector dissipation | max. | 700 | kW | note 9 |
| Dissipation body circuit I | max. | 10 | kW | |
| Dissipation body circuit II | max. | 10 | kW | |
| C.W. output power | max. | 420 | kW | |
| Load VSWR | max. | 1.2 | | note 10 |
| Temperature rise, window cooling air flow | max. | 70 | K | |

**TYPICAL OPERATING CONDITIONS**

| **350 kW operation into matched load** | min. | typ. | max. | | |
|---|---|---|---|---|---|
| Cathode voltage to body (ground) | −54 | −56 | −57 | kV | |
| Cathode current | 0 | 10.4 | 11 | A | |
| Input power, d.c. | – | 614 | – | kW | |
| Accelerator anode voltage to cathode | – | 31 | – | kV | |
| Accelerator anode current | – | 1 | 5 | mA | |
| C.W. output power, VSWR ⩽ 1.1 | 330 | 350 | – | kW | |
| Collector dissipation | – | 264 | 500 | kW | note 9 |
| Efficiency | 55 | 57 | – | % | |
| C.W. drive power | – | 20 | 40 | W | |
| **400 kW operation into matched load** | | | | | |
| Cathode voltage to body (ground) | – | −60.3 | – | kV | |
| Cathode current | – | 11.8 | 12 | A | |
| Input power, d.c. | – | 712 | – | kW | |
| Accelerator anode voltage to cathode | – | 34.5 | 40 | kV | |
| Accelerator anode current | – | 0.3 | 5 | mA | |
| C.W. output power, VSWR ⩽ 1.1 | – | 418 | – | kW | |
| Collector dissipation | – | 294 | 500 | kW | note 9 |
| Efficiency | 56 | 58 | – | % | |
| C.W. drive power | – | 9 | 40 | W | |

## PERFORMANCE DATA

| | | | |
|---|---|---|---|
| Phase shift to cathode current | < | 20 | °/A |
| Phase shift to rel. cathode voltage | < | 20 | °/% |
| Phase shift to r.f. drive | < | 12 | °/dB |
| R.F. output to rel. cathode voltage | < | 0.3 | dB/% |
| Spurious noise amplitude | | | |
| for f < 300 Hz | ≤ | 3 | % |
| for f = 300 to 1000 Hz | ≤ | 1 | % |
| for f > 1000 Hz | ≤ | 0.5 | % |

**Notes**

1. When switching on the heater voltage, the heater current must never exceed a peak value of 60 A.
2. Required values are given with each tube.
3. For further recommendations please contact the tube manufacturer.
4. Separately shipped together with each tube and to be returned together with each burnt-out tube.
5. It is recommended to return the coaxial waveguide transition together with burnt-out tube for inspection.
6. R3 sockets are only usable together with optional R3 plugs.
7. These parts are needed for all handling operations at the site (only one set required).
8. The accelerator anode voltage may never become positive with respect to the body (ground).
9. It must be observed that for operation with reduced r.f. drive the maximum value for collector dissipation is not exceeded.
10. For reflections exceeding this value please contact the tube manufacturer.

## INSTALLATION AND OPERATION REQUIREMENTS

### A. Required interlocks

1. Fast switch-off of the drive power within 10 ms has to be done if the arc detector and/or r.f. reflection indicator is activated. An arc detector must be provided at the knee of the output waveguide.
2. A fast switch-off of the beam supply has to be provided when one of the following situations occurs:
   a) the beam current increases rapidly,
   b) the solenoid current deviates by more than ±5% from the adjusted value.

   The switching sensors and the discharge facilities for the power supply must be designed so that a copper wire of 0.35 mm diameter, connected to the power supply instead of the klystron (length approx. 1 cm/kV), will not be destroyed, if the full operating voltage is switched on and applied to the wire.
3. The mains for the beam power supply has to be switched off within 100 ms when one of the following situations occur:
   a) the beam current either exceeds the limiting value or increases by more than 30% or max. 2 A above the adjusted value,
   b) the pump current exceeds 10 $\mu$A ,
   c) the collector temperature monitor (with internal thermocouple) is activated (switch-off value adjustable between 30 and 60 K above the water inlet temperature),
   d) the monitored temperarure differences between inlet and outlet in the collector and/or body cooling circuits are too high;

      | | | |
      |---|---|---|
      | max. values permitted: | collector | $\Delta\theta$ = 15 K |
      | | body circuit I | $\Delta\theta$ = 15 K |
      | | body circuit II | $\Delta\theta$ = 15 K |

   e) the water flow of the collector and body cooling circuits decreases below the required minimum value,
   f) the air flow for the r.f. window and cathode cooling decreases below the required minimum value.
4. Switch-off the heater voltage for pump current $>$ 4 mA.

Restarting is not allowed within 10 s after any interruption.

### B. Switching-on and off sequence

Switching-on sequence

1. Cathode cooling on.
2. Getter-ion pump supply on.
3. Check that the pump current is $<$ 10 $\mu$A.
4. Heater voltage supply on.
5. Wait for preheating time (min. 15 minutes).
6. Cooling air r.f. window on.
7. Cooling body circuits I and II on.
8. Collector cooling supply on.
9. Solenoid current supply on.
10. Check that the heater current has reached the adjusted value ± 0.5 A.
11. R.F. drive on.
12. Beam voltage supply on.

Switching-off sequence

1. Beam voltage supply off.
2. All other supplies and cooling circuits off.

**C. Radiation dangers**

*R.F. radiation*

R.F. power may be emitted not only through the normal output coupling but also through other apertures (for example, r.f. leaks). This r.f. power may be sufficiently intense to cause danger to the human body, particularly to the eyes. Such radiation may be increased if the tube is functioning incorrectly.

*X-radiation*

A highly dangerous intensity of X-rays may be emitted by tubes operating at voltages higher than approximately 5 kV. Adequate protection (X-ray shielding) for the operator is then necessary. The emisson intensity of X-rays may correspond to a value of voltage much higher than that expected from the actual value applied to the tube.

Poor focusing may result in excessive X-radiation.

This tube and accessories are equipped with a lead shielding which under normal conditions reduces the radiation values below 0.75 mR/h, measured at a distance of 1 m from the tube assembly.

# U.H.F. POWER KLYSTRONS

For u.h.f. band IV/V vision transmitters and sound transmitters.
Metal-ceramic construction, four external cavities, electromagnetic focusing and a high-stability dispenser type cathode.
Suitable for vapour, vapour-condensation or water cooling.
Comprising a non-intercepting annular beam control electrode (ABC) for low-voltage beam modulation.

## QUICK REFERENCE DATA

| | | | |
|---|---|---|---|
| Frequency range | 470 to 810 | MHz | note 10 |
| Output power as vision transmitter | | | |
| YK1263 | 40 and 55 | kW | |
| YK1265 | 40, 55 and 60 | kW | |
| Cooling | vapour, vapour condensation, or water | | |

This data must be read in conjunction with GENERAL OPERATIONAL RECOMMENDATIONS for KLYSTRONS.

| **HEATING:** indirect by d.c. | | | | notes |
|---|---|---|---|---|
| Cathode | dispenser type | | | |
| Heater voltage | $V_f$ | 8.5 | V ±3 % | |
| Heater current | $I_f$ ≈ | 24 to 28 | A | 1 |
| Cold heater resistance | $R_{fo}$ ≈ | 30 | mΩ | |
| Waiting time | | | | 2 |
| from cold, $V_f$ = 0 V | $t_w$ min. | 300 | s | |
| from black heat, $V_f$ = 6 V | $t_w$ min. | 0 | s | |

| **FOCUSING** | | | |
|---|---|---|---|
| Focusing coil current | 10 to 12 | A | |
| Resistance of focusing coils | | | |
| cold (20 °C) | 7.2 to 9.5 | Ω | |
| operating at an ambient temperature of 20 °C | ⩽ 11 | Ω | |

**BEAM CONTROL** 6, 7

The klystrons comprise a non-intercepting annular beam control (ABC) electrode for low-voltage beam modulation. See Fig. 7.
Additionally the accelerator electrode voltage allows adjustment of the beam current between 0 and 100%.

| **GETTER-ION PUMP SUPPLY** | | | 3 |
|---|---|---|---|
| Pump voltage, no-load condition | 3 to 4 | kV | |
| Internal resistance of supply | 300 | kΩ | |

## MECHANICAL DATA

Dimensions in mm

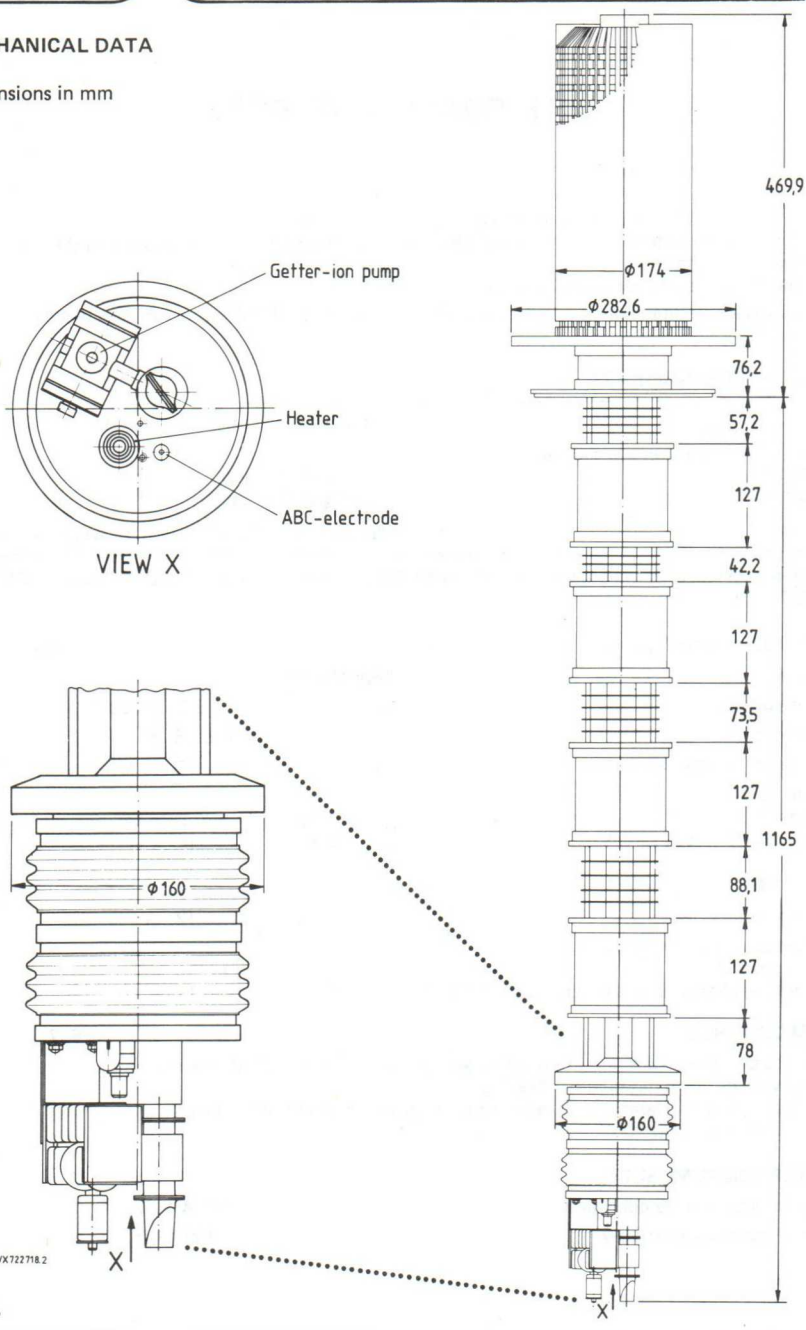



Fig. 1.

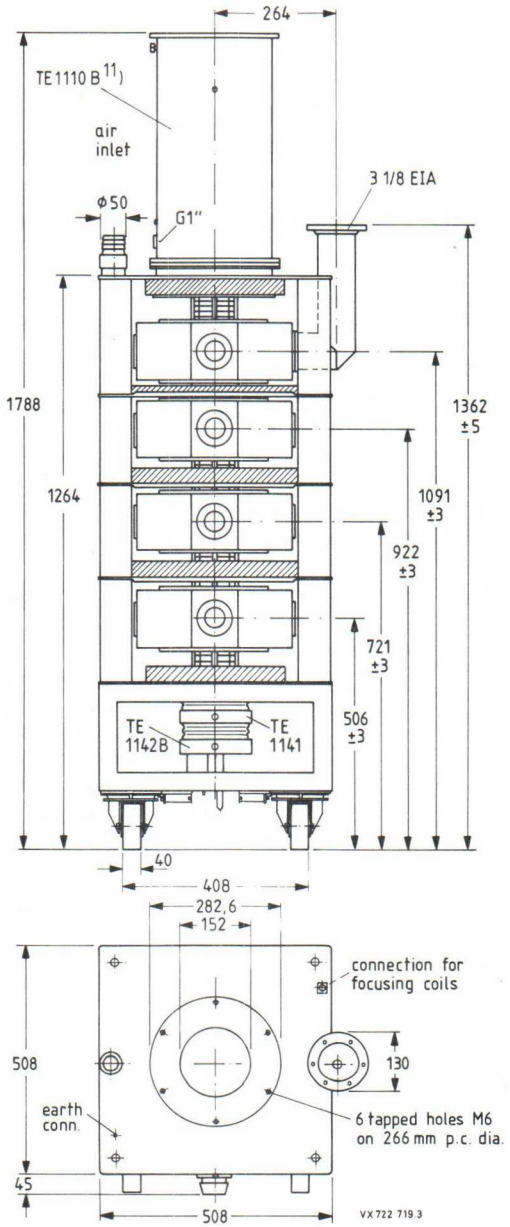

264
TE1110 B 11)
air inlet
3 1/8 EIA
Φ50
G1"
1788
1264
1362 ±5
1091 ±3
922 ±3
721 ±3
506 ±3
TE 1142B
TE 1141
40
408
282,6
152
connection for focusing coils
508
130
earth conn.
6 tapped holes M6 on 266 mm p.c. dia.
45
508
VX 722 719.3

Fig. 2.

## MASS AND DIMENSIONS

Klystron

| | |
|---|---|
| net | approx. 79 kg |
| gross | approx. 232 kg |
| outline dimensions of packing (cm) | 182 x 75 x 75 |
| Cavities | approx. 45 kg |
| Magnet frame with coils | approx. 230 kg |

## MOUNTING

Mounting position: vertical with collector up.
To remove the tube from the magnet frame a total free height of 3 m, excluding hoist, is required.

## COOLING

| | | |
|---|---|---|
| YK1263 | Cavities 1, 2, 3 and 4, drift tubes 4 and 5 and cathode socket via manifold | forced air, $T_i$ max. 50 °C<br>$q \approx 2$ m³/min, $\Delta p = 1600$ Pa (16 mbar) |
| YK1265 | Cavities 1, 2, 3 and 4, drift tube 4 and cathode socket via manifold | forced air, $T_i$ max. 50 °C<br>$q \approx 3$ m³/min, $\Delta p = 1600$ Pa (16 mbar) |
| | Drift tube 5, seperate cooling | forced air, $T_i$ max. 50 °C, $q \approx 3$ m³/min, flow area $\approx 50$ cm² |
| Cathode socket only, during black heat | | forced air, $T_i$ max. 50 °C, $q \approx 0.15$ m³/min |
| Collector | | vapour with boiler TE1110B, note 4<br>volume of water converted to steam: 27 cm³/min per kW collector dissipation resulting in 43 ℓ/min steam per kW collector dissipation |
| | | water or vapour condensation (with water jacket TE1194B) q = 35 to 60 ℓ/min, $T_o$ max 90 °C, see Fig. 3. For 60 ℓ/min, $\Delta p = 100$ kPa (1 bar) |

## ACCESSORIES

Correct operation can be guaranteed only if approved accessories are used.

| | | | |
|---|---|---|---|
| Collector radiation suppressor | TE1221 | | |
| Anode ring | TE1141 | | |
| Cathode ring | TE1142B | | |
| Spark gap | TE1183 | | |
| Set of connectors (heater, cathode, accelerator electrode, getter-ion pump) | TE1146 | | |
| Cavities | 4 x TE1224 | | |

| | front panel controlled | direct controlled |
|---|---|---|
| Inlet coupler and load coupler for cavities 2 and 3 | 3 x TE1226 and 3 x TE1226D | 3 x TE1226 |

| | | |
|---|---|---|
| Output coupler, 3 1/8 inch, 90° elbow | TE1227 | |
| Magnet frame with coils | TE1222 | |
| Collector jacket for water or vapour condensation cooling | TE1194B | note 11 |
| Boiler for vapour cooling | TE1110B | note 11 |
| Tool set | TE1190 | |
| Temperature sensor | TE1199 | |
| Arc detector | TE1107B | |

Recommended circulators (optional)

| | |
|---|---|
| 470 to 600 MHz | 2722 162 01551 (T100/IV-N) |
| 600 to 800 MHz | 2722 162 01561 (T100/V-N) |
| 790 to 1000 MHz | 2722 162 03261 (T100/V-3-N) |

**LIMITING VALUES** (Absolute maximum rating system)

| | | | |
|---|---|---|---|
| Heater voltage | max. 9.5 | V | |
| Beam voltage | max. 28 | kV | |
| Cold cathode voltage | max. −30 | kV | |
| Beam current | max. 7 | A | note 6 |
| Body current | max. 150 | mA | |
| Accelerator electrode current | max. 6 | mA | note 5 |
| Collector dissipation | max. 150 | kW | |
| Load VSWR | max. 1.5 | | |
| Temperature of tube envelope | max. 175 | °C | |
| Static pressure in the cooling system TE1194B | max. 600 | kPa (6 bar) | |
| ABC-electrode voltage with respect to cathode | max. −1.4 | kV | |

**PERFORMANCE DATA**

| of ABC-electrode | min. | typ. | max. | |
|---|---|---|---|---|
| Capacity | 80 | 90 | 100 | pF |
| D.C. current at −1000 V* | – | – | 1 | mA |

**PRODUCT SAFETY**

*1. X-radiation*

Correct operation of the tube can be guaranteed only if a set of accessories, approved by the tube manufacturer, is used.

The operating tube generates X-rays which can penetrate the ceramic parts of the tube envelope. In order to reduce the radiation at any accessible points to an officially acceptable, non-dangerous level the tube must be shielded and any possible radiation path blocked by at least 1 mm of brass or an equivalent depth of non-magnetic X-ray absorbing material. The proper use of accessories will provide the necessary shielding.

*2. R.F. radiation*

R.F. power may be emitted through apertures other than the normal output coupling (for example r.f. leaks). This r.f. power may be sufficiently intense to cause danger to the human body, particularly to the eyes. Such radiation may be increased if the tube is functioning incorrectly.

**Instruction manual**

For detailed mounting and tuning instructions see klystron instruction manual, delivered with each tube.

* The d.c. electrode current may rise up to max. 2 mA during life time. The applied modulator should be designed for an ABC-electrode current of at least 2 mA.

**TYPICAL OPERATING CONDITIONS** (modulation electrode at cathode potential)

| **As 40 kW vision transmitter** | | | | | notes |
|---|---|---|---|---|---|
| Standard CCIR-G | | | | | |
| Channel | 21 | 45 | 68 | | |
| Output power, peak sync. | 45 | 45 | 45 | kW | |
| Beam voltage | 21 | 22.5 | 24.5 | kV | |
| Beam current | 5.2 | 4.45 | 4.15 | A | 6,7 |
| Accelerator to cathode voltage | 19 | 17.5 | 16.5 | kV | 5 |
| Body current | | | | | |
| without drive | 8 | 5 | 5 | mA | |
| at black level | 60 | 30 | 30 | mA | |
| Focusing coil current | 11 | 10.5 | 10 | A | |
| Drive power, peak sync. max. | 20 | 10 | 10 | W | 8 |
| Operating efficiency | 41 | 45 | 44 | % | |
| Bandwidth at −1 dB points | 7 | 7 | 7 | MHz | 9 |
| **As 55 kW vision transmitter** | | | | | |
| Standard RTMA-M and RTMA-M* | | | | | |
| Channel | 14 | 45 | 69 | | |
| Output power, peak sync. | 58 | 58 | 58 | kW | |
| Beam voltage | 23 | 25 | 26 | kV | |
| Beam current | 6.0 | 5.05 | 4.85 | A | 6,7 |
| Accelerator to cathode voltage | 21.5 | 19 | 18.5 | kV | 5 |
| Body current | | | | | |
| without drive | 8 | 5 | 5 | mA | |
| at 58 kW peak sync., black level | 80 | 40 | 40 | mA | |
| Focusing coil current | 11.5 | 11 | 10.5 | A | |
| Drive power, peak sync. | 20 | 10 | 10 | W | |
| Operating efficiency | 42 | 46 | 46 | % | |
| Bandwidth at −1 dB points | 7 | 7 | 7 | MHz | 9 |

| **As 60 kW vision transmitter** (YK1265 only) | | | | | notes |
|---|---|---|---|---|---|
| Standard* | M/G | M/G | M/G | | |
| Channel | 14/21 | 42/42 | 69/62 | | |
| Output power, peak sync. | 64 | 64 | 64 | kW | |
| Beam voltage | 24.5 | 25.5 | 26.5 | kV | |
| Beam current | 6.1 | 5.3 | 5 | A | 6,7 |
| Accelerator to cathode voltage | 21.5 | 20 | 18.5 | kV | 5 |
| Body current | | | | | |
| without drive | 8 | 7 | 5 | mA | |
| at 64 kW peak sync., black level | 80 | 60 | 40 | mA | |
| Focusing coil current | 11.5 | 11 | 10.5 | A | |
| Drive power, peak sync. | 20 | 10 | 10 | W | 8 |
| Operating efficiency | 43 | 47.5 | 48 | % | |
| Bandwidth at −1 dB points | 7 | 7 | 7 | MHz | 9 |
| **As 8 kW FM sound transmitter** | | | | | |
| Output power | 9 | 9 | 9 | kW | |
| Beam voltage | 21 | 22.5 | 24.5 | kV | |
| Beam current | 1.15 | 1.0 | 0.95 | A | |
| Accelerator to cathode voltage | 7 | 6.5 | 6 | kV | 5 |
| Focusing coil current | 9 | 9 | 9 | A | |
| Drive power | 5 | 5 | 5 | W | 8 |
| Bandwidth at −1 dB points | 1 | 1 | 1 | MHz | |
| **As 11 kW FM sound transmitter** | | | | | |
| Output power | 12 | 12 | 12 | kW | |
| Beam voltage | 23 | 25 | 26 | kV | |
| Beam current | 1.4 | 1.2 | 1.1 | A | |
| Accelerator to cathode voltage | 8 | 7.5 | 7 | kV | 7 |
| Focusing coil current | 9 | 9 | 9 | A | |
| Drive power | 5 | 5 | 5 | W | 8 |
| Bandwidth at −1 dB points | 1 | 1 | 1 | MHz | |
| **As 12 kW FM sound transmitter** | | | | | |
| Output power | 13 | 13 | 13 | kW | |
| Beam voltage | 24.5 | 25.5 | 26.5 | kV | |
| Beam current | 1.4 | 1.3 | 1.2 | A | |
| Accelerator to cathode voltage | 8 | 7.5 | 7.5 | kV | 7 |
| Focusing coil current | 9 | 9 | 9 | A | |
| Drive power | 5 | 5 | 5 | W | 8 |
| Bandwidth at −1 dB points | 1 | 1 | 1 | MHz | |

* Standards: RTMA-M, RTMA-M* and CCIR-G.

| **As 60 kW vision transmitter** (YK1265 only) | | | | | notes |
|---|---|---|---|---|---|
| Standard* | M/G | M/G | M/G | | |
| Channel | 14/21 | 42/42 | 69/62 | | |
| Output power, peak sync. | 64 | 64 | 64 | kW | |
| Saturated output power | 68 | 68 | 68 | kW | |
| Beam voltage | 25 | 26 | 27 | kV | |
| Beam current | 6.3 | 5.5 | 5.25 | A | 6, 7 |
| Accelerator to cathode voltage | 22 | 20 | 19.5 | kV | 5 |
| Body current | | | | | |
| without drive | 8 | 7 | 5 | mA | |
| at 64 kW peak sync., black level | 80 | 60 | 40 | mA | |
| Focusing coil current | 11 | 10.5 | 10 | A | |
| Drive power, peak sync. | 20 | 10 | 10 | W | 8 |
| Saturated efficiency | 43 | 47.5 | 48 | % | |
| Bandwidth at −1 dB points | 7 | 7 | 7 | MHz | 9 |
| **As 6 kW FM sound transmitter** | | | | | |
| Output power | 6.4 | 6.4 | 6.4 | kW | |
| Beam voltage | 25 | 26 | 27 | kV | |
| Beam current | 0.85 | 0.77 | 0.72 | A | |
| Accelerator to cathode voltage | 5.3 | 5.0 | 4.8 | kV | 5 |
| Focusing coil current | 10 | 9.5 | 9 | A | |
| Drive power | 5 | 5 | 5 | W | 8 |

| **CW operation for synchrotron radiation sources** (YK1265 only) | | | |
|---|---|---|---|
| Frequency | ≈ 500 | ≈ 500 | MHz |
| Output power | 52 | 42 | kW |
| Beam voltage | 23 | 21 | kV |
| Beam current | 5.6 | 4.9 | A |

*Standards: RTMA-M, RTMA-M* and CCIR-G.

**Notes**

1. When switching on the heater voltage, the heater current must never exceed a peak value of 65 A.
2. In case of a mains failure an interruption up to 30 s can be tolerated without new waiting time. After min. 10 minutes of stand-by heating time at 6 V (black heat), the beam current may be switched on; the heater voltage must be increased to its nominal value of 8.5 V simultaneously. Continuous black heat periods should not exceed two weeks and should be separated by similar periods of rest or full operation.
3. To ensure that the klystron is always ready for operation, operate the ion getter pump at least every 6 months (preferably every 3 months) during storage. For details see klystron instruction manual.
4. In order to avoid corrosion of the cooling system, coolant water must be pure and deionized (resistivity min. 100 kΩ·cm).
5. The accelerator electrode voltage must not be positive with respect to the body (ground).
6. For beam current (tolerance ± 5%) versus accelerator-to-cathode voltage, see Fig. 4.
7. A voltage divider for adjusting the beam current should be dimensioned on the basis of an accelerator electrode current of max. 1.5 mA.
8. The drive power is defined as the power delivered to a matched load.
9. Variation of the signal level between black and white at any sideband frequency may cause a reaction of the peak sync. level. Proper tube design limits this reaction to less than 0.5 dB.
10. For operation in the frequency range 810 to 860 MHz please contact tube manufacturer.
11. TE1110B with 1" inlet and steam outlet on top. TE1194B with two 1" tube fittings SWAGE LOCK SS-1610-1-16 at one side of the cooling jacket.

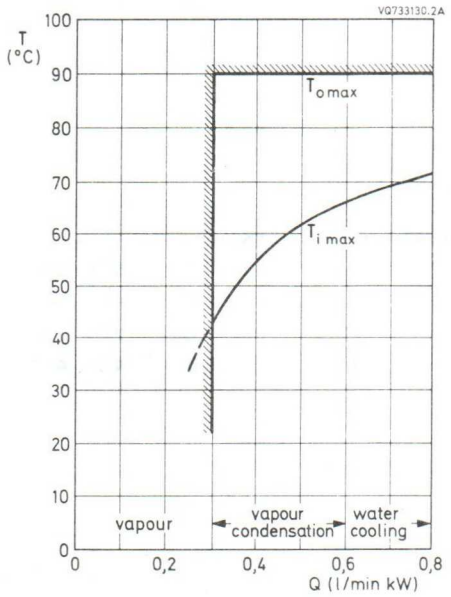



Fig. 3.

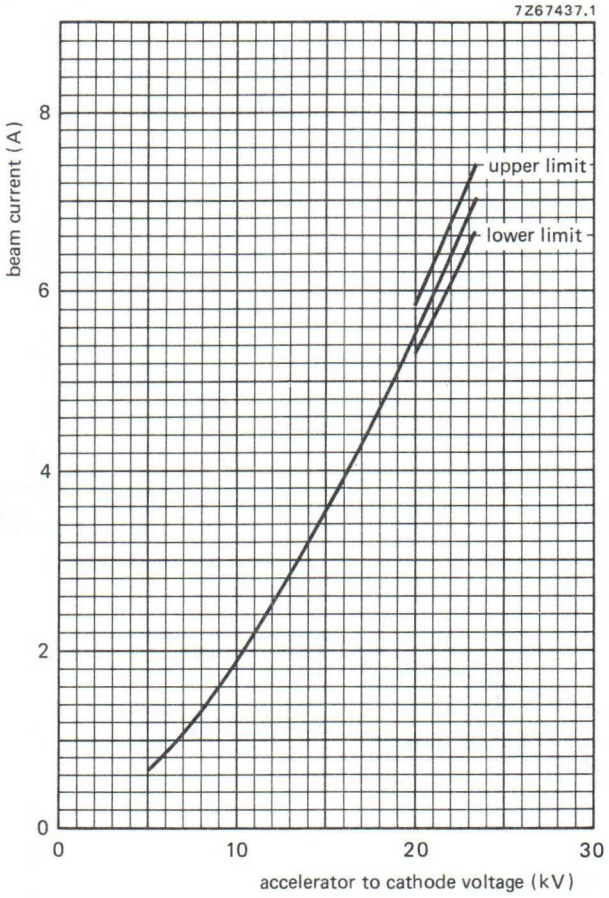

7Z67437.1
beam current (A)
8
6
4
2
0
upper limit
lower limit
0
10
20
30
accelerator to cathode voltage (kV)

Fig. 4.

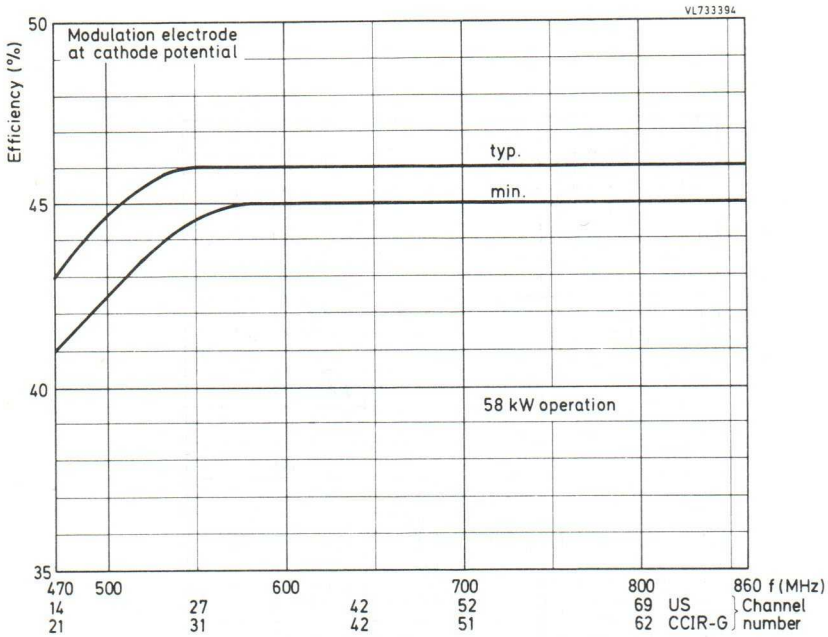

VL733394
Efficiency (%)
50
45
40
35
Modulation electrode
at cathode potential
typ.
min.
58 kW operation
470
500
600
700
800
860 f (MHz)
14
21
27
31
42
42
52
51
69 US
62 CCIR-G
Channel
number

Fig. 5.

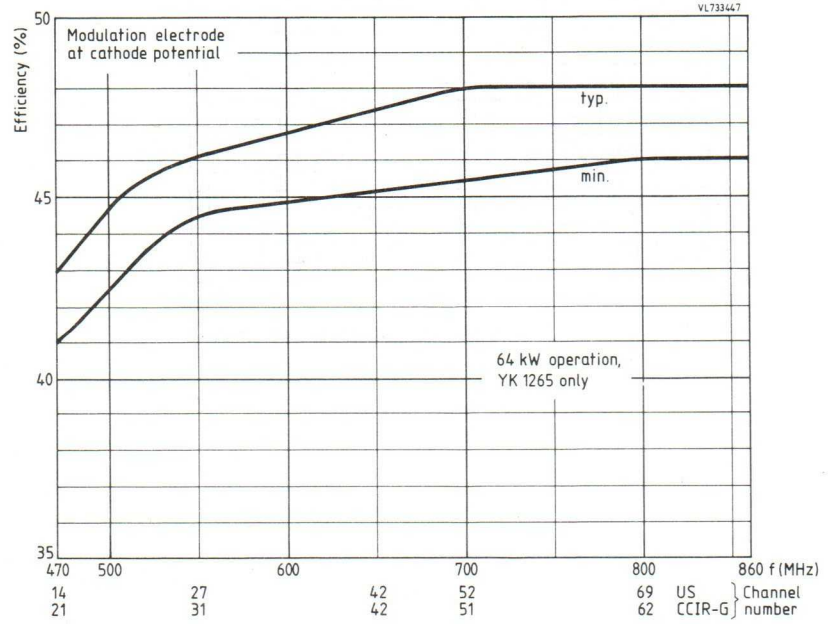

VL733447
Efficiency (%)
50
45
40
35
Modulation electrode
at cathode potential
typ.
min.
64 kW operation,
YK 1265 only
470
500
600
700
800
860 f (MHz)
14
21
27
31
42
42
52
51
69 US
62 CCIR-G
Channel
number

Fig. 6.

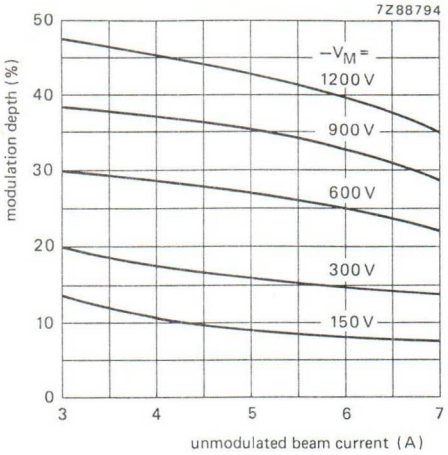



Fig. 7 ABC-operation.
Parameter: modulation voltage $-V_M$ (with respect to cathode).

# U.H.F. POWER KLYSTRONS

For u.h.f. band IV/V vision transmitters and sound transmitters.
Metal-ceramic construction, four external cavities, electromagnetic focusing and a high-stability dispenser type cathode.
Suitable for vapour, vapour-condensation or water cooling.
Comprising a non-intercepting annular beam control electrode (ABC) for low-voltage beam modulation.

## QUICK REFERENCE DATA

| | |
|---|---|
| Frequency range | |
| YK1295 | 470 to 610 MHz |
| YK1296 | 590 to 720 MHz |
| YK1297 | 710 to 860 MHz |
| Output power as vision transmitter | 40 and 55 kW |
| Cooling | vapour, vapour condensation, or water |

This data must be read in conjunction with GENERAL OPERATIONAL RECOMMENDATIONS for KLYSTRONS.

| **HEATING:** indirect by d.c. | | | notes |
|---|---|---|---|
| Cathode | dispenser type | | |
| Heater voltage | $V_f \approx$ | 8.5 V ±3 % | |
| Heater current | $I_f \approx$ | 22 to 27 A | 1 |
| Cold heater resistance | $R_{fo} \approx$ | 30 mΩ | |
| Waiting time | | | 2 |
| at $V_f$ = 8.5 V | $t_w$ min. | 300 s | |
| at $V_f$ = 6.0 V (black heat) | $t_w$ min. | 0 s | |

| **FOCUSING:** electromagnetic | | |
|---|---|---|
| Focusing coil current | | 9 to 12 A |
| Resistance of focusing coils | | |
| cold (20 °C) | | 7.2 to 9.5 Ω |
| operating at an ambient temperature of 20 °C | ⩽ | 11 Ω |

### BEAM CONTROL

The klystron comprises a non-intercepting annular beam control (ABC) electrode for low-voltage beam modulation. See Fig. 5.
Additionally the accelerator electrode voltage allows adjustment of the beam current between 0 and 100%.

| **GETTER-ION PUMP SUPPLY** | | 3 |
|---|---|---|
| Pump voltage, no-load condition | 3 to 4 kV | |
| Internal resistance of supply | 300 kΩ | |

## MECHANICAL DATA YK1295

Dimensions in mm

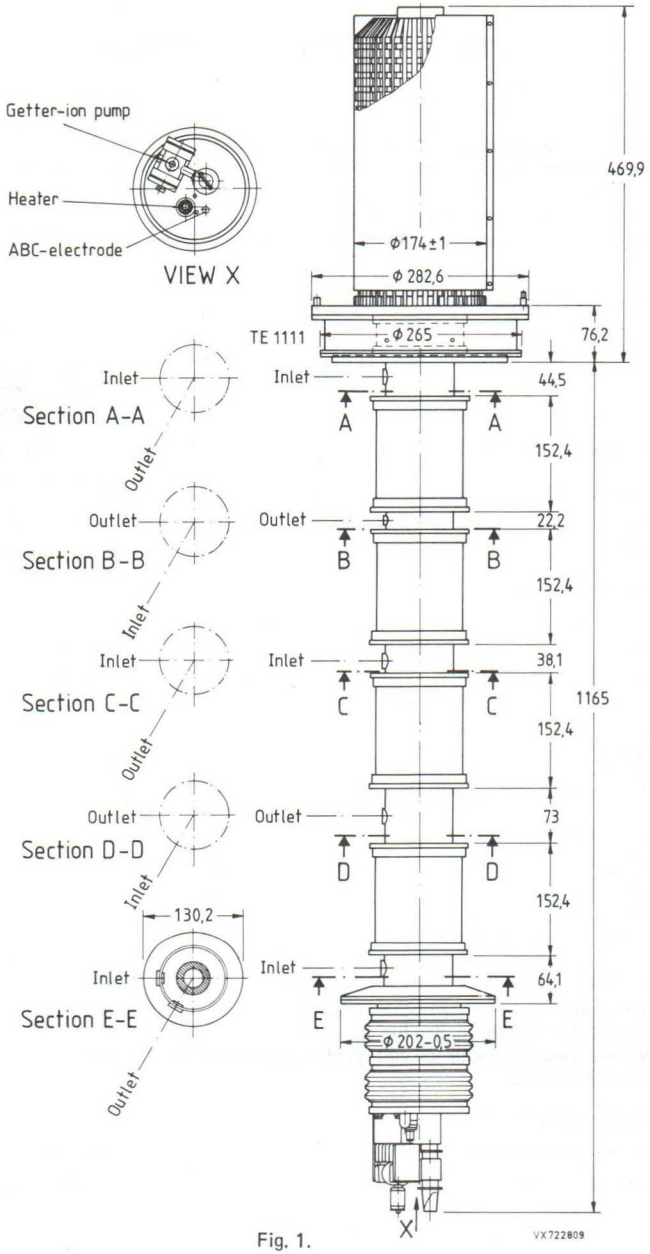



Fig. 1.

YK1296, YK1297

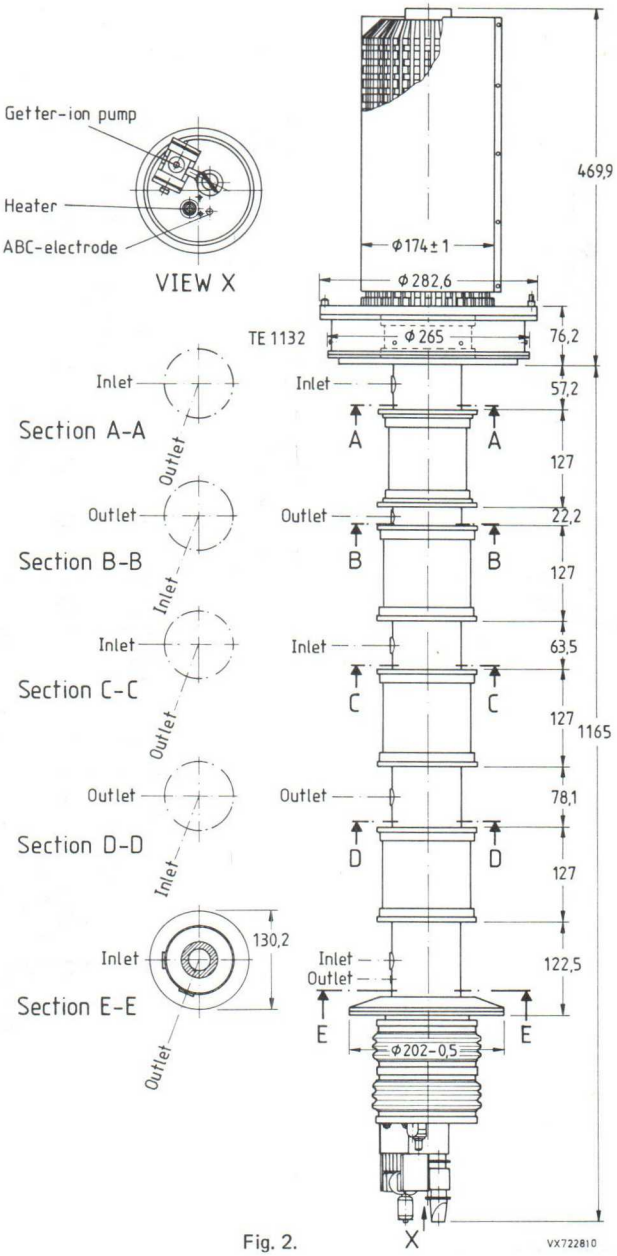



Fig. 2.

## Mechanical outlines of trolley

Dimensions in mm

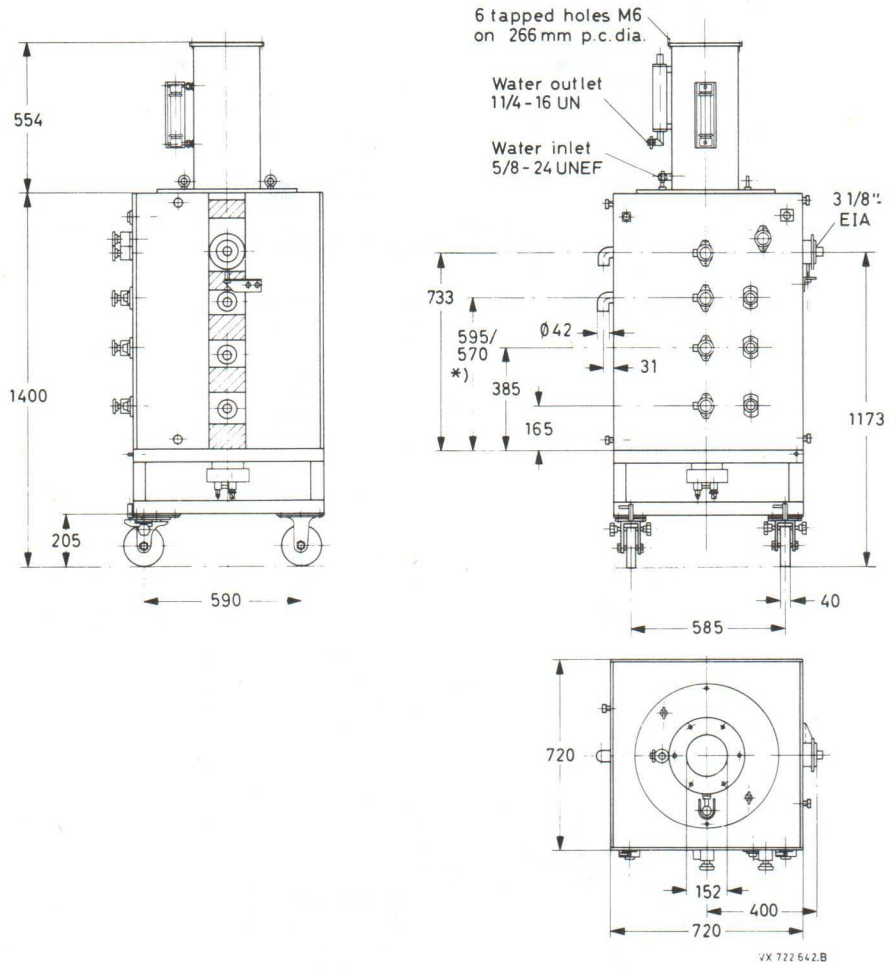



Fig. 3.

* YK1295 = 570 mm.
YK1296/1297 = 595 mm.

## COOLING

| | |
|---|---|
| Cathode socket accelerator electrode | air; $q \approx 0.15$ m$^3$/min, $T_i$ max. 40 °C |
| Collector | vapour (with boiler TE1110), note 4<br>volume of water converted to steam: 27 cm$^3$/min per kW collector dissipation resulting in 43 ℓ/min steam per kW collector dissipation<br>water or vapour condensation (with cooler TE1194)<br>$q$ = 35 to 60 ℓ/min, $T_o$ max 80 °C, |
| Drift tubes | water; rate of flow to drift tubes and collector connected in series $q \approx 9$ ℓ/min, $T_i$ max. 80 °C, $\Delta p$ = 200 kPa (2 bar) |
| Cavities 3 and 4 | forced air; $q$ = 1.5 m$^3$/min, $\Delta p$ = 250 Pa (2.5 mbar) $T_i$ max. 45 °C |

## MASS AND DIMENSIONS

| | | | |
|---|---|---|---|
| Klystron | | | |
| net | approx. | 80 | kg |
| gross | approx. | 230 | kg |
| outline dimensions of packing (cm) | 182 x 75 x 75 | | |
| Cavities | approx. | 45 | kg |
| Magnet frame with coils | approx. | 885 | kg |

## MOUNTING

Mounting position: vertical with collector up.
To remove the tube from the magnet frame a total free height of 3.5 m, excluding hoist, is required.

## PRODUCT SAFETY

*1. X-radiation*

Correct operation of the tube can be guaranteed only if a set of accessories, approved by the tube manufacturer, is used.

The operating tube generates X-rays which can penetrate the ceramic parts of the tube envelope. In order to reduce the radiation at any accessible points to an officially acceptable, non-dangerous level the tube must be shielded and any possible radiation path blocked by at least 1 mm of brass or an equivalent depth of non-magnetic X-ray absorbing material. The proper use of accessories will provide the necessary shielding.

*2. R.F. radiation*

R.F. power may be emitted through apertures other than the normal output coupling (for example r.f. leaks). This r.f. power may be sufficiently intense to cause danger to the human body, particularly to the eyes. Such radiation may be increased if the tube is functioning incorrectly.

### Instruction manual

For detailed mounting and tuning instructions see klystron instruction manual, delivered with each tube.

**ACCESSORIES** (note 5)

**A. Accessories required for first equipment**

| | YK1295 | YK1296 | YK1297 |
|---|---|---|---|
| Collector radiation suppressor | TE1111 | TE1132 | TE1195 |
| Accelerator electrode ring | TE1141 | TE1141 | TE1141 |
| Cathode ring | TE1142B | TE1142B | TE1142B |
| Set of sealing rings | TE1147 | TE1147 | TE1147 |
| Magnet flux ring | TE1138 | TE1138 | TE1138 |
| Spark gap | TE1140 | TE1140 | TE1140 |
| Set of connectors (heater, cathode, acc. electrode, getter-ion pump) | TE1146 | TE1146 | TE1146 |
| Extension pipes for drift tubes | 6x TE1133A<br>2x TE1133B | 6x TE1133A<br>2x TE1133B | 6x TE1133A<br>2x TE1133B |
| Water interconnecting pipes between drift tubes | | | |
| $T_2 - T_2$ | TE1134A | TE1135A | TE1135A |
| $T_2 - T_3$ | TE1134B | TE1135B | TE1135B |
| $T_3 - T_4$ | TE1134C | TE1135C | TE1135C |
| $T_4 - T_5$ | TE1134D | TE1135D | TE1135D |
| Flexible water pipes between tube and boiler for vapour cooling | TE1145A | TE1145A | TE1145A |
| between frame and tube | TE1145B | TE1145B | TE1145B |
| tube outlet for water cooling | TE1145C | TE1145C | TE1145C |
| Boiler for vapour cooling | TE1110 | TE1110 | TE1110 |
| or | | | |
| Cooler for water cooling | TE1194 | TE1194 | TE1194 |
| Cavities | 3x TE1121D<br>1x TE1121D | 3x TE1098A<br>1x TE1098D | 3x TE1191A<br>1x TE1191B |
| Input coupler | TE1122A | TE1102 | TE1102 |
| Load coupler for cavities 2 and 3 | 2x TE1122B | 2x TE1102 | 2x TE1102 |
| Blanking plates | 3x TE1157 | 3x TE1157 | 3x TE1157 |
| Output coupler for cavity 4 | TE1123 | TE1105 | TE1196 |
| Arc detector | TE1107 | TE1107 | TE1107 |
| Magnet frame with coils | TE1108 | TE1108 | TE1108 |
| Tool set | TE1137 | TE1137 | TE1137 |

**B. Accessories to be ordered separately when replacing equivalent other brand types**

| | | | |
|---|---|---|---|
| Magnet flux ring | TE1138 | TE1138 | – |
| Spark gap | TE1140 | TE1140 | – |
| Set of connectors (heater, cathode, acc. electrode, getter-ion pump) | TE1146 | TE1146 | TE1146 |

| C. Spare and optional parts | YK1295 | YK1296 | YK1297 |
|---|---|---|---|
| Set of connectors (heater, cathode, acc. electrode, getter-ion pump) | TE1146 | TE1146 | TE1146 |
| Set of sealing rings | TE1147 | TE1147 | TE1147 |
| Water protection shield | TE1139 | TE1139 | TE1139 |
| Recommended circulators | | | |
| 470 to 600 MHz | 2722 162 01551 (T100/IV-N) | | |
| 600 to 800 MHz | 2722 162 01561 (T100/V-N) | | |
| 790 to 1000 MHz | 2722 162 03261 (T100/V-3-N) | | |

**LIMITING VALUES** (Absolute maximum rating system)

| | | | | |
|---|---|---|---|---|
| Heater voltage | max. | 9.5 | V | |
| Beam voltage | max. | 28 | kV | |
| Cold cathode voltage | max. | −30 | kV | |
| Beam current | max. | 7 | A | |
| Body current | max. | 150 | mA | |
| Accelerator electrode current | max. | 6 | mA | note 7 |
| Collector dissipation | max. | 150 | kW | |
| Load VSWR | max. | 1.5 | | |
| Temperature of tube envelope | max. | 175 | °C | |
| Static pressure in the cooling system | max. | 600 | kPa | (6 bar) note 6 |
| ABC-electrode voltage with respect to cathode | max. | −1.4 | kV | |

**PERFORMANCE DATA**

| of ABC-electrode | min. | typ. | max. | |
|---|---|---|---|---|
| Capacity | 80 | 90 | 100 | pF |
| D.C. current at −1000 V* | – | – | 1 | mA |

* The d.c. electrode current may rise up to max. 2 mA during life time. The applied modulator should be designed for an ABC-electrode current of at least 2 mA.

## TYPICAL OPERATING CONDITIONS

**As 55 kW/40 kW vision transmitter (standards: RTMA-M, RTMA-M* and CCIR-G)**

| | | | YK1295/YK1296 | | | YK1297 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Output power, peak sync. | | | 58 | 58 | 45 | 58 | 58 | 45 | kW | |
| Beam voltage | | | 22.5 | 26 | 22.5 | 23.5 | 27 | 25.5 | kV | |
| Beam current | | | 6.4 | 4.85 | 3.8 | 5.9 | 4.9 | 3.9 | A | note 8 |
| Accelerator to cathode voltage | | | ≈22.5 | ≈18.5 | ≈16 | ≈21 | ≈19 | ≈16 | kV | |
| Body current | | | | | | | | | | |
| without drive | | | 15 | 15 | 15 | 15 | 15 | 15 | mA | |
| at black level | | | 40 | 40 | 40 | 40 | 40 | 40 | mA | |
| Focusing coil current | | | 10.5 | 10.5 | 9.5 | 10.5 | 10.5 | 10 | A | |
| Drive power, peak sync. | | | | | | | | | | |
| Standard* | M | G | | | | | | | | |
| YK1295 - channel | 14 | 21 | 10 | 6 | 6 | – | – | – | W | note 9 |
| channel | 37 | 38 | 7 | 4 | 4 | – | – | – | W | note 9 |
| YK1296 - channel | 37 | 36 | 7 | 4 | 4 | – | – | – | W | note 9 |
| channel | 52 | 51 | 5 | 3 | 3 | – | – | – | W | note 9 |
| YK1297 | | | – | – | – | 2 | 2 | 2 | W | note 9 |
| Bandwidth at −1 dB points | | | 8 | 8 | 8 | 8 | 8 | 8 | MHz | note 10 |
| Differential gain | | | 75 | 70 | 70 | 70 | 70 | 70 | % | note 11 |
| Differential phase | | | 6 | 10 | 10 | 10 | 10 | 10 | deg | note 11 |
| Linearity | | | 65 | 60 | 60 | 60 | 60 | 60 | % | note 12 |
| Operating efficiency | | | 40 | 46 | 46.5 | 42 | 44 | 45 | % | |
| Saturation output power | | | 63 | 60 | 46.5 | 60 | 60 | 46.5 | kW | |
| Saturation efficiency | | | 44 | 47.5 | 48 | 43 | 45 | 46.5 | % | |
| **As 11 kW/8 kW FM sound transmitter** | | | | | | | | | | |
| Output power | | | 12 | 12 | 9 | 12 | 12 | 9 | kW | |
| Beam voltage | | | 22.5 | 26 | 25.5 | 23.5 | 27 | 25.5 | kV | |
| Beam current | | | 1.5 | 1.2 | 1.3 | 1.5 | 1.2 | 1.3 | A | |
| Accelerator cathode voltage | | | 8.5 | 7.5 | ≈8 | 8.5 | 7.5 | ≈8 | kV | note 13 |
| Focusing coil current | | | 9 | 9 | 9 | 9 | 9 | 9 | A | |
| Drive power | | | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | W | note 9 |
| Bandwidth at −1 dB points | | | 1 | 1 | 1 | 1 | 1 | 1 | MHz | |

* Standards: RTMA-M, RTMA-M* and CCIR-G.

**Notes**

1. When switching on the heater voltage, the heater current must never exceed a peak value of 65 A.
2. In case of a mains failure an interruption up to 30 s can be tolerated without new waiting time. After min. 10 minutes of stand-by heating time at 6 V (black heat), the beam current may be switched on; the heater voltage must be increased to its nominal value of 8.5 V simultaneously. Continuous black heat periods should not exceed two weeks and should be separated by similar periods of rest or full operation.
3. To ensure that the klystron is always ready for operation, operate the ion getter pump at least every 6 months (preferably every 3 months) during storage. For details see klystron instruction manual.
4. In order to avoid corrosion of the cooling system, coolant water must be pure and deionized (resistivity min. 100 kΩ·cm).
5. Correct operation of the tube can be guaranteed only if a set of accessories, approved by the tube manufacturer, is used. The operating tube generates X-rays which can penetrate the ceramic parts of the tube envelope. In order to reduce the radiation at any accessible points to an officially admissible, non-dangerous level the tube must be shielded and any possible radiation path must be blocked by at least 1 mm of brass or an equivalent portion of non-magnetic X-ray absorbing material. The proper use of our accessory parts will provide the necessary shielding.
6. Static pressure in the body-cooling system and in the water-cooling jacket TE1194.
7. The accelerator electrode voltage must not be positive with respect to the body (ground).
8. If the accelerator electrode is connected to the body (ground) via 10 kΩ resistor, the beam current is within ± 5% of the value given in the graph of Fig. 4.
9. The drive power is defined as the power delivered to a matched load.
10. Variation of the signal level between black and white at any sideband frequency may cause a reaction of the peak sync. level. Proper tube design limits this reaction to less than 0.5 dB.
11. Measured with a sawtooth signal from black level to peak white occuring at each line and superimposed colour subcarrier with a 10 % peak to peak amplitude.
12. Measured with a ten-step staircase signal from black level to peak with occuring at each line.
13. A voltage divider for adjusting the beam current should be dimensioned on the basis of an accelerator electrode current of max. 1.5 mA.

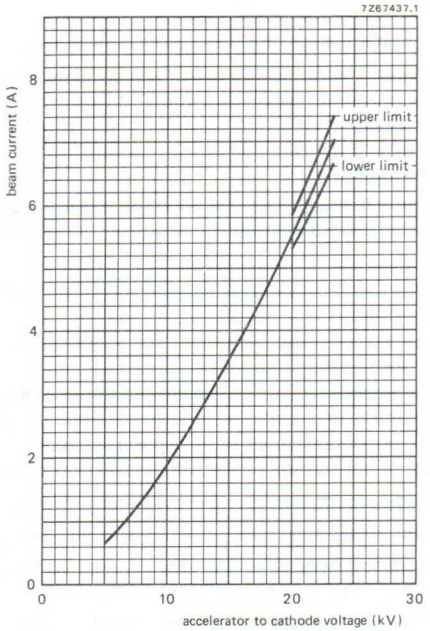



Fig. 4.

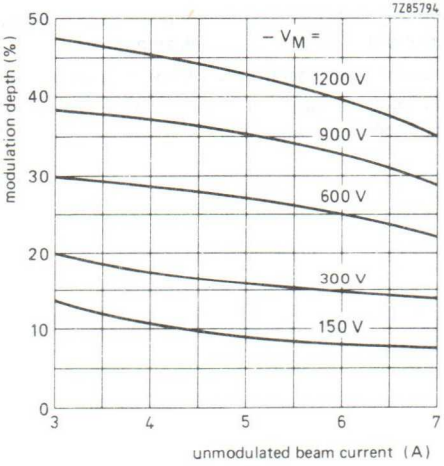



Fig. 5 ABC-operation.
Parameter: modulation voltage $-V_M$ (with respect to cathode).

# CONTINUOUS-WAVE HIGH-POWER KLYSTRONS

Water cooled, high efficiency, fixed frequency, continuous-wave high-power klystrons in metal-ceramic construction, for use in scientific and industrial applications. The tubes have internal cavities, solenoid focusing, beam control by accelerator anode and a high stability dispenser-type cathode.

## QUICK REFERENCE DATA

| | | |
|---|---|---|
| Centre frequency (fixed tuned) | 499.7 | MHz |
| Bandwidth at saturation (−1 dB points) | 2 | MHz |
| Output power | | |
| YK1300 | 500 to 600 | kW |
| YK1301 | 600 to 800 | kW |
| YK1305 | ⩽ 350 | kW |
| Cooling | water | |

This data must be read in conjunction with GENERAL OPERATIONAL RECOMMENDATIONS for KLYSTRONS.

**HEATING:** indirect by a.c. or d.c.

Cathode — dispenser type

| | | min. | typ. | max. | | |
|---|---|---|---|---|---|---|
| Heater voltage | $V_f$ | 22 | 25 | 27 | V | |
| Heater current | $I_f$ | 20 | 23 | 25 | A | notes 1, 2 |
| Cold heater resistance | $R_{fo}$ | – | 100 | – | mΩ | |
| Waiting time | $t_w$ | 15 | – | – | minutes | |
| **FOCUSING:** electromagnetic | | | | | | |
| Solenoid current | | 7 | 9 | 15 | A | |
| Solenoid voltage | | – | 140 | 220 | V | |
| Solenoid resistance | | – | 15 | – | Ω | |
| **GETTER-ION PUMP SUPPLY** | | | | | | |
| Operating voltage | | 3 | 3.3 | 4 | kV | |
| Operating current | | – | $10^{-3}$ | 80 | mA | |
| Internal resistance of power supply | | 25 | 300 | – | kΩ | |

## MECHANICAL DATA

Dimensions in mm

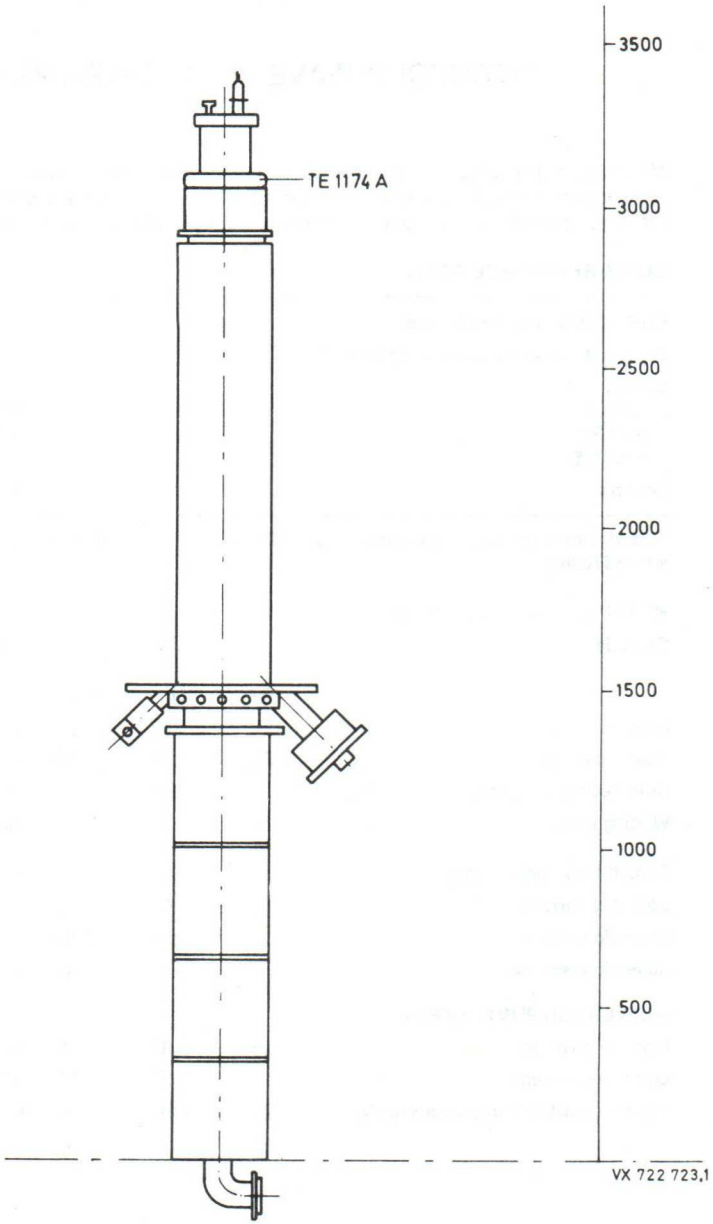



Fig. 1.

Tube mounted in the mounting frame with solenoid.

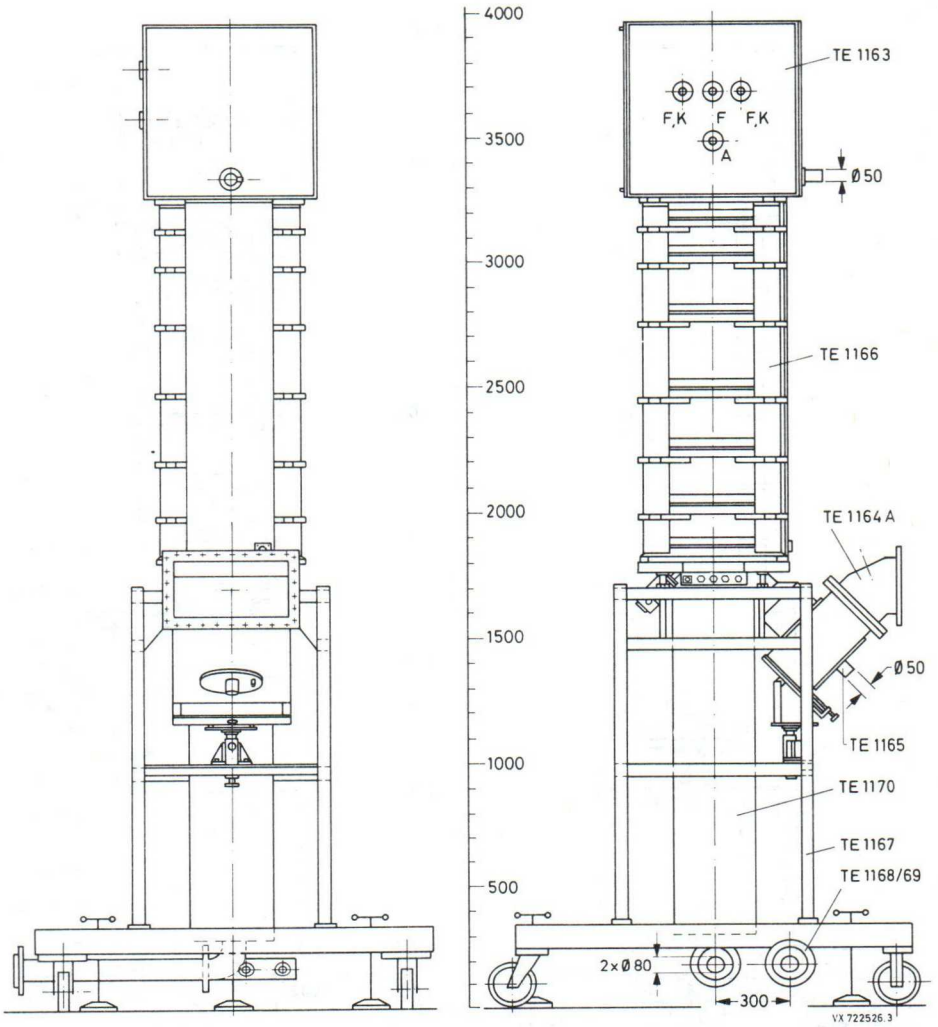



Fig. 2.

## MECHANICAL DATA (continued)

Tube mounted in the mounting frame with solenoid.
Dimensions in mm

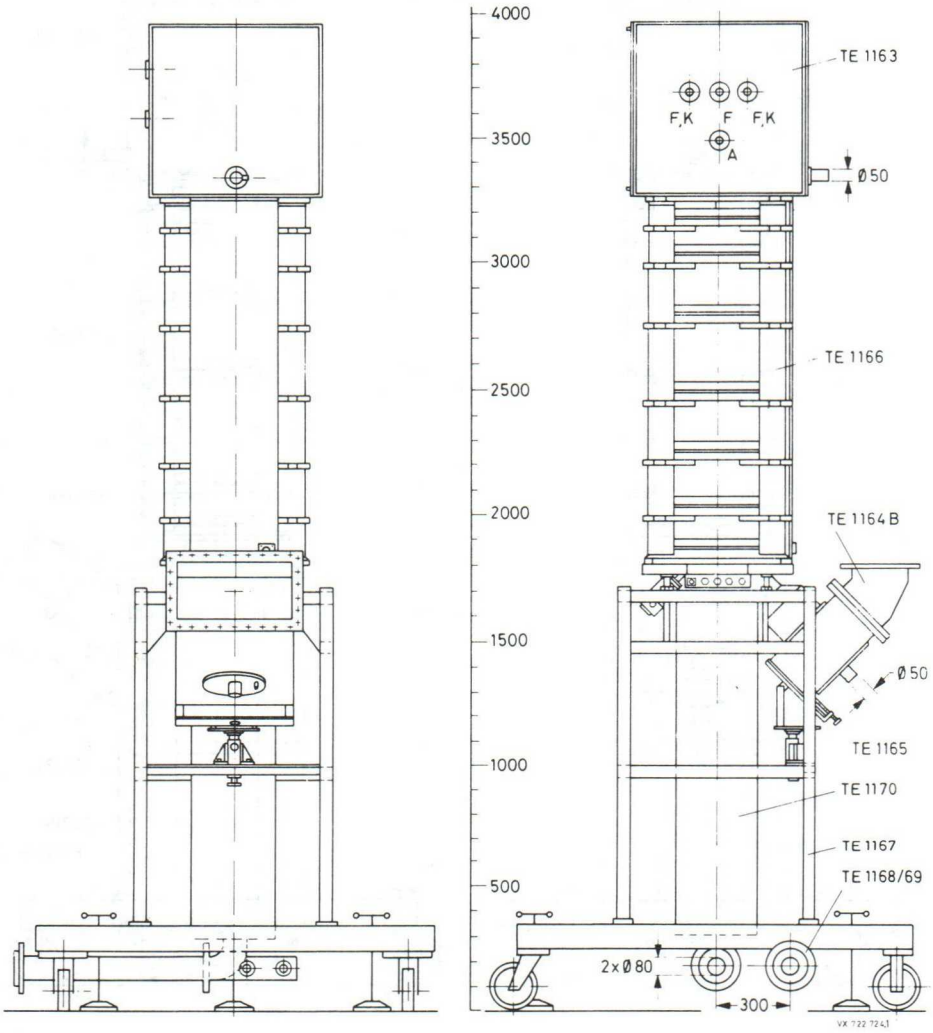



Fig. 3.

Drawing shows klystron and trolley without operational lead-shielding.

| COOLING | min. | typ. | max. | | |
|---|---|---|---|---|---|
| Collector | | | | | |
| demineralized or distilled water with 10% stabilized glycol added | | | | | |
| YK1300, YK1301 | 750 | 900 | 1000 | ℓ/min | note 3 |
| YK1305 | 200 | 500 | 700 | ℓ/min | note 3 |
| pressure drop | – | 200 | – | kPa | (= 2 bar) |
| Body circuit I | | | | | |
| demineralized or distilled water with 10% stabilized glycol added | 7 | 10 | – | ℓ/min | note 3 |
| pressure drop | – | 300 | – | kPa | (= 3 bar) |
| Body circuit II | | | | | |
| demineralized or distilled water with 10% stabilized glycol added | | | | | |
| YK1300, YK1301 | 20 | 25 | – | ℓ/min | |
| YK1305 | 15 | 18 | – | ℓ/min | note 3 |
| pressure drop | – | 300 | – | kPa | (= 3 bar) |
| Cathode socket and accelerator anode | | | | | |
| air | 2 | – | – | $m^3$/min | |
| pressure drop | – | – | 500 | Pa | (= 5 mbar) |
| Output window | | | | | |
| air | 0.6 | 1.2 | – | $m^3$/min | |
| pressure drop | – | 9 | – | kPa | (= 90 mbar) |
| Inlet water temperature | – | – | +50 | °C | |
| Inlet air temperature | – | – | +45 | °C | |

**MASS**

| | | | |
|---|---|---|---|
| Net mass YK1300, YK1301, YK1305 | 400 | kg | |
| Mounting frame with solenoid | | | |
| YK1300, YK1305 | 800 | kg | |
| YK1301 | 900 | kg | |
| Capability of hoist min. | 600 | kg | |

**DIMENSIONS**

| | |
|---|---|
| Tube and mounting frame | see drawings |
| Required ground clearance for lifting hoist | min. 580 cm |

**MOUNTING** vertical, cathode up

**R.F. CONNECTORS**

| | |
|---|---|
| Input | N-type, female |
| Output | waveguide R5 (WR1800)<br>mating flange UDR5 |

## ACCESSORIES

### A. Tube parts

| | | |
|---|---|---|
| Collector water cooling jacket | | note 4 |
| Waveguide coupling iris | | note 4 |
| Magnet for getter-ion pump (factory fitted) | | |

### B. Operational parts for first equipment

| | | |
|---|---|---|
| Coaxial/waveguide transition, WR1800 with 45° elbow | | |
| YK1300 | TE1164A | note 5 |
| YK1301, YK1305 | TE1164B | note 5 |
| Window cooling air inlet | TE1165 | |
| Accelerator anode ring (factory fitted) | TE1173 | |
| Cathode ring | TE1174A | |
| Corona protector | TE1174B | |
| H.V. connection unit with R3 sockets | | |
| YK1300 | TE1163A | note 6 |
| YK1301, YK1305 | TE1163B | note 6 |
| Klystron trolley with waveguide support | TE1167 | |
| Focusing coil unit | | |
| YK1300 | TE1166A | |
| YK1301, YK1305 | TE1166B | |
| Water outlet collecting tube | TE1168 | |
| Set of interconnecting water hoses | TE1169 | |
| Connection cables, | | |
| heater/cathode | 2x TE1171A | |
| heater | TE1171B | |
| accelerator anode | TE1171C | |

### C. Optional parts

| | | |
|---|---|---|
| H.V. socket R3 | 4x TE1158 | note 7 |
| H.V. cable with R3 plugs, | | |
| length 6 m | 4x TE1159 | note 7 |
| length 9 m | 4x TE1160 | note 7 |
| H.V. dummy plug R3 | 4x TE1161 | note 7 |
| Collector water cooling jacket | TE1170 | |

### D. Parts for handling

note 8

| | |
|---|---|
| Yoke for lifting TE1166 and TE1163 | TE1175 |
| Yoke for lifting and turning a klystron from any position | TE1176 |
| Supporting frame for storage and any movement of burnt-out or spare klystrons in any position other than vertical | TE1177 |
| Trolley for transportation of a klystron in horizontal position without lifting gear | TE1178 |

## LIMITING VALUES (Absolute maximum rating system)

| | | | | |
|---|---|---|---|---|
| Heater voltage<br>Heater current | } max. 10% above specified values | | | |
| Cathode voltage to body (ground) | max. | −65 | kV | |
| Cold cathode voltage to body (ground) | max. | −75 | kV | |
| Cathode current | max. | 18 | A | |
| Accelerator anode voltage to cathode | max. | 55 | kV | note 9 |
| Cold accelerator anode voltage to cathode | max. | 65 | kV | |
| Accelerator anode current | max. | 10 | mA | |
| Collector dissipation | max. | 850 | kW | note 10 |
| Dissipation body circuit I | max. | 10 | kW | |
| Dissipation body circuit II | max. | 15 | kW | |
| C.W. output power | max. | 630 | kW | |
| Load VSWR | max. | 1.2 | | note 12 |
| Temperature rise, window cooling air flow | max. | 30 | K | |

## TYPICAL OPERATING CONDITIONS

| **500 kW operation into matched load** | min. | typ. | max. | | |
|---|---|---|---|---|---|
| Cathode voltage to body (ground) | −60 | −62 | −63 | kV | |
| Cathode current | 4 | 14 | 15 | A | note 13 |
| Input power, d.c. | – | 867 | – | kW | |
| Accelerator anode voltage to cathode | 0 | 43 | – | kV | note 13 |
| Accelerator anode current | – | 1 | 5 | mA | |
| C.W. output power, VSWR ⩽ 1.1 | 500 | 520 | – | kW | |
| Collector dissipation | – | 347 | 850 | kW | note 10 |
| Efficiency | 58 | 60 | – | % | |
| C.W. drive power | – | 25 | 50 | W | |
| **600 kW operation into matched load** | | | | | |
| Cathode voltage to body (ground) | −62 | −64 | −65 | kV | |
| Cathode current | 4 | 15.9 | 16.5 | A | note 13 |
| Input power, d.c. | – | 1017 | – | kW | |
| Accelerator anode voltage to cathode | 0 | 47 | – | kV | note 13 |
| Accelerator anode current | – | 1 | 5 | mA | |
| C.W. output power, VSWR⩽ 1.1 | 600 | 610 | – | kW | |
| Collector dissipation | – | 407 | 850 | kW | note 10 |
| Efficiency | 57 | 60 | – | % | |
| C.W. drive power | – | 25 | 50 | W | |

**LIMITING VALUES** (Absolute maximum rating system)

| | | | | |
|---|---|---|---|---|
| Heater voltage<br>Heater current | } max. 10% above specified values | | | |
| Cathode voltage to body (ground) | max. | −77 | kV | |
| Cold cathode voltage to body (ground) | max. | −85 | kV | |
| Cathode current | max. | 18 | A | |
| Accelerator anode voltage to cathode | max. | 65 | kV | note 9 |
| Cold accelerator anode voltage to cathode | max. | 75 | kV | |
| Accelerator anode current | max. | 10 | mA | |
| Collector dissipation | max. | 850 | kW | note 10 |
| Dissipation body circuit I | max. | 10 | kW | |
| Dissipation body circuit II | max. | 15 | kW | |
| C.W. output power | max. | 820 | kW | |
| Load VSWR | max. | 1.2 | | note 12 |
| Temperature rise, window cooling air flow | max. | 30 | K | |

**TYPICAL OPERATING CONDITIONS**

| **800 kW operation into matched load** | min. | typ. | max. | | |
|---|---|---|---|---|---|
| Cathode voltage to body (ground) | −75 | −76 | −77 | kV | |
| Cathode current | 4 | 17 | 18 | A | note 13 |
| Input power, d.c. | – | 1300 | – | kW | |
| Accelerator anode voltage to cathode | 0 | 47 | 50 | kV | note 13 |
| Accelerator anode current | – | 2 | 5 | mA | |
| C.W. output power, VSWR $\leqslant$ 1.1 | 750 | 800 | 820 | kW | |
| Collector dissipation | – | 500 | 850 | kW | note 10 |
| Efficiency | 60 | 61 | – | % | |
| C.W. drive power | – | 40 | 70 | W | |

**LIMITING VALUES** (Absolute maximum rating system)

| | | | | |
|---|---|---|---|---|
| Heater voltage<br>Heater current | max. 10% above specified values | | | |
| Cathode voltage to body (ground) | max. | −50 | kV | |
| Cold cathode voltage to body (ground) | max. | −55 | kV | |
| Cathode current | max. | 15 | A | |
| Accelerator anode voltage to cathode | max. | 45 | kV | note 9 |
| Cold accelerator anode voltage to cathode | max. | 50 | kV | |
| Accelerator anode current | max. | 10 | mA | |
| Collector dissipation | max. | 400 | kW | note 10 |
| Dissipation body circuit I | max. | 6 | kW | |
| Dissipation body circuit II | max. | 10 | kW | |
| C.W. output power | max. | 370 | kW | |
| Load VSWR | max. | 1.2 | | note 12 |
| Temperature rise, window cooling air flow | max. | 30 | K | |

**TYPICAL OPERATING CONDITIONS**

| **350 kW operation into matched load** | min. | typ. | max. | | |
|---|---|---|---|---|---|
| Cathode voltage to body (ground) | −47 | −48 | −49 | kV | |
| Cathode current | 4 | 12 | 13 | A | note 13 |
| Input power, d.c. | – | 580 | 600 | kW | |
| Accelerator anode voltage to cathode | 0 | 36.5 | – | kV | note 13 |
| Accelerator anode current | – | 1 | 5 | mA | |
| C.W. output power, VSWR $\leqslant$ 1.1 | 315 | 330 | 370 | kW | |
| Collector dissipation | – | 230 | 400 | kW | note 10 |
| Efficiency | 55 | 58 | – | % | |
| C.W. drive power | – | 16 | 30 | W | |

## PERFORMANCE DATA

| | | | |
|---|---|---|---|
| Phase shift to cathode current | < | 20 | °/A |
| Phase shift to rel. cathode voltage | < | 20 | °/% |
| Phase shift to r.f. drive | < | 12 | °/dB |
| R.F. output to rel. cathode voltage | < | 0.3 | dB/% |
| Spurious noise amplitude | | | |
| for f < 300 Hz | ⩽ | 3 | % |
| for f = 300 to 1000 Hz | ⩽ | 1 | % |
| for f > 1000 Hz | ⩽ | 0.5 | % |

**Notes**

1. When switching on the heater voltage, the heater current must never exceed a peak value of 65 A.
2. Required values are given with each tube.
3. For further recommendations please contact the tube manufacturer.
4. Separately shipped together with each tube and to be returned together with each burnt-out tube.
5. It is recommended to return the coaxial/waveguide transition together with burnt-out tube for inspection.
6. R3 sockets are only usable together with optional accessories TE1159 and TE1160.
7. Cable with R3 plugs on each end, to be fed into the R3 sockets of the H.V. connection unit TE1163 and into R3 sockets TE1158 applied to the power supply. Dummy plugs are provided for cable termination on H.V. test of the cable set.
8. Parts are needed for all handling operations at the site and are to be ordered once for the site.
9. The accelerator anode voltage may never become positive with respect to the body (ground).
10. It must be observed that for operation with reduced r.f. drive the maximum value for collector dissipation is not exceeded.
11. For reflections exceeding this value please contact the tube manufacturer.
12. The klystron should not be operated with a cathode current below 4 A except for switching purposes.

## INSTALLATION AND OPERATION REQUIREMENTS

### A. Required interlocks

1. Fast switch-off of the drive power within 10 ms has to be done if the arc detector and/or r.f. reflection indicator is activated. An arc detector must be provided at the knee of the output waveguide.

2. A fast switch-off of the beam supply has to be provided when one of the following situations occurs:

   a) the beam current increases rapidly,

   b) the solenoid current deviates by more than ± 5% from the adjusted value.

   The switching sensors and the discharge facilities for the power supply must be designed so that a copper wire of 0.35 mm diameter, connected to the power supply instead of the klystron (length approx. 1 cm/kV), will not be destroyed, if the full operating voltage is switched on and applied to the wire.

3. The mains for the beam power supply has to be switched off within 100 ms when one of the following situations occur:

   a) the beam current either exceeds the limiting value or increases by more than 30% or max. 2 A above the adjusted value,

   b) the pump current exceeds 10 $\mu$A,

   c) the monitored temperature differences between inlet and outlet in the collector and/or body cooling circuits are too high;

   | | | |
   |---|---|---|
   | max. values permitted: | collector | $\Delta\theta$ = 15 K |
   | | body circuit I | $\Delta\theta$ = 15 K |
   | | body circuit II | $\Delta\theta$ = 15 K |

   d) the water flow of the collector and body cooling circuits decreases below the required minimum value,

   e) the air flow for the r.f. window and cathode cooling decreases below the required minimum value.

4. Switch-off the heater voltage for pump current $>$ 4 mA.

Restarting is not allowed within 10 s of any interruption.

### B. Switching-on and off sequence

Switching-on sequence

1. Cathode cooling on.
2. Getter-ion pump supply on.
3. Check that the pump current is $<$ 10 $\mu$A.
4. Heater voltage supply on.
5. Wait for preheating time (min. 15 minutes).
6. Cooling air r.f. window on.
7. Cooling body circuits I and II on.
8. Collector cooling supply on.
9. Solenoid current supply on.
10. Check that the heater current has reached the adjusted value ± 0.5 A.
11. R.F. drive on.
12. Beam supply on.

Switching-off sequence

1. Beam voltage supply off.
2. All other supplies and cooling circuits off.

**C. Radiation dangers**

*R.F. radiation*

R.F. power may be emitted not only through the normal output coupling but also through other apertures (for example, r.f. leaks). This r.f. power may be sufficiently intense to cause danger to the human body, particularly to the eyes. Such radiation may be increased if the tube is functioning incorrectly.

*X-radiation*

A highly dangerous intensity of X-rays may be emitted by tubes operating at voltages higher than approximately 5 kV. Adequate protection (X-ray shielding) for the operator is then necessary. The emission intensity of X-rays may correspond to a value of voltage much higher than that expected from the actual value applied to the tube.

Poor focusing may result in excessive X-radiation.

These tubes and accessories are equipped with a lead shielding which under normal conditions reduces the radiation values below 0.75 mR/h, measured at a distance of 1 m from the tube assembly.

# CONTINUOUS-WAVE HIGH-POWER KLYSTRON

Vapour cooled, high efficiency, fixed frequency, continuous-wave high-power klystrons in metal-ceramic construction, for use in scientific and industrial applications. The tubes have internal cavities, solenoid focusing, beam control by accelerator anode and a high stability dispenser-type cathode.

## QUICK REFERENCE DATA

| | | |
|---|---|---|
| Centre frequency (fixed tuned) | 508.6 | MHz |
| Bandwidth at saturation (−1 dB points) | 2 | MHz |
| Output power | 800 | kW |
| Cooling | vapour | |

This data must be read in conjunction with GENERAL OPERATIONAL RECOMMENDATIONS for KLYSTRONS.

**HEATING:** indirect by a.c. or d.c.

| Cathode | | dispenser type | | | | notes |
|---|---|---|---|---|---|---|
| | | min. | typ. | max. | | |
| Heater voltage | $V_f$ | 22 | 25 | 27 | V | |
| Heater current | $I_f$ | 20 | 23 | 25 | A | 1, 2 |
| Cold heater resistance | $R_{fo}$ | – | 100 | – | mΩ | |
| Waiting time | $t_w$ | 15 | – | – | minutes | |
| **FOCUSING:** electromagnetic | | | | | | |
| Main focusing section | | | | | | |
| Solenoid current | | – | 7 | 8 | A | 2, 3 |
| Solenoid voltage | | – | 500 | 600 | V | |
| Solenoid resistance | | – | 80 | – | Ω | |
| Prefocusing coil | | | | | | |
| Solenoid current | | – | 5 | 7 | A | 2, 3 |
| Solenoid voltage | | – | 30 | 40 | V | |
| Solenoid resistance | | – | 6 | – | Ω | |
| **GETTER-ION PUMP SUPPLY** | | | | | | |
| Operating voltage | | 3 | 3.3 | 4 | kV | |
| Operating current | | – | $\approx 10^{-3}$ | 80 | mA | |
| Internal resistance of power supply | | 25 | 300 | – | kΩ | |

## MECHANICAL DATA

Dimensions in mm

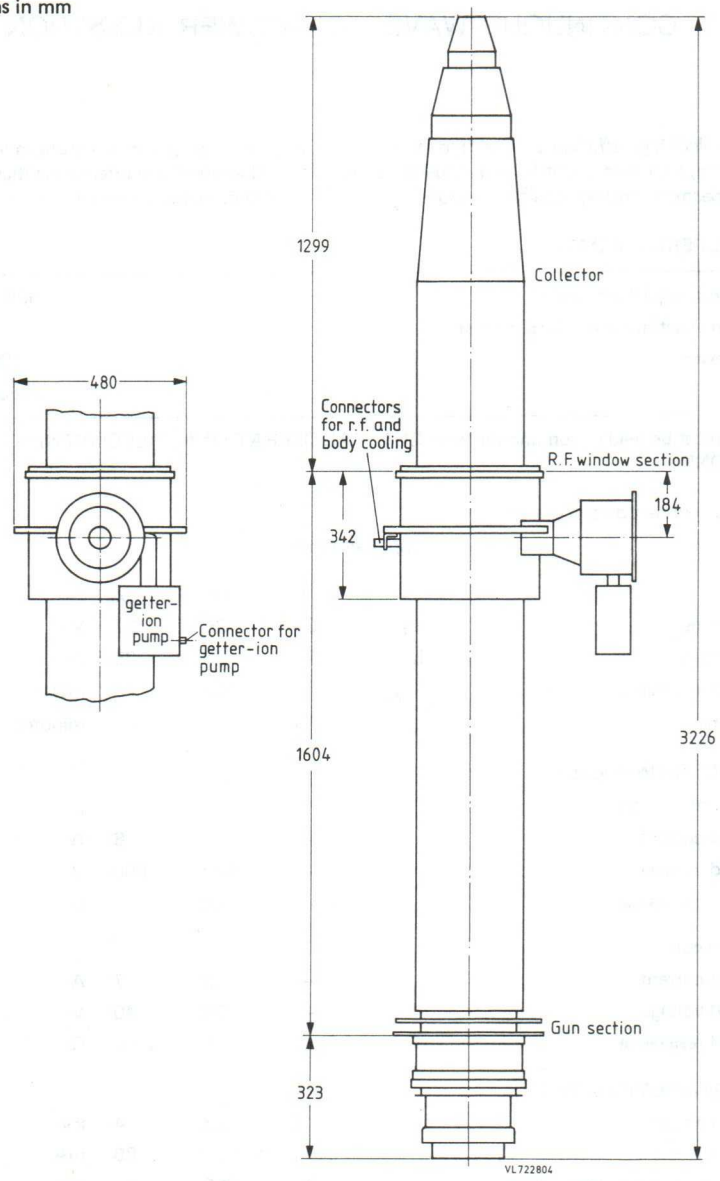



Fig. 1.

Tube mounted in the mounting frame with solenoid.

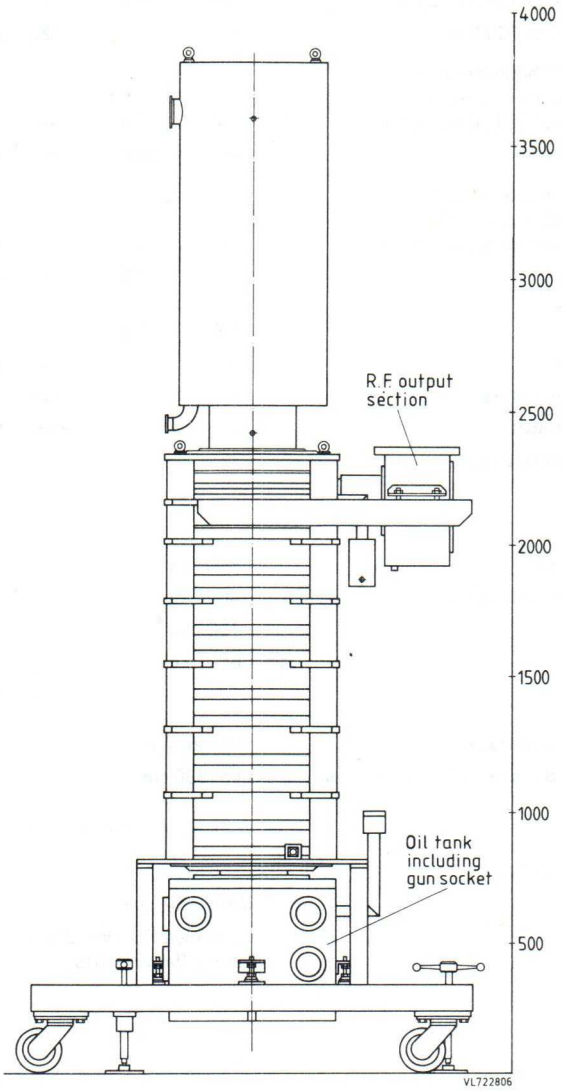



Fig. 2.

Drawing shows klystron and trolley without operational lead shielding.

| COOLING | min. | typ. | max. | | |
|---|---|---|---|---|---|
| Vapour cooling of collector | | | | | |
| demineralized or distilled water | 50 | 100 | – | ℓ/min | note 4, 5 |
| pressure drop at 100 ℓ/min | – | – | 20 | kPa | (= 200 mbar) |
| Water cooling of body circuit I | | | | | |
| demineralized or distilled water with 10% stabilized glycol added | 10 | 14 | – | ℓ/min | note 5 |
| pressure drop | – | 300 | – | kPa | (= 3 bar) |
| Water cooling of body circuit II | | | | | |
| demineralized or distilled water with 10% stabilized glycol added | 15 | 20 | – | ℓ/min | note 5 |
| pressure drop | – | 300 | – | kPa | (= 3 bar) |
| Output window | | | | | |
| air | 0.6 | 1.2 | – | $m^3$/min | |
| pressure drop | – | 9 | – | kPa | (= 90 mbar) |
| Inlet water temperature | – | – | +50 | °C | |
| Inlet air temperature | – | – | +45 | °C | |
| Cathode socket and accelerator anode under oil | | | | | |

| MASS | | | |
|---|---|---|---|
| Net mass YK1302 | | 500 | kg |
| Mounting frame with solenoid | | 1400 | kg |
| Boiler | | 150 | kg |
| Capability of hoist | min. | 600 | kg |

| DIMENSIONS | |
|---|---|
| Tube and mounting frame | see drawings |
| Required ground clearance for lifting hoist | min. 650 cm |

| MOUNTING | vertical, collector up |
|---|---|

| R.F. CONNECTORS | |
|---|---|
| Input | N-type, female |
| Output | waveguide R5 (WR1800)<br>mating flange UDR5 |

## ACCESSORIES

| | |
|---|---|
| Klystron trolley with waveguide support | TE1312 |
| Focusing coil unit | TE1322 |
| Oil tank | TE1332 |
| Coaxial/waveguide transition, WR1800 | TE1342A |
| Lead shielding | TE1362 |
| Trolley for transportation of a klystron in horizontal position without lifting gear | TE1372A |
| Supporting frame for storage and any movement of burnt-out or spare klystrons in any position other than vertical | TE1372B |
| Handling equipment | TE1382 |
| Boiler | TE1392 |

## LIMITING VALUES (Absolute maximum rating system)

| | | | | |
|---|---|---|---|---|
| Heater voltage<br>Heater current | { max. 10% above specified values | | | |
| Cathode voltage to body (ground) | max. | −85 | kV | |
| Cold cathode voltage to body (ground) | max. | −90 | kV | |
| Cathode current | max. | 20 | A | |
| Accelerator anode voltage to cathode | max. | 65 | kV | note 6 |
| Accelerator anode current | max. | 5 | mA | |
| Collector dissipation | | | | note 7 |
| output power > 200 kW | max. | 750 | kW | |
| output power < 200 kW | max. | 500 | kW | |
| Dissipation body circuit I | max. | 15 | kW | |
| Dissipation body circuit II | max. | 10 | kW | |
| C.W. output power | max. | 850 | kW | |
| Load VSWR | max. | 1.2 | | note 8 |
| Temperature rise, window cooling air flow | max. | 30 | K | |

## TYPICAL OPERATING CONDITIONS

| **800 kW operation into matched load** | min. | typ. | max. | | |
|---|---|---|---|---|---|
| Cathode voltage to body (ground) | −76 | −80 | – | kV | |
| Cathode current | – | 16.5 | – | A | note 9 |
| Input power, d.c. | – | 1322 | – | kW | |
| Accelerator anode voltage to cathode | – | 52 | – | kV | note 9 |
| Accelerator anode current | – | 1.5 | – | mA | |
| C.W. output power, VSWR ≤1.1 | – | 800 | – | kW | |
| Collector dissipation | – | 522 | – | kW | note 7 |
| Efficiency | 60 | 60.5 | – | % | |
| C.W. drive power | – | 60 | 80 | W | |

## PERFORMANCE DATA

| | | | |
|---|---|---|---|
| Harmonic content with respect to fundamental | | | |
| 2nd order | max. | −25 | dB |
| 3rd order | max. | −25 | dB |
| Spurious noise amplitude | | | |
| for f < 300 Hz | ≤ | 1 | % |
| for f = 300 to 1000 Hz | ≤ | 1 | % |
| for f > 1000 Hz | ≤ | 0.5 | % |

Notes

1. When switching on the heater voltage, the heater current must never exceed a peak value of 65 A.
2. Required values are given with each tube.
3. Further adjustment according to operating instructions.
4. Volume of water converted to steam: 27 $cm^3$/min per kW collector dissipation in 43 ℓ/min steam per kW collector dissipation.
5. For further recommendations please contact the tube manufacturer.
6. The accelerator anode voltage may never become positive with respect to the body (ground).
7. It must be observed that for operation with reduced r.f. drive the maximum value for collector dissipation is not exceeded.
8. For reflections exceeding this value please contact the tube manufacturer.
9. The klystron should not be operated with a cathode current below 4 A except for switching purposes.

## INSTALLATION AND OPERATION REQUIREMENTS

### A. Required interlocks

1. Fast switch-off of the drive power within 30 ms has to be done if the arc detector and/or r.f. reflection indicator is activated. An arc detector must be provided at the knee of the output wave guide.
2. A fast switch-off of the beam supply has to be provided when one of the following situations occurs:
   a) the beam current increases rapidly,
   b) the solenoid current deviates by more than ± 5% from the adjusted value.

   The switching sensors and the discharge facilities for the power supply must be designed so that a copper wire of 0.35 mm diameter, connected to the power supply instead of the klystron (length approx. 1 cm/kV), will not be destroyed, if the full operating voltage is switched on and applied to the wire.
3. The mains for the beam power supply has to be switched off within 100 ms when one of the following situations occur:
   a) the collector temperature monitor (with internal thermocouple) is activated ( $T$ = max. 150 $^{o}C$ ),
   b) the monitored temperature differences between inlet and outlet in the collector and/or body cooling circuits are too high:

      max. values permitted: body circuit I $\Delta\theta$ = 15 K
      body circuit II $\Delta\theta$ = 15 K
   c) the beam current either exceeds the limiting value or increases by more than 30% or max. 2 A above the adjusted value,
   d) the water flow of the body cooling circuits decreases below the required minimum value,
   e) the air flow for the r.f. window cooling decreases below the required minimum value,
   f) the thermocouple temperature at the inner conductor of the output window exceeds 90 $^{o}C$,
   g) the pump current exceeds 10 $\mu$A.

Restarting is not allowed within 10 s of any interruption.

### B. Switching-on and off sequence

Switching-on sequence

1. Getter-ion pump supply on.
2. Check that the pump current is $< 10\ \mu$A.
3. Heater voltage supply on.
4. Wait for preheating time (min. 15 minutes).
5. Cooling air r.f. window on.
6. Cooling body circuits I and II on.
7. Collector cooling supply on.
8. Solenoid current supply on.
9. Check that the heater current has reached the adjusted value ±0.5 A.
10. R.F. drive on.
11. Beam supply on.

Switching-off sequence

1. Beam voltage supply off.
2. All other supplies and cooling circuits off.

## C. Radiation dangers

*R.F. radiation*

R.F. power may be emitted not only through the normal output coupling but also through other apertures (for example, r.f. leaks). This r.f. power may be sufficiently intense to cause danger to the human body, particularly to the eyes. Such radiation may be increased if the tube is functioning incorrectly.

*X-radiation*

A highly dangerous intensity of X-rays may be emitted by tubes operating at voltages higher than approximately 5 kV. Adequate protection (X-ray shielding) for the operator is then necessary. The emission intensity of X-rays may correspond to a value of voltage much higher than that expected from the actual value applied to the tube.

Poor focusing may result in excessive X-radiation.

This tube and accessories are equipped with a lead shielding which under normal conditions reduces the radiation values below 1 mR/h, measured at a distance of 1 m from the tube assembly.

# CONTINUOUS-WAVE HIGH-POWER KLYSTRON

Water cooled, high efficiency, fixed frequency, continuous-wave high-power klystron in metal-ceramic construction, for use in scientific and industrial applications. The tube has internal cavities, solenoid focusing, beam control by modulation anode and a high stability dispenser-type cathode.

## QUICK REFERENCE DATA

| | | |
|---|---|---|
| Centre frequency (fixed tuned) | 352.21 | MHz |
| Bandwidth for 1dB drop in output power | ± 0.5 | MHz |
| Output power | 1 | MW |
| Cooling | water | |

This data must be in conjunction with GENERAL OPERATIONAL RECOMMENDATIONS for KLYSTRONS.

**HEATING:** indirect by a.c. or d.c.

Cathode: dispenser type

| | | min. | typ. | max. | |
|---|---|---|---|---|---|
| Heater voltage | $V_f$ | 22 | 25 | 27 | V |
| Heater current | $I_f$ | 20 | 23 | 25 | A |
| Cold heater resistance | $R_{fo}$ | – | 100 | – | mΩ |
| Waiting time | $t_w$ | 15 | – | – | minutes |

**FOCUSING:** electromagnetic

| | | | | | |
|---|---|---|---|---|---|
| Solenoid current | | 8 | 10 | 12 | A |
| Solenoid voltage | | – | 200 | 250 | V |
| Solenoid resistance | | – | 20 | – | Ω |

**GETTER-ION PUMP SUPPLY** *

| | | | | | |
|---|---|---|---|---|---|
| Operating voltage | | 3 | 3.3 | 4 | kV |
| Operating current | | – | $10^{-3}$ | 80 | mA |
| Internal resistance of power supply | | 25 | 300 | – | kΩ |

* The tube is equipped with two ion getter pumps which can be operated individually or in a parallel arrangement at one power supply.

## MECHANICAL DATA

Tube mounted in the mounting frame with solenoid.
Dimensions in mm

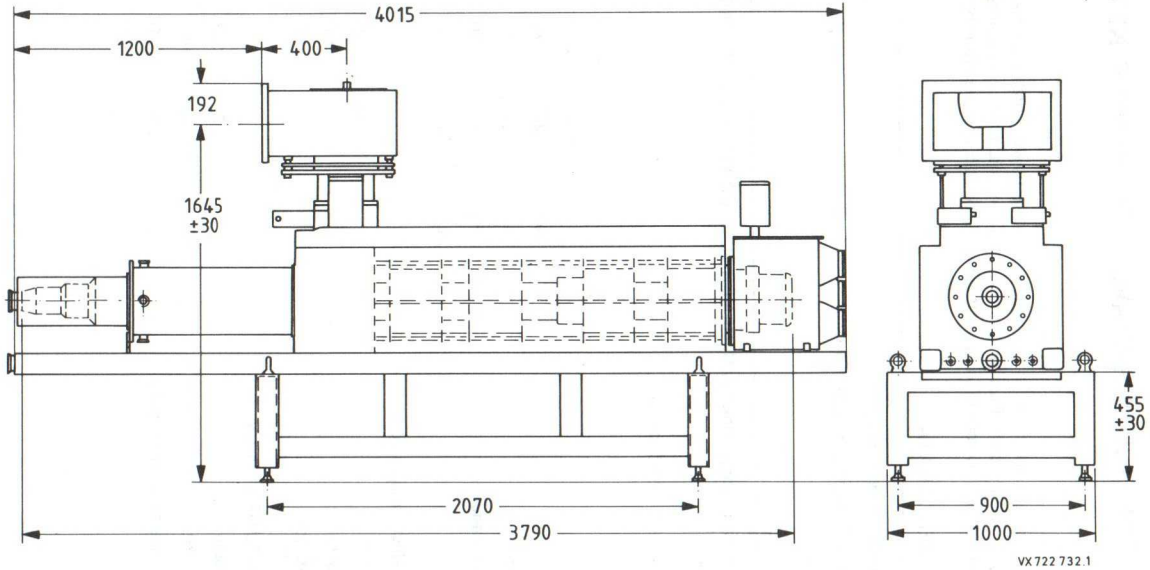



Fig. 1.

| COOLING | min. | typ. | max. | | |
|---|---|---|---|---|---|
| Cooling of collector and any body is achieved by filterd soft water. | | | | | |
| Pressure in any cooling water circuit | – | – | 700 | kPa | (=7 bar) |
| Pressure drop | – | – | 300 | kPa | (=3 bar) |
| Collector | | | | | |
| cooling water flow rate | 800 | 1000 | 1200 | ℓ/min | |
| inlet water temperature | – | +20 | +75 | °C | |
| outlet water temperature | – | +30 | +90 | °C | |
| Body circuit I | | | | | |
| cooling water flow rate | 15 | 20 | 25 | ℓ/min | |
| inlet water temperature | – | +20 | +40 | °C | |
| outlet water temperature | – | +40 | +60 | °C | |
| Body circuit II | | | | | |
| cooling water flow rate | 15 | 20 | 25 | ℓ/min | |
| inlet water temperature | – | +20 | +40 | °C | |
| outlet water temperature | – | +40 | +60 | °C | |
| Output window | | | | | |
| air | – | 1 | – | $m^3$/min | |
| pressure drop | – | 15 | – | kPa | (=150 mbar) |

**MASS**

Mass of complete assembly without demountable X-ray shield: max. 3000 kg

**DIMENSIONS** of complete assembly

| | |
|---|---|
| Length | approx. 4 kg |
| Height | approx. 1.9 m |
| Width | approx. 1 m |

**MOUNTING**: horizontal

**COOLING WATER CONNECTORS**

| | |
|---|---|
| Body circuits I and II | Walther series 0 - Type 4 (NW12) |
| Collector | Sandvik FCL-316L-76, 1-S-V |

**R.F. CONNECTORS**

| | |
|---|---|
| Input | female connector, 50 Ω, type N |
| Output | WR2300 waveguide |

## ACCESSORIES

| | |
|---|---|
| Transportation and operation frame | TE1351A |
| Focusing coil unit I | TE1351B |
| Focusing coil unit II | TE1351C |
| Coaxial/waveguide transition, WR2300 (R3) | TE1352 |
| Waveguide support | TE1353 |
| Collector cooling jacket I | TE1354A |
| Collector cooling jacket II | TE1354B |
| Cooling water collector | TE1355A |
| Interconnecting hoses | 2 x TE1355B |
| H.V. oil tank | TE1356 |
| Mounting rack | TE1359 |

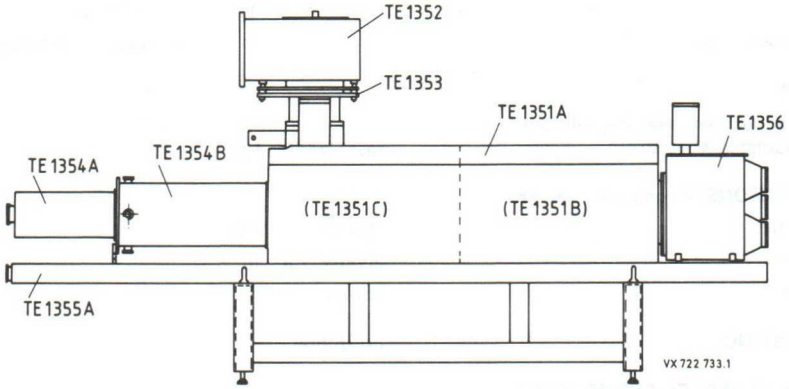



Fig. 2.

## LIMITING VALUES (Absolute maximum rating system)

| | | | |
|---|---|---|---|
| Heater voltage<br>Heater current | } max. 10% above specified values | | |
| Cathode voltage to body (ground) | max. | −95 | kV |
| Cathode current | max. | 25 | A |
| Modulation anode current | max. | 10 | mA |
| R.F. drive power | max. | 150 | W |
| C.W. output power | max. | 1.1 | MW |
| Load VSWR | max. | 1.3 | |
| Body dissipation | max. | 20 | kW |
| Collector dissipation | max. | 900 | kW * |

## TYPICAL OPERATING CONDITIONS

| **1 MW operation into matched load** | typ. | |
|---|---|---|
| Input power, d.c. | 1470 | kW |
| R.F. drive power | 90 | W |
| Collector dissipation | 460 | kW |
| Body dissipation | 10 | kW |
| C.W. output power | 1000 | kW |
| Efficiency | 68 | % |
| Beam voltage | 90 | kV |
| Beam current | 16.3 | A |

## PERFORMANCE DATA

| | | |
|---|---|---|
| Phase shift to cathode current | < 15 | °/A |
| Phase shift to rel. cathode voltage | < 15 | °/% |
| Phase shift to r.f. drive | < 10 | °/dB |
| R.F. output to rel. cathode voltage | <0.2 | dB/% |
| Signal-to-noise ratio at saturation | 60 | dB |
| Harmonic levels to fundamental at saturation | 30 | dB |
| Ratio of fundamental to other discrete frequencies within bandwidth at saturation | 70 | dB |

* 1600 kW for 1 s. can be tolerated with reduced drive.

## INSTALLATION AND OPERATION REQUIREMENTS

### A. Required interlocks

1. Fast switch-off of the drive power within 10 ms has to be done if the arc detector and/or r.f. reflection indicator is activated. An arc detector must be provided at the knee of the output waveguide.
2. A fast switch-off of the beam supply has to be provided when one of the following situations occurs:
   a) the beam current increases rapidly,
   b) the solenoid current deviates by more than ±5% from the adjusted value.

   The switching sensors and the discharge facilities for the power supply must be designed so that a copper wire of 0.35 mm diameter, connected to the power supply instead of the klystron (length approx. 1 cm/kV), will not be destroyed, if the full operating voltage is switched on and applied to the wire.
3. The mains for the beam power supply has to be switched off within 100 ms when one of the following situations occur:
   a) the beam current either exceeds the limiting value or increases by more than 30% or max. 2 A above the adjusted value,
   b) the pump current exceeds 10 $\mu$A.
   c) the monitored temperature differences between inlet and outlet in the collector and/or body cooling circuits are too high,
   d) the collector temperature monitor (with internal thermocouple) is activated (switch-off value adjustable between 30 and 60 K above the water inlet temperature),
   e) the water flow of the collector and body cooling circuits decreases below the required minimum value,
   f) the air flow for the r.f. window and cathode cooling decreases below the required minimum value.
4. Switch-off the heater voltage for pump current $>$ 4 mA.

Restarting is not allowed within 10 s after any interruption.

### B. Switching-on and off sequence

Switching-on sequence

1. Getter-ion pump supply on.
2. Check that the pump current is $<$ 10 $\mu$A.
3. Heater voltage supply on.
4. Wait for preheating time (min. 15 minutes).
5. Cooling air r.f. window on.
6. Cooling body circuits I and II on.
7. Collector cooling supply on.
8. Solenoid current supply on.
9. Check that the heater current has reached the adjusted value ± 0.5 A.
10. R. F. drive on.
11. Beam voltage supply on.

Switching-off sequence

1. Beam voltage supply off.
2. All other supplies and cooling circuits off.

## C. Radiation dangers

*R.F. radiation*

R.F. power may be emitted not only through the normal output coupling but also through other apertures (for example, r.f. leaks). This r.f. power may be sufficiently intense to cause danger to the human body, particularly to the eyes. Such radiation may be increased if the tube is functioning incorrectly.
The r.f. radiation 1 m from any part of the klystron at 1 MW output power is max. 0.1 $mW/cm^2$.

*X-radiation*

Due to the high accelerating voltage, the klystron generates a high level of X-rays which is reduced by the supplied shielding plates of the focus mount and the H.V. oil container. Nevertheless the complete assembly has to be shielded additionally during operation in order to reduce the radiation to a non-dangerous level. The tube manufacturer recommends a "lead garage", as shown in the drawing Fig. 3. Though the overall dimensions are not critical, it is essential, that any possible radiation path is blocked by at least 2 mm of lead sheets.

### LEAD GARAGE

Dimensions in mm

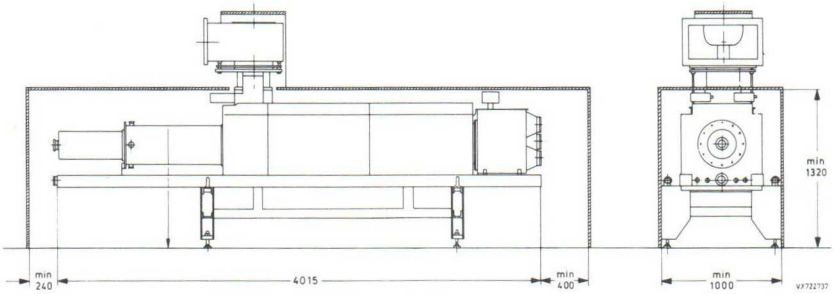



Fig. 3.

The "lead garage" will not be supplied by the tube manufacturer.

# PULSED POWER KLYSTRONS

Fixed frequency 20 MW pulsed power amplifier klystrons in metal-ceramic construction with 5 internal cavities, electromagnetic focusing, continuously operating getter-ion pump.
Coaxial input connector and S-band output waveguide fitted with a ceramic window.
Water cooling system for r.f. waveguide and window, collector and body.
Intended for use in long-range radar transmitters.

## QUICK REFERENCE DATA

| | | | | |
|---|---|---|---|---|
| Operating frequency | | | | |
| YK1510<br>YK1511<br>YK1512 | S-band, the klystrons are factory tuned to the specified frequency range | | | |
| R.F. output power* | | | | |
| peak | | > | 20 | MW |
| average | | > | 20 | KW |
| Duration of r.f. pulse (–3 dB down) | | | 4 | μs |
| Gain | | | 44 | dB |

This data must be read in conjunction with GENERAL OPERATIONAL RECOMMENDATIONS for KLYSTRONS.

**HEATING,** indirect by a.c. or d.c.

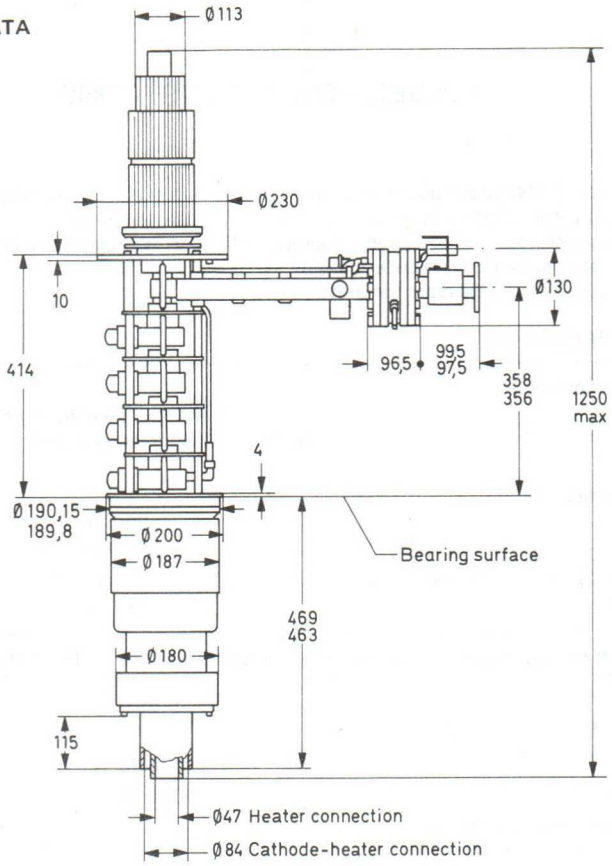
| | | | | |
|---|---|---|---|---|
| Heater voltage** | $V_F$ | | 15 to 30 | V |
| Heater current | $I_F$ | | 20 to 30 | A |
| Heater supply current at switch-on; the surge current must never exceed a peak value of 50 A. | | | | |
| Resistance of heater | | | | |
| cold | $R_{fo}$ | > | 0.125 | Ω |
| hot | $r_f$ | | 0.9 to 1.1 | Ω |
| Waiting time | $t_w$ | min. | 12 | min |

* At least one point in the band.

** The exact value is marked on each tube test report. During operation the heater voltage may not fluctuate more than ±5 %.

## MECHANICAL DATA

Dimensions in mm



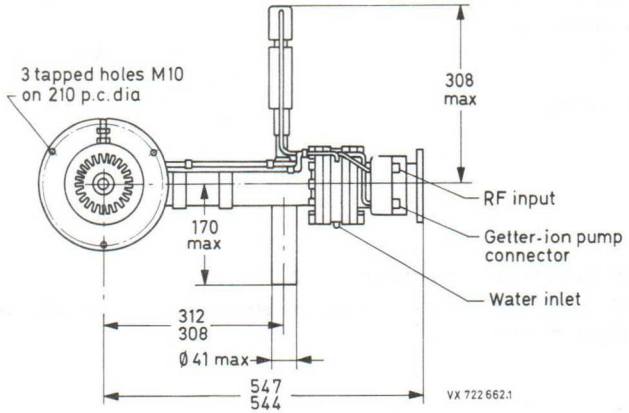




Fig. 1.

| | | | |
|---|---|---|---|
| **MASS** (net) | approx. | 70 | kg |

**MOUNTING**

Mounting position: vertical with collector up

**GETTER-ION PUMP POWER SUPPLY**

| | | | |
|---|---|---|---|
| Pump voltage | | 4.5 to 5.5 | kV |
| Supply current | | | |
| tube operating | max. | 50 | μA |
| tube turned off | max. | 200 | mA |

**ELECTROMAGNET**

| | | | |
|---|---|---|---|
| Current $I_1$, $I_2$, $I_3$ | max. | 175 | A |
| Impedance of each coil (20 °C) | | 0.08 | Ω |

**COOLING**

| | min. | max. | | |
|---|---|---|---|---|
| Collector, body and window* | | | | |
| Cooling-water inlet temperature | – | 60 | °C | |
| Cooling-water flow | 10 | – | ℓ/min | |
| Cooling-water inlet pressure | – | 1000 | kPa | (= 10 bar) |
| Cooling-circuit pressure drop | – | 600 | kPa | (= 6 bar) |
| Electromagnet | min. | max. | | |
| Water flow | 13 | – | ℓ/min | |
| Water inlet pressure | – | 1000 | kPa | (= 10 bar) |
| Water inlet temperature | – | 60 | °C | |

* By means of a single water circuit.

**LIMITING VALUES** (Absolute maximum rating system)

| | | | | |
|---|---|---|---|---|
| Beam voltage, peak | max. | 270 | kV | |
| Beam current, peak | max. | 275 | A | |
| R.F. input power | | | | |
| peak | max. | 5 | kW | |
| average | max. | 10 | W | |
| R.F. output power | | | | |
| peak | max. | 23 | MW | |
| average | max. | 23 | kW | |
| Load VSWR | max. | 1.4 | | |
| Collector dissipation | max. | 80 | kW | |
| Voltage pulse duration (measured at 70 %) | max. | 6 | μs | |
| Duty factor | max. | 0.003 | | |
| Pressure on the output window | max. | 1300 | kPa | (= 13 bar) |
| | min. | 1100 | kPa | (= 11 bar) |

**PRODUCT SAFETY**

*1. X-radiation*

Correct operation of the tube can be guaranteed only if a set of accessories, approved by the tube manufacturer, is used.

The operating tube generates X-rays which can penetrate the ceramic parts of the tube envelope. In order to reduce the radiation at any accessible points to an officially acceptable, non-dangerous level the tube must be shielded and any possible radiation path blocked by at least 1 mm of brass or an equivalent depth of non-magnetic X-ray absorbing material. The proper use of our acessories will provide the necessary shielding.

*2. R.F. radiation*

R.F. power may be emitted through apertures other than the normal output coupling (for example r.f. leaks). This r.f. power may be sufficiently intense to cause danger to the human body, particularly to the eyes. Such radiation may be increased if the tube is functioning incorrectly.

## TYPICAL OPERATING CONDITIONS

Measured under matched load conditions (VSWR ⩽ 1.1)

| | | | | | |
|---|---|---|---|---|---|
| Operating frequency* | | | | S-Band | |
| Bandwidth (−1 dB) | | | | 100 | MHz |
| Beam voltage | | | | 240 | kV |
| Beam current | | | | 254 | A |
| R.F. input power, peak | | | | 1 | kW |
| Operating mode | A | B | C | | |
| Output power | | | | | |
| peak | 20 | 10 | 10 | | MW |
| average | 20 | 20 | 10 | | kW |
| R.F. pulse duration (−3 dB) | 4 | 4 | 4 | | μs |
| Pulse repetition rate | 250 | 500 | 250 | | Hz |
| Duty factor | 0.001 | 0.002 | 0.001 | | |
| Gain | | | | 44 | dB |
| Efficiency | | | | > 30 | % |
| Perveance | | | | 2.0 to 2.3 | $\mu A \cdot V^{-3/2}$ |

* The tube is tuned to a fixed frequency at the factory.

# PULSED POWER KLYSTRON

Fixed frequency, pulsed power klystron in metal-ceramic construction for S-band with 5 internal cavities, electromagnetic focusing, continuously operating getter-ion pump.
Coaxial input connector and r.f. output split into two parallel waveguide arms with two r.f. ceramic windows.
Water cooling systems for r.f. windows, collector and body.
Intended for use for linear particle accelerator applications.

## QUICK REFERENCE DATA

| | | | | |
|---|---|---|---|---|
| Frequency (fixed tuned) | f | | 2998.5 | MHz |
| R.F. pulse width (at −3 dB) | | | 4.5 | μs |
| R.F. output power | | | | |
| peak | $W_{op}$ | ⩾ | 35 | MW |
| average | $W_o$ | ⩾ | 15.75 | kW |
| Gain | G | ⩾ | 52 | dB |
| Efficiency | $\eta$ | ⩾ | 45 | % |

This data must be read in conjunction with GENERAL OPERATIONAL RECOMMENDATIONS for KLYSTRONS.

**HEATING:** indirect by a.c.

| Cathode | | long life oxide type | | | |
|---|---|---|---|---|---|
| | | min. | typ. | max. | |
| Heater voltage * | $V_f$ | 17 | 20 | 25 | V |
| Heater current | $I_f$ | 18 | 21 | 24 | A |
| Cold heater resistance (20 °C) | $R_{fo}$ | – | 125 | – | mΩ |
| Waiting time | $t_w$ | 15 | – | – | minutes |

**GETTER-ION PUMP SUPPLY**

| | | | | | |
|---|---|---|---|---|---|
| Pump voltage | | – | – | 5 | kV |

* The actual value is marked on each tube test report.

## MECHANICAL DATA

Dimensions in mm

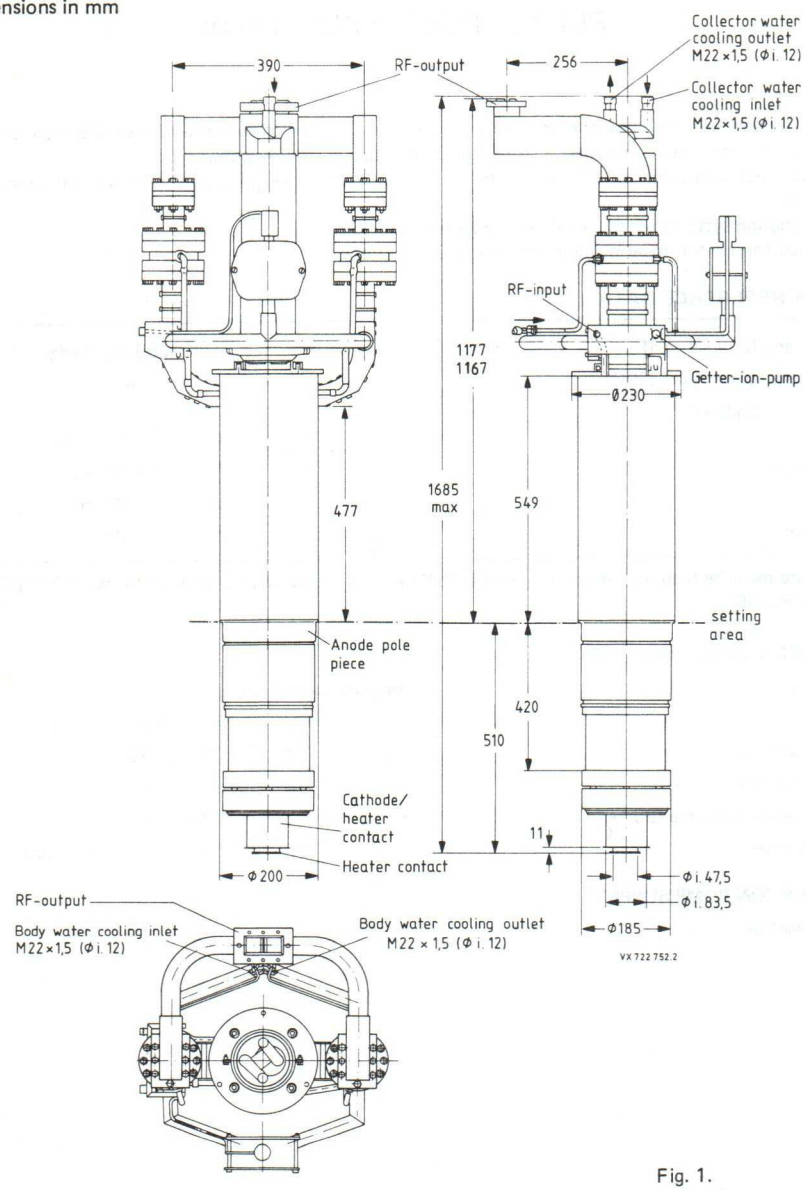



Fig. 1.

| COOLING | min. | typ. | max. | |
|---|---|---|---|---|
| Collector | | | | |
| demineralized or distilled water with 10% stabilized glycol added | – | 60 | – | ℓ/min |
| pressure drop | – | 70 | – | kPa (= 0.7 bar) |
| Body circuit | | | | |
| demineralized or distilled water with 10% stabilized glycol added | – | 10 | – | ℓ/min |
| pressure drop | – | 170 | – | kPa (= 1.7 bar) |
| Focusing coils | | | | |
| demineralized or distilled water with 10 % stabilized glycol added | – | 100 | – | kPa (= 1 bar) |

| MASS | |
|---|---|
| Net mass YK1600, incl. combiner | 120 kg |
| Magnet trolley | 450 kg |
| X-ray shield collector | 170 kg |
| X-ray shield body | 300 kg |

| DIMENSIONS | |
|---|---|
| Tube and mounting frame | see drawing |
| **MOUNTING** | vertical, cathode down |
| **R.F. CONNECTORS** | |
| Input | N-type, female |
| Output | waveguide, LIL-Flange V.W. 31 1240–2 |
| **CONNECTOR GETTER-ION PUMP** | HN-type, female |

| ACCESSORIES | |
|---|---|
| R.F. power combiner | TE1610 |
| Focusing magnet | TE1612 |
| Counter coil | TE1613 |
| X-ray shield for body | TE1620 |
| X-ray shield for collector | TE1621 |
| Transport trolley klystron | TE1630 |
| Lifting yoke for klystron | TE1631 |
| Lifting device for collector shield | TE1632 |
| Lifting device for magnet | TE1633 |
| Magnet trolley | TE1634 |

**LIMITING VALUES** (Absolute maximum rating system)

| | | | |
|---|---|---|---|
| Heater voltage | max. | 25 | V |
| Heater current | max. | 24 | A |
| Cathode voltage, peak | max. | 300 | kV |
| Cathode current, peak | max. | 300 | A |
| Collector dissipation | max. | 80 | kW |
| R.F. drive power | | | |
| peak | max. | 1000 | W |
| average | max. | 10 | W |
| R.F. pulse width | max. | 6 | μs |
| H.V. pulse width | max. | 7 | μs |
| Load VSWR | | | |
| for normal operation | max. | 1.15 | |
| permissable value * | max. | 1.5 | |
| Pressure on r.f. output windows $SF_6$ | max. | 550 | kPa (5.5 bar) |

* Without destruction of the tube.

## TYPICAL OPERATING CONDITIONS

| | | | |
|---|---|---|---|
| Frequency | | 2998.5 | MHz |
| Heater current | | 21 | A |
| Heater power | | 420 | W |
| Preheating time cathode | | 15 | minutes |
| Supply voltage of getter-ion pump | | 5 | kV |
| Load VSWR | ⩽ | 1.04 | |
| Cathode voltage, peak | | 270 | kV |
| Cathode current peak | | 280 | A |
| Bandwidth (−1dB) | ⩾ | 10 | MHz |
| Perveance | | 2 | $\mu A/V^{3/2}$ |
| R.F. drive power, peak | | 175 | W |
| R.F. pulse width at −3 dB | | 4.5 | $\mu s$ |
| Pulse repetition rate | | 100 | Hz |
| Pressure on r.f. output windows $SF_6$ | | 550 | kPa (5.5 bar) |
| R.F. output power | | | |
| peak | | 35 | MW |
| average | | 15.75 | kW |
| Gain | | 53 | dB |
| Efficiency | ⩾ | 45 | % |
| Dissipation on klystron body | ⩽ | 2 | kW |

DEVELOPMENT DATA

## PRODUCT SAFETY

*R.F. radiation*

R.F. power may be emitted not only through the normal output coupling but also through other apertures (for example, r.f. leaks). This r.f. power may be sufficiently intense to cause danger to the human body, particularly to the eyes. Such radiation may be increased if the tube is functioning incorrectly.

*X-radiation*

A highly dangerous intensity of X-rays may be emitted by tubes operating at voltages higher than approximately 5 kV. Adequate protection (X-ray shielding) for the operator is then necessary. The emission intensity of X-rays may correspond to a value of voltage much higher than that expected from the actual value applied to the tube.

Poor focusing may result in excessive X-radiation.

This tube and accessories are equipped with a lead shielding which under normal conditions reduces the radiation values below 2.5 mR/h, measured at a distance of 0.4 m from the tube assembly.

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