Mullard

technical handbook

Book 2

Valves and tubes

Part 4c

Klystrons, TWTs and microwave diodes

For microwave solid-state devices, please refer to Book 1 part 5

1983

KLYSTRONS, TWTs AND MICROWAVE DIODES

CONTENTS

Book 2 Part 4c

Valves and tubes

Klystrons, TWTs and microwave diodes

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The Mullard technical handbook system...

The Mullard Technical Handbook is made up of four sets of Books, each comprising several parts:-

Book 1 (light blue)	Semiconductor Devices
Book 2 (orange)	Valves and Tubes
Book 3 (green)	Components, Materials and Assemblies
Book 4 (purple or dark blue)	Integrated Circuits

Book 2, Valves and Tubes, comprises the following parts:-

Part 1a	Picture tubes and components
Part 1b	Cathode-ray tubes
Part 2a	Camera tubes and image intensifiers
Part 2b	Geiger-Muller tubes
Part 3	Photomultipliers, phototubes and channel electron multipliers
Part 4a	Tubes for r.f. heating
Part 4b	Transmitting tubes for communications
Part 4c	Klystrons, TWTs and microwave diodes
Part 4d	Magnetrons

......a comprehensive data library

Most of the devices for which full data is given in these books are those around which we would recommend equipment to be designed. Where appropriate, other types no longer recommended for new equipment designs but generally available for equipment production, are listed separately. Data sheets for these types may be obtained on request. Older devices for which data may be obtained on request are also included in the index of the appropriate part of each book.

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The data contained in these books is as accurate and up to date as possible at the time of going to press. It must be understood, however, that no guarantee can be given on the availability of the various devices, or that their specifications may not be changed before the next edition is published.

Each part is reviewed regularly, and revised and re-issued where necessary. Revisions to previous data are indicated by an arrow in the margin.

Requests for copies of Quick Reference Guides and individual data sheets (please quote the type number) should be sent to:-

Technical Publications Department, Mullard Limited, New Road, Mitcham, Surrey CR4 4XY. Telex 22194.

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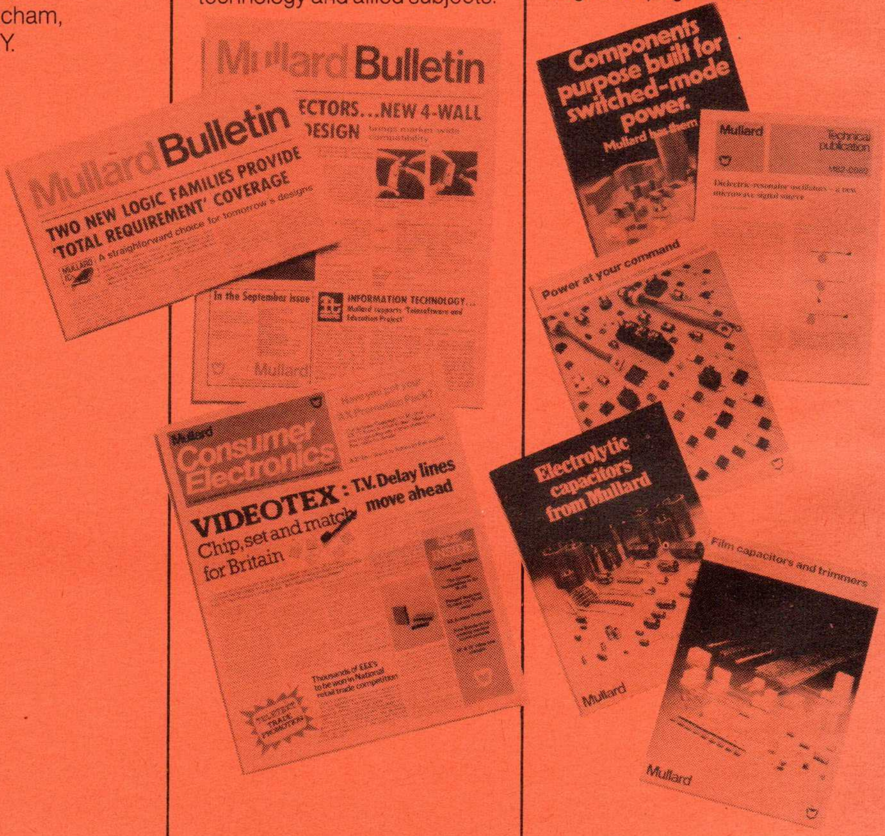
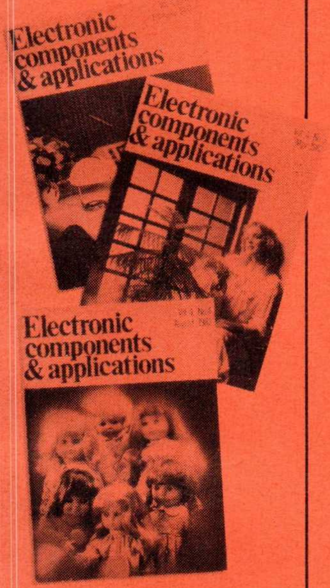
The Mullard data base begins on page 556201.



Electronic Components and Applications

A quarterly technical journal covering, in depth, developments in electronics based on the work of Philips, Signetics and Mullard laboratories. Please ask for a sample copy and subscription form.



Quick reference guides

All products marketed by Mullard are listed alpha-numerically and described briefly in these guides. Part 1 covers passive components, discrete semiconductors, and valves and tubes; Part 2 deals with integrated circuits, including Signetics.

Technical Data Service

This service provides detailed, up-to-date information on the characteristics and performance of Mullard components.

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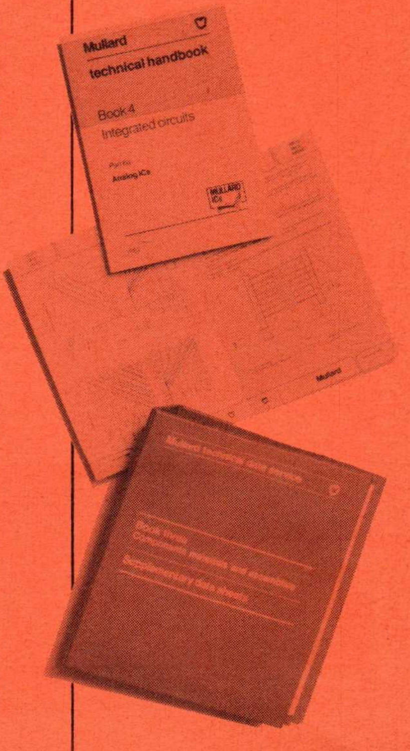
For those not wishing to subscribe to the Data Service, handbook parts can be purchased individually.

Individual data sheets are available free-of-charge, and can be obtained by quoting the type number.



General safety recommendations

ELECTRONIC TUBES AND ASSOCIATED DEVICES

1. GENERAL

When properly used and handled, electronic tubes and associated devices do not constitute a risk to health or to the environment.
However, certain hazards may arise and it is important that the following recommendations are observed. Care should be taken to ensure that all personnel who may handle, use or dispose of these products are aware of the necessary safety precautions.
Individual product data sheets will indicate if any of the specific hazards given in sections 2 to 9 are likely to be present.

1.1 Breakage

If the tube is broken or otherwise damaged, precautions must be taken against the following hazards which may arise:

- Broken glass or ceramics (see section 4). Protective clothing such as gloves should be worn.
- Contamination by toxic materials and vapours. In particular skin contact and inhalation should be avoided,

1.2 Disposal

These products should be disposed of in accordance with relevant legislation; in the UK the 'Control of Pollution Act 1974' applies. Most electronic tubes contain toxic materials, therefore, particularly when disposing of large quantities, the advice of the manufacturers' service department should be sought.

1.3 Fire

Electronic tubes themselves do not present a fire hazard.
However, since most packaging materials are flammable, care should be taken in the disposal of such materials; some of which will emit toxic fumes if burned.
If packaged tubes are involved in a fire, implosion may occur (see section 7), together with the consequent release of toxic vapours and materials.

2. X-RADIATION

All high voltage electronic tubes produce progressively more dangerous X-rays as the operating voltage is increased. The tube envelope usually provides limited protection; however further shielding may be required in the equipment if the voltage exceeds 10 kV. Should such shielding be required to reduce the X-ray dose rate to below the permitted limit of 0.5 mr/h, this will be indicated on the individual data sheets.
Under some equipment fault conditions the X-ray hazard may be considerably increased.
This hazard may be present only when the tube is energized.

3. RADIO FREQUENCY (R.F.) AND MICROWAVE RADIATION

Exposure to r.f. fields may be a hazard even at relatively low frequencies. Absorbtion of r.f. energy by the human body is dependent on frequency. Although at frequencies below 30 MHz most energy passes straight through the body with little heating effect it may still represent a hazard. At microwave frequencies a power density above 10 mW/sq cm may comprise a definite hazard, particularly to the eyes.

3. RADIO FREQUENCY (R.F.) AND MICROWAVE RADIATION (Continued)

For this reason care should be exercised when using r.f. and microwave tubes. All r.f. connectors and cavities must be correctly fitted before operation so that no leakage of energy may occur and the r.f. energy must be coupled efficiently to the load. It is particularly dangerous to look into open waveguide, coaxial feeders or transmitter antennae while the tube is energized.
Power klystrons must not be operated without a suitable load at the output and at any intermediate cavities.
Screening of terminal insulators on some high power tubes may be necessary.
This hazard may be present only when the tube is energized.

4. BERYLLIUM OXIDE CERAMICS

The insulators of some microwave power tubes are made of beryllium oxide. Beryllium oxide dust is toxic if inhaled or if particles enter a cut or an abrasion. Avoid handling beryllium oxide ceramics; if they are touched the hands must be thoroughly washed with soap and water. Do nothing to beryllium oxide ceramics which may produce dust or fumes.
All tubes containing beryllium oxide are marked as such. Care should be taken upon eventual disposal that they are not thrown out with general industrial waste. Devices requiring disposal may be handled by the manufacturer's service department. Users seeking disposal of tubes incorporating beryllium oxide ceramics should first take advice from the manufacturer's service department.
This hazard is present at all times from receipt to disposal of tubes.

5. CADMIUM COMPOUNDS

Cadmium compounds are toxic. In the event of accidental breakage, cadmium dust may be released. Gloves should be worn and the dust should be mopped up with a damp cloth. On disposal the cloth should be sealed in a plastic bag and the hands thoroughly washed with soap and water.
Controlled disposal of tubes containing cadmium compounds should be conducted in the open air or in a well ventilated area.
Inhalation of cadmium dust must be avoided.
This hazard is present, if breakage occurs, at all times from receipt to disposal of tubes.

6. MERCURY

Mercury is a toxic substance, especially in the vapour phase. Should breakage occur, gloves should be worn and all droplets brushed up as soon as possible and placed in an airtight container for disposal. Afterwards the hands must be thoroughly washed with soap and water. Direct contact with the skin should be avoided.
This hazard is present, if breakage occurs, at all times from receipt to disposal of tubes.

7 IMPLOSION - HANDLING OF CATHODE RAY TUBES

All vacuum tubes store potential energy by virtue of their vacuum. The energy level is low in small tubes but represents a hazard in the larger sizes of cathode ray tubes.
Some modern tubes are provided with integral implosion protection which conforms to IEC65, clause 18. With these tubes, no additional protection is needed. For those tubes without integral implosion protection, precautions taken during manufacture reduce the possibility of spontaneous implosion to a minimum. However, additional stresses due to mishandling may considerably increase the risk of implosion. Implosions may occur immediately or may be delayed.
The strength of the glass envelope will inevitably be impaired by surface damage, such as scratches or bruises (localized surface cracks caused by impact). When a tube is not in its equipment or original packing, it should be placed faceplate downwards on a pad of suitable ribbed material which is kept free from abrasive substances.
Under no circumstances should any attempt be made to remove the bonded faceplate or integral implosion protection band when fitted to the cathode ray tubes.

Stresses on the neck of the tube must be avoided. Handle by the recommended methods illustrated for those cathode ray tubes which have relatively small necks with large envelopes.

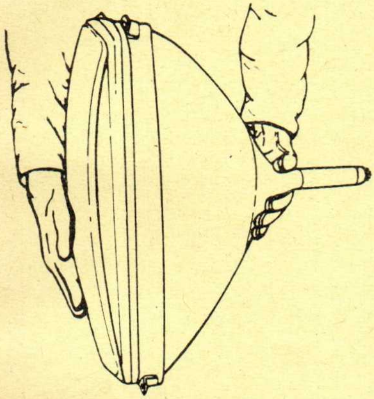


Fig.1 – Lifting cathode ray tube from edge-down position.

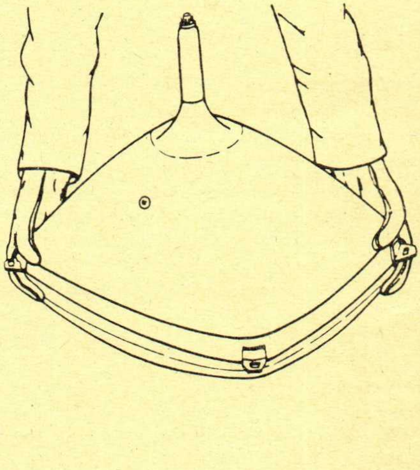


Fig.2 – Lifting cathode ray tube from face-down position.

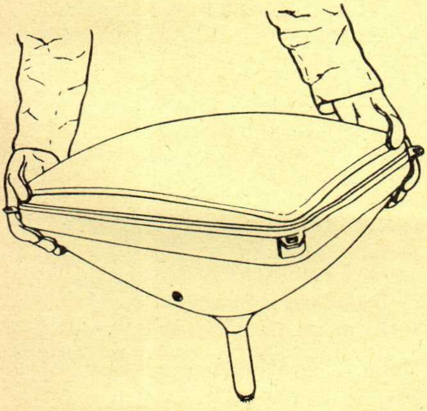


Fig.3 – Lifting cathode ray tube from face-up position.

Tube on one edge

To lift a tube from the edge-down position, one hand should be placed around the parabola section of the cone and the other hand should be placed near (slightly below) the centre of the faceplate as shown in Fig.1 **UNDER NO CIRCUMSTANCES SHOULD ANY FORCE BE APPLIED TO THE NECK OF THE TUBE.**

Tube face-down

To lift a tube from the face-down position, the hands should be placed under the areas of faceplate close to the fixing lugs (if fitted), at diagonally opposite corners of the faceplate as shown in Fig.2. The tube must not be lifted from this position by the lugs themselves. **UNDER NO CIRCUMSTANCES SHOULD ANY FORCE BE APPLIED TO THE NECK OF THE TUBE.**

Tube face-up

To lift a tube from the face-up position, the hands should be placed under the areas of cone close to the fixing lugs (if fitted), at diagonally opposite corners of the cone as shown in Fig.3. The tube must not be lifted from this position by the lugs themselves. **UNDER NO CIRCUMSTANCES SHOULD ANY FORCE BE APPLIED TO THE NECK OF THE TUBE.**
If the handling procedures for tubes prior to insertion in the equipment are such that there is a risk of personal injury as a consequence of severe accidental damage to the tube, then it is recommended that protective clothing should be worn, particularly eye shielding.
When fitted, lugs are primarily provided for fixing in equipment and must not be subjected to excessive forces while the tube is being handled. Adequate protection must be provided if there is a possibility of the tube falling as a result of failure of a lug or lugs.

8 HIGH VOLTAGE - APPLICABLE TO CATHODE RAY TUBES

Attention is called to the fact that a high voltage may be carried by the internal conductive coating which is connected to the final anode connector and also by the external coating if not earthed, even after a tube has been removed from equipment. Anyone handling such a tube may receive an electric shock which, while generally not dangerous to the person, might cause an involuntary reaction resulting in damage to the tube which might, for example, be dropped. When it is required to discharge the tube capacitance, connection should be made via a resistor of not less than 10 kΩ which is capable of withstanding high voltages.
In equipment where the chassis can be connected directly to the mains, there is a risk of electric shock if access can be gained to the metal rimband through the aperture at the front of the equipment. In order to reduce the magnitude of the shock, it is recommended that a 2 MΩ resistor, capable of withstanding peak voltages of e.h.t. value (as specified in IEC65, clause 14.1) is inserted between rimband and the braided earth contact to the external coating. This safety arrangement will provide substantial separation from the mains.
An appreciable capacitance is formed between the rimband and the internal conductive layer of the tube. In the event of flashover, high voltages of low energy will be induced on the rimband. In order to bypass these voltages, an extra-high-voltage low-inductance capacitor of a few nanofarads (in compliance with IEC65, clause 14.2) should be inserted between the rimband and the braided earth contact to the external coating.

9 STRONG MAGNETIC FIELDS

Some electronic tubes use permanent magnets in their operation. When handling or mounting such tubes, a distance of at least 5 cm should be maintained between the magnet and any piece of magnetic material to avoid mechanical shock to the magnet or to the glass or ceramic seals. For this reason it is recommended that non-magnetic tools be used during installation, such as non-magnetic stainless steel, brass, beryllium copper and aluminium. Furthermore, the user should be aware of the detrimental influence of the strong magnetic field around the magnet on compasses, electrical meters, watches and

other precision instruments.
Packaged tubes must be stored in such a way as to prevent a decrease of the field strength of the magnets due to interaction with adjacent magnets. Unless otherwise stated on the data sheet, a minimum distance of 15 cm should be maintained between the tubes.
The best protection for the tube is its original packing because this ensures an adequate spacing between the tubes and ferrous objects, and moreover protects the tube against reasonable vibration and shock. Despite this controlled spacing, magnetically-sensitive instruments such as compasses, electrical meters, watches and other precision instruments should not be brought close to a bank of packaged tubes.

UNPACKED PERMANENT - MAGNET TUBES SHOULD NEVER BE PLACED ON STEEL BENCHES OR SHELVES.

SAFETY RECOMMENDATIONS

SUMMARY

HAZARD:	X-Radiation	Radio Frequency (R.F.) and Microwave Radiation	Beryllium Oxide Ceramics	Cadmium Compounds	Mercury	Implosion	High Voltage	Strong Magnetic Fields
INDUSTRIAL CATHODE RAY TUBES	X			X		X	X	
RECTIFIERS					X			
THYRATRONS					X			
TRANSMITTING TUBES	X	X						
HIGH POWER KLYSTRONS	X	X	X					
MAGNETRONS		X						X
TRAVELLING WAVE TUBES		X						X
IGNITRONS					X			
REFER TO:	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Section 8	Section 9

Safety recommendations under the heading GENERAL (section 1) refer to all electronic tubes and associated devices.

GENERAL SECTION A

TUBES FOR MICROWAVE EQUIPMENT

LIST OF SYMBOLS

1. Symbols denoting electrodes and electrode connections

Anode	a
Accelerator electrode	acc
Collector electrode	coll
Anode of a detection diode	d
Filament or heater	f
Filament or heater tap	f_c
Grid	g
Tube pin which must not be connected externally	i.c.
Cathode	k
Reflector electrode	refl
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}
Anode voltage of a detection diode	V_d

2. Symbols denoting voltages (continued)

Filament or heater voltage	V_f
Filament or heater starting voltage	V_{fo}
Grid voltage	V_g
A.C. input voltage	V_i
Ignition voltage (voltage necessary for breakdown to the electrode concerned)	V_{ign}
Inverse voltage	V_{inv}
Voltage between cathode and heater	V_{kf}
A.C. output voltage	V_o
Peak value of a voltage	V_p
Reflector voltage	V_{refl}
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}
Current of a detection diode	I_d
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 fall other elements being earthed)	C_{ak}
Capacitance between anode of a detection diode and all other elements of diode	C_d
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}
Pushing figure of a magnetron	$\frac{\Delta f}{\Delta I_a}$
Frequency temperature coefficient	$\frac{\Delta f}{\Delta t}$
Pulling figure of a magnetron	Δf_p
Power gain	G
Magnetic field strength	H
Height above sea level	h
Pressure drop of cooling air or cooling water	Pi
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	σ
Duty factor	δ
Efficiency	η
Wavelength	λ
Amplification factor	μ

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.
Δf_p	The pulling figure Δf_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 50% of the smooth peak current (see Fig. 1).

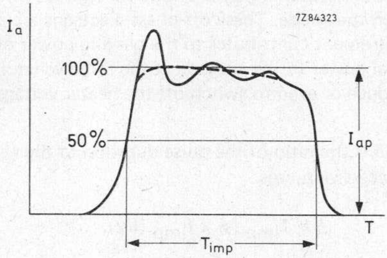


Fig. 1 Current pulse.

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 20 and 85 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).

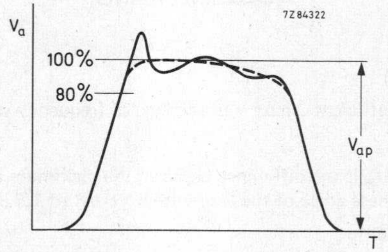


Fig. 2 Voltage pulse.

V_{fo} — Heater voltage before switching on of anode voltage. When the magnetron oscillates, not all electrons reach the anode. These off-phase electrons are driven back to the cathode. This back bombardment contributes to the heating power of the cathode. In order to maintain the total power to the cathode at the rated value, it is therefore necessary in some cases to reduce or even to switch off the heater voltage after application of high voltage.

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

$$\delta = T_{imp}\,(s) \times f_{imp}\,(Hz).$$

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)

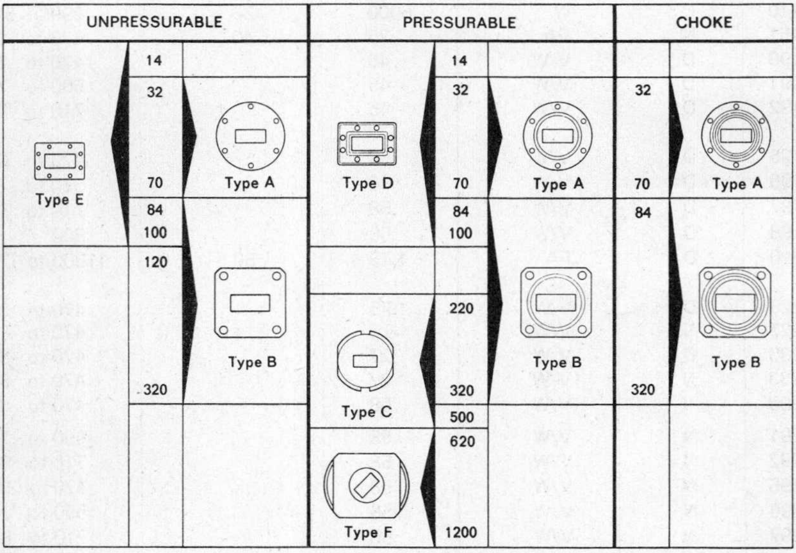
FLANGE DESIGNATIONS

FOR WAVEGUIDE 153 - IEC*	FLANGE DESIGNATION: PLAIN FLANGE			FLANGE DESIGNATION: CHOKE FLANGE		
	154 - IEC	JAN UG /U Brass	JAN UG /U Aluminium	154 - IEC	JAN UG /U Brass	JAN UG /U 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 PAR 32 UAR 32	53	584	CAR 32	54A	585A
R 40	UER 40 PDR 40					
R 48	PAR 48 PDR 48 UAR 48 UER 48	149A	407	CAR 48	148C	406B
R 58	PAR 58 PDR 58 UAR 58 UER 58			CAR 58		
R 70	PAR 70 PDR 70 UAR 70 UER 70	344	441	CAR 70	343B	440B
R 84	PBR 84 PDR 84 UBR 84 UER 84	51	138	CBR 84	52B	137B
R 100	PBR 100 PDR 100 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 PCR 220	595	597	CBR 220	596A	598A
R 260	PCR 260					
R 320	PBR 320 PCR 320 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 letters "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

SURVEY

High-power klystrons

type	status	cooling	W_o kW	gain dB	frequency range MHz
YK1000	M	W/FA	11	30	400 to 620
YK1001	M	FA	11	30	470 to 860
YK1002	M	W/FA/V	11	30	470 to 860
YK1004	M	W/FA	11	30	610 to 790
YK1005	M	FA	11	40	470 to 860
YK1110	C	W	6000	30	2998 ± 5
YK1151	M	FA	25	40	470 to 860
YK1190	D	V/W	45		470 to 610
YK1191	D	V/W	45		590 to 720
YK1192	D	V/W	45		710 to 860
YK1195	D	V/W	58		470 to 610
YK1196	D	V/W	58		590 to 720
YK1197	D	V/W	58		710 to 860
YK1198	D	V/W	58		800
YK1210	D	FA	1,15	50	11800 to 12200
YK1220	D	V/W	16,5		470 to 860
→ YK1223	N	V/W	16,5		470 to 860
YK1230	D	V/W	27		470 to 860
→ YK1233	N	V/W	27		470 to 860
→ YK1290	N	V/W	58		470 to 610
→ YK1291	N	V/W	58		590 to 720
→ YK1292	N	V/W	58		710 to 860
→ YK1295	N	V/W	58		470 to 610
→ YK1296	N	V/W	58		590 to 720
→ YK1297	N	V/W	58		710 to 860
YK1300	D	W	600		499,7

Reflex klystrons

type	status	cooling	W_o mW	output	frequency range MHz
→ YK1090	O	N/FA	400	waveguide	10,5 to 12,2
→ YK1091	O	N/FA	400	waveguide	10,5 to 12,2

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

SURVEY

Travelling-wave tubes

type	status	cooling	W_o W	gain dB	frequency range GHz
LB6-25	M	N/FA	25	38	5,925 to 6,425
YH1090	O	N	25	42	3,4 to 4,2
YH1170	O	H	20	45	5,8 to 8,5
YH1172	O	H	22	45	7,0 to 8,0
	O	H	17	42	8,0 to 8,5
7537	O	N	6	36	4,4 to 5,0
55340	O	N	8	39	3,8 to 4,2

Diodes

type	status	I_c mA	V_f V	I_f mA	frequency MHz
EA52/53	O		6,3	300	1000 ←
K50A	O	150	2	2000	
K51A	O	300	2	3500	
8020	O	100	5	6000	←

T-R switches

type	status				frequency range GHz
56032	O				8,490 to 9,580 ←

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

HIGH-POWER KLYSTRONS B

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 focusing 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

Large klystrons must be mounted in a vertical position, the cathode terminals pointing upwards. Reflex klystrons may as a rule be mounted in any desired position. 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 an 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 precision 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-glass or 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 aircooling 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% dyamide 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 suitable anti-freezing mixture should be added.

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.

U.H.F. POWER KLYSTRONS

Power amplifier klystrons in metal-ceramic construction designed for four external resonant cavities, magnetic beam focusing, continuous operating getter-ion pump. The tubes are intended for use as u.h.f. power amplifier in TV transmitters.

QUICK REFERENCE DATA

Frequency range	
YK1000	400 to 620 MHz
YK1004	610 to 790 MHz
Power output	11 kW
Power gain	30 dB
Cooling	water and air

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

Cathode		dispenser type
Heater voltage	V_f	7,5 to 8 V

During operation the applied heater voltage should not fluctuate more than ± 3%.

Heater current	I_f	32 (⩽ 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	unit 180 s

GETTER-ION PUMP POWER SUPPLY

Pump voltage,	
unloaded (cathode reference)	3,9 kV
loaded (≈ 3 mA)	3,0 kV
Internal resistance	approx. 300 kΩ

FOCUSING COILS POWER SUPPLY

Focusing coil	
voltage	35 to 50 V
current	1,0 to 1,5 A
Focusing coils for drift tubes (connected in series)	
voltage	250 to 500 V
current	1,8 to 2,8 A

COOLING

Cathode base	low velocity air flow
Accelerating electrode	low velocity air flow
Drift tubes	water or glycol solution (30%) $q = 2\ \ell/min$, T_i = max. 60 °C
Output resonator	forced air $q = 2\ m^3/min$ at T_i = 20 °C
Collector	water or glycol solution (30%) See cooling curves, Figs 4 and 5

MOUNTING

Vertical, cathode up. All connections should be free from strain.

ACCESSORIES

Heater connector	type	40649
Heater/cathode connector	type	40649
Focusing electrode connector	type	40634
Accelerating electrode connector	type	TE1052
Ion pump connector	type	55351
Magnet unit for ion pump	type	TE1053
Collector connector for YK1004 only	type	40634

MASS (net)

YK1000	approx. 30 kg
YK1004	approx. 40 kg

LIMITING VALUES (Absolute maximum rating system)

Unless otherwise mentioned all voltages are specified with respect to ground.

Cathode voltage	max.	−20	kV
Cathode voltage at zero current	max.	−21	kV
Cathode current	max.	2,1	A
Total drift tube current	max.	100	mA
Focusing electrode to cathode voltage	max.	−500	V
Pump voltage (cathode reference)	max.	4	kV
Pump current	max.	15	mA
Temperature limits			
cathode base	max.	125	°C
accelerating electrode	max.	125	°C
Collector dissipation	max.	50	kW

OPERATING CONDITIONS

As a 10 kW TV vision amplifier in the band 470 MHz to 790 MHz according to the CCIR system with negative modulation. Unless otherwise mentioned all voltages are specified with respect to ground.

Cathode voltage	19,0	18,0	kV
Focusing electrode to cathode voltage	−250	−200	V
Cathode current	2,05	2,0	A
Drift tube current,			
static	40	40	mA
dynamic	50	50	mA

For optimum operating conditions the electron beam should be focused for minimum drift tube current.

Driving power, sync	see Fig. 1		
Output power, sync	11	11	kW
Power gain	30	30	dB

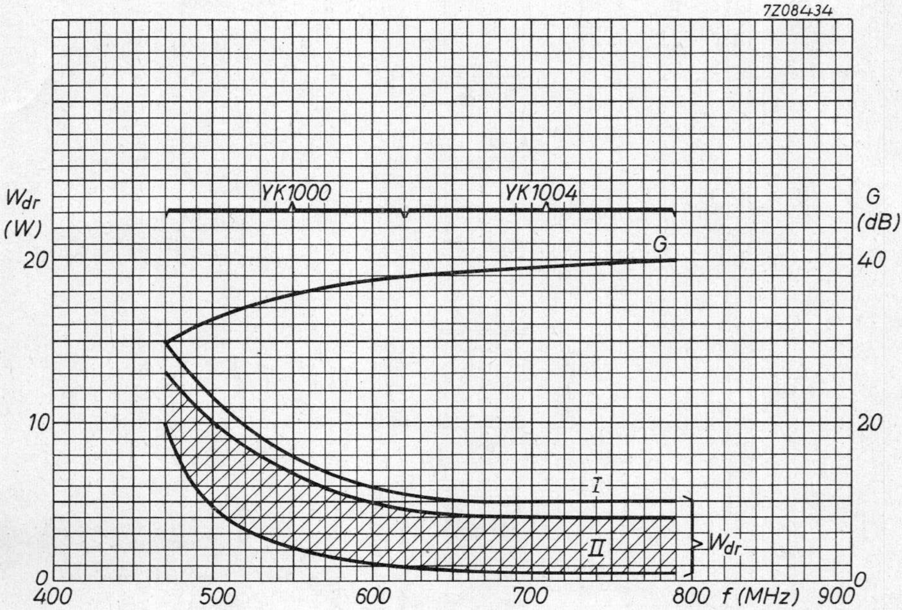


Fig. 1.

I. Maximum driving power with circulator between driver and first resonator, measured at circulator point.

II. Driving power with circulator between driver and first resonator, measured between circulator and first resonator.

MECHANICAL DATA YK1000 Dimensions in mm

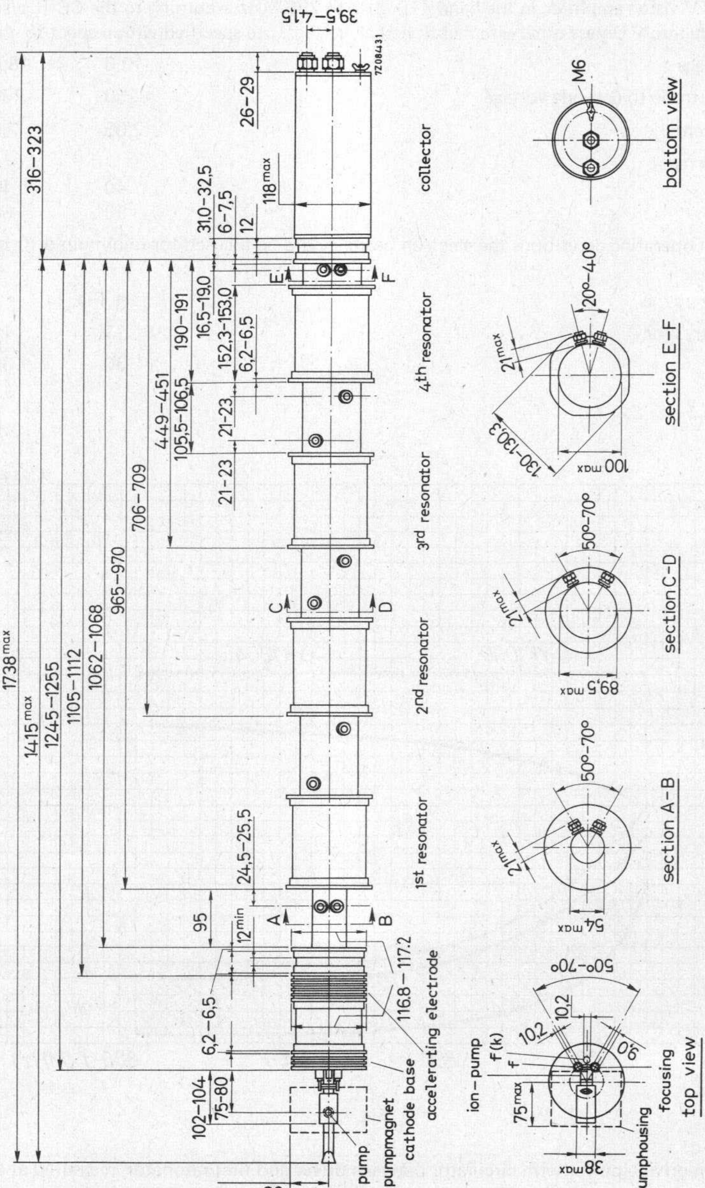


Fig. 2.

YK1004

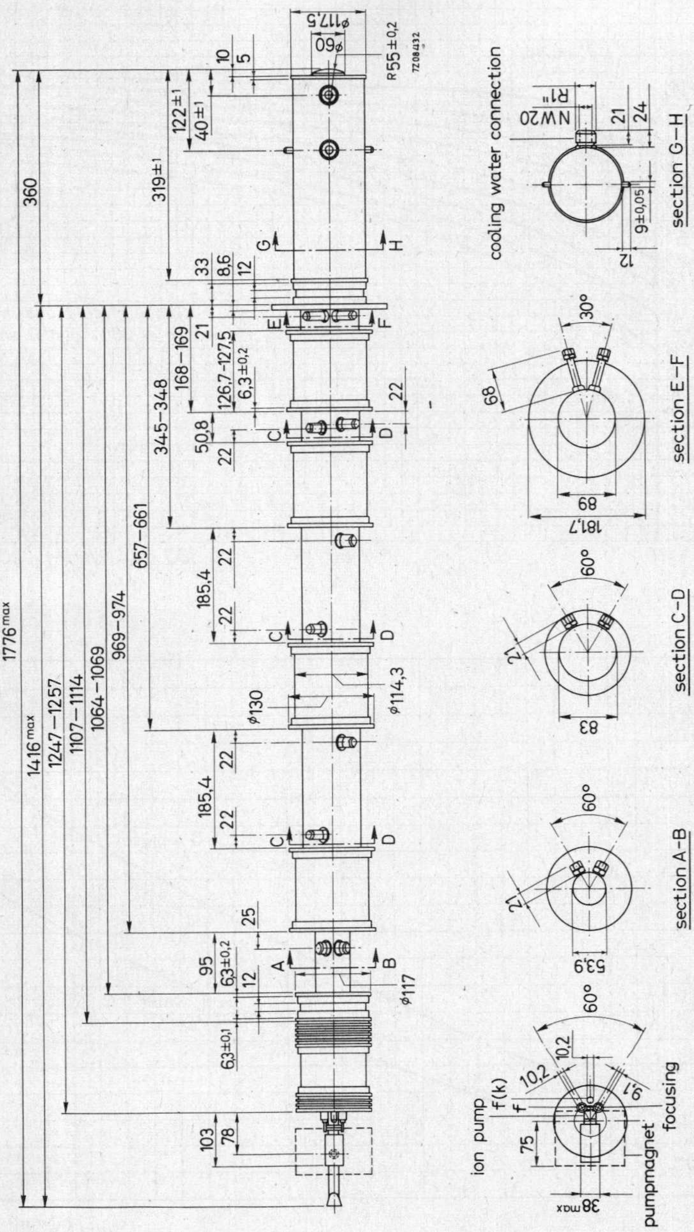

cooling water connection
section G–H
section E–F
section C–D
section A–B
view 1
ion pump
f(k)
f
focusing
pumpmagnet
7Z08432

Fig. 3.

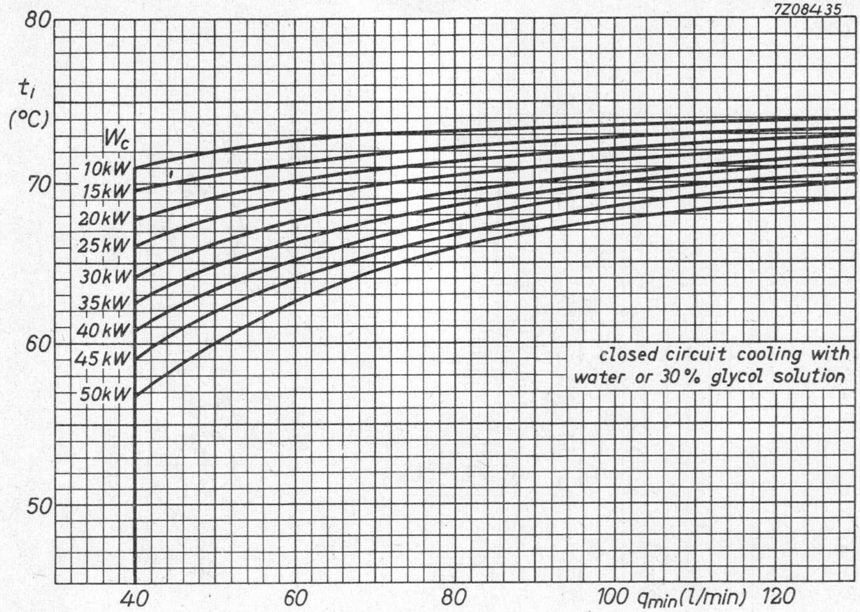

7Z08435
80
t_i
(°C)
70
60
50
W_c
10kW
15kW
20kW
25kW
30kW
35kW
40kW
45kW
50kW
closed circuit cooling with
water or 30 % glycol solution
40
60
80
100 q_{min}(l/min) 120

Fig. 4.

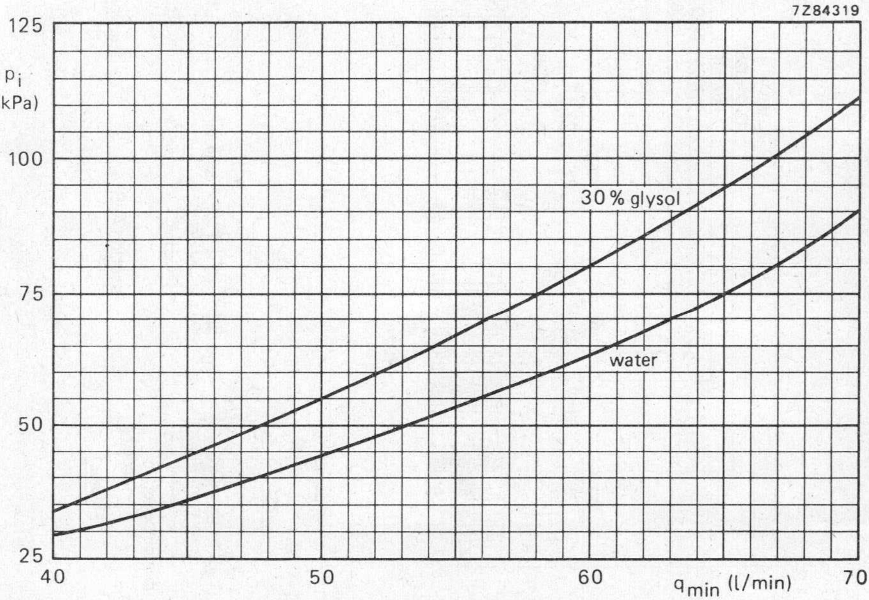

7Z84319
125
p_i
(kPa)
100
75
50
25
30 % glysol
water
40
50
60
q_{min} (l/min)
70

Fig. 5.

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, or, optionally, vapour-cooled collector

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 (≤ 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

COOLING

Except collector, applicable up to an air-inlet temperature T_i of 40 °C and an altitude of 3000 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 (p_i = 900 P_a)
Resonant cavity D	forced air, q = approx. 2,0 m^3/min (p_i = 900 P_a)
Collector YK1001	forced air, see cooling curves Figs 3, 4 and 5
Collector YK1002	water, see cooling curves Figs 6 and 7.

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.

ACCESSORIES

Heater connector	type 40649
Heater/cathode connector	type 40649
Focusing electrode connector	type 40634
Accelerating electrode connector	type 40634
Collector connector	type 40634
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 resonant cavities for 470 MHz to 790 MHz	type TE1066 (3xA, 1xD)
or	
Set of four resonant cavities for 700 MHz to 860 MHz	type TE1067 (3xA, 1xD)
2 magnet field adaptor plates for collector (YK1001 only)**	type TE1073
Circulators, temperature compensated up to 70 °C (optional)	type 2722 162 01061 (470 MHz to 600 MHz) 01071 (590 MHz to 720 MHz) 01081 (710 MHz to 860 MHz) 01101 (608 MHz to 790 MHz)

MASS (net)

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

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

** When operating with a collector voltage less than −2kV these plates should be fitted along the collector in order to keep the collector temperatures below the maximum values. See "Instructions for operation and maintenance".

MECHANICAL DATA

Dimensions in mm

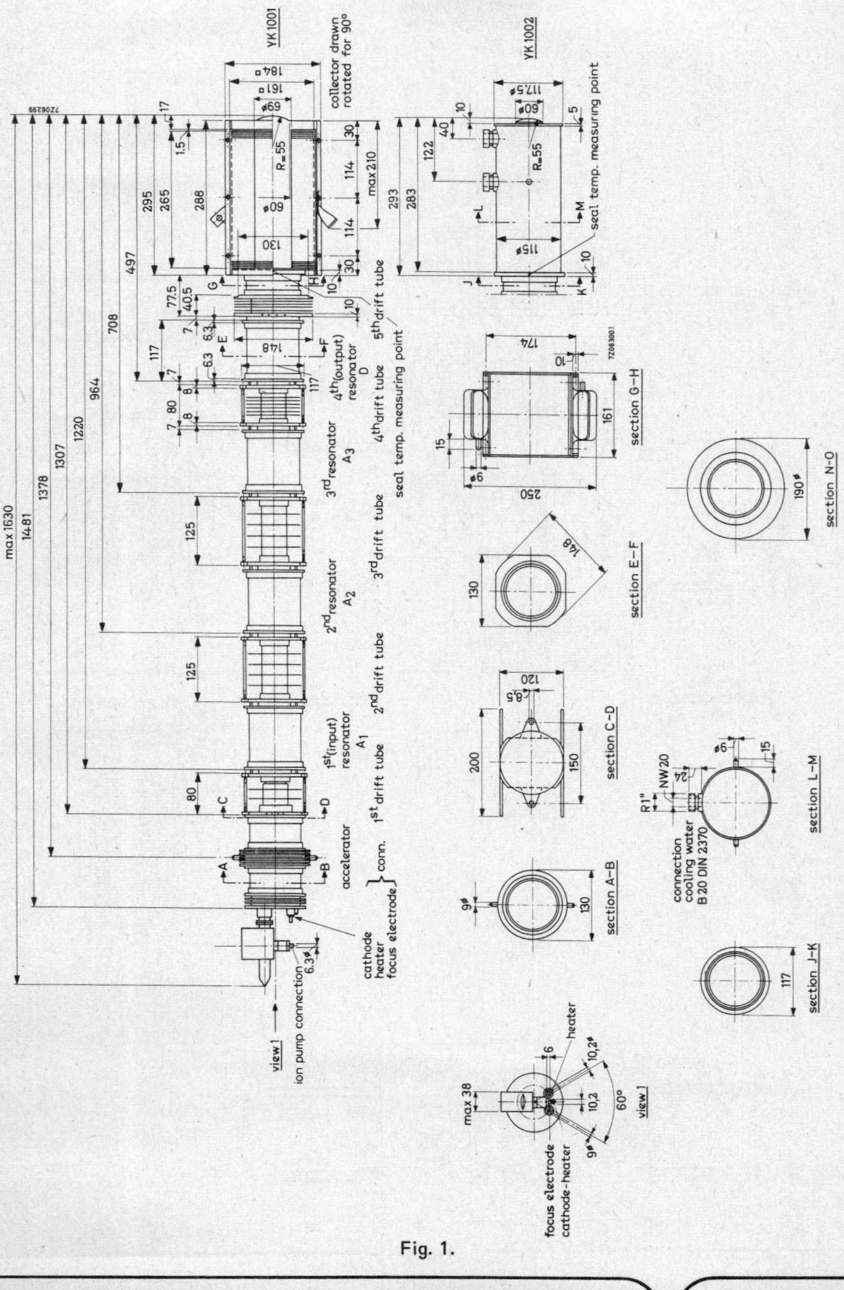


Fig. 1.

MECHANICAL DATA (continued)

Dimensions in mm

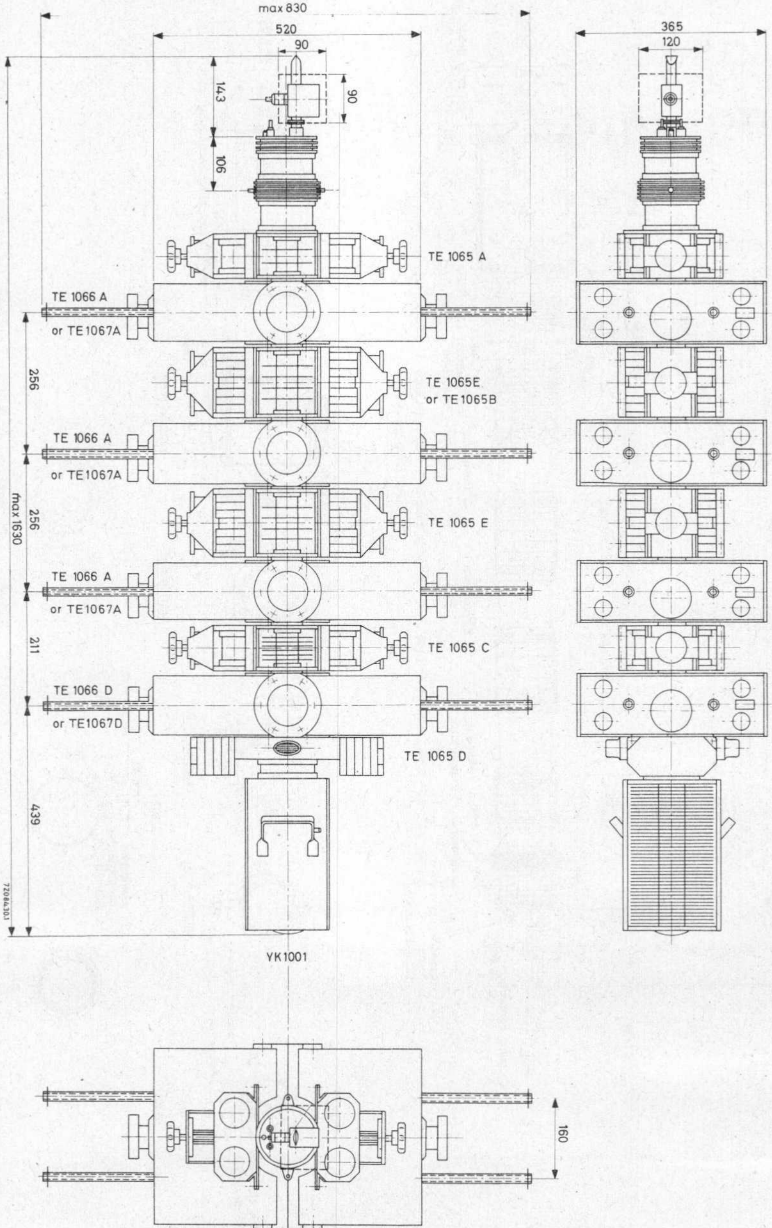


Fig. 2.

LIMITING VALUES (Absolute maximum rating system)

Unless otherwise mentioned all voltages are specified with respect to ground.

Heater voltage	max.	8,5 V
Cathode voltage	max.	−22 kV
Cathode voltage at zero current	max.	−25 kV
Accelerating electrode voltage at zero current	max.	−25 kV
Collector voltage	max.	−7 kV
	min.	−0,5 kV
Focusing electrode to cathode voltage	max.	−700 V
	min.	−100 V
Series resistance in accelerating electrode circuit	max.	20 kΩ
	min.	10 kΩ
Cathode current	max.	2,3 A
Drift tube current*	max.	150 mA
Beam power	max.	42 kW
Collector dissipation	max.	40 kW
Voltage standing-wave ratio	max.	1,5
Pump voltage	max.	4,5 kV
Pump current	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
resonant cavity D	max.	125 °C
collector seal YK1001	max.	200 °C
collector body YK1001**	max.	300 °C
outlet cooling water YK1002	max.	75 °C

* The limiting values for various operating conditions are given in Fig. 8.

** For safeguarding this temperature limit it is recommended that the air outlet temperature be measured at least at two places; one at 50 mm and one at 150 mm from the upper collector plate and at a distance of 50 mm from the cooling fins. See also "Instructions for operation and maintenance".

OPERATING CONDITIONS

Unless otherwise mentioned all voltages are specified with respect to ground. During operation the applied voltages should not fluctuate more than ±3%.

notes

As 5 kW and 10 kW vision amplifier in the band 470 MHz to 860 MHz in accordance with the CCIR system with negative modulation. 2,3

Bandwidth (−1 dB): 6 MHz.

							notes
Output power, peak sync		5,5	5,5	11	11	kW	
Driving power, peak sync		8	8	10	10	W	4,5,6
Power gain		30	30	30	30	dB	4
Cathode to collector voltage		−16,0	−11,5	−18	−13,5	kV	7
Collector voltage		−0,5	−5	−0,5	−5	kV	8
Accelerating electrode voltage		0	0	0	0	kV	9
Focusing electrode to cathode voltage	≈	−400	−400	−400	−400	V	16
Cathode current		1,6	1,6	1,9	1,9	A	
Drift tube current,							
static		25	30	25	30	mA	10
black level	≈	40	80	40	100	mA	11
Differential gain	≈	80	80	80	80	%	12
Sync compression	⩽	45/25	45/25	45/25	45/25		13
V.S.B. suppression	⩽	−20	−20	−20	−20	dB	14
Noise with reference to black level	⩽	−46	−46	−46	−46	dB	15

Tuning of cavities with respect to carrier frequency

Cavity A1	approx.	+3	MHz
Cavity A2	approx.	−0,5	MHz
Cavity A3	approx.	+4,5	MHz
Cavity D	approx.	0	MHz

External cavity loading at black level for 11 kW sync power output

Cavity A1	max.	5	W
Cavity A2	max.	100	W
Cavity A3	max.	200	W

As 1 kW, 2 kW and 4 kW TV sound amplifier in the band 470 to 860 MHz 2,3

									notes
Output power		1,1	1,1	2,2	2,2	4,4	4,4	kW	
Driving power	⩽	0,5	0,5	0,5	0,5	0,5	0,5	W	4,5
Cathode to collector voltage		−18	−13,5	−18	−13,5	−18	−13,5	kV	7
Collector voltage		−0,5	−5	−0,5	−5	−0,5	−5	kV	
Accelerating electrode voltage		−9	−9	−7,5	−7,5	−5,5	−5,5	kV	
Focusing electrode to cathode voltage	≈	−400	−400	−400	−400	−400	−400	V	
Cathode current		0,5	0,5	0,7	0,7	1,0	1,0	A	
Drift tube current dyn	≈	40	50	40	50	50	70	mA	10

For notes see next page.

Notes

1. 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%.
2. With the appropriate focusing magnets TE1065, cavities TE1066 and a circulator between the driver and input cavity A1.
3. In case of a failure all electrode voltages for the klystron except the pump and heater voltages should be switched off, and reduced to less than 5% of the nominal value within 500 ms after the failure has occurred.
4. Dependent on operating frequency, see Fig. 9.
5. The driving power W_{dr} is measured between the circulator and the first cavity at a 50 Ω resistance and represents the sum of the forward and the reflected power in the first cavity.
6. A pre-correction is to be introduced in the pre-stage to compensate for the level dependency of the bandpass curve caused by non-linearities of the klystron, see "Instructions for operation and maintenance".
7. At frequencies above 790 MHz a higher beam power is required to meet the nominal output requirement. Operating data on request.
8. When operating with a collector voltage less than −2 kV the temperature-compensating plates TE1073 should be fitted along the collector. See "Instructions for operation and maintenance".
9. 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.
10. To be focused for minimum drift tube current.
11. 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. 8, may however, not be exceeded.
12. 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.
13. A picture/sync ratio of 75/25 for the outgoing signal of the klystron requires a ratio of maximum 55/45 for the incoming signal.
14. Measured with 10 to 70% modulation, without compensation. V.S.B. filter between driver and klystron.
15. Produced by the klystron itself, without hum from power supplies.
16. The power supply should be adjustable from −100 V to −700 V and be preloaded with min. 10 mA at −700 V.

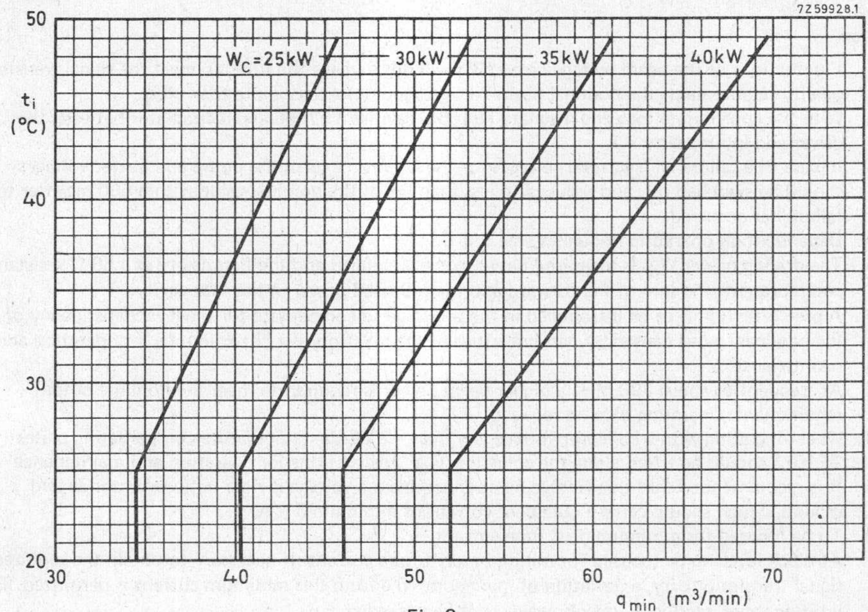

7Z59928.1
W_C=25kW
30kW
35kW
40kW
t_i
(°C)
50
40
30
20
30
40
50
60
70
q_{min} (m^3/min)

Fig. 3.

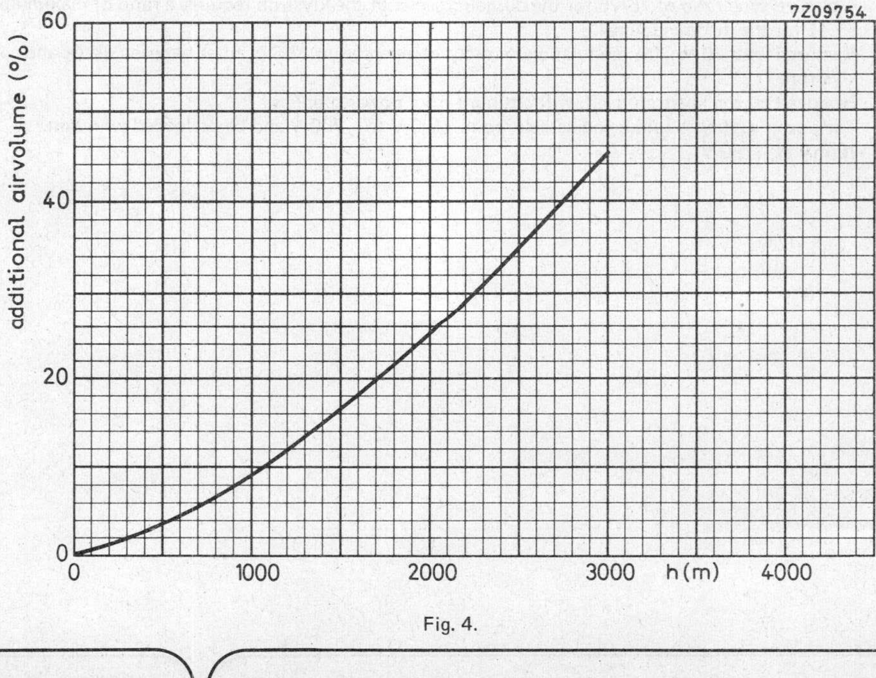

7Z09754
additional airvolume (%)
60
40
20
0
0
1000
2000
3000
h(m)
4000

Fig. 4.

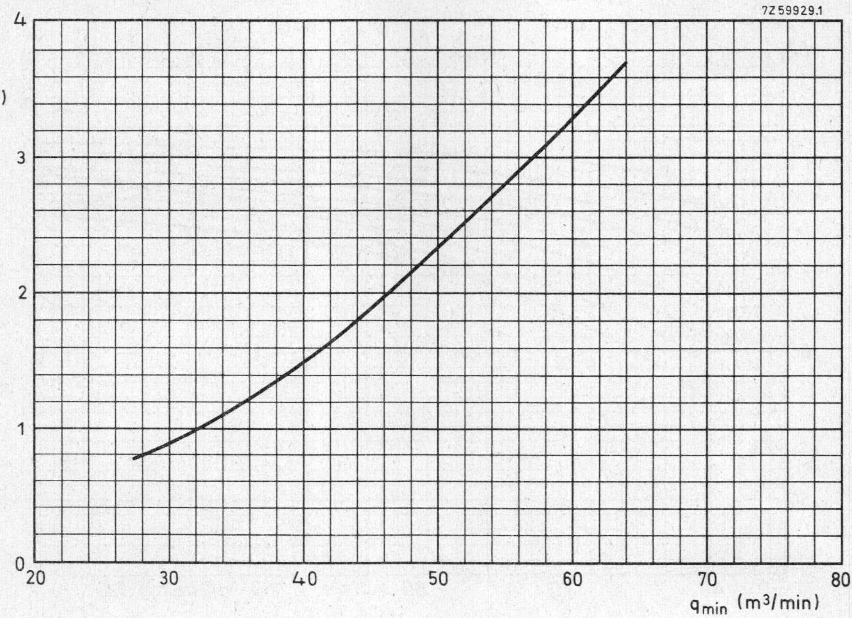


Fig. 5 Ratio of cooling air pressure to cooling air volume of YK1001.

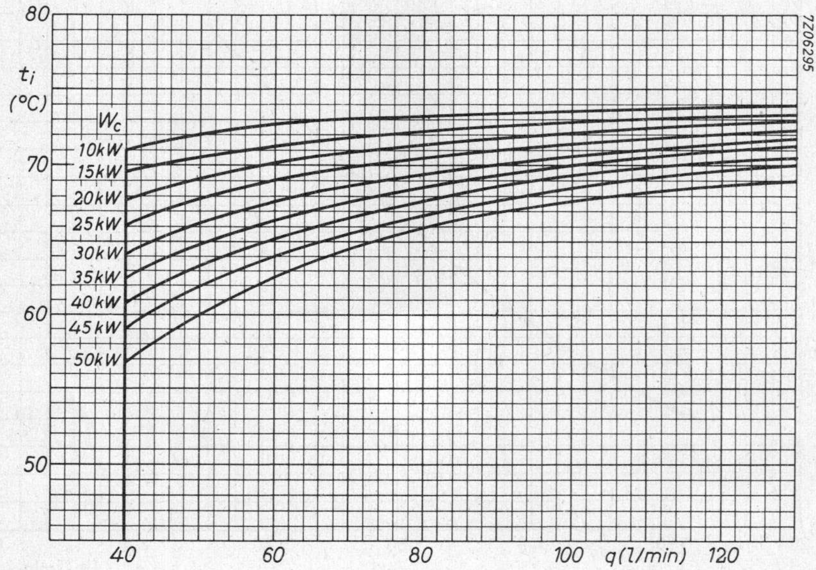


Fig. 6 Cooling curves for top water or closed circuit cooling with 30% glycol solution for YK1002.

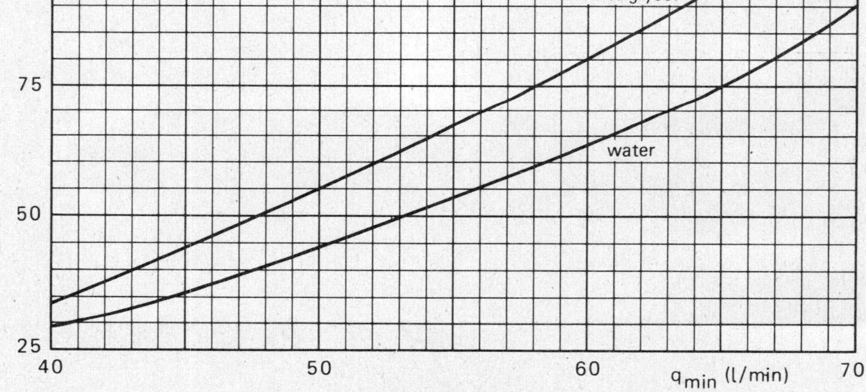


Fig. 7 Ratio of cooling water pressure to cooling water volume for YK1002.

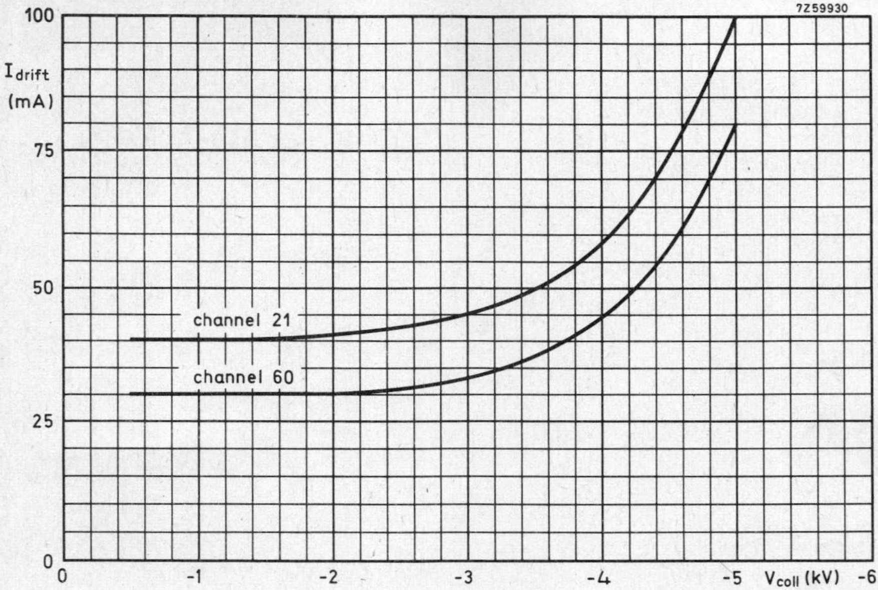

7Z59930
100
I_{drift}
(mA)
75
50
25
0
channel 21
channel 60
0
-1
-2
-3
-4
-5
V_{coll} (kV)
-6

Fig. 8.

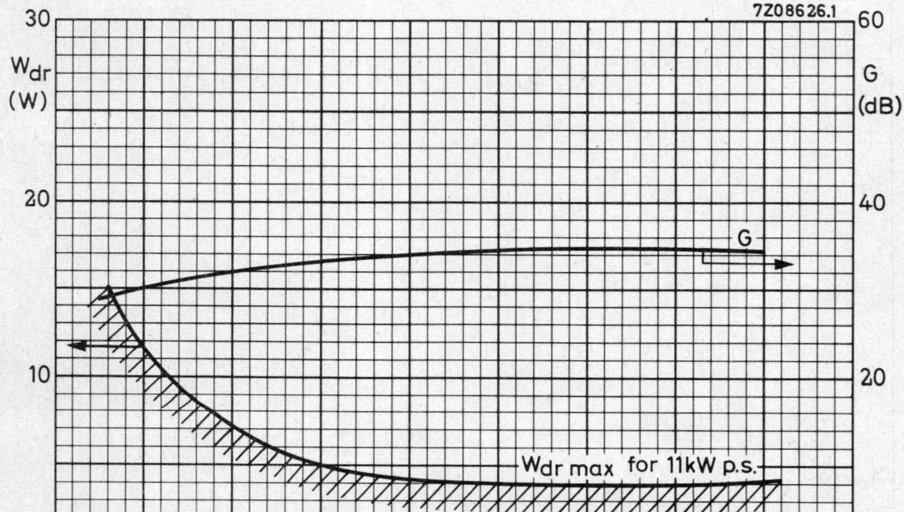

7Z08626.1
30
W_{dr}
(W)
20
10
0
60
G
(dB)
40
20
0
G
$W_{dr\ max}$ for 11kW p.s.
500
600
700
800
f (MHz)
900

Fig. 9.

U.H.F. POWER KLYSTRON

Air-cooled power amplifier klystron in metal-ceramic construction for the frequency range 470 to 860 MHz, designed for four external resonant cavities, beam focusing by means of permanent magnets, continuously operating getter-ion pump and operation with depressed collector potential. This klystron is intended for use as u.h.f. power amplifier in vision and/or sound transmitters as well as in translators for the TV bands IV and V.

QUICK REFERENCE DATA

Frequency range, covered with two sets of resonators	470 to 860 MHz
Power output (vision amplifier)	11 kW
Power gain	≈ 40 dB

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 8,0 V (including mains fluctuations) during the first 300 hours. The heater voltage should then be reduced to 7,5 to 8,0 B.

Heater current	I_f		32 (≤ 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

COOLING

Applicable up to an air-inlet temperature T_i of 40 °C and an altitude of 3000 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 (p_i = 900 Pa)
Resonant cavity (output)	forced air, q = approx. 2,0 m^3/min (p_i = 900 Pa)
Collector	forced air, see cooling curves Figs 3, 4 and 5

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.

ACCESSORIES

Heater connector	type 40649
Heater/cathode connector	type 40649
Focusing electrode connector	type 40634
Accelerating electrode connector	type 40634
Collector connector	type 40634
Ion pump connector	type 55351
Magnet unit for ion pump	type TE1053 (1x)
Set of four resonant cavities	type TE1056G (3x)
for 470 MHz to 650 MHz, or	type TE1056H (1x)
Set of four resonant cavities	type TE1067A (3x)
for 650 MHz to 860 MHz	type TE1067D (1x)
Focusing magnets	type TE1065A (2x)
	type TE1065C (2x)
	type TE1065E (4x)
	type TE1065G (2x)
	type TE1065H (2x)
Air duct	type TE1071 (1x)
Circulators, temperature compensated	type 2722 162 01061 (470 MHz to 600 MHz)
up to 70 °C (optional)	162 01071 (590 MHz to 720 MHz)
	162 01081 (710 MHz to 860 MHz)
	162 01101 (608 MHz to 790 MHz)

MASS (net)

YK1005	approx. 60 kg
Total mass of accessories	approx. 130 kg

MECHANICAL DATA

Dimensions in mm

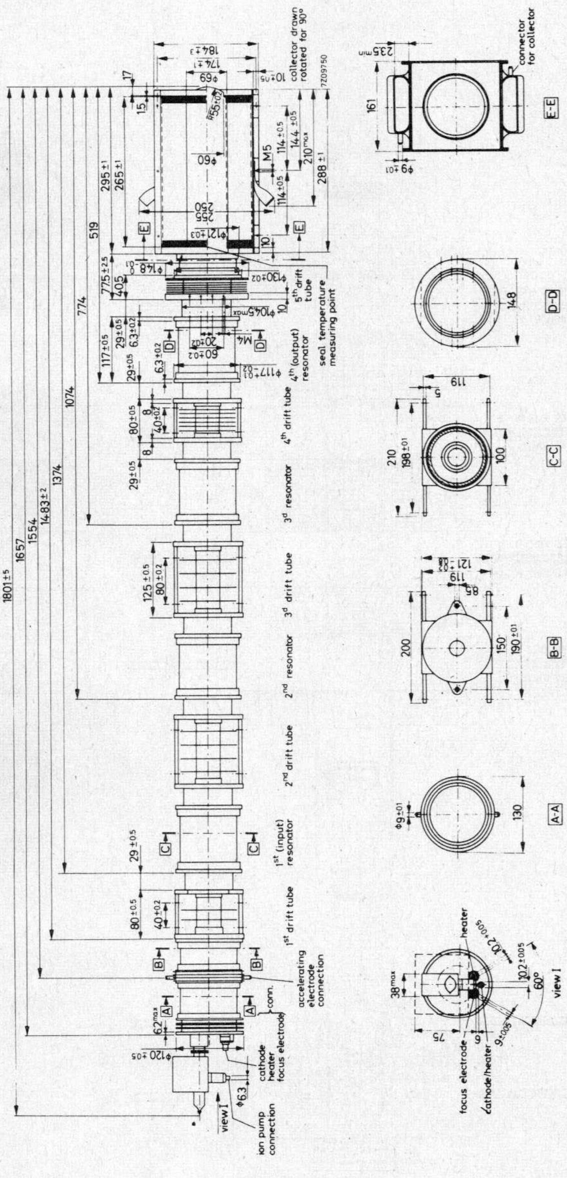


Fig. 1

MECHANICAL DATA (continued)

Dimensions in mm

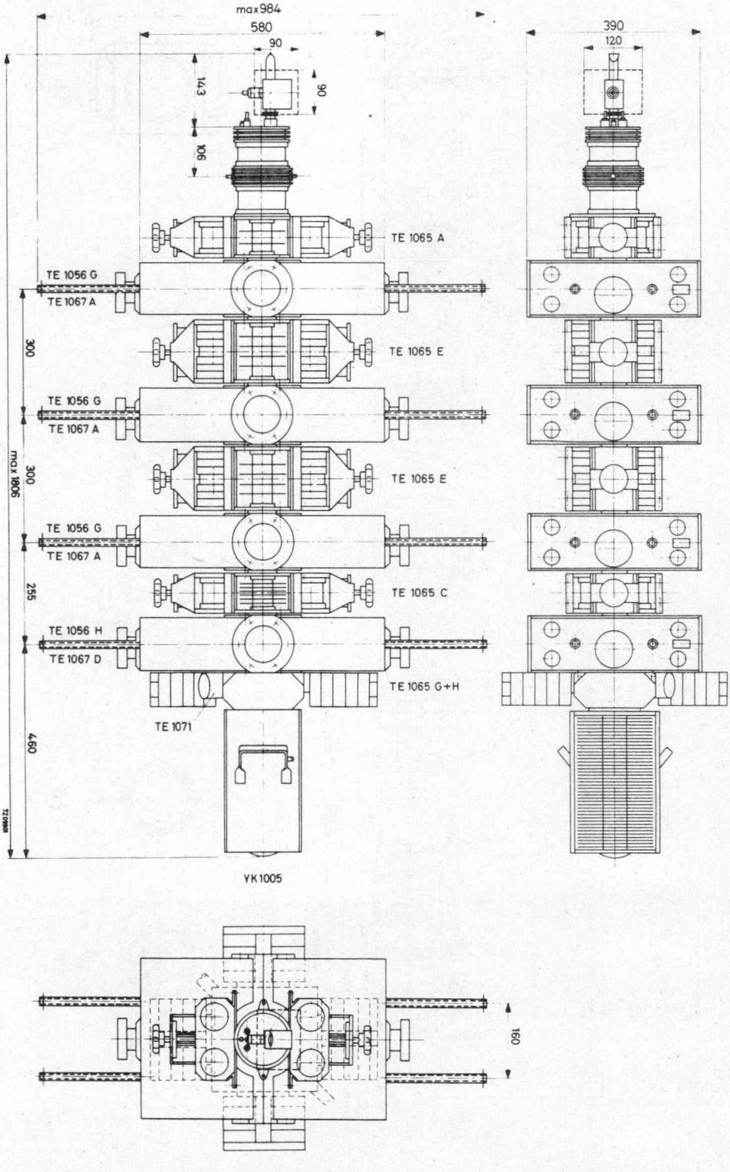


Fig. 2.

LIMITING VALUES (Absolute maximum system)

Unless otherwise mentioned all voltages are specified with respect to ground.

Heater voltage	max.	8,5 V
Cathode voltage	max.	−22 kV
Cathode voltage at zero current	max.	−25 kV
Accelerating electrode voltage at zero current	max.	−25 kV
Collector voltage	max.	−7 kV
	min.	−0,5 kV
Focusing electrode voltage (cathode reference)	max.	−700 V
	min.	−100 V
Series resistance in accelerating electrode circuit	max.	20 kΩ
	min.	10 kΩ
Cathode current	max.	2,3 A
Drift tube current	max.	150 mA
Collector dissipation	max.	40 kW
Voltage standing-wave ratio	max.	1,5
Pump voltage	max.	4,5 kV
Pump current	max.	15 mA
Temperature of		
cathode and accelerating electrode	max.	125 °C
drift tubes 1, 2 and 3	max.	80 °C
drift tubes 4 and 5	max.	150 °C
resonant cavity (output)	max.	125 °C
collector seal	max.	200 °C
collector body*	max.	300 °C

* For safeguarding this temperature limit it is recommended that the air outlet temperature be measured at least at two places; one at 50 mm and one at 150 mm from the upper collector plate and at a distance of 50 mm from the cooling fins.

OPERATING CONDITIONS (for depressed collector operation)

Unless otherwise mentioned all voltages are specified with respect to ground. notes
During operation the applied voltages should not fluctuate more than ±3%.
Measured with focusing magnets TE1065 and cavities TE1056 or TE1067. 1

As 10 kW vision amplifier in the band 470 MHz to 860 MHz in accordance with the CCIR system with negative modulation. Bandwidth (−1 dB): 6 MHz. 2,3

Frequency	470	790	MHz	
Output power, peak sync	11	11	kW	
Driving power, peak sync	2	< 1	W	4,5,6
Power gain	38	> 40	dB	4
Cathode to collector voltage	−13,5	−16	kV	
Collector to body voltage	−4	−4	kV	
Accelerating electrode to body voltage	0	0	kV	7
Focusing electrode to cathode voltage	−240	-600	V	14
Cathode current	2,0	1,85	A	
Body current,				
static	30	30	mA	8
black level	80	60	mA	9
Linearity	80	80	%	10
Sync compression	⩽45/25	⩽45/25		11
V.S.B. suppression	−20	−20	dB	12
Noise with reference to black level	−46	−46	dB	13

Tuning of cavities with respect to carrier frequency

Cavity 1	approx.	+3	MHz
Cavity 2	approx.	−0,5	MHz
Cavity 3	approx.	+4,5	MHz
Cavity 4	approx.	0	MHz

External cavity loading at black level for 11 kW sync power output

Cavity 1	max.	5
Cavity 2	max.	100
Cavity 3	max.	200

As 2 or 4 kW sound amplifier in the band 470 MHz to 860 MHz 2,3

Output power	2,2	4,4	kW	
Driving power	⩽0,5	⩽0,5	W	
Cathode to collector voltage	−13,5	−13,5	kV	
Collector to body voltage	−5	−5	kV	
Accelerating electrode to body voltage	−7,5	−5,5	kV	
Focusing electrode to cathode voltage	−400	−400	V	
Cathode current	0,7	1,0	A	
Body current	50	70	mA	8

For notes see next page.

Notes

1. Fluctuations of the beam voltage up to ±3% will not damage the tube; to obtain a good signal-transfer quality the nominal beam voltage should not vary more than ±1%.
2. With a circulator between the driver stage and input cavity 1.
3. In case of operating failures all klystron-electrode voltages except the pump and heater voltages should be switched off and made to drop to less than 5% of the nominal value within 500 ms after occurrence of this failure.
4. Dependent on operating frequency, see Fig. 6.
5. The driving power W_{dr} is measured between the circulator and first cavity at a 50 Ω resistance and represents the sum of the forward and the reflected power in the first cavity.
6. A pre-correction network is to be incorporated in the pre-stage to compensate for the level dependency of the bandpass characteristic caused by non-linearities of the klystron.
7. It is recommended that this voltage be obtained from a voltage divider between cathode and ground, which should carry a quiescent current of min. 3 mA.
8. To be focused for minimum body current.
9. At black level to be focused for minimum body current. If necessary, to obtain the required signal-transfer quality, a deviation of max. 10% from this minimum current is permitted.
10. 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.
11. A picture/sync ratio of 75/25 for the outgoing signal of the klystron requires a ratio of max. 55/45 for the incoming signal.
12. Measured with modulation 10 to 75%, without compensation, V.S.B. filter between driver and klystron.
13. Produced by the klystron itself; excluded hum from power supplies.
14. The power supply should be adjustable from −100 V to −700 V and be pre-loaded with min. 10 mA at −700 V.

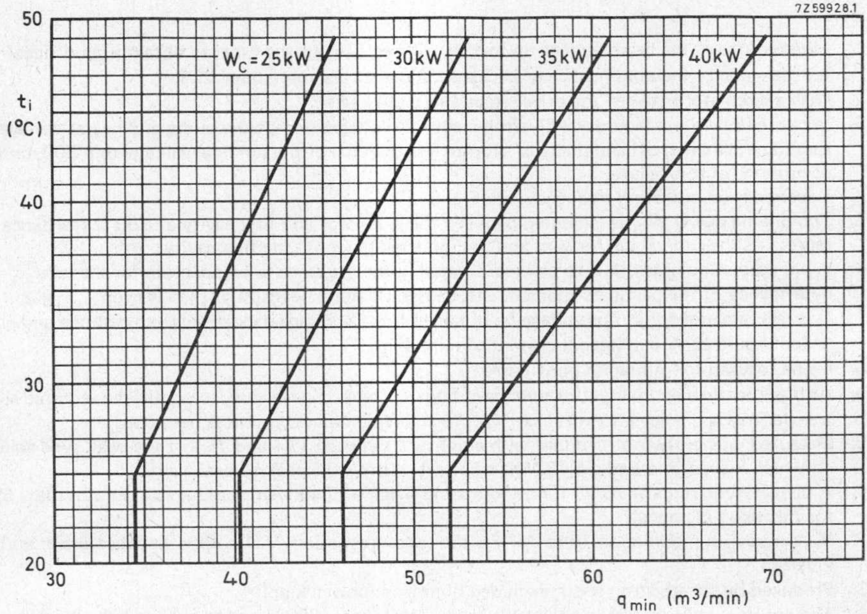

7Z59928.1
50
40
30
20
t_i
(°C)
W_C=25kW
30kW
35kW
40kW
30
40
50
60
70
q_{min} (m^3/min)

Fig. 3.

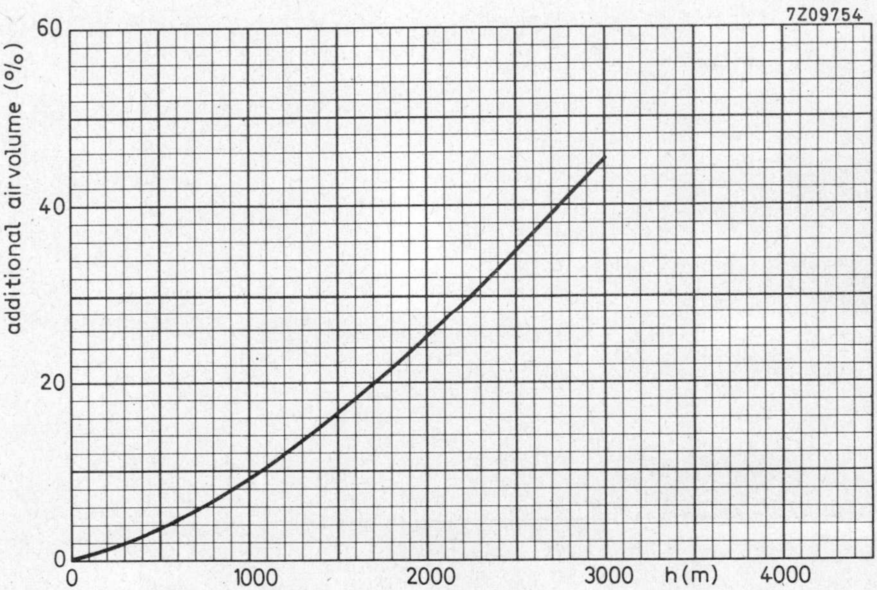

7Z09754
60
40
20
0
additional airvolume (%)
0
1000
2000
3000
4000
h(m)

Fig. 4.

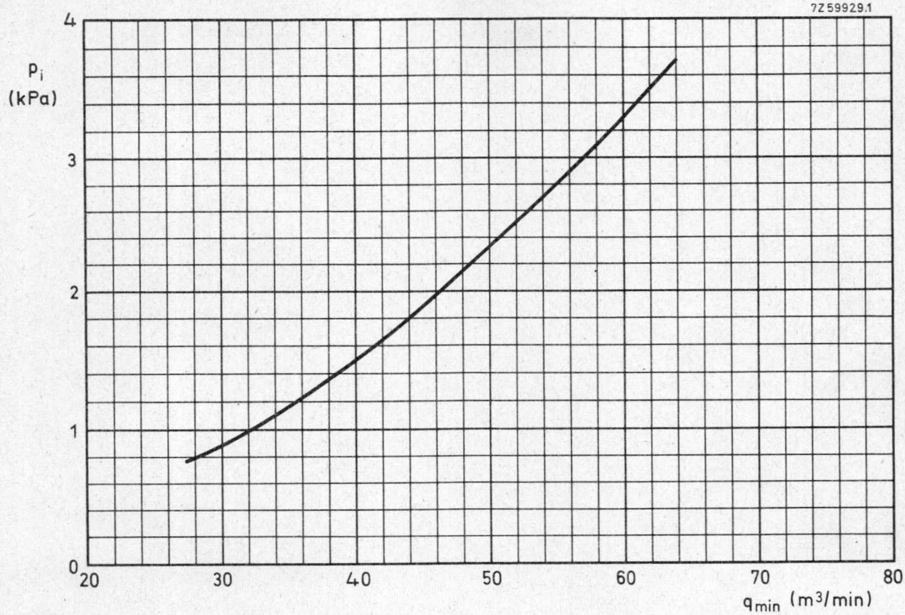

7Z59929.1
4
p_i
(kPa)
3
2
1
0
20
30
40
50
60
70
80
q_{min} (m^3/min)

Fig. 5.

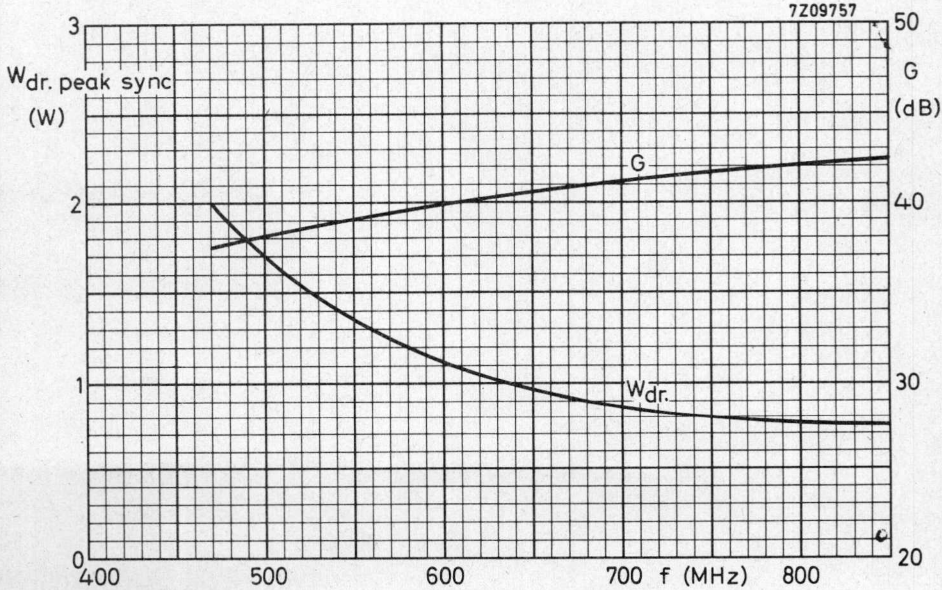

7Z09757
3
$W_{dr.\ peak\ sync}$
(W)
2
1
0
400
500
600
700 f (MHz)
800
50
G
(dB)
40
30
20
G
$W_{dr.}$

Fig. 6.

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

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

MECHANICAL DATA

Dimensions in mm

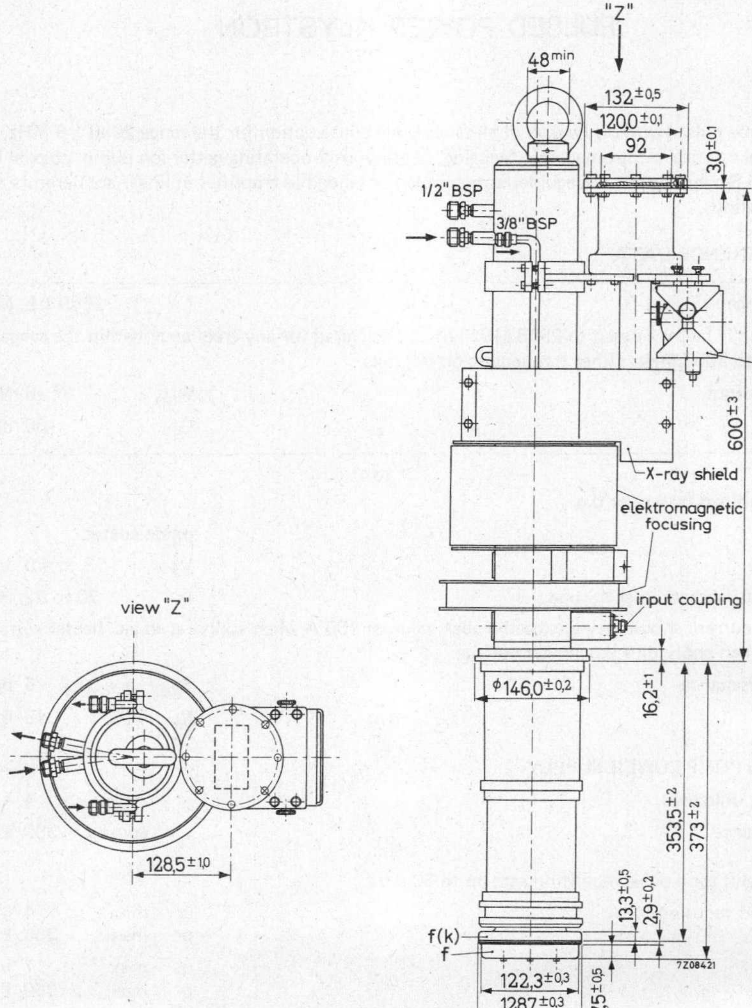


Fig. 1.

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.

All voltages are specified with respect to ground.

			notes
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. min.	32 A 24 A	
Pump voltage	max.	4,5 kV	
Pump current	max.	15 mA	
Water outlet temperature	max.	75 °C	

OPERATING CONDITIONS 1

Frequency	2998 MHz	
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.

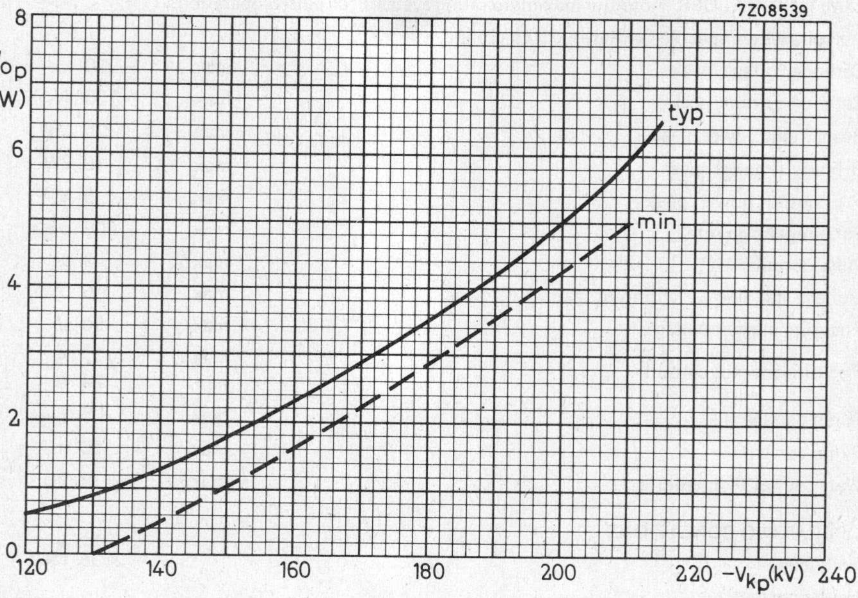

7Z08539
W_{op}
(MW)
8
6
4
2
0
120
140
160
180
200
220
240
$-V_{kp}$(kV)
typ
min

Fig. 2.

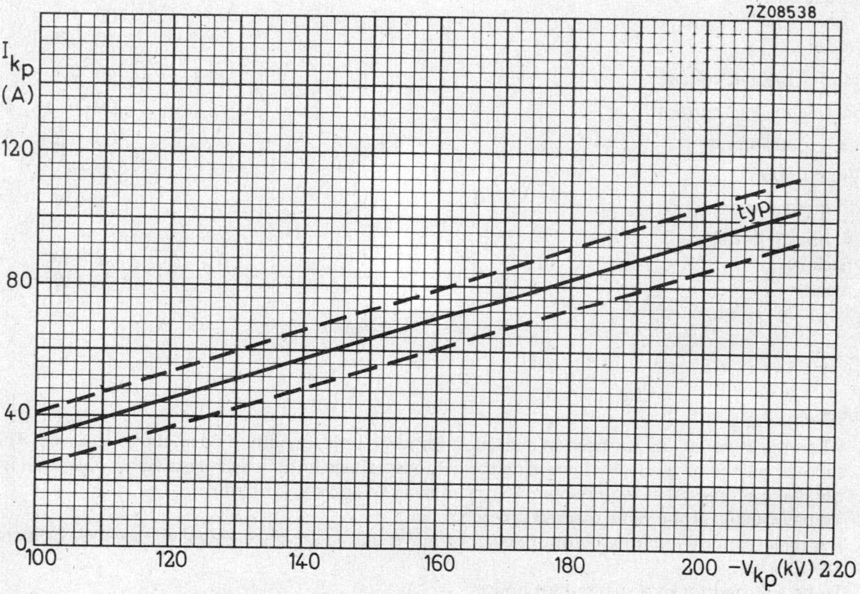

7Z08538
I_{kp}
(A)
120
80
40
0
100
120
140
160
180
200
220
$-V_{kp}$(kV)
typ

Fig. 3.

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
Gain	⩾40 dB
Cooling	forced air

HEATING: indirect by d.c.

Cathode		dispenser type	
Heater voltage	V_f		8 V

During operation the heater voltage should not fluctuate more than ± 3 %.

Heater current	I_f	≈ 32 (⩽ 36) A

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

Cold heater resistance	R_{fo}	≈ 28 mΩ

Waiting time

a. Heater voltage 8 V		t_w	min.	180 s
b. Flash heating 9 V	Detailed information (120 s/9 V)		on request	
c. Stand-by 5,5 V		T_w	min.	0 s

Valid after a waiting time of at least 8 min (on V_f = 5,5,V); as soon as the beam voltage is switched on, the heater voltage must be increased to 8 V.

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 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.

MOUNTING

Mounting position: vertical with collector down.

MASS (net) approx. 100 kg

COOLING

Cathode socket and accelerating electrode	low velocity air flow } 0,5 m^3/min with reference
Drift tube 3	low velocity air flow } to an area of 100 cm^2.
Drift tube 4	forced air, 1 m^3/min, P_i = 800 Pa
Drift tube 5	forced air, 2 m^3/min, P_i = 800 Pa
Cavity 3	forced air, 1 m^3/min, P_i = 800 Pa
Output cavity 4	forced air, 1 m^3/min, P_i = 800 Pa
Collector (60 kW dissipation)	forced air, min. 55 m^3/min, P_i = 1700 Pa, see also cooling curves, Figs 3 and 4.

Cooling data, using the trolley TE1081

Cathode socket, drift tubes, and cavities	forced air, approx 5 m^3/min, P_i = 800 Pa
Collector (60 kW dissipation)	forced air, min 55 m^3/min. P_i = 2100 Pa, see cooling curves, Fig. 5

LIMITING VALUES (Absolute maximum rating system)

Heater voltage	max.	8,5 V
Cathode to body voltage	max.	−28 kV
Accelerator to body voltage	max.	−28 kV
	min.	0 kV
Collector to body voltage	max.	−5 kV
	min.	−0,5 kV
Focusing electrode to cathode voltage	max.	−600 V
	min.	−100 V
Cathode current	max.	4 A
Accelerator electrode current	max.	1,5 mA
Drift tube current,		
static	max.	60 mA
dynamic*	max.	200 mA
Collector dissipation	max.	65 kW
Series resistor in accelerator electrode circuit	min.	10 kΩ
Pump voltage, no load condition	max.	5 kV
	min.	3 kV
Pump current	max.	15 mA
VSWR of load at operating frequency	max.	1,5
Temperature of focusing magnets	max.	65 °C
Inlet temperature of cooling air	max.	45 °C

* 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.

ACCESSORIES (standard)

Frequency range (MHz)	470 to 638	638 to 790	790 to 860
Channel	21 to 41	42 to 60	61 to 68
Stub	TE1089	TE1089	TE1089
Circulator	*	2722 162 01561	2722 162 03261
Cavity 1	TE1077A	TE1078A	TE1078A
Input coupling device	TE1083	TE1084	TE1084
Cavity 2	TE1077A	TE1078A	TE1078A
Load coupling device	TE1085	TE1086	TE1086
Cavity 3	TE1077A	TE1078A	TE1078D
Load coupling device	TE1085	TE1086	TE1086
Adaptor flange	–	–	TE1090
Cavity 4	TE1077D	TE1078D	TE1078D
Output coupling device	TE1091A	TE1092A	TE1092A
Trolley	TE1081	TE1081	TE1081
Air duct for cavities	–	TE1115	TE1116
Air duct for drift tube 3	TE1117	TE1117	TE1117
Air duct for drift tube 4	TE1118	TE1118	TE1118
Air duct for drift tube 5	TE1119	TE1119	TE1119
Magnet for ion pump	TE1053A	TE1053A	TE1053A
Connectors			
Heater	40649	40649	40649
Heater/cathode	40649	40649	40649
Focusing electrode	40634	40634	40634
Accelerating electrode	40634	40634	40634
Collector	40649	40649	40649
Ion pump	40634	40634	40634
Earth	40649	40649	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	TE1091B
Plug connection mating TE1092A	TE1092B
Tube extractor	TE1113

* For frequency range 470 to 604 MHz (channels 21 to 37): 2722 162 01551.
For frequency range 604 to 638 MHz (channels 38 to 41): 2722 162 01561.

MECHANICAL DATA

Dimensions in mm

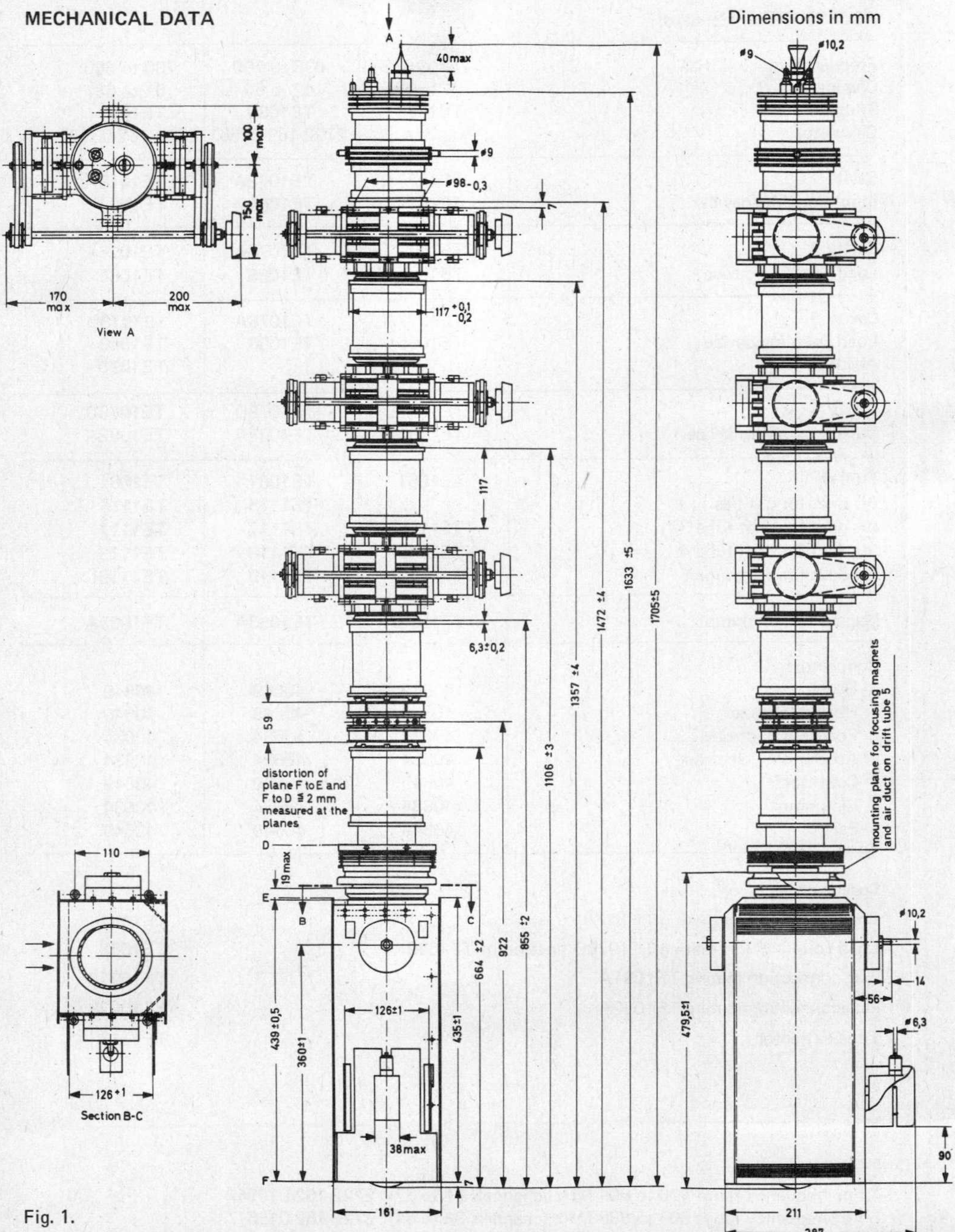


Fig. 1.

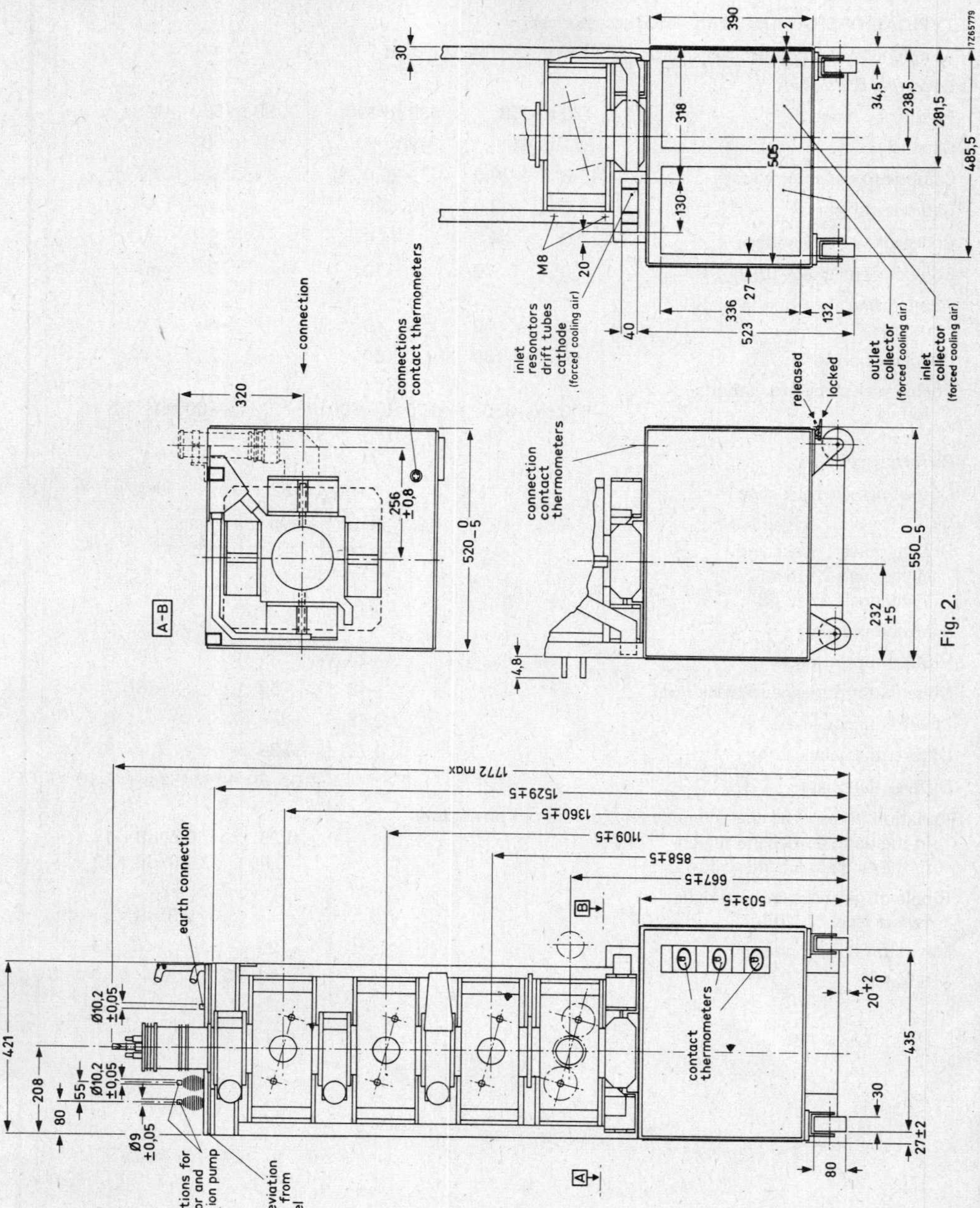

A-B
320
connection
connections
contact thermometers
256
±0,8
520_-5^0
connection
contact
thermometers
4,8
550_-5^0
232
±5
released
locked
390
2
30
318
505
130
M8
20
27
336
523
40
132
34,5
238,5
281,5
485,5
inlet
resonators
drift tubes
cathode
(forced cooling air)
outlet
collector
(forced cooling air)
inlet
collector
(forced cooling air)
7Z65779
1772 max
1529±5
1360±5
1109±5
858±5
667±5
503±5
B
A
421
208
80
55
Ø10,2
±0,05
Ø9
±0,05
earth connection
connections for
collector and
getter ion pump
max. deviation
±5 mm from
ref. level
contact
thermometers
435
20+2/0
30
27±2
80

Fig. 2.

TYPICAL OPERATION (With stated accessories) — notes 1

As a 20 kW vision transmitter in accordance with CCIR-G standard

Operating conditions

						notes
Frequency range	470 to 638		638 to 790	790 to 860	MHz	
Channel	21 to 41		42 to 60	61 to 68		
Cathode to collector voltage	−16,5	−20,0	−20,0	−20,0	kV	2
Cathode current	3,6	3,0	3,0	3,1	A	
Collector to body voltage	−4,0	−4,0	−4,0	−4,5	kV	
Body current (black level)	100	70	70	70	mA	
Accelerating electrode to body voltage	0	≈ −6	≈ −6	≈ −6	kV	
D.C. input power	59	60	60	62	kW	
Focusing electrode to cathode voltage	−100 to −600		−100 to −600	−100 to −600	V	3

Performance — notes 4

Output power, peak sync: 22 kW

	min.	typ.	max.		notes
Driving power, peak sync					
in channels 21 to 41			2,5	W	
in channels 42 to 68			1,7	W	
Sync compression			40/25		5
V.S.B. suppression	23	25		dB	6
Noise, with reference to black level	−48	> −50		dB	7
Low-frequency linearity	0,75	0,8			8
Differential gain	0,75	0,85			9
Differential phase		+10/−3	+15/−5	deg	9,10
Variation in response characteristic as a function of power level					
in the double-sideband region		0,25	0,5	dB	11
in the single-sideband region		0,4	0,6	dB	12
Ripple of response characteristic (white level 10/20)			0,3	dB	
Maximum output power		25		kW	13
Efficiency		42		%	

Notes see page B47

As a 10 kW vision transmitter in accordance with the CCIR-G standard

Operating conditions

						notes
Frequency range	470 to 638		638 to 790	790 to 860	MHz	
Channel	21 to 41		42 to 60	61 to 68		
Cathode to collector voltage	−13,5	−16,0	−16,0	−16,0	kV	2
Cathode current	2,4	2,1	2,1	2,2	A	
Collector to body voltage	−4,0	−4,0	−4,0	−4,5	kV	
Body current (black level)	70	50	50	50	mA	
Acceleration electrode to body voltage	≈ −2,0	≈ −5,5	≈ −5,5	≈ −6,0	kV	
D.C. input power	33,0	33,5	33,5	35,0	kW	
Focusing electrode to cathode voltage	−100 to −600		−100 to −600	−100 to −600	V	3

Performance 4

	min.	typ.	max.		notes
Output power, peak sync		11		kW	
Driving power, peak sync					
in channels 21 to 41			2,5	W	
in channels 42 to 68			1,7	W	
Sync compression			40/25		5
V.S.B. compression	23	25		dB	6
Noise, with reference to black level	−48	> −50		dB	7
Low-frequency linearity	0,75	0,80			8
Differential gain	0,75	0,85			9
Differential phase		+10/−3	+15/−5	deg	9,10
Variation of response characteristic as a function of power level					
in the double-sideband region		0,25	0,50	dB	11
in the single-sideband region		0,4	0,6	dB	12
Ripple of response characteristic (white level 10/20)			0,3	dB	
Maximum output power		12,5		kW	13
Efficiency		38		%	

Notes see page B47.

notes

TYPICAL OPERATION (With stated accessories) 1

As a sound transmitter in accordance with the CCIR-G standard

For operation in combination with a 22 kW vision stage.

										notes
Frequency range	470 to 638				638 to 790		790 to 860		MHz	
Channels	21 to 41				42 to 60		61 to 68			
Cathode to collector voltage	−16,5		−20,0		−20,0		−20,0		kV	
Collector to body voltage	−4,0		−4,0		−4,0		−4,5		kV	
Focusing electrode to cathode voltage	−100 to −600				−100 to −600				V	
Driving power	⩽0,5				⩽0,5				W	
Accelerating electrode to body voltage	−12,5	−14,5	−16,5	−18,5	−16,5	−18,5	−17,0	−19,0	kV	
Cathode current	0,9	0,6	0,8	0,5	0,8	0,8	0,8	0,5	A	14
Output power	4,4	2,2	4,4	2,2	4,4	2,2	4,4	2,2	kW	

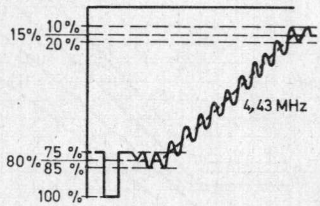
For operation in combination with an 11 kW vision stage.

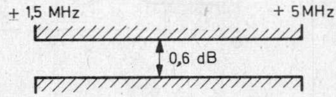
										notes
Frequency range	470 to 638				638 to 790		790 to 860			
Channels	21 to 41				42 to 60		61 to 68			
Cathode to collector voltage	−13,5		−16,0		−16,0		−16,0		kV	
Collector to body voltage	−4,0		−4,0		−4,0		−4,5		kV	
Focusing electrode to cathode voltage	−100 to −600				−100 to −600				V	
Driving power	⩽0,5				⩽0,5				W	
Accelerating electrode to body voltage	−11,5	−13,0	−14,5	−16,0	−14,5	−16,0	−15,0	−16,5	kV	
Cathode current	0,6	0,4	0,5	0,3	0,5	0,3	0,5	0,3	A	14
Output power	2,2	1,1	2,2	1,1	2,2	1,1	2,2	1,1	kW	

Notes see page B47.

Notes

1. In case of failure the beam voltage must be switched-off and made to drop below 5% of its nominal value within 500 ms after occurrence of this failure.
2. 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%.
3. To be adjusted for the stated cathode current.
4. The signal transfer quality is measured with matched load (VSWR ⩽ 1,05).
5. Calculated from $(1\text{-}V_{black}/V_{sync})_{in}/(1\text{-}V_{black}/V_{sync})_{out}$
6. Measured with 10 to 75% modulation without compensation; V.S.B. filter between driving stage and klystron.
7. Produced by the klystron itself; without hum from power supplies.
8. Measured with a staircase signal of 10 to 75% of the peak sync value.
9. 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.
10. Phase difference to burst signal.
11. With respect to ±0,5 MHz around the carrier frequency.
12. With respect to indicated tolerance range
13. With increased driving power under the given operating conditions, without guarantee for signal transfer quality.
14. Cathode current adjusted by accelerating electrode voltage (coarse), and focusing electrode voltage (fine).





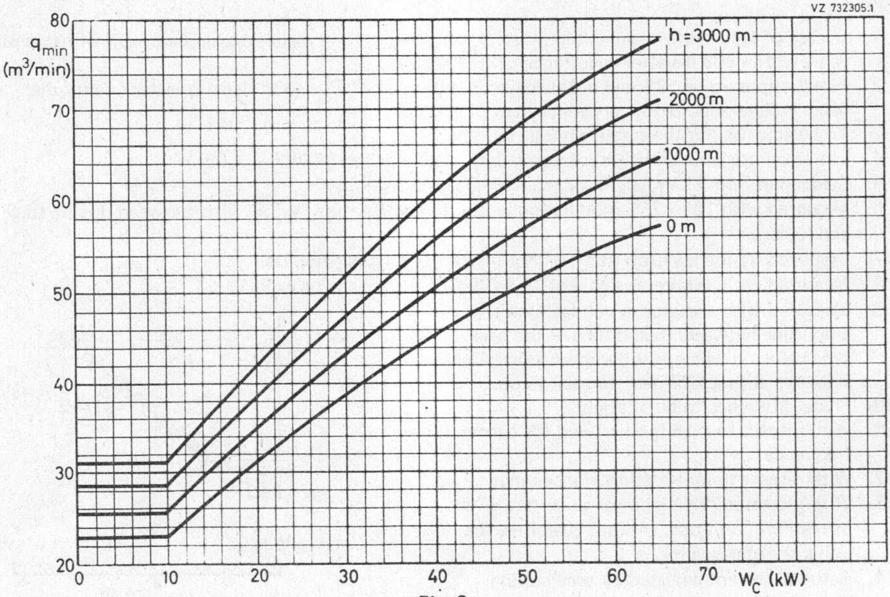
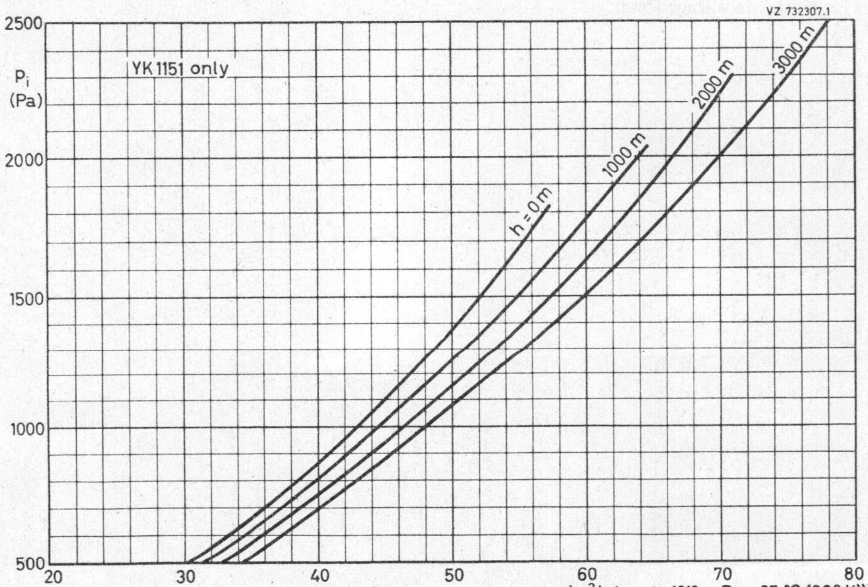


Fig. 3.



1 Pa = approx. 0, 1 mm H_2O

Fig. 4.

The above curves apply to air inlet temperatures up to 45 °C.

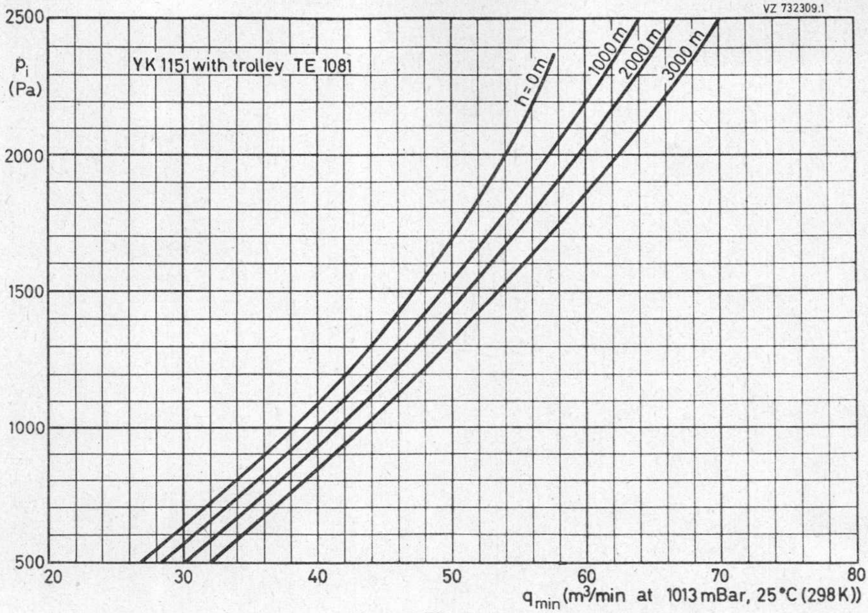

VZ 732309.1
2500
2000
1500
1000
500
p_i
(Pa)
YK 1151 with trolley TE 1081
h=0m
1000m
2000m
3000m
20
30
40
50
60
70
80
q_{min} (m^3/min at 1013 mBar, 25 °C (298 K))

Fig. 5.

U.H.F. POWER KLYSTRONS

Optionally vapour, vapour condensation, or water-cooled power klystrons in metal-ceramic construction for 40 kW vision transmitters and sound transmitters in the U.H.F. bands IV/V. The tubes have four external cavities, electromagnetic focusing and a high stability dispenser-type cathode.

QUICK REFERENCE DATA

Frequency range	
YK1190	470 to 610 MHz
YK1191	590 to 720 MHz
YK1192	710 to 860 MHz
Cooling	vapour, vapour condensation, or water

HEATING: indirect by d.c. — notes: see page B59

Cathode	dispenser type				
Heater voltage	V_f		8,5	V*	
Heater current	I_f	≈	22 to 27	A	note 1
Cold heater resistance	R_{fo}	≈	30	mΩ	
Waiting time					note 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: 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 — note 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 ± 3%.

MECHANICAL DATA YK1190

Dimensions in mm

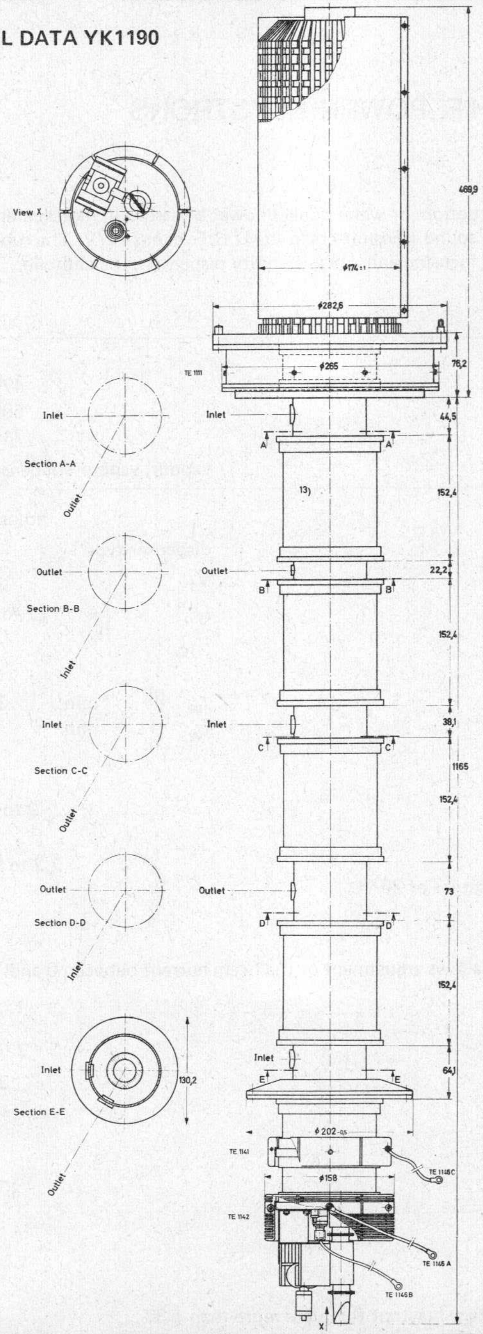


Fig. 1

YK1191, YK1192

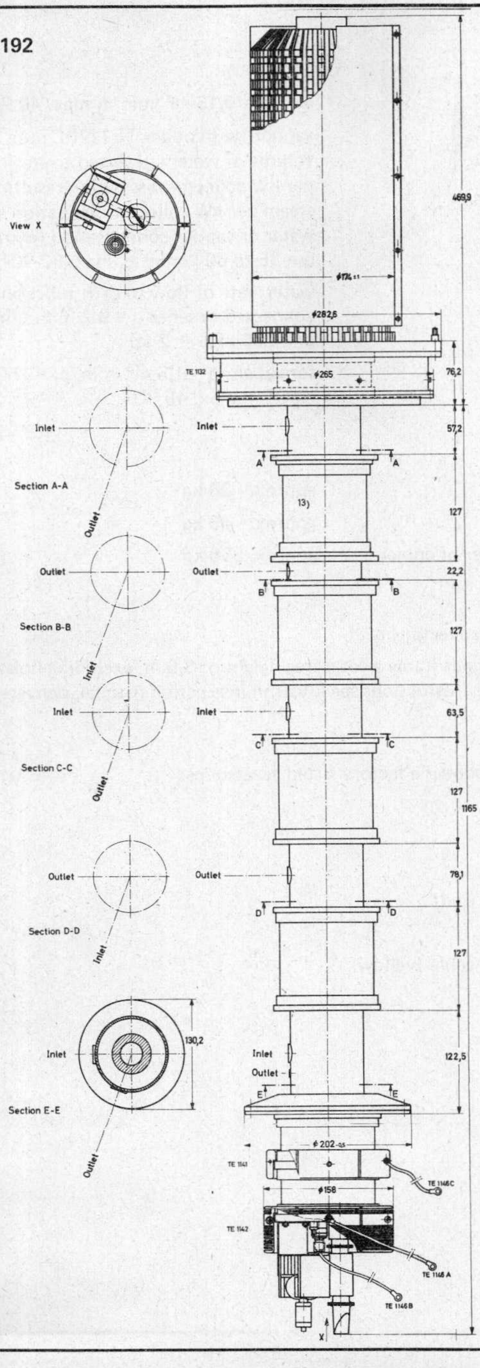


Fig. 2

COOLING

Cathode socket and accelerator electrode	air ; q ≈ 0,15 m^3/min, t_i max. 40 ^oC
Collector	vapour (with boiler TE1110), note 4 volume of water converted to steam: 27 cm^3/min per kW collector dissipation resulting in 43 ℓ/min steam per kW collector dissipation water or vapour condensation (with cooler TE1194) q = 35 to 60 ℓ/min, t_o max. 80 ^oC
Drift tubes	water; rate of flow to drift tubes and collector connected in series q = 9 ℓ/min, t_i max. 80 ^oC, p_i = 200 kPa (≈ 2 at)
Cavities 3 and 4	forced air; q = 1,5 m^3/min, p_i = 250 Pa (≈ 25 mm H_2O), t_i max. 45 ^oC

MASS (net)

Tube	approx. 80 kg
Cavities	approx. 45 kg
Magnet frame with coils and boiler or cooler	approx. 850 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.
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:

Collector radiation suppressor

Accelerator electrode ring

Cathode ring

Heater/cathode connection cable (red)

Heater connection cable (blue)

Accelerator electrode connection cable (yellow)

Set of sealing rings

ACCESSORIES (continued):	YK1190	YK1191	YK1192
A. Accessories to be ordered separately when replacing equivalent other brand types			
Magnet flux ring	TE1138	TE1138	–
Spark gap	TE1140	TE1140	–
B. Accessories required for first equipment			
Magnet flux ring	TE1138	TE1138	TE1138
Spark gap	TE1140	TE1140	TE1140
Extension pipes for drift tubes	6x TE1133A 2x TE1133B	6x TE1133A 2x TE1133B	6x TE1133A 2x 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	3x TE1121A 1x TE1121D	3x TE1098A 1x TE1098D	3x TE1191A 1x TE1191B
Input coupler	TE1122A	TE1102	TE1197
Load coupler for cav. 2 and 3	2x TE1122B	2x TE1102	2x TE1197
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
Spare and optional parts			
Collector radiation suppressor	TE1111	TE1132	TE1195
Accelerator electrode ring	TE1141	TE1141	TE1141
Cathode ring	TE1142	TE1142	TE1142
Heater/cathode connection cable	TE1146A	TE1146A	TE1146A
Heater connection cable	TE1146B	TE1146B	TE1146B
Accel. electr. connection cable	TE1146C	TE1146C	TE1146C
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	−26	kV	note 6
Cold cathode voltage	max.	−27	−30	kV	note 6
Beam current	max.		7	A	
Body current	max.		150	mA	
Accelerator electrode current	max.		6	mA	note 7
Collector dissipation	max.		150	kW	
Load v.s.w.r.	max.		1,5		
Temperature of tube envelope	max.		175	^oC	

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	45	kW	
Beam voltage	−22	−20,5	−22	−25,5	kV	note 6
Beam current	6,3	5,7	4,8	3,8	A	note 8
Accelerator to cathode voltage	22	20,5	18	16	kV	
Body current						
without drive	15	15	15	15	mA	
at 45 kW peak sync., black level	30	40	40	40	mA	
Focusing coil current	10,5	10,5	10,0	9,5	A	
Drive power, peak sync.						
YK1190 - channel 21	2	10	6	6	W	note 9
channel 38	1,5	7	4	4	W	note 9
YK1191 - channel 37	1,5	7	4	4	W	note 9
channel 51	1	5	3	3	W	note 9
Bandwidth at −1 dB points	8	8	8	8	MHz	note 10
Differential gain	80	75	70	70	%	note 11
Differential phase	6	7	10	10	deg	note 11
Linearity	70	65	60	60	%	note 12
Operating efficiency	32	38,5	42,5	46,5	%	
Saturation output power	55	60	46,5	46,5	kW	
Saturation efficiency	40	43	44	48	%	

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

Output power	4,5	9	4,5	9	4,5	9	kW	
Beam voltage	−20,5	−20,5	−22	−22	−25,5	−25,5	kV	note 6
Beam current	1,25	1,5	1,15	1,4	1,0	1,3	A	
Accelerator cathode voltage	≈ 7,5	≈ 8,5	≈ 7	≈ 8	≈ 6,5	≈ 8	kV	note 14
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	45	kW	
Beam voltage	−23	−25,5	kV	note 6
Beam current	4,6	3,9	A	note 8
Accelerator to cathode voltage	18	16	kV	
Body current				
without drive	15	15	mA	
at 45 kW peak sync., black level	40	40	mA	
Focusing coil current	10	10	A	
Drive power, peak sync.	2	2	W	note 9
Bandwidth at −1 dB points	8	8	MHz	note 10
Differential gain	70	70	%	note 11
Differential phase	10	10	deg	note 11
Linearity	60	60	%	note 12
Operating efficiency	42,5	45	%	
Saturation output power	46,5	46,5	kW	
Saturation efficiency	44	46,5	%	

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

Output power	4,5	9	4,5	9	kW	
Beam voltage	−23	−23	−25,5	−25,5	kV	note 6
Beam current	1,1	1,3	1,0	1,3	A	
Accelerator to cathode voltage	≈ 7	≈ 8	≈ 6,5	≈ 8	kV	note 14
Focusing coil current	9				A	
Drive power	1,5				W	note 9
Bandwidth at −1 dB points	1				MHz	

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

Notes

1. When switching on the heater voltage, the heater current must never exceed a peak value of 65 A.
2. In cases of a mains failure an interruption up to 30 s can be tolerated without new preheating. After min. 10 minutes of stand-by heating time at 6,0 V, the beam current may be switched on; the heater voltage must be increased to its nominal value of 8,5 V simultaneously. Operation under stand-by conditions is restricted to continuous periods of 2 weeks at a time. Stand-by periods should be separated by similar periods of rest or full operation.
3. To ensure that the klystron is ready for immediate operation the ion getter pump should be operated at least every 6 months during storage, 3 months being recommended. For details see klystron instruction manual.
4. In order to avoid corrosion of the cooling system, pure deionised water must be used as the coolant (resistivity min. 10 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. Pertaining to the highest value: special high-voltage protection on tube is required. When using this value please contact the tube manufacturer beforehand.
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 a 10 kΩ resistor, the beam current is within ± 5% of the value given in the graph of Fig. 3.
9. The drive power is defined as the power delivered to a matched load.
10. Varying the input level between black and white at any sideband frequency within this bandwidth will not cause a variation of the peak sync. output power exceeding 0,5 dB.
11. Measured with a sawtooth signal from black level to peak white occurring 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 white occurring at each line.
13. Where the ceramic of the output section is beryllium oxide, this is indicated on the tube. The dust of beryllium oxide is toxic. For the disposal of burnt-out tubes observe government regulations. For adjusting the beam current in sound operation a voltage divider should be dimensioned according to an accelerator electrode current of max. 1,5 mA.

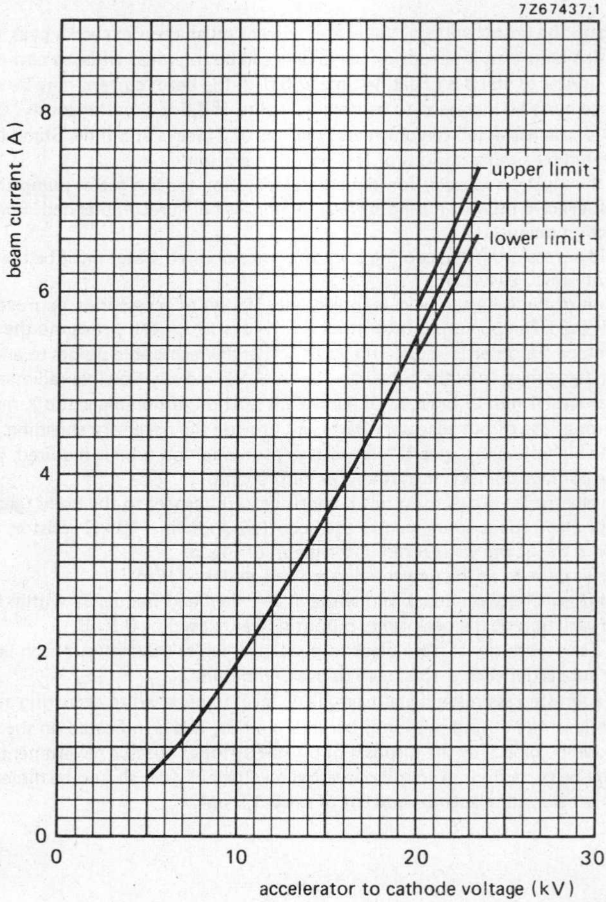

7Z67437.1
beam current (A)
8
6
4
2
0
upper limit
lower limit
0
10
20
30
accelerator to cathode voltage (kV)

Fig. 3.

U.H.F. POWER KLYSTRONS

Optionally vapour, vapour condensation, or water-cooled power klystrons in metal-ceramic construction for 55 kW vision transmitters and sound transmitters in the U.H.F. bands IV/V. The tubes have four external cavities, electromagnetic focusing and a high stability dispenser-type cathode.

QUICK REFERENCE DATA

Frequency range	
YK1195	470 to 610 MHz
YK1196	590 to 720 MHz
YK1197	710 to 860 MHz
Cooling	vapour, vapour condensation, or water

HEATING: indirect by d.c. notes; see page B69

Cathode	dispenser type				
Heater voltage	V_f		8,5	V*	
Heater current	I_f	≈	22 to 27	A	note 1
Cold heater resistance	R_{fo}	≈	30	mΩ	
Waiting time					note 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: 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 note 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 ± 3%.

MECHANICAL DATA YK1195

Dimensions in mm

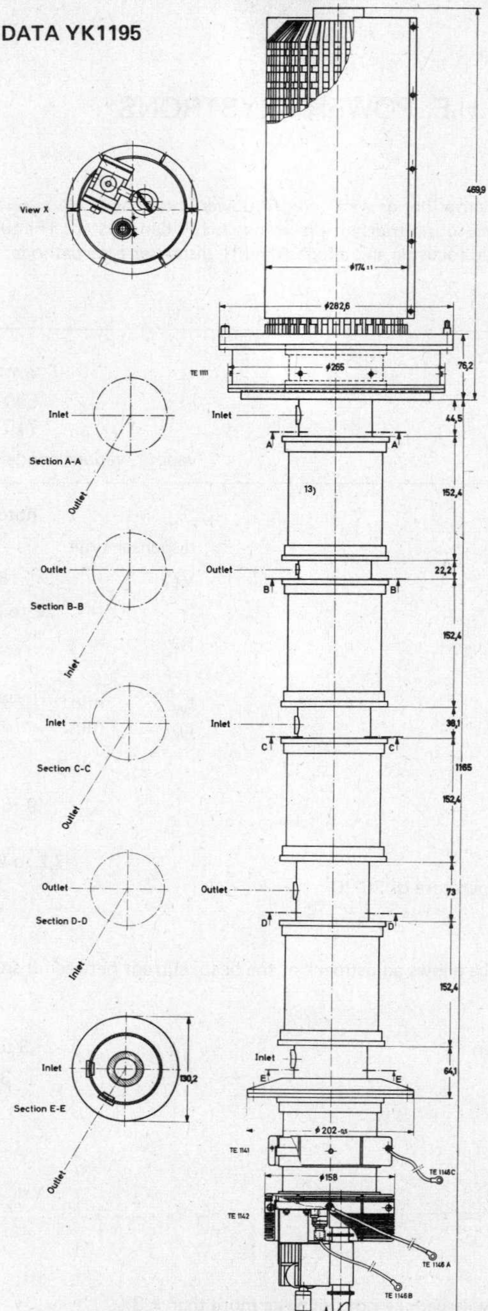


Fig. 1.

YK1196, YK1197

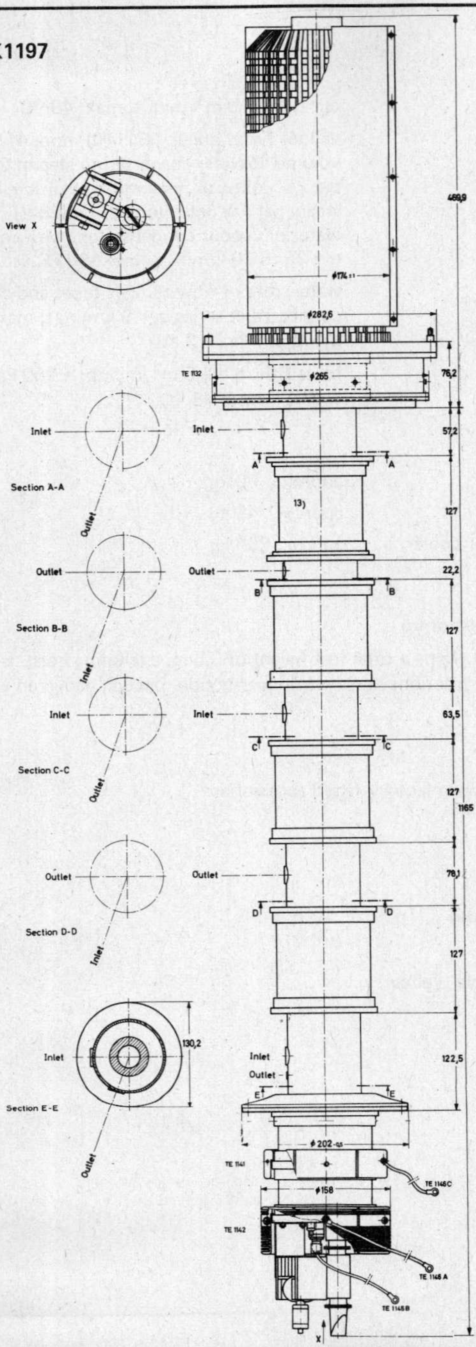


Fig. 2.

COOLING

Cathode socket and accelerator electrode	air; $q \approx 0{,}15\ m^3/min$, t_i max. 40 °C
Collector	vapour (with boiler TE1110), note 4 volume of water converted to steam: 27 cm^3/min per kW collector dissipation resulting in 43 ℓ/min steam per kW collector dissipation 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, p_i = 200 kPa ($\approx$ 2 at)
Cavities 3 and 4	forced air; $q = 1{,}5\ m^3/min$, p_i = 250 Pa ($\approx$ 25 mm H_2O), t_i max. 45 °C

MASS (net)

Tube	approx. 80 kg
Cavities	approx. 45 kg
Magnet frame with coils and boiler or cooler	approx. 855 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. 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:

Collector radiation suppressor

Accelerator electrode ring

Cathode ring

Heater/cathode connection cable (red)

Heater connection cable (blue)

Accelerator electrode connection cable (yellow)

Set of sealing rings

ACCESSORIES (continued):	YK1195	YK1196	YK1197
A. Accessories to be ordered separately when replacing equivalent other brand types			
Magnet flux ring	TE1138	TE1138	
Spark gap	TE1140	TE1140	
B. Accessories required for first equipment			
Magnet flux ring	TE1138	TE1138	TE1138
Spark gap	TE1140	TE1140	TE1140
Extension pipes for drift tubes	6x TE1133A 2xTE1133B	6x TE1133A 2x TE1133B	6x TE1133A 2x 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	3x TE1121A 1x TE1121D	3x TE1098A 1x TE1098D	3x TE1191A 1x TE1191B
Input coupler	TE1122A	TE1102	TE1197
Load coupler for cavities 2 and 3	2x TE1122B	2x TE1102	2x TE1197
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
Spare and optional parts			
Collector radiation suppressor	TE1111	TE1132	TE1195
Accelerator electrode ring	TE1141	TE1141	TE1141
Cathode ring	TE1142	TE1142	TE1142
Heater/cathode connection cable	TE1146A	TE1146A	TE1146A
Heater connection cable	TE1146B	TE1146B	TE1146B
Accel. electr. connection cable	TE1146C	TE1146C	TE1146C
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.	−24	−28	kV	note 6
Cold cathode voltage	max.	−27	−30	kV	note 6
Beam current	max.		7	A	
Body current	max.		150	mA	
Accelerator electrode current	max.		6	mA	note 7
Collector dissipation	max.		150	kW	
Load v.s.w.r.	max.		1,5		
Temperature of tube envelope	max.		175	°C	

TYPICAL OPERATING CONDITIONS: YK1190/YK1191

As 55 kW vision transmitter (CCIR-G standard)

	YK1195/YK1196		YK1197			
Output power, peak sync.	58	58	58	58	kW	
Beam voltage	−22,5	−26	−23,5	−27	kV	note 6
Beam current	6,4	4,85	5,9	4,9	A	note 8
Accelerator to cathode voltage	22,5	16,5	21	17	kV	
Body current						
without drive	15	15	15	15	mA	
at 58 kW peak sync., black level	40	40	40	40	mA	
Focusing coil current	10,5	10,5	10,5	10,5	A	
Drive power, peak sync.						
YK1195 - channel 21	10	6	–	–	W	note 9
channel 38	7	4	–	–	W	note 9
YK1196 - channel 37	7	4	–	–	W	note 9
channel 51	5	3	–	–	W	note 9
YK1197	–	–	2	2	W	note 9
Bandwidth at −1 dB points	8	8	8	8	MHz	note 10
Differential gain	75	70	70	70	%	note 11
Differential phase	6	10	10	10	deg	note 11
Linearity	65	60	60	60	%	note 12
Operating efficiency	40	46	42	44	%	
Saturation output power	63	60	60	60	kW	
Saturation efficiency	44	47,5	43	45	%	

As 11 kW FM sound transmitter

Output power	12	12	12	12	kW	
Beam voltage	−22,5	−26	−23,5	−27	kV	note 6
Beam current	1,5	1,2	1,5	1,2	A	
Accelerator cathode voltage	8,5	7,5	8,5	7,5	kV	note 14
Focusing coil current	9	9	9	9	A	
Drive power	1,5	1,5	1,5	1,5	W	note 9
Bandwidth at −1 dB points	1	1	1	1	MHz	

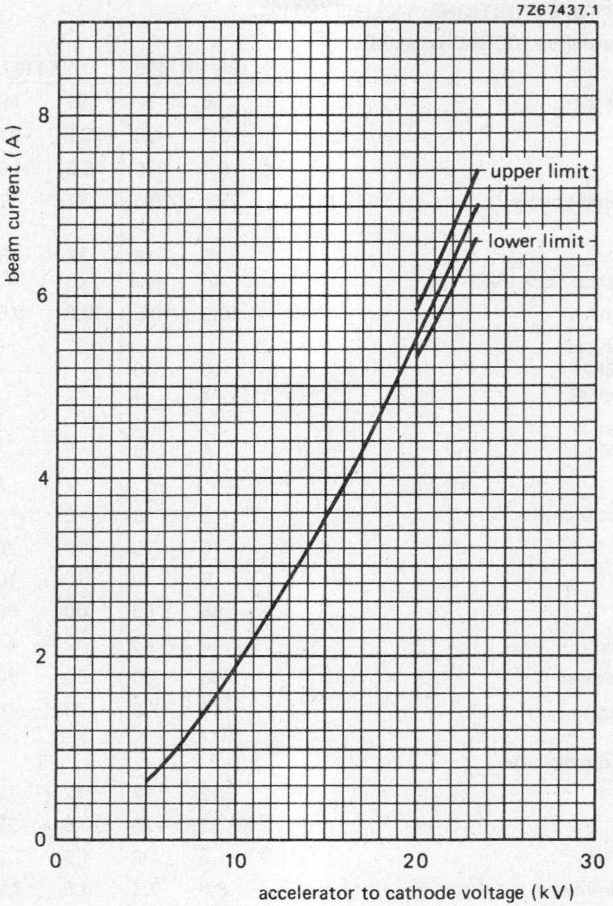

7Z67437.1
beam current (A)
8
6
4
2
0
0
10
20
30
accelerator to cathode voltage (kV)
upper limit
lower limit

Fig. 3.

Notes

1. When switching on the heater voltage, the heater current must never exceed a peak value of 65 A.
2. In cases of a mains failure an interruption up to 30 s can be tolerated without new preheating. After min. 10 minutes of stand-by heating time at 6,0 V, the beam current may be switched on; the heater voltage must be increased to its nominal value of 8,5 V simultaneously. Operation under stand-by conditions is restricted to continuous periods of 2 weeks at a time. Stand-by periods should be separated by similar periods of rest or full operation.
3. To ensure that the klystron is ready for immediate operation the getter ion pump should be operated at least every 6 months during storage, 3 months being recommended. For details see klystron instruction manual.
4. In order to avoid corrosion of the cooling system, pure deionised water must be used as the coolant (resistivity min. 10 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 tubes 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. Pertaining to the highest value: special high-voltage protection on tube is required. When using this value please contact the tube manufacturer beforehand.
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 a 10 kΩ resistor, the beam current is within ± 5% of the value given in the graph of Fig. 3.
9. The drive power is defined as the power delivered to a matched load.
10. Varying the input level between black and white at any sideband frequency within this bandwidth will not cause a variation of the peak sync. output power exceeding 0,5 dB.
11. Measured with a sawtooth signal from black level to peak white occurring 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 white occurring at each line.
13. Where the ceramic of the output section is beryllium oxide, this is indicated on the tube. The dust of beryllium oxide is toxic. For the disposal of burnt-out tubes observe government regulations.
14. For adjusting the beam current in sound operation a voltage divider should be dimensioned according to an accelerator electrode current of max. 1,5 mA.

U.H.F. POWER KLYSTRON

Optionally vapour, vapour condensation, or water-cooled power klystron in metal-ceramic construction for 58 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

HEATING: indirect by d.c. notes: see page B77

Cathode	dispenser type				
Heater voltage	V_f		8,5	V*	
Heater current	I_f	≈	22 to 27	A	note 1
Cold heater resistance	R_{fo}	≈	30	mΩ	
Waiting time					note 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: 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 note 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 ± 3%.

MECHANICAL DATA

Dimensions in mm

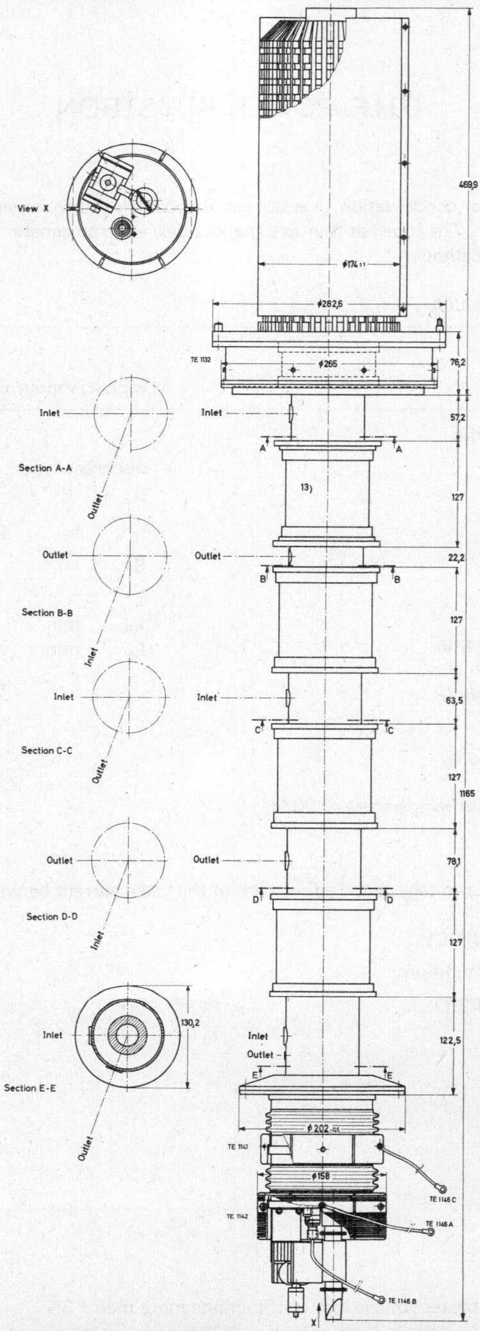


Fig. 1.

COOLING

Cathode socket and accelerator electrode	air; q ≈ 0,15 m³/min, t_i max. 45 °C
Collector	vapour (with boiler TE1110), note 4 volume of 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 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 ≈ 9 ℓ/min, t_i max. 80 °C, p_i = 200 kPa (≈ 2 at)
Cavities 3 and 4	forced air; q = 1,5 m³/min, p_i = 250 Pa (≈ 25 mm H_2O), t_i max. 45 °C

MASS (net)

Tube	approx. 80 kg
Cavities	approx. 45 kg
Magnet frame with coils and boiler or cooler	approx. 855 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. For detailed mounting and tuning instructions see klystron instruction manual, delivered with each tube.

ACCESSORIES

Set of sealing rings	TE1147	
Collector radiation suppressor (factory fitted)	TE1195	
Accelerator electrode ring (factory fitted)	TE1141	
Cathode ring (factory fitted)	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 2 x TE1133B	
Flexible water pipes	for vapour cooling	for water cooling
between tube and boilar	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	
Heater/cathode connection cable (red)	TE1146A	
Heater connection cable (blue)	TE1146B	
Accelerator electrode connection cable (yellow)	TE1146C	
Cavities	3 x TE1191A 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	
Cathode voltage	max.	−28	kV	
Cold cathode voltage	max.	−30	kV	
Cathode current	max.	7	A	
Drift tube current	max.	60	mA	
Accelerator electrode current	max.	6	mA	note 5
Collector dissipation	max.	150	kW	
Load v.s.w.r.	max.	1,5		
Temperature of tube envelope	max.	175	°C	

TYPICAL OPERATING CONDITIONS

As 58 kW CW amplifier

Output power		58	kW	
Cathode voltage		−27	kV	
Cathode current		5	A	note 6
Accelerator to cathode voltage	≈	17,5	kV	
Drift tube current				
without drive		10	mA	
at 58 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	⩾	43	%	

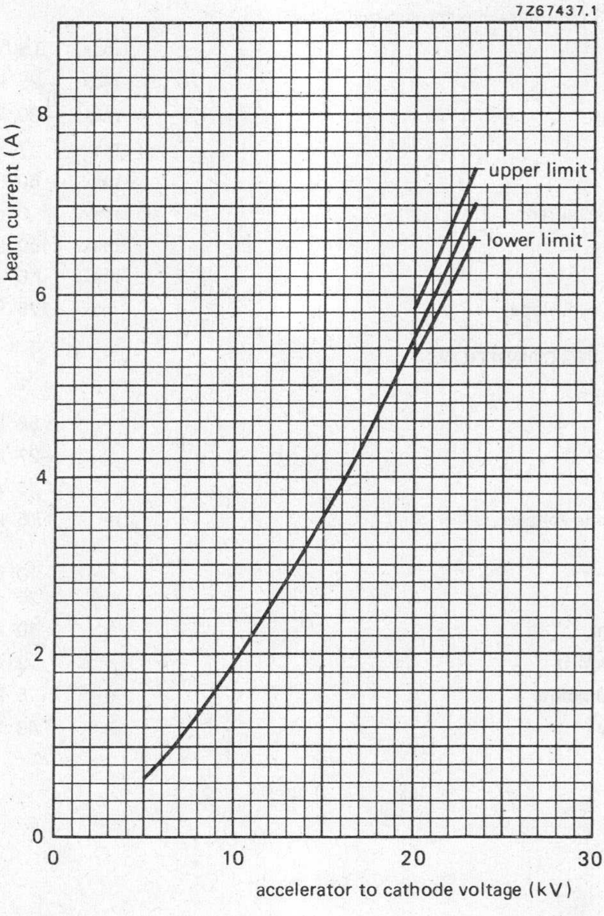

7Z67437.1
beam current (A)
8
6
4
2
0
0
10
20
30
accelerator to cathode voltage (kV)
upper limit
lower limit

Fig. 2.

WARNING - Health hazard

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 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.

2. R.F. radiation

R.F. power may be emitted not only through the normal output coupling but also through other apertures (e.g. 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.

3. Beryllia ceramic

The ceramic of the output section is beryllium oxide, the dust of which is toxic. For the disposal of burnt-out tubes government regulations must be observed.

Notes

1. When switching on the heater voltage, the heater current must never exceed a peak value of 65 A.
2. In cases of a mains failure an interruption up to 30 s can be tolerated without new preheating. After min. 10 minutes of stand-by heating time at 6,0 V, the beam current may be switched on; the heater voltage must be increased to its nominal value of 8,5 V simultaneously. Operation under stand-by conditions is restricted to continuous periods of 2 weeks at a time. Stand-by periods should be separated by similar periods of rest or full operation.
3. To ensure that the klystron is ready for immediate operation the ion getter pump should be operated at least every 6 months during storage, 3 months being recommended. For details see klystron instruction manual.
4. In order to avoid corrosion of the cooling system, pure deionized water must be used as the coolant (resistivity min. 10 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 a 10 kΩ resistor, the cathode current is within ± 5% of the value given in the graph of Fig. 2.
7. The drive power is defined as the power delivered to a matched load.

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

HEATING: indirect by d.c.

Cathode	dispenser type			
Heater voltage	V_f		5 to 6	V
Heater current	I_f		4 (≤ 5)	A
Heater peak starting current	$I_{f\,p}$	max	8	A
Cold heater resistance	R_{fo}	≈	20	mΩ
Waiting time	t_w	min	120	s

COOLING

Cathode socket and accelerating electrode	low-velocity air flow 0,5 m^3/min, 100 cm^2
Body	forced air, ≈ 0,5 m^3/min $p_i \leqslant 1000$ Pa
Collector	forced air, ≈ 6 m^3/min $p_i \leqslant 1000$ Pa

GETTER-ION PUMP SUPPLY

Pump voltage, no-load condition	3 kV
Internal resistance of supply	300 kΩ

MOUNTING

Vertical

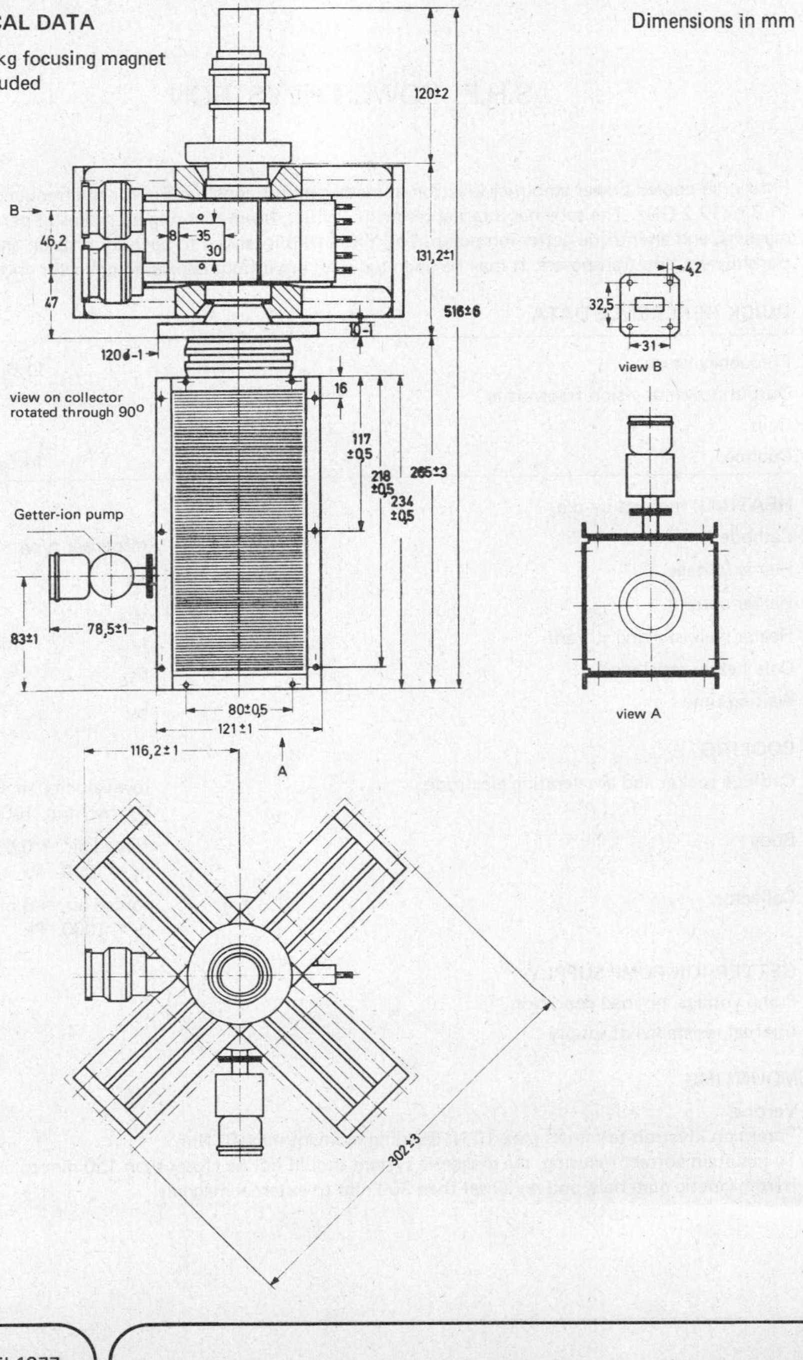
Forces on klystron terminals max 10 N. Bending moment max 10 Nm.

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

Dimensions in mm

Mass: ≈ 30 kg focusing magnet included



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_o 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_o 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 Ω	< 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 Ω	< 0,1%
Body to accelerator voltage	Via potentiometer. Total resistance ≈ 5 MΩ and series resistor 10 kΩ (suitable for 15 kV) between accelerator electrode and tap.		

* 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 KLYSTRON

For u.h.f. band IV/V sound transmitters and vision transmitters up to 15 kW.
Metal-ceramic construction, four external cavities, high-stability dispenser cathode.
Suitable for water, vapour, or vapour-condensation cooling.

QUICK REFERENCE DATA

Frequency range	470 to 860 MHz
Cooling	vapour, vapour condensation, or water

HEATING; indirect by d.c. notes: see page B92

Cathode	dispenser type				
Heater voltage	V_f		5,5	V *	
Heater current	I_f	≈	19 to 26	A	note 1
Cold heater resistance	R_{fo}	≈	25	mΩ	
Waiting time					note 2
from cold, V_f = 0 V	t_w	min.	300	s	
from black heat, V_f = 4,5 V	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 notes 6, 7

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

GETTER-ION PUMP SUPPLY

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 ± 3%.

MECHANICAL DATA

Dimensions in mm

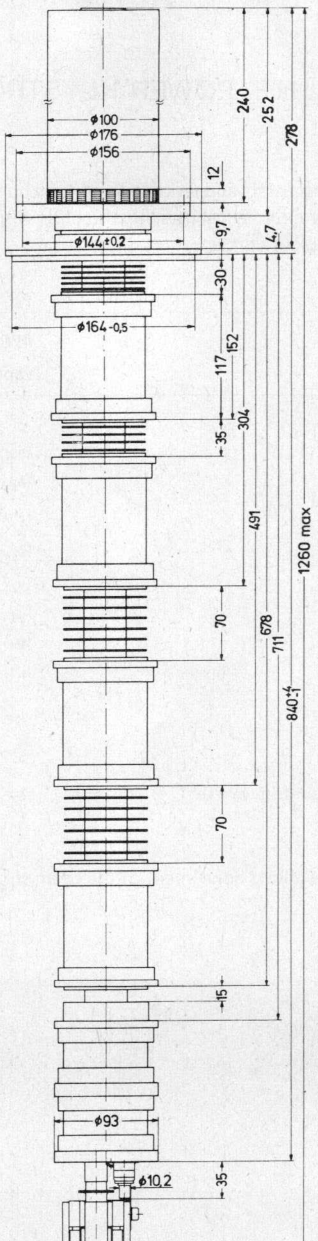


Fig. 1.

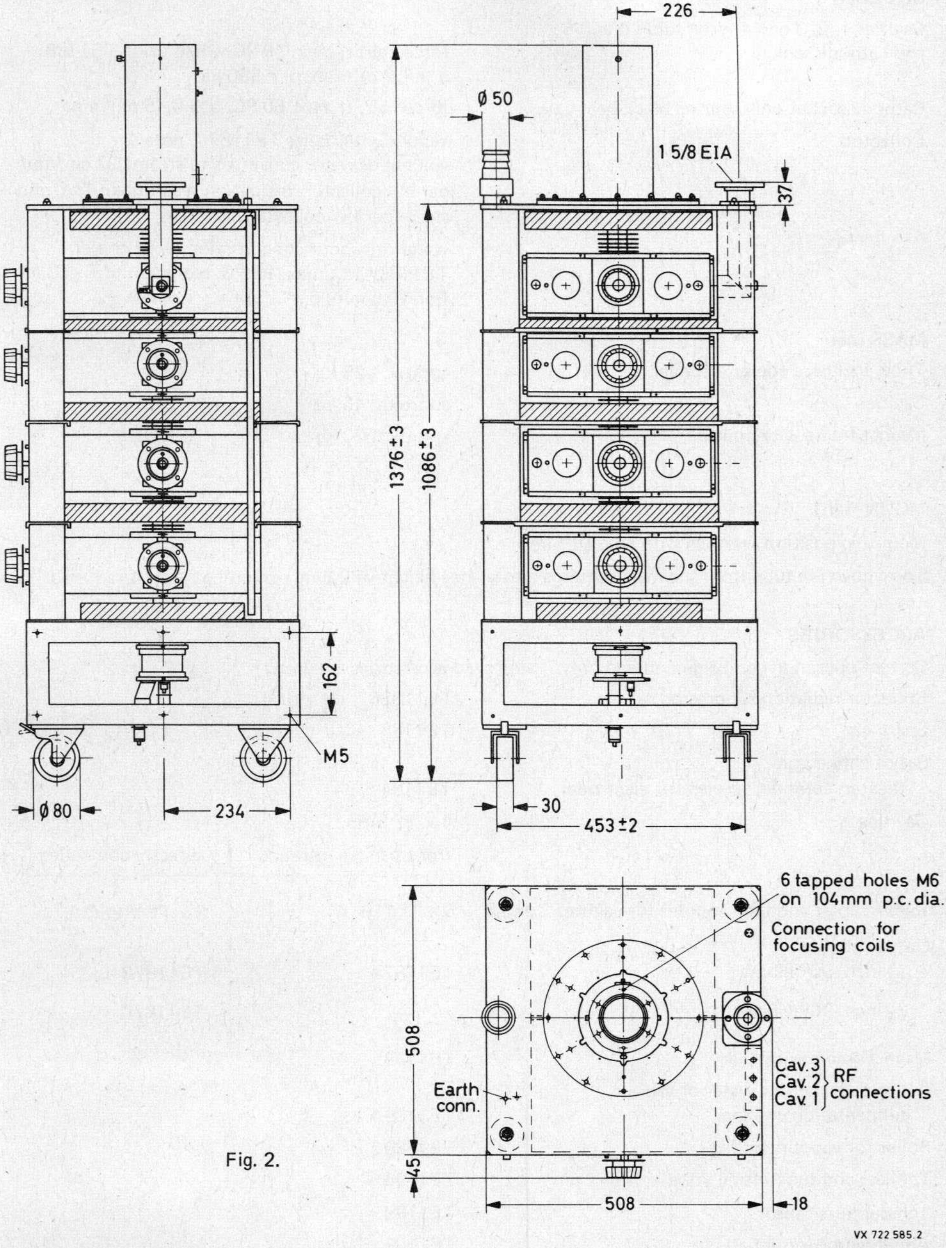

226
Ø 50
1 5/8 EIA
37
1376±3
1086±3
162
M5
Ø 80
234
30
453±2
6 tapped holes M6
on 104mm p.c.dia.
Connection for
focusing coils
508
Earth
conn.
Cav. 3
Cav. 2
Cav. 1
RF
connections
45
508
18
VX 722 585.2

Fig. 2.

COOLING

Cavities 1, 2, 3 and 4, drift tubes 4 and 5 and cathode socket	forced air, t_i max. 50 °C; when using TE1188: $q \approx 1{,}2\ m^3/min$, $p_i = 350\ Pa$
Cathode socket only, during black heat	forced air, t_i max. 50 °C, $q \approx 0{,}15\ m^3/min$
Collector	vapour with boiler TE1189C, note 4 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 cooler TE1189A) t_o max. 90 °C, see graph of Fig. 3. For 10 ℓ/min, p_i = 16 kPa.

MASS (net)

Tube, inclusive cooler or boiler	approx. 25 kg
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.

ACCESSORIES

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

Collector radiation suppressor	TE1182B	
Spark gap	TE1183	
Set of connectors (heater, cathode, accelerator electrode)	TE1184	
Cavities	4 x TE1185	
	front panel controlled	directly controlled
Inlet coupler and load coupler for cavities 2 and 3	3 x TE1186A	3 x TE1186C
Output coupler		
$1\frac{5}{8}$ inch, 90°-elbow	TE1187A	TE1187B
$3\frac{1}{8}$ inch, 90°-elbow	–	TE1187C
Magnet frame with coils	TE1188	
Collector jacket for water or vapour condensation cooling	TE1189A	
Boiler for vapour cooling	TE1189C	
Tool set and tube lifting yoke	TE1190	
Temperature sensor	TE1199	
Arc detector (optional)	TE1107	
Isolator (optional)	I 10/IV-N, I 10/V-N or I 10/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	note 5
Collector dissipation	max.	42	kW	
Load v.s.w.r.	max.	1,5		
Temperature of tube envelope	max.	175	°C	
Static pressure in the cooling system TE1189A	max.	600	kPa	(≈ 6 at)

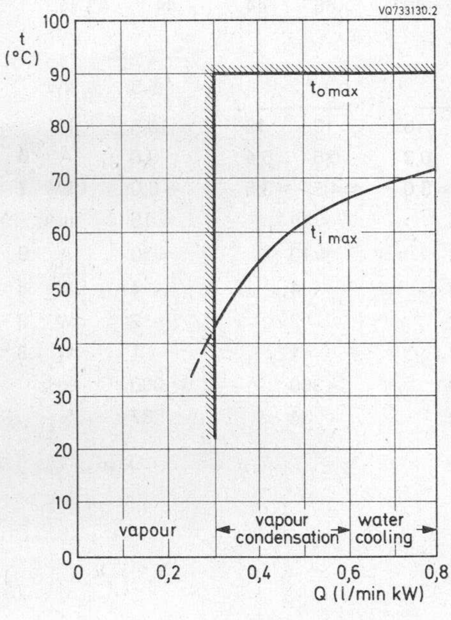


Fig. 3.

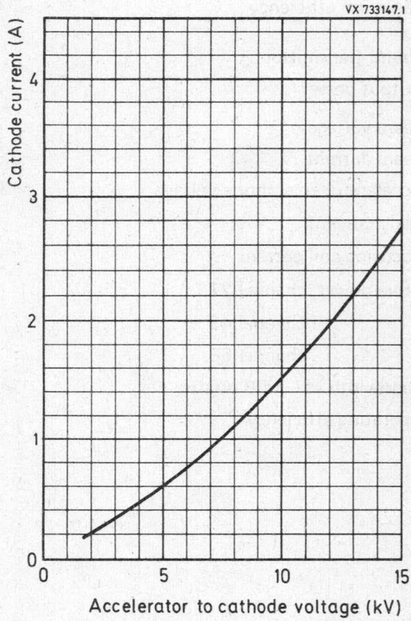


Fig. 4.

TYPICAL OPERATING CONDITIONS

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	%	

TYPICAL OPERATING CONDITIONS (continued)

As 15 kW vision transmitter

								notes
Standard CCIR:	G	I	G	I	G	I		10
Channel	21		45		68			
Output, peak sync.	16,5		16,5		16,5		kW	
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	16,5		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		%	

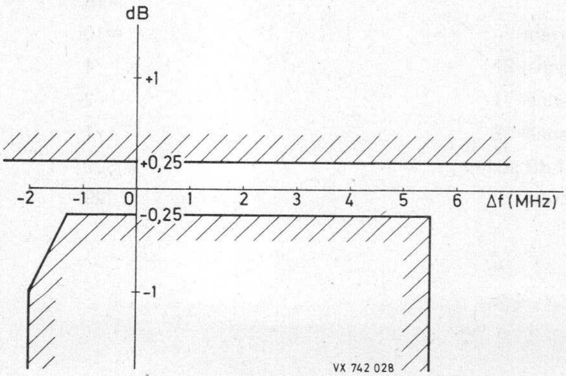
CAUTION

To limit X-radiation to officially permissible levels, fit collector radiation suppressor TE1182B and enclose the lower part of the magnet frame TE1188 in 1 mm sheet steel.

Keep away from the tube when it is in operation. R.F. leakage may be sufficient to cause bodily harm, particularly to the eyes. The risk is greater if the tube is functioning incorrectly.

Notes

1. When switching on the heater voltage, the heater current must never exceed a peak value of 70 A.
2. In case of a mains failure an interruption up to 30 s can be tolerated without new preheating. After min. 10 minutes of stand-by heating time at 4,5 V (black heat), the beam current may be switched on; the heater voltage must be increased to its nominal value of 5,5 V simultaneously.
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 (tolerance ± 5%) versus accelerator-to-cathode voltage, see Fig. 4.
7. Connect the accelerator electrode to its supply (power supply or voltage divider) via a 10 kΩ resistor. A voltage divider for adjusting the cathode 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. Value is not critical. It may be set in accordance with the vision klystron focusing coil current. Operation of one vision and one sound klystron focusing unit in series is permissible.
10. Standard CCIR-G: klystron tuned to frequency response according to the specification CCIR-G. Standard CCIR-I: klystron tuned to frequency response according to the following diagram:



U.H.F. POWER KLYSTRON

For u.h.f. band IV/V sound transmitters and vision transmitters of 10 and 15 kW.
Metal-ceramic construction, four external cavities, electromagnetic focusing and a high-stability dispenser-type cathode.
Suitable for water, vapour, or vapour-condensation cooling.
Comprising a non-intercepting annular beam control electrode for low-voltage beam modulation.

QUICK REFERENCE DATA

Frequency range	470 to 860 MHz
Cooling	vapour, vapour condensation, or water

HEATING; indirect by d.c. — notes: see page 8

Cathode	dispenser type			
Heater voltage	V_f		5,5 V*	
Heater current	I_f	≈	19 to 26 A	note 1
Cold heater resistance	R_{fo}	≈	25 mΩ	
Waiting time				note 2
from cold, V_f = 0 V	t_w	min.	300 s	
from black heat, V_f = 4,5 V	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 — notes 6,7

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

GETTER-ION PUMP SUPPLY

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 ± 3%.

MECHANICAL DATA

Dimensions in mm

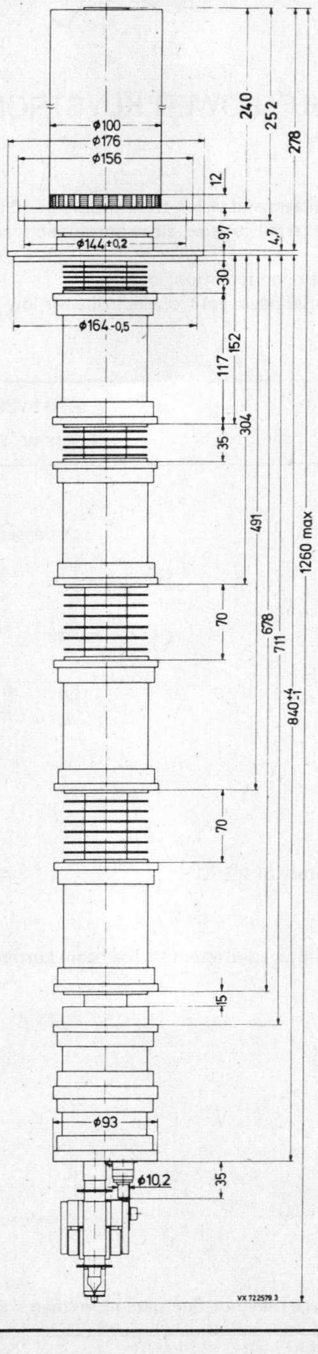


Fig. 1.

DEVELOPMENT SAMPLE DATA

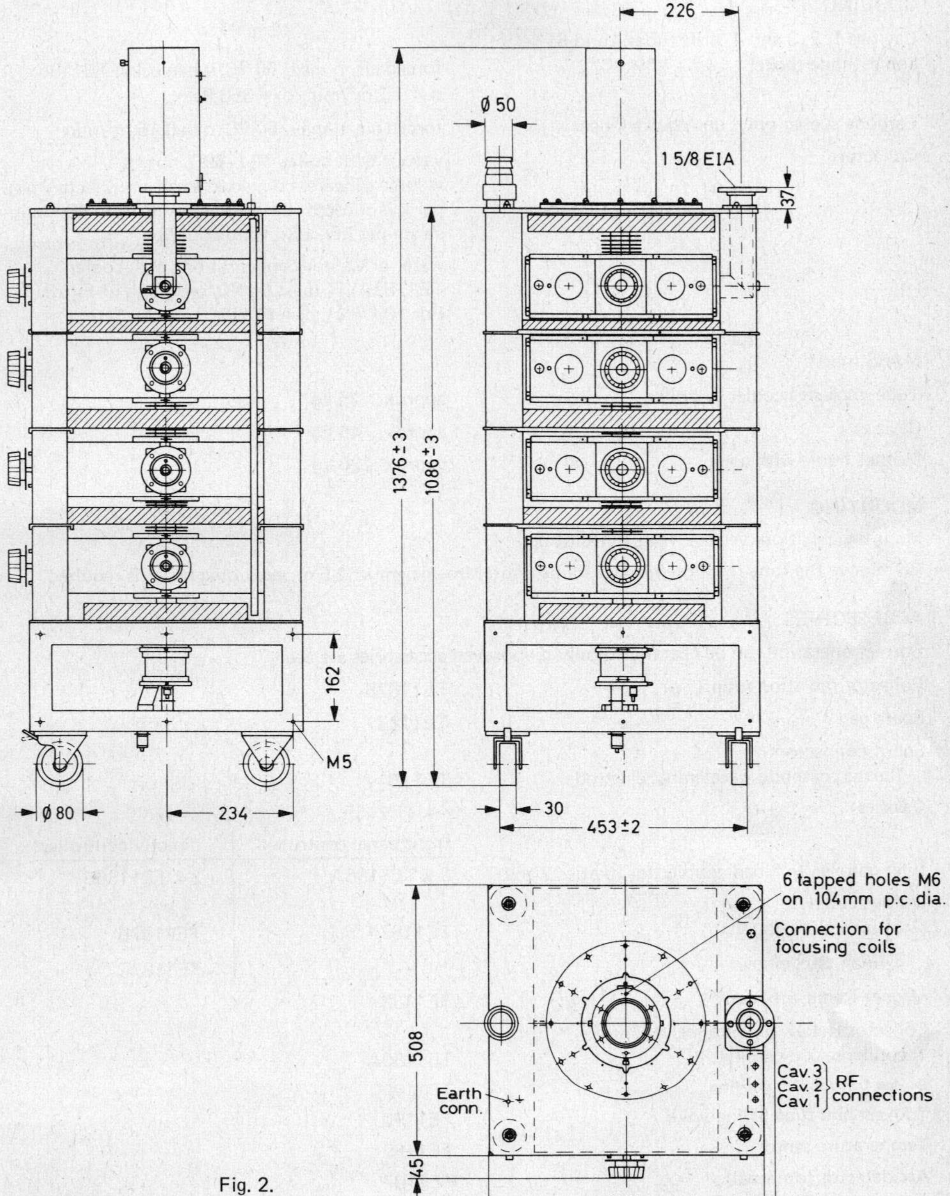


Fig. 2.

VX 722 585.2

COOLING

Cavities 1, 2, 3 and 4, drift tubes 4 and 5 and cathode socket	forced air, t_i max. 50 °C; when using TE1188: $q \approx 1{,}2\ m^3/min$, $p_i = 350$ Pa
Cathode socket only, during black heat	forced air, t_i max. 50 °C, $q \approx 0{,}15\ m^3/min$
Collector	vapour with boiler TE1189C, note 4 volume of water converted to steam: 27 cm^3/min per kW collector dissipation resulting in 43 ℓ/min steam per kW collector dissipation; water or vapour condensation (with cooler TE1189A) t_o max. 90 °C, see graph of Fig. 3. For 10 ℓ/min, p_i = 16 kPa.

MASS (net)

Tube, inclusive cooler or boiler	approx. 25 kg
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.

ACCESSORIES

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

Collector radiation suppressor	TE1182B	
Spark gap	TE1183	
Set of connectors (heater, cathode, accelerator electrode)	TE1184	
Cavities	4 x TE1185	
	front panel controlled	directly controlled
Inlet coupler and load coupler for cavities 2 and 3	3 x TE1186A	3 x TE1186C
Output coupler		
$1\frac{5}{8}$ inch, 90°-elbow	TE1187A	TE1187B
$3\frac{1}{8}$ inch, 90°-elbow	–	TE1187C
Magnet frame with coils	TE1188	
Collector jacket for water or vapour condensation cooling	TE1189A	
Boiler for vapour cooling	TE1189C	
Tool set and tube lifting yoke	TE1190	
Temperature sensor	TE1199	
Arc detector (optional)	TE1107	
Isolator (optional)	I 10/IV-N, I 10/V-N or I 10/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	note 5
Collector dissipation	max.	42	kW	
Load v.s.w.r.	max.	1,5		
Temperature of tube envelope	max.	175	°C	
Static pressure in the cooling system TE1189A	max.	600	kPa	(≈ 6 at)

DEVELOPMENT SAMPLE DATA

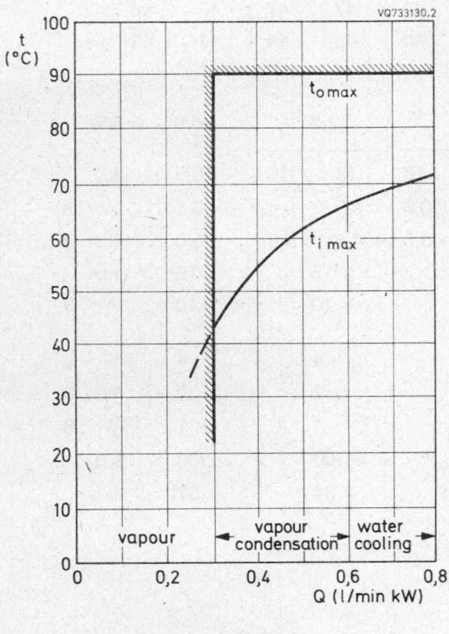


Fig. 3.

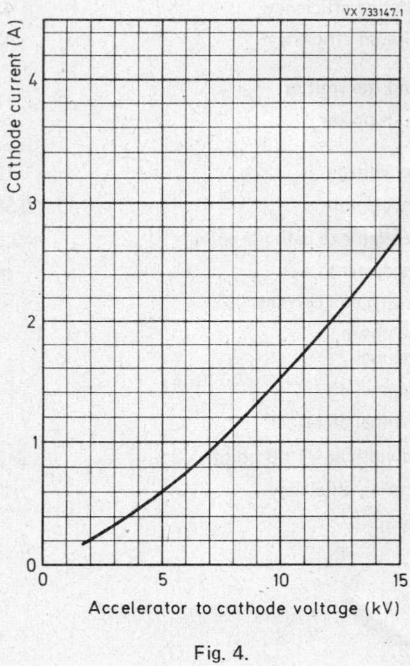


Fig. 4.

TYPICAL OPERATING CONDITIONS

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	10	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	%	

TYPICAL OPERATING CONDITIONS (continued)

As 15 kW vision transmitter

								notes
Standard CCIR:	G	I	G	I	G	I		10
Channel	21		45		68			
Output, 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	16,5		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		%	

DEVELOPMENT SAMPLE DATA

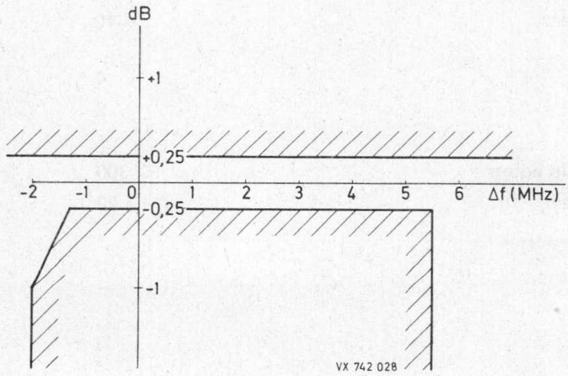
CAUTION

To limit X-radiation to officially permissible levels, fit collector radiation suppressor TE1182B and enclose the lower part of the magnet frame TE1188 in 1 mm sheet steel.

Keep away from the tube when it is in operation. R.F. leakage may be sufficient to cause bodily harm, particularly to the eyes. The risk is greater if the tube is functioning incorrectly.

Notes

1. When switching on the heater voltage, the heater current must never exceed a peak value of 70 A.
2. In case of a mains failure an interruption up to 30 s can be tolerated without new preheating. After min. 10 minutes of stand-by heating time at 4,5 V (black heat), the beam current may be switched-on; the heater voltage must be increased to its nominal value of 5,5 V simultaneously.
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 (tolerance ± 5%) versus accelerator-to-cathode voltage, see Fig. 4.
7. Connect the accelerator electrode to its supply (power supply or voltage divider) via a 10 kΩ resistor. A voltage divider for adjusting the cathode 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. Value is not critical. It may be set in accordance with the vision klystron focusing coil current. Operation of one vision and one sound klystron focusing unit in series is permissible.
10. Standard CCIR-G: klystron tuned to frequency response according to the specification CCIR-G
    Standard CCIR-I: klystron tuned to frequency response according to the following diagram:



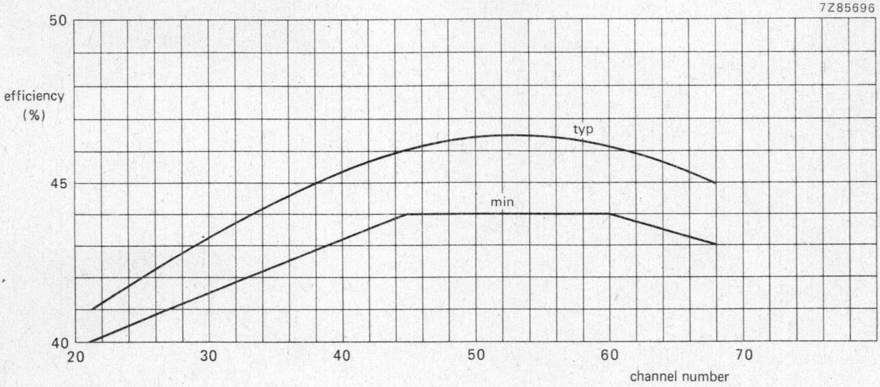

7Z85696
50
45
40
efficiency
(%)
typ
min
20
30
40
50
60
70
channel number

Fig. 5.

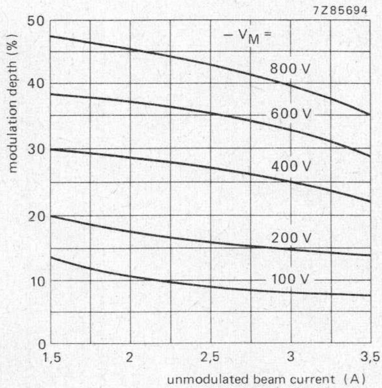

7Z85694
50
40
30
20
10
0
modulation depth (%)
$-V_M$ =
800 V
600 V
400 V
200 V
100 V
1,5
2
2,5
3
3,5
unmodulated beam current (A)

Fig. 6.

U.H.F. POWER KLYSTRON

For u.h.f. band IV/V sound transmitters and vision transmitters up to 25 kW.
Metal-ceramic construction, four external cavities, high-stability dispenser cathode.
Suitable for water, vapour, or vapour-condensation cooling.

QUICK REFERENCE DATA

Frequency range	470 to 860 MHz
Cooling	vapour, vapour condensation, or water

HEATING; indirect by d.c. — notes: see page B110

Cathode	dispenser type			
Heater voltage	V_f		5,5	V *
Heater current	I_f	≈	19 to 26	A note 1
Cold heater resistance	R_{fo}	≈	25	mΩ
Waiting time				note 2
from cold, $V_f = 0$ V	t_w	min.	300	s
from black heat, $V_f = 4,5$ V	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

notes 6, 7

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

GETTER-ION PUMP SUPPLY

note 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 ± 3%.

MECHANICAL DATA

Dimensions in mm

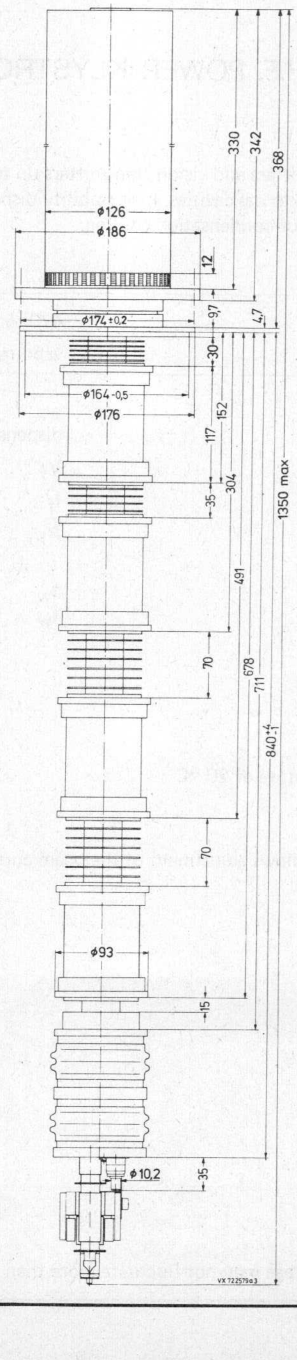


Fig. 1.

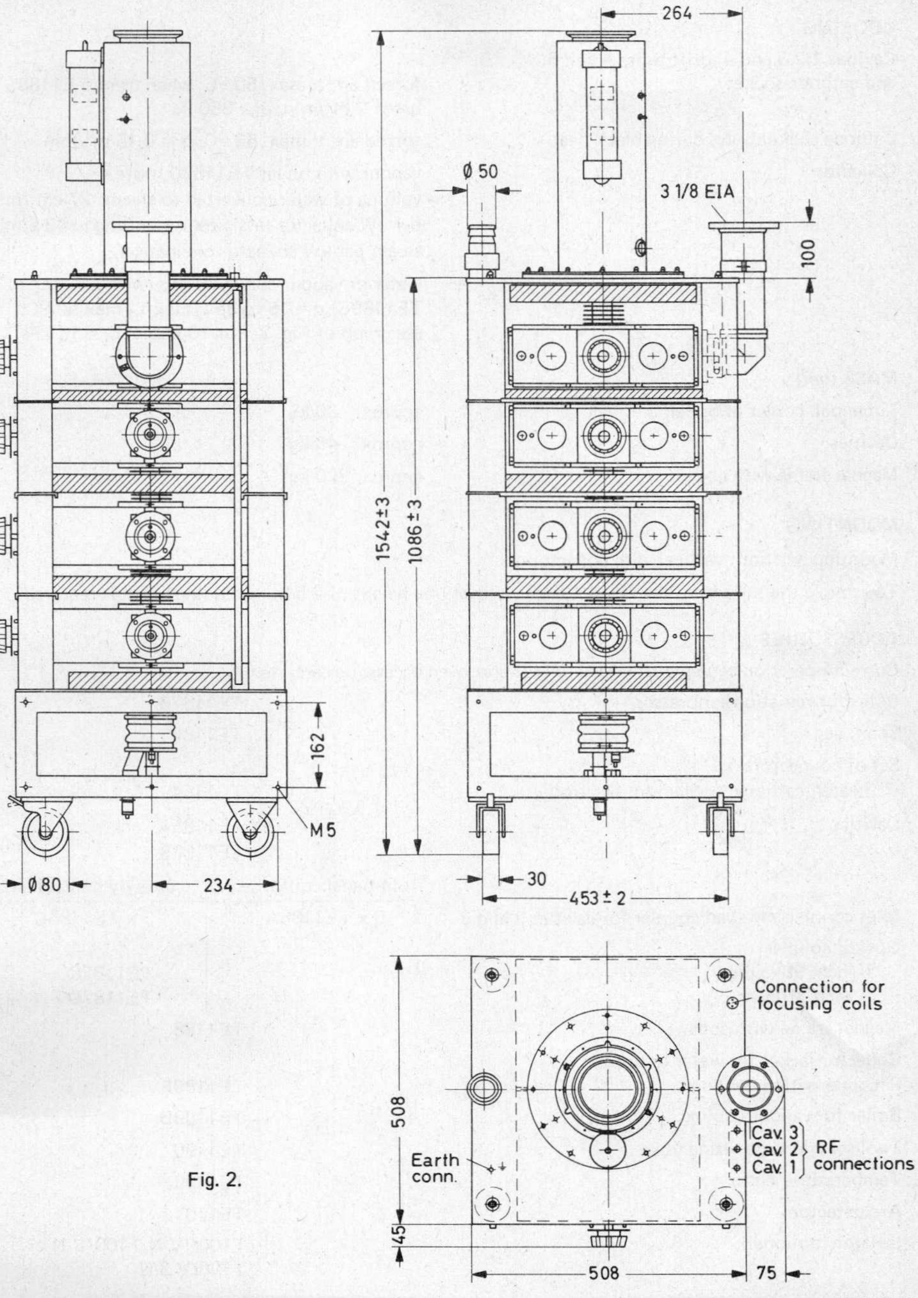

264
Ø 50
3 1/8 EIA
100
1542±3
1086±3
162
M5
Ø80
234
30
453±2
Connection for focusing coils
508
Cav. 3
Cav. 2
Cav. 1
RF connections
Earth conn.
45
508
75
VX 722 585a2

Fig. 2.

COOLING

Cavities 1,2,3 and 4, drift tubes 4 and 5 and cathode socket	forced air, t_i max. 50 °C; when using TE1188: $q \approx 1{,}2\ m^3/min$, p_i = 350 Pa
Cathode socket only, during black heat	forced air, t_i max. 50 °C, $q \approx 0{,}15\ m^3/min$
Collector	vapour with boiler TE1189D, note 4 volume of water converted to steam: 27 cm^3/min per kW collector dissipation resulting in 43 ℓ/min steam per kW collector dissipation; water or vapour condensation (with cooler TE1189B) q = 16 to 36 ℓ/min, t_o max 90 °C, see graph of Fig. 3. For 10 ℓ/min, p_i = 16 kPa.

MASS (net)

Tube incl. cooler or boiler	approx. 30 kg
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.

ACCESSORIES

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

Collector radiation suppressor	TE1182B	
Spark gap	TE1183	
Set of connectors (heater, cathode, accelerator electrode)	TE1184	
Cavities	3 x TE1185A 1 x TE1185B	
	front panel controlled	directly controlled
Inlet coupler and load coupler for cavities 2 and 3	3 x TE1186A	3 x TE1186C
Output coupler		
$3\frac{1}{8}$ inch, 90°-elbow	–	TE1187C
$3\frac{1}{8}$ inch, straight	–	TE1187D
Magnet frame with coils	TE1188	
Collector jacket for water or vapour condensation cooling	TE1189F	
Boiler for vapour cooling	TE1189D	
Tool set and tube lifting yoke	TE1190	
Temperature sensor	TE1199	
Arc detector	TE1107	
Isolator (optional)	T100/IV-N,T100/V-N or 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	note 5
Collector dissipation	max.	70	kW	
Load v.s.w.r.	max.	1,5		
Temperature of tube envelope	max.	175	°C	
Static pressure in the cooling system TE1189B	max.	600	kPa	(≈ 6 at)

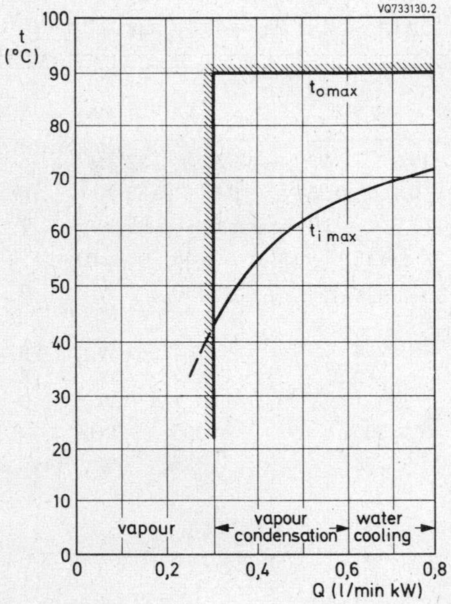


Fig. 3.

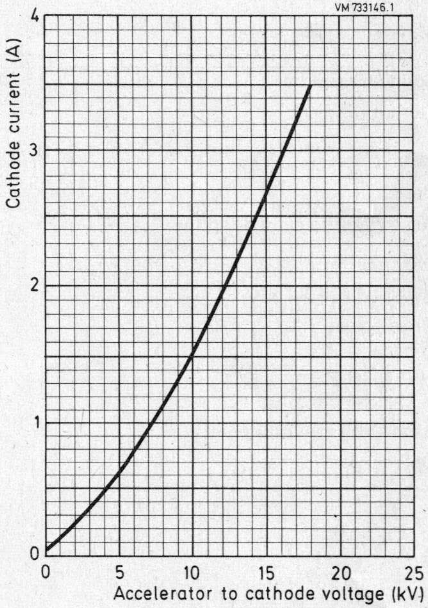


Fig. 4.

TYPICAL OPERATING CONDITIONS

As 20 kW vision transmitter

					notes
Standard CCIR:	G	G	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		%	

TYPICAL OPERATING CONDITIONS (continued)

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	5,5		kW	
Beam voltage	19	23,5	kV	
Beam current	0,7	0,55	A	6
Accelerator to cathode voltage	≈ 5,5	≈ 4,5	kV	7
Body current	≈ 15		mA	
Focusing coil current	≈ 10		A	9
Drive power,				
channel 21	4		W	8
channel 45	2		W	8
channel 68	1		W	8
Bandwidth at −1 dB points	⩾ 300		kHz	
Operating efficiency	41		%	

Notes see next page.

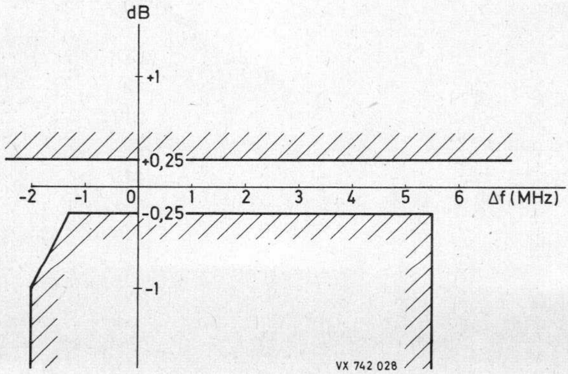
CAUTION

To limit X-radiation to officially permissible levels, fit collector radiation suppressor TE1182B and enclose the lower part of the magnet frame TE1188 in 1 mm sheet steel.

Keep away from the tube when it is in operation. R.F. leakage may be sufficient to cause bodily harm, particularly to the eyes. The risk is greater if the tube is functioning incorrectly.

Notes

1. When switching on the heater voltage, the heater current must never exceed a peak value of 70 A.
2. In case of a mains failure an interruption up to 30 s can be tolerated without new preheating. After min. 10 minutes of stand-by heating time at 4,5 V (black heat), the beam current may be switched on; the heater voltage must be increased to its nominal value of 5,5 V simultaneously.
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 (tolerance ± 5%) versus accelerator-to-cathode voltage, see Fig. 4.
7. Connect the accelerator electrode to its supply (power supply or voltage divider) via a 10 kΩ resistor. A voltage divider for adjusting the cathode 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. Value is not critical. It may be set in accordance with the vision klystron focusing coil current. Operation of one vision and one sound klystron focusing unit in series is permissible.
10. Standard CCIR-G: klystron tuned to frequency response according to the specification CCIR-G
    Standard CCIR-I: klystron tuned to frequency response according to the following diagram:



U.H.F. POWER KLYSTRON

For u.h.f. band IV/V sound transmitters and vision transmitters of 20 and 25 kW.
Metal-ceramic construction, four external cavities, electromagnetic focusing and a high-stability dispenser-type cathode.
Suitable for water, vapour, or vapour-condensation cooling.
Comprising a non-intercepting annular beam control electrode for low-voltage beam modulation.

QUICK REFERENCE DATA

Frequency range	470 to 860 MHz
Cooling	vapour, vapour condensation, or water

HEATING; indirect by d.c.

notes: see page B118

Cathode	dispenser type				
Heater voltage	V_f		5,5	V*	
Heater current	I_f	≈	19 to 26	A	note 1
Cold heater resistance	R_{fo}	≈	25	mΩ	
Waiting time					note 2
from cold, V_f = 0 V	t_w	min.	300	s	
from black heat, V_f = 4,5 V	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

notes 6, 7

The klystron comprises a non-intercepting annular beam control electrode for low-voltage beam modulation. See Fig. 6.
The accelerator electrode voltage allows adjustment of the beam current between 0 and 100%.

GETTER-ION PUMP SUPPLY

note 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 ± 3%.

MECHANICAL DATA

Dimensions in mm

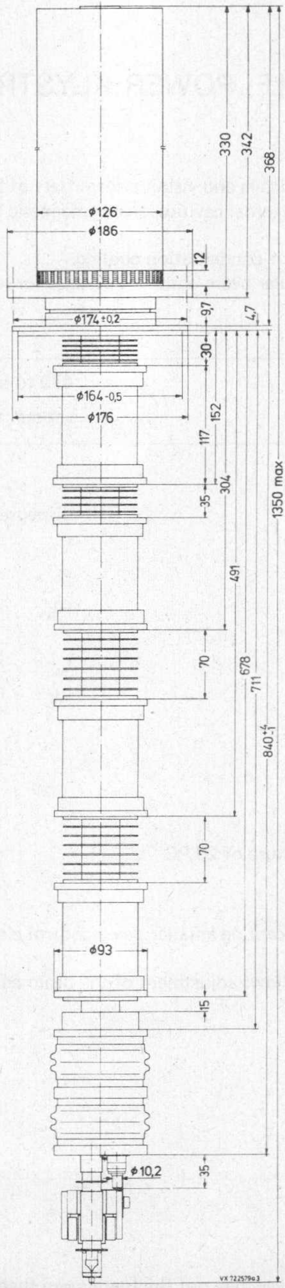


Fig. 1.

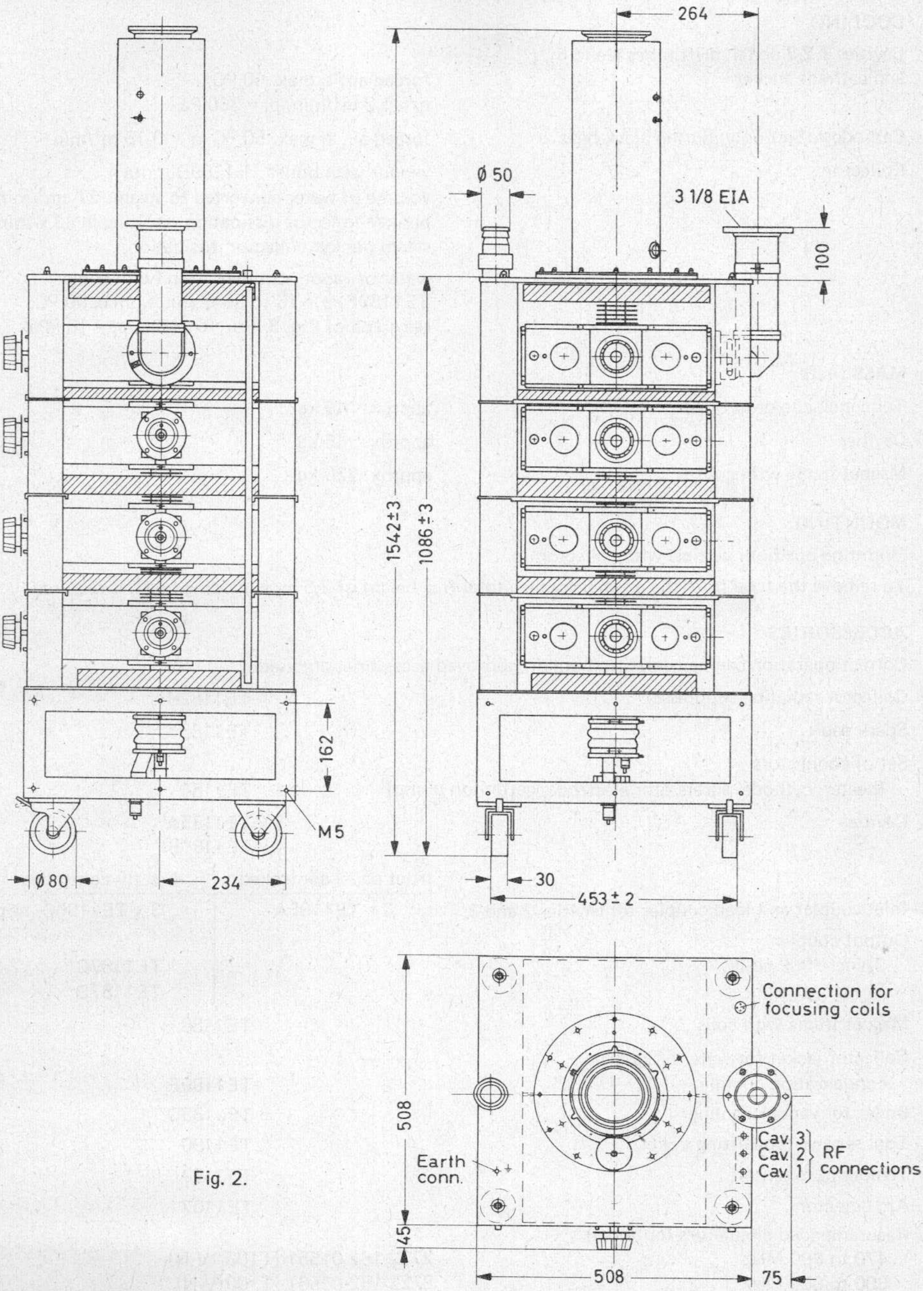


Fig. 2.

VX 722 585a3

COOLING

Cavities 1,2,3 and 4, drift tubes 4 and 5 and cathode socket	forced air, t_i max. 50 °C; $q \approx 1{,}2\ m^3/min$, $p_i = 350$ Pa
Cathode socket only, during black heat	forced air, t_i max. 50 °C, $q \approx 0{,}15\ m^3/min$
Collector	vapour with boiler TE1189D, note 4 volume of water converted to steam: 27 cm^3/min per kW collector dissipation resulting in 43 ℓ/min steam per kW collector dissipation; water or vapour condensation (with cooler TE1189F) q = 16 to 36 ℓ/min, t_o max 90 °C, see graph of Fig. 3. For 10 ℓ/min, p_i = 16 kPa.

MASS (net)

Tube incl. cooler or boiler	approx. 40 kg
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.

ACCESSORIES

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

Collector radiation suppressor	TE1182B	
Spark gap	TE1183	
Set of connectors (heater, cathode, accelerator electrode, getter-ion pump)	TE1184	
Cavities	3 x TE1185A 1 x TE1185B	
	front panel controlled	directly controlled
Inlet coupler and load coupler for cavities 2 and 3	3 x TE1186A	3 x TE1186C note 11
Output coupler		
$3\frac{1}{8}$ inch, 90°-elbow	–	TE1187C
$3\frac{1}{8}$ inch, straight	–	TE1187D
Magnet frame with coils	TE1188	
Collector jacket for water or vapour condensation cooling	TE1189F	
Boiler for vapour cooling	TE1189D	
Tool set and tube lifting yoke	TE1190	
Temperature sensor	TE1199	
Arc detector	TE1107	
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	note 5
Collector dissipation	max.	70	kW	
Load v.s.w.r.	max.	1,5		
Temperature of tube envelope	max.	175	°C	
Static pressure in the cooling system TE1189F	max.	600	kPa	(≈ 6 at)
Focusing coil current	max.	11,5	A	
Modulation electrode voltage	max.	1000	V	

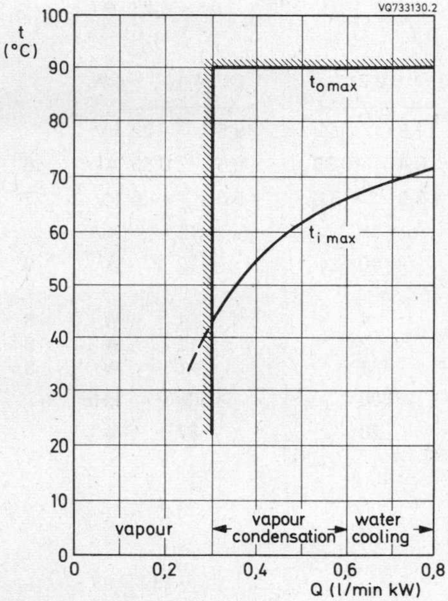


Fig. 3.

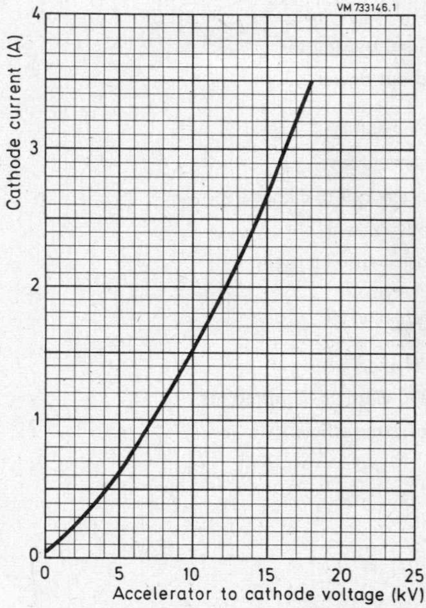


Fig. 4.

TYPICAL OPERATING CONDITIONS, (modulation electrode at cathode potential)

As 20 kW vision transmitter

					notes
Standard CCIR:	G	G	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		%	

TYPICAL OPERATING CONDITIONS (continued)

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

				notes
Output power	5,5		kW	
Beam voltage	19	23,5	kV	
Beam current	0,7	0,55	A	6
Accelerator to cathode voltage	≈ 5,5	≈ 4,5	kV	7
Body current	≈ 15		mA	
Focusing coil current	≈ 10		A	9
Drive power,				
channel 21	4		W	8
channel 45	2		W	8
channel 68	1		W	8
Bandwidth at −1 dB points	⩾ 300		kHz	
Operating efficiency	41		%	

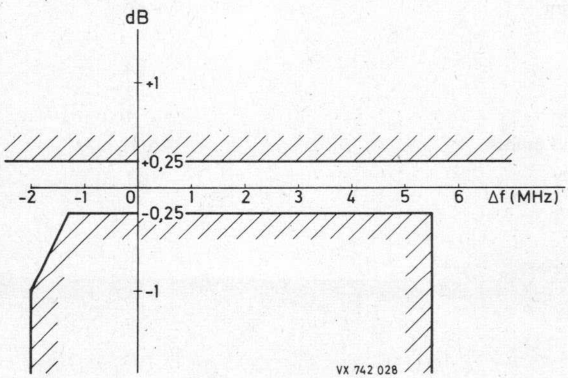
CAUTION

To limit X-radiation to officially permissible levels, fit collector radiation suppressor TE1182B and enclose the lower part of the magnet frame TE1188 in 1 mm sheet steel.

Keep away from the tube when it is in operation. R.F. leakage may be sufficient to cause bodily harm, particularly to the eyes. The risk is greater if the tube is functioning incorrectly.

Notes

1. When switching on the heater voltage, the heater current must never exceed a peak value of 70 A.
2. In case of a mains failure an interruption up to 30 s can be tolerated without new preheating. After min. 10 minutes of stand-by heating time at 4,5 V (black heat), the beam current may be switched on; the heater voltage must be increased to its nominal value of 5,5 V simultaneously.
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 (tolerance ± 5%) versus accelerator-to-cathode voltage, see Fig. 4.
7. Connect the accelerator electrode to its supply (power supply or voltage divider) via a 10 kΩ resistor. A voltage divider for adjusting the cathode 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. Value is not critical. It may be set in accordance with the vision klystron focusing coil current. Operation of one vision and one sound klystron focusing unit in series is permissible.
10. Standard CCIR-G: klystron tuned to frequency response according to the specification CCIR-G
    Standard CCIR-I: klystron tuned to frequency response according to the following diagram:



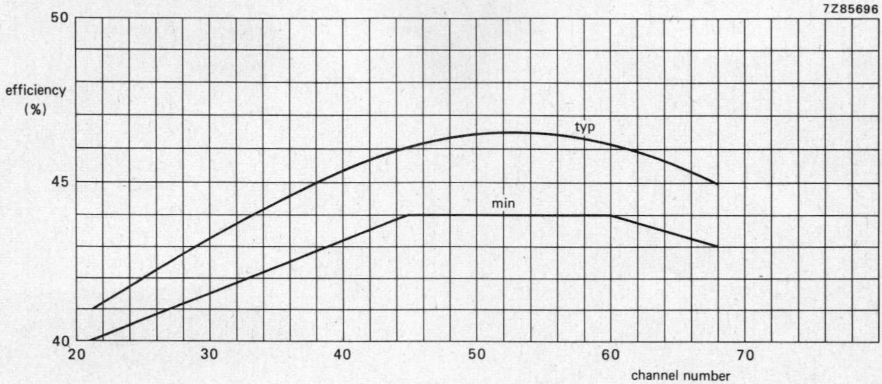

7Z85696
efficiency (%)
50
45
40
20
30
40
50
60
70
channel number
typ
min

Fig. 5.

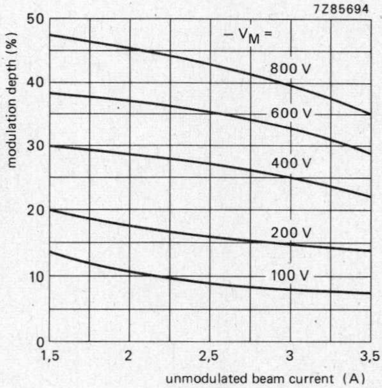

7Z85694
modulation depth (%)
50
40
30
20
10
0
1,5
2
2,5
3
3,5
unmodulated beam current (A)
– V_M =
800 V
600 V
400 V
200 V
100 V

Fig. 6.

U.H.F. POWER KLYSTRONS

Optionally vapour, vapour condensation, or water-cooled power klystrons in metal-ceramic construction for 55 kW vision transmitters and sound transmitters in the U.H.F. bands IV/V. The tubes have four external cavities, electromagnetic focusing and a high stability dispenser-type cathode. They contain non-intercepting annular beam control electrodes for low-voltage beam modulation.

QUICK REFERENCE DATA

Frequency range	
YK1290	470 to 610 MHz
YK1291	590 to 720 MHz
YK1292	710 to 860 MHz
Cooling	vapour, vapour condensation, or water

HEATING: indirect by d.c.

notes; see page B129

Cathode	dispenser type				
Heater voltage	V_f		8,5	V*	
Heater current	I_f	≈	22 to 27	A	note 1
Cold heater resistance	R_{fo}	≈	30	mΩ	
Waiting time					note 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: 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 note 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 ± 3%.

MECHANICAL DATA YK1290

Dimensions in mm

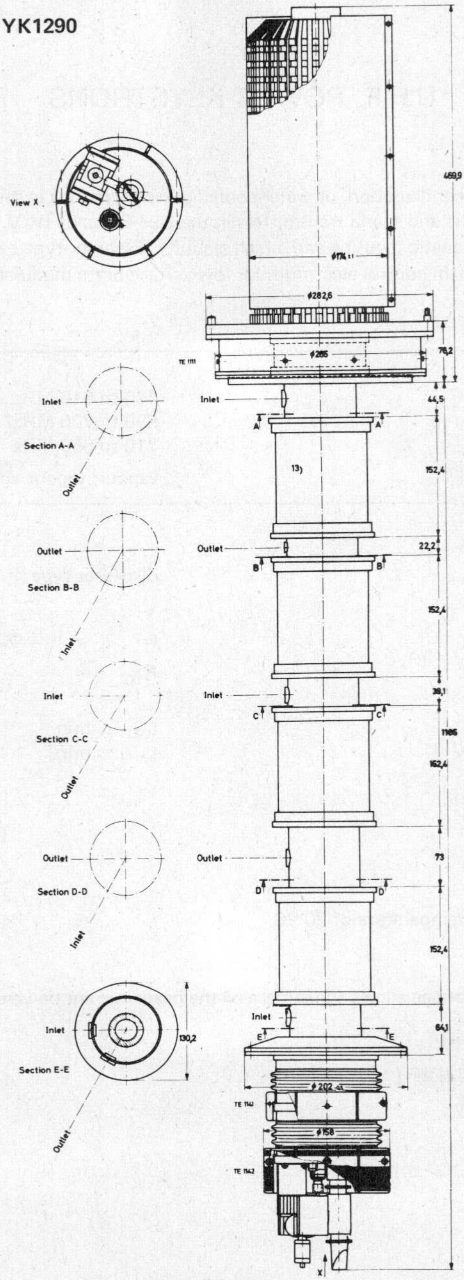


Fig. 1.

DEVELOPMENT SAMPLE DATA

YK1291, YK1292

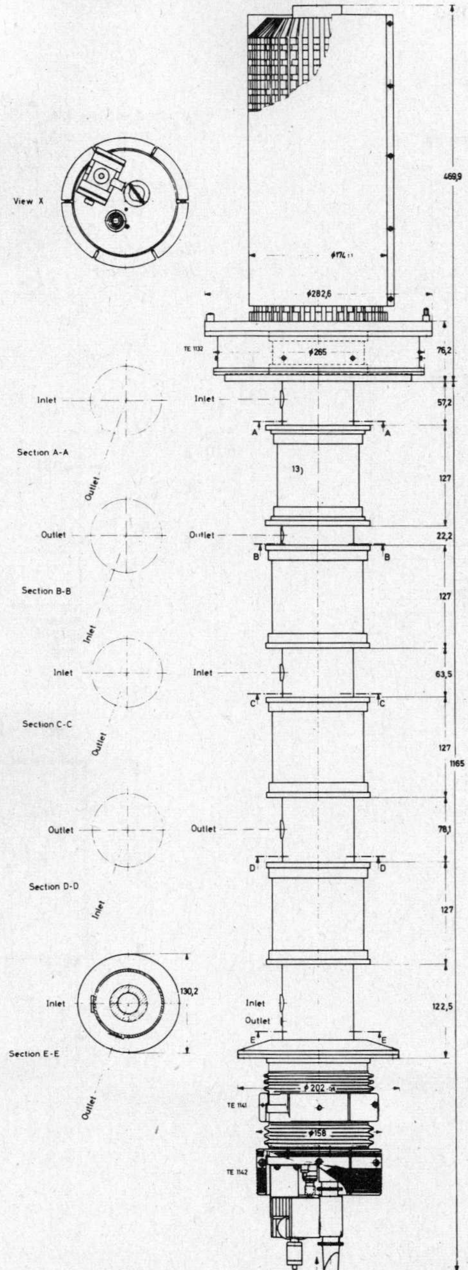


Fig. 2.

Mechanical outlines of trolley

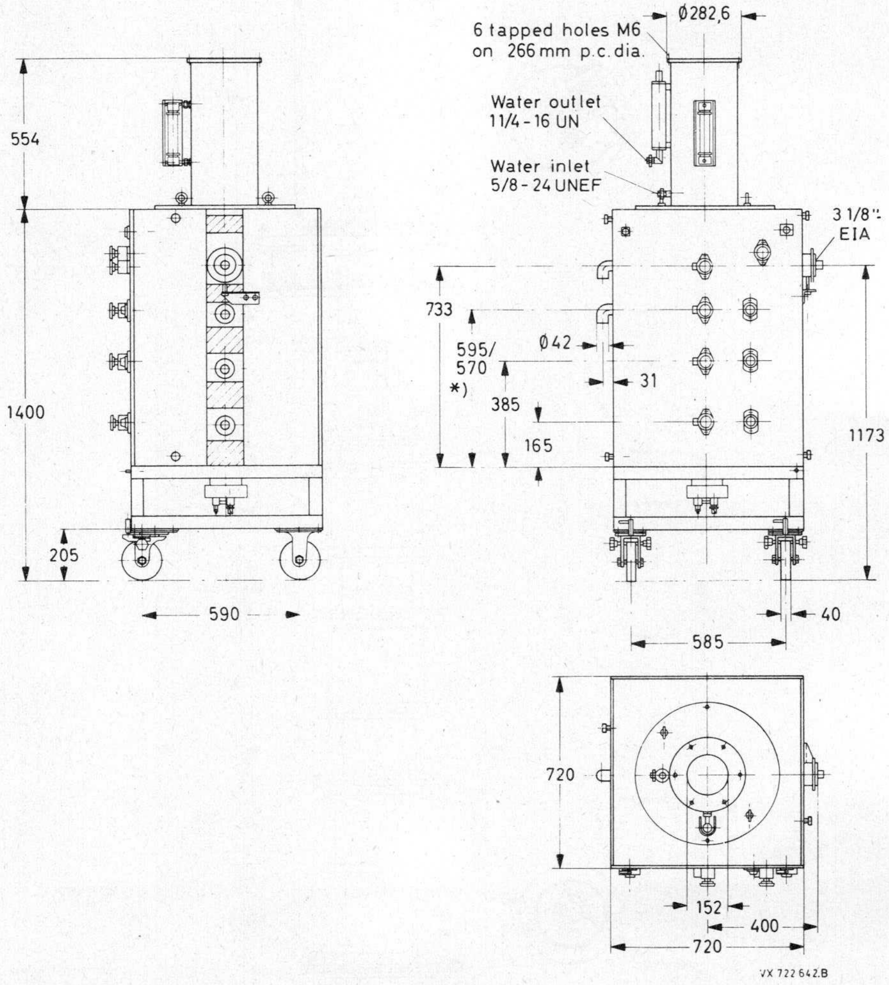


Fig. 3.

* YK1290 = 570 mm
YK1291/1292 = 595 mm

COOLING

Cathode socket and accelerator electrode	air; q ≈ 0,15 m^3/min, t_i max. 40 °C
Collector	vapour (with boiler TE1110), note 4 volume of water converted to steam: 27 cm^3/min per kW collector dissipation resulting in 43 ℓ/min steam per kW collector dissipation 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 ≈ 9 ℓ/min, t_i max. 80 °C, p_i = 200 kPa
Cavities 3 and 4	forced air; q = 1,5 m^3/min, p_i = 250 Pa, t_i max. 45 °C

MASS (net)

Tube	approx. 80 kg
Cavities	approx. 45 kg
Magnet frame with coils and boiler or cooler	approx. 855 kg

DEVELOPMENT SAMPLE DATA

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. 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:

Collector radiation suppressor

Accelerator electrode ring

Cathode ring

Set of sealing rings

	YK1290	YK1291	YK1292
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

ACCESSORIES (continued)	YK1290	YK1291	YK1292
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 2 x TE1133B	6 x TE1133A 2 x TE1133B	6 x TE1133A 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 1 x TE1121D	3 x TE1098A 1 x TE1098D	3 x TE1191A 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
C. Spare and optional parts			
Collector radiation suppressor	TE1111	TE1132	TE1195
Accelerator electrode ring	TE1141	TE1141	TE1141
Cathode ring	TE1142	TE1142	TE1142
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 v.s.w.r.	max.	1,5		
Temperature of tube envelope	max.	175	°C	
Static pressure	max.	600	kPa	note 6
Modulation electrode voltage	max.	1000	V	

CAUTION – HEALTH HAZARD

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 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.

2. 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.

Instruction manual

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

DEVELOPMENT SAMPLE DATA

TYPICAL OPERATING CONDITIONS

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

	YK1290/YK1291			YK1292				
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	16,5	16	21	17	16	kV	
Body current								
without drive	15	15	15	15	15	15	mA	
at 58/45 kW peak sync., 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.								
YK1290 - channel 21	10	6	6	–	–	–	W	note 9
channel 38	7	4	4	–	–	–	W	note 9
YK1291 - channel 37	7	4	4	–	–	–	W	note 9
channel 51	5	3	3	–	–	–	W	note 9
YK1292	–	–	–	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 11/8 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 14
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	

Notes

1. When switching on the heater voltage, the heater current must never exceed a peak value of 65 A.
2. In cases of a mains failure an interruption up to 30 s can be tolerated without new preheating. After min. 10 minutes of stand-by heating time at 6,0 V, the beam current may be switched on; the heater voltage must be increased to its nominal value of 8,5 V simultaneously. Operation under stand-by conditions is restricted to continuous periods of 2 weeks at a time. Stand-by periods should be separated by similar periods of rest or full operation.
3. To ensure that the klystron is ready for immediate operation the getter-ion pump should be operated at least every 6 months during storage, 3 months being recommended. For details see klystron instruction manual.
4. In order to avoid corrosion of the cooling system, pure deionised water must be used as the coolant (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 tubes 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 a 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. Varying the input level between black and white at any sideband frequency within this bandwidth will not cause a variation of the peak sync. output power exceeding 0,5 dB.
11. Measured with a sawtooth signal from black level to peak white occurring 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 white occurring at each line.
13. Where the ceramic of the output section is beryllium oxide, this is indicated on the tube. The dust of beryllium oxide is toxic. For the disposal of burnt-out tubes observe government regulations.
14. For adjusting the beam current in sound operation a voltage divider should be dimensioned according to an accelerator electrode current of max. 1,5 mA.

DEVELOPMENT SAMPLE DATA

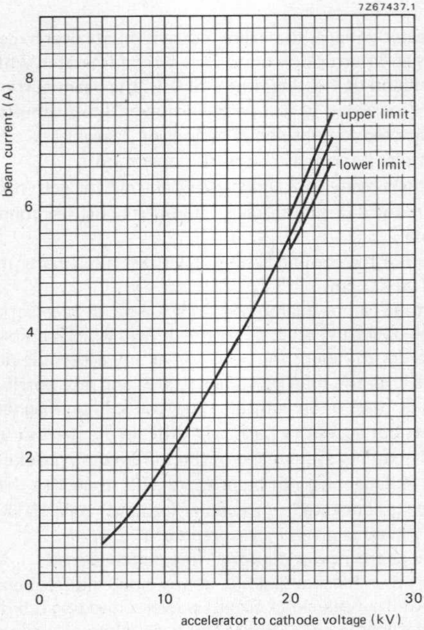


Fig. 4.

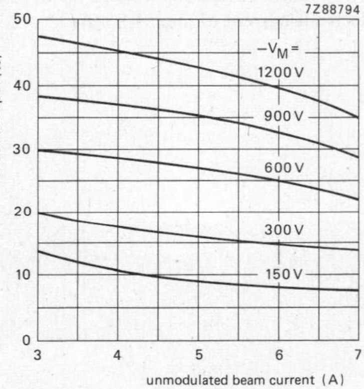


Fig. 5 Parameter: modulation voltage $-V_M$ (with respect to cathode).

U.H.F. POWER KLYSTRONS

Optionally vapour, vapour condensation, or water-cooled power klystrons in metal-ceramic construction for 55 kW vision transmitters and sound transmitters in the U.H.F. bands IV/V. The tubes have four external cavities, electromagnetic focusing and a high stability dispenser-type cathode. They contain non-intercepting annular beam control electrodes 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
Cooling	vapour, vapour condensation, or water

HEATING: indirect by d.c. notes; see page B139

Cathode	dispenser type				
Heater voltage	V_f		8,5	V*	
Heater current	I_f	≈	22 to 27	A	note 1
Cold heater resistance	R_{fo}	≈	30	mΩ	
Waiting time					note 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: 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 klystrons contain a non-intercepting annular beam control electrode for low-voltage beam modulation. See Fig. 5.
The accelerator electrode voltage allows adjustment of the beam current between 0 and 100%.

GETTER–ION PUMP SUPPLY note 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 ± 3%.

MECHANICAL DATA YK1295

Dimensions in mm

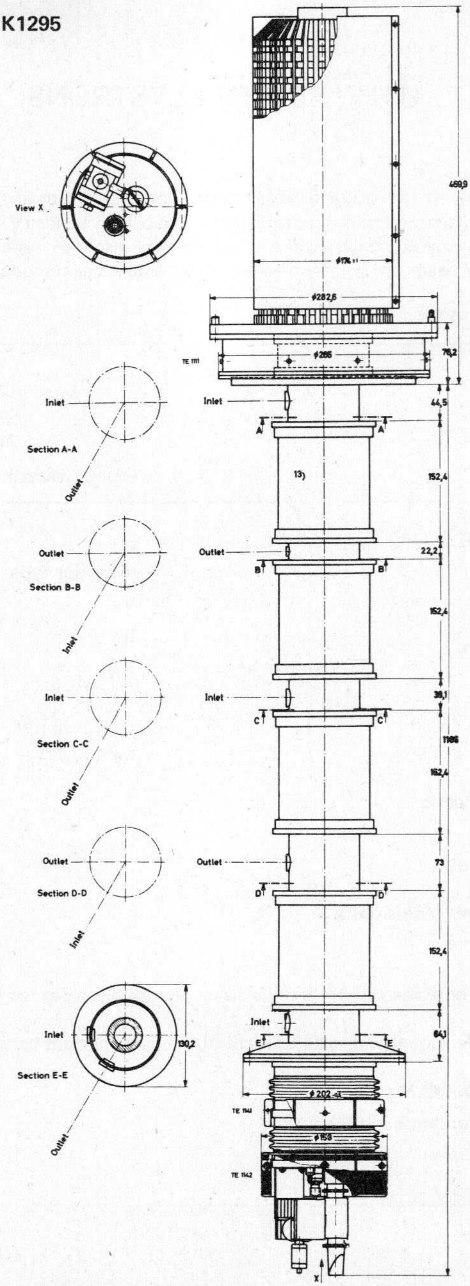


Fig. 1.

DEVELOPMENT SAMPLE DATA

YK1296, YK1297

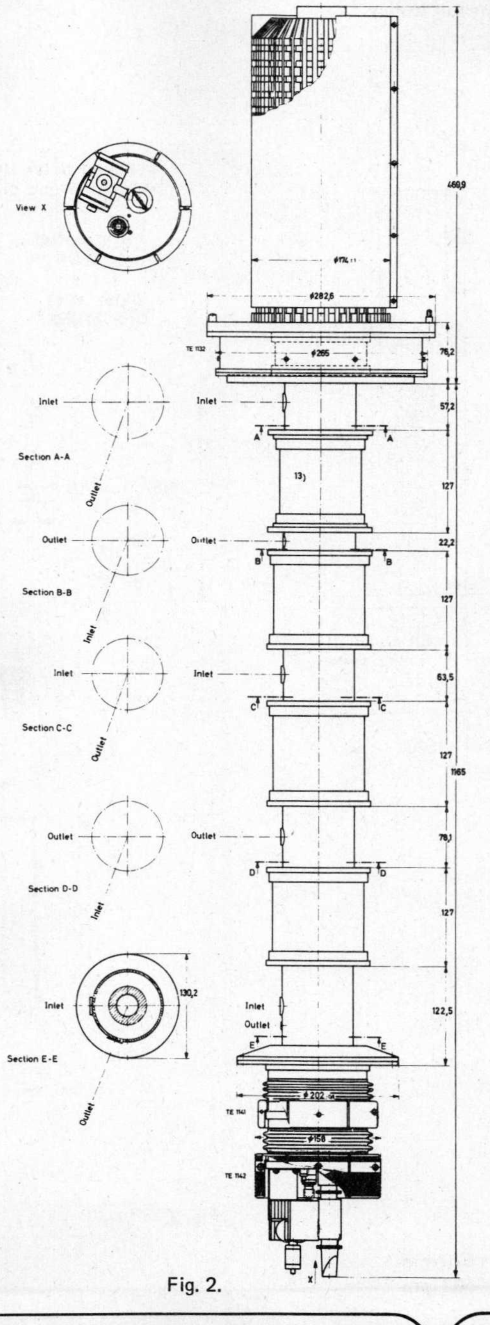


Fig. 2.

Mechanical outlines of trolley

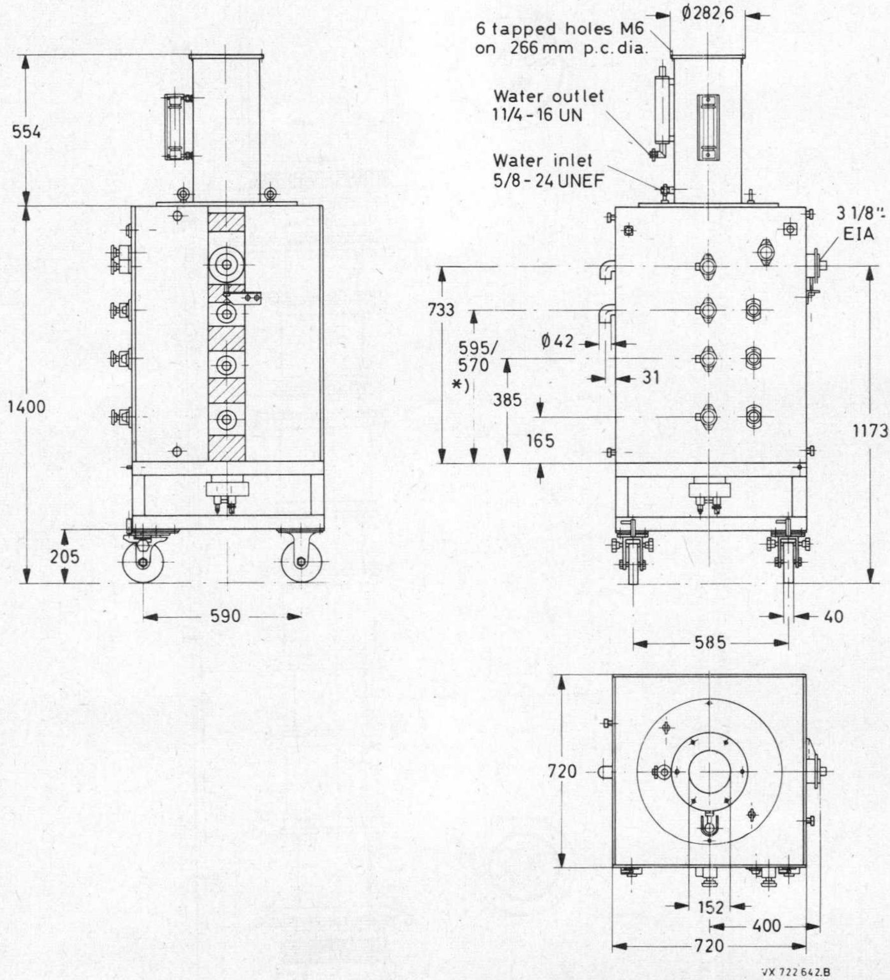


Fig. 3.

* YK1295 = 570 mm
YK1296/1297 = 595 mm

COOLING

Cathode socket and accelerator electrode	air; q ≈ 0,15 m^3/min, t_i max. 40 °C
Collector	vapour (with boiler TE1110), note 4 volume of water converted to steam: 27 cm^3/min per kW collector dissipation resulting in 43 ℓ/min steam per kW collector dissipation 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 ≈ 9 ℓ/min, t_i max. 80 °C, p_i = 200 kPa
Cavities 3 and 4	forced air; q = 1,5 m^3/min, p_i = 250 Pa, t_i max. 45 °C

MASS (net)

Tube	approx. 80 kg
Cavities	approx. 45 kg
Magnet frame with coils and boiler or cooler	approx. 855 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. 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:

Collector radiation suppressor

Accelerator electrode ring

Cathode ring

Set of sealing rings

	YK1295	YK1296	YK1297
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

DEVELOPMENT SAMPLE DATA

ACCESSORIES (continued)	YK1295	YK1296	YK1297
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 2 x TE1133B	6 x TE1133A 2 x TE1133B	6 x TE1133A 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 1 x TE1121D	3 x TE1098A 1 x TE1098D	3 x TE1191A 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
C. Spare and optional parts			
Collector radiation suppressor	TE1111	TE1132	TE1195
Accelerator electrode ring	TE1141	TE1141	TE1141
Cathode ring	TE1142	TE1142	TE1142
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 v.s.w.r.	max.	1,5		
Temperature of tube envelope	max.	175	°C	
Static pressure	max.	600	kPa	note 6
Modulation electrode voltage	max.	1000	V	

CAUTION – HEALTH HAZARD

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 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.

2. 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.

Instruction manual

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

TYPICAL OPERATING CONDITIONS

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

	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	16,5	16	21	17	16	kV	
Body current								
without drive	15	15	15	15	15	15	mA	
at 58/45 kW peak sync., 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.								
YK1295 - channel 21	10	6	6	–	–	–	W	note 9
channel 38	7	4	4	–	–	–	W	note 9
YK1296 - channel 37	7	4	4	–	–	–	W	note 9
channel 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	
Satuartion efficiency	44	47,5	48	43	45	46,5	%	

As 11/8 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 14
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	

Notes

1. When switching on the heater voltage, the heater current must never exceed a peak value of 65 A.
2. In cases of a mains failure an interruption up to 30 s can be tolerated without new preheating. After min. 10 minutes of stand-by heating time at 6,0 V, the beam current may be switched on; the heater voltage must be increased to its nominal value of 8,5 V simultaneosuly. Operation under stand-by conditions is restricted to continuous periods of 2 weeks at a time. Stand-by periods should be separated by similar periods of rest or full operation.
3. To ensure that the klystron is ready for immediate operation the getter-ion pump should be operated at least every 6 months during storage, 3 months being recommended. For details see klystron instruction manual.
4. In order to avoid corrosion of the cooling system, pure deionised water must be used as the coolant (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 tubes 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 a 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. Varying the input level between black and white at any sideband frequency within this bandwidth will not cause a variation of the peak sync. output power exceeding 0,5 dB.
11. Measured with a sawtooth signal from black level to peak white occurring 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 white occurring at each line.
13. Where the ceramic of the output section is beryllium oxide, this is indicated on the tube. The dust of beryllium oxide is toxic. For the disposal of burnt-out tubes observe government regulations.
14. For adjusting the beam current in sound operation a voltage divider should be dimensioned according to an accelerator electrode current of max. 1,5 mA.

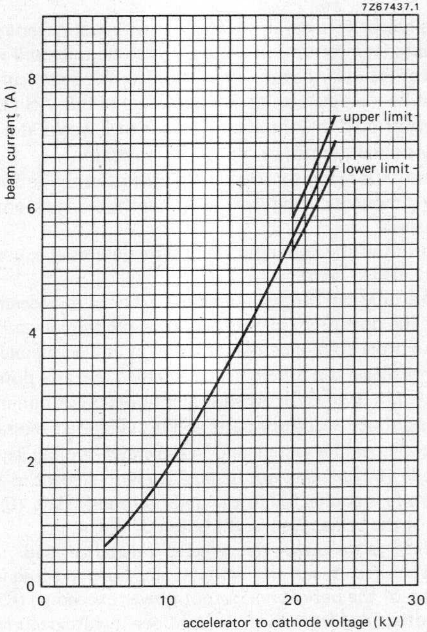


Fig. 4.

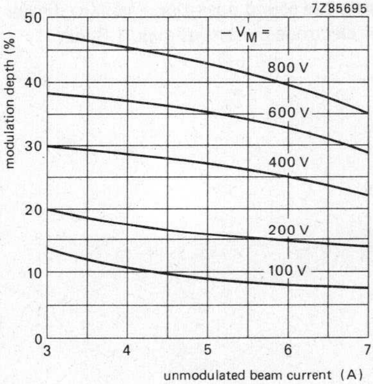


Fig. 5 Parameter: modulation voltage $-V_M$ (with respect to cathode).

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)	499,7 MHz
Bandwidth at saturation (−1 dB points)	2 MHz
Output power	500 to 600 kW
Cooling	water

HEATING: indirect by d.c. notes: see page B147

Cathode: dispenser type

		min.	typ.	max.	
Heater voltage	V_f	20	25	30	V
Heater current	I_f	20	25	30	A notes 1, 2
Cold heater resistance	R_{fo}	–	100	–	mΩ
Waiting time	t_w	15	–	–	minutes
FOCUSING: electromagnetic					
Solenoid current		5	9	15	A
Solenoid voltage		–	130	200	V
Solenoid resistance		–	14	–	Ω
GETTER-ION PUMP SUPPLY					
Operating voltage		3	3,3	4	kV
Operating current		–	10^{-3}	80	mA
Internal resistance of power supply		25	–	–	kΩ

MECHANICAL DATA

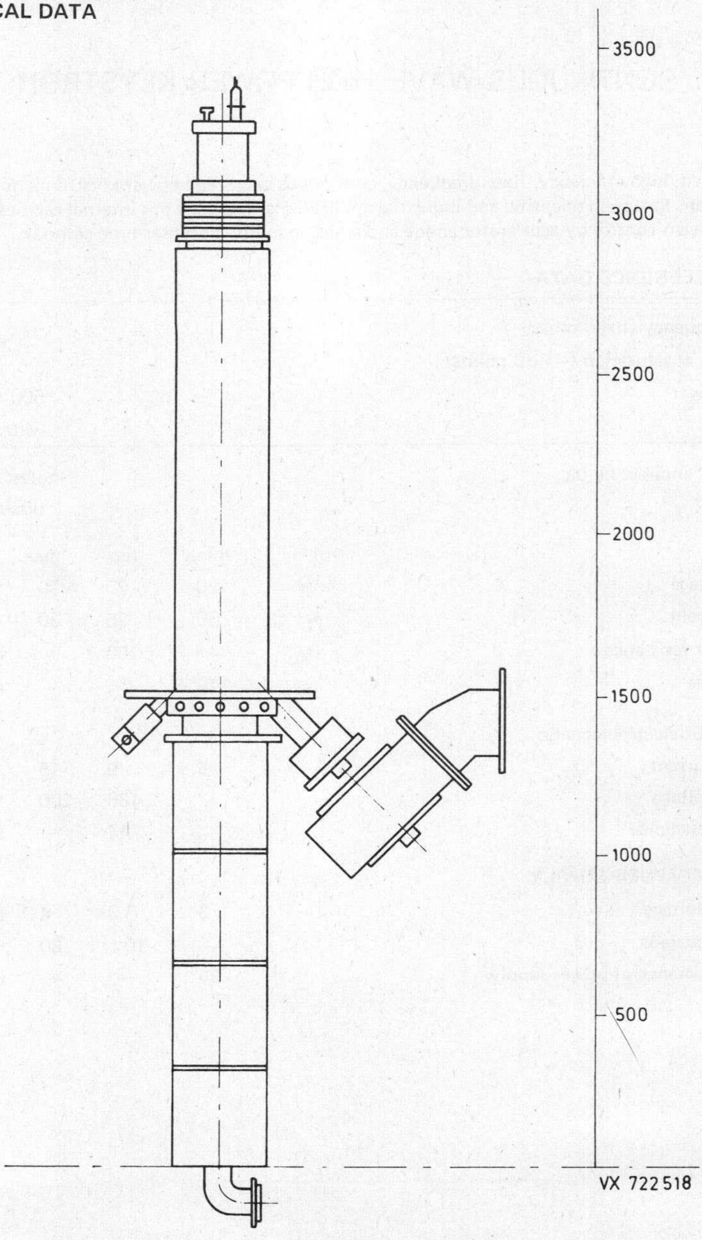


Fig. 1.

Tube mounted in the mounting frame with solenoid.

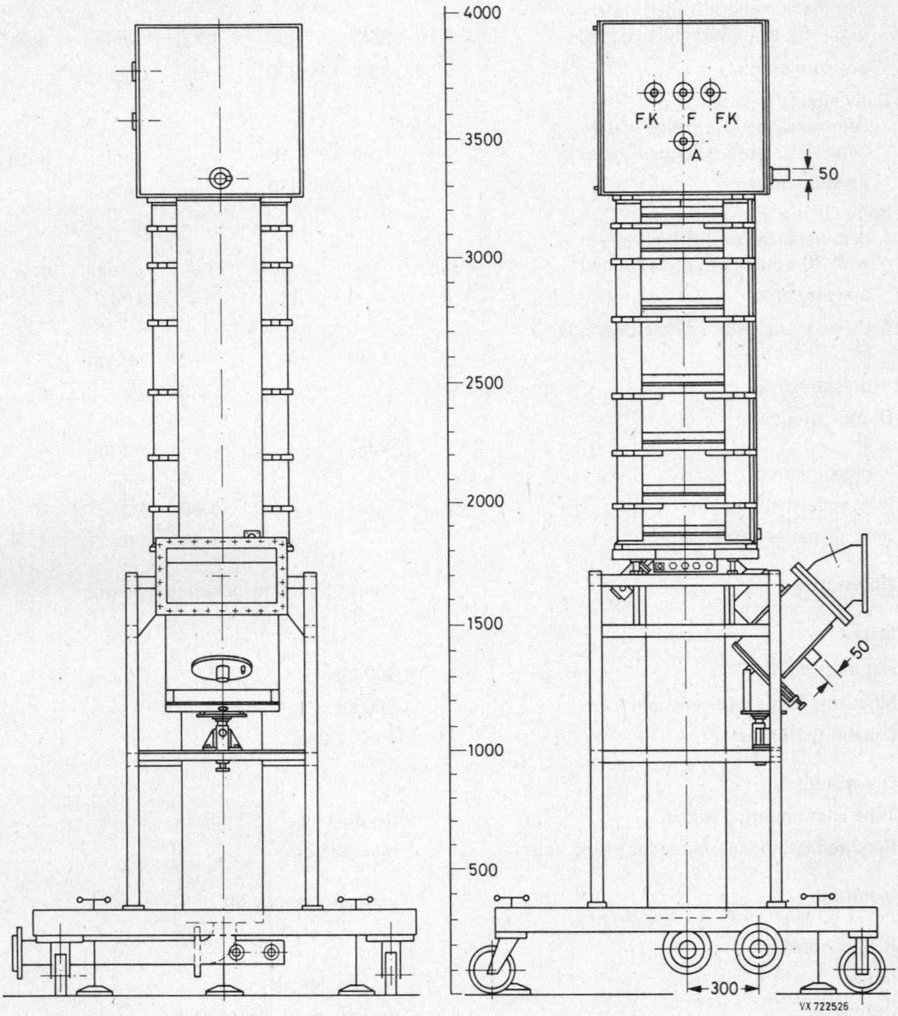


Fig. 2.

Cooling	min.	typ.	max.		
Collector					
demineralized or distilled water with 10% stabilized glycol added	850	900	1000	l/min	note 3
pressure drop	230	330	450	kPa	
Body circuit I					
demineralized or distilled water with 10% stabilized glycol added	7	10	–	l/min	note 3
pressure drop	–	330	–	kPa	
Body circuit II					
demineralized or distilled water with 10% stabilized glycol added	14	20	–	l/min	note 3
pressure drop	–	330	–	kPa	
Cathode socket and accelerator anode					
air	2	–	–	m^3/min	
pressure drop	–	–	500	Pa	
Output window					
air	2,5	–	–	m^3/min	
pressure drop	–	4	6	kPa	
Inlet water temperature	–	–	+50	^oC	
Inlet air temperature	–	–	+45	^oC	

Accessories — mounting frame including solenoid

Mass

Net mass YK1300	400 kg
Mounting frame with solenoid	800 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) mating flange UDR5

ACCESSORIES

A. Separate parts

		note 4
Collector water cooling jacket	TE 1170	
Coax/waveguide transition, WR1800 with 45° knee	TE 1164	
Window cooling air inlet	TE 1165	
Accelerator anode ring	TE 1173	
Cathode ring	TE 1174 A	
Corona protector	TE 1174 B	

B. Operational parts for first equipment

H.V. connection unit with R3 sockets	TE 1163	note 5
Klystron trolley with waveguide support	TE 1167	
Focusing coil unit	TE 1166	
Water outlet collecting tube	TE 1168	
Interconnecting water hoses	4x TE 1169	
Connection cables,		
heater/cathode	2x TE 1171 A	
heater	TE 1171 B	
accelerator anode	TE 1171 C	

C. Optional parts

H.V. socket R3	4x TE 1158	note 6
H.V. cable with R3 plugs,		
length 6 m	4x TE 1159	note 6
length 9 m	4x TE 1160	note 6
H.V. dummy plug R3	4x TE 1161	note 6
Yoke for lifting TE 1166 and TE 1163	TE 1175	note 11
Yoke for lifting and turning a klystron from any position	TE 1176	note 11
Supporting frame for storage and any movement of burnt-out or spare klystrons in any position other than vertical	TE 1177	note 11
Trolley for transportation of a klystron in horizontal position without lifting gear	TE 1178	note 12

LIMITING VALUES (Absolute maximum rating system)

Heater voltage	max. 10% above specified values			
Heater current				
Cathode voltage	max.	−65	kV	
Cold cathode voltage	max.	−70	kV	
Cathode current	max.	20	A	
Accelerator anode voltage	min.	0	V	note 7
	max.	−65	kV	
Cold accelerator anode voltage	max.	−70	kV	
Accelerator anode current	max.	5	mA	
Collector dissipation	max.	850	kW	note 8
Dissipation body circuit I	max.	10	kW	
Dissipation body circuit II	max.	20	kW	
Load VSWR	max.	1,1		note 9

TYPICAL OPERATING CONDITIONS

500 kW operation into matched load	min.	typ.	max.		
Cathode voltage	–	−58	−60	kV	note 10
Cathode current	–	14,4	18,6	A	
Input power	–	835	–	kW	
Accelerator anode voltage	−1	–	–	kV	
Accelerator anode current	–	1	5	mA	
C.W. output power, VSWR ⩽1,1	–	500	–	kW	
Collector dissipation	–	335	–	kW	
Efficiency	58	60	–	%	
C.W. drive power	–	25	50	W	

600 kW operation into matched load	min.	typ.	max.	
Cathode voltage	–	−58	−62	kV
Cathode current	–	18,6	19	A
Input power	–	1,08	1,1	MW
Accelerator anode voltage	−1	–	–	kV
Accelerator anode current	–	1	5	mA
C.W. output power, VSWR ⩽1,1	570	600	–	kW
Collector dissipation	–	480	530	kW
Efficiency	52	56	–	%
C.W. drive power	–	25	50	W

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. Separate parts, matched individually to each tube, to be delivered together with each tube and to be returned together with each burnt-out tube.
5. R3 sockets are only usable together with optional accessories TE 1159 and TE 1160.
6. Cable with R3 plugs on each end, to be fed into the R3 sockets of the H.V. connection unit TE 1163 and into R3 sockets TE 1158 applied to the power supply. Dummy plugs are provided for cable termination on H.V. test of the cable set.
7. The accelerator anode voltage may never become positive with repsect to the body (ground).
8. 1100 kW up to 10 s.
9. For reflections exceeding this value please contact the tube manufacturer.
10. Maximum values will not occur simultaneously.
11. Parts are needed for all handling operations at the site and are to be ordered once for the site.
12. Free option.

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

   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 (switch-off value adjustable between 30 and 60 K above the water inlet temperature),

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

max. values permitted:	collector	$\Delta\theta$ = 14 K
	body circuit I	$\Delta\theta$ = 30 K
	body circuit II	$\Delta\theta$ = 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 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.

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 < 4 mA.
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 ± 2 A.
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 is equipped with a lead shielding which under normal conditions reduces the radiation values below 0,5 mR/h, measured at a distance of 1 m from the tube axis.

REFLEX KLYSTRONS C

RUGGEDIZED TUNABLE REFLEX KLYSTRON

Mechanically tunable lightweight rugged reflex klystron with integral cavity, waveguide output and flying leads, suitable for operation at low pressures.

QUICK REFERENCE DATA

Frequency range, tunable within the band	f	10,5 to 12,2	GHz
Power output	W_o	400	mW
Construction	waveguide output		

HEATING: indirect

Heater voltage	V_f		6,3	V ± 10%
Heater current at V_f = 6,3 V	I_f		1,2	A
Cathode heating time	t_w	min.	15	s

LIMITING VALUES (Absolute limits)

Resonator voltage	max.	450	V
Resonator current	max.	70	mA
Negative reflector voltage		20 to 1000	V
Body temperature	max.	200	°C

For maximum life the body temperature should be kept below 100 °C.

COOLING: natural or forced air

Forced-air cooling is necessary for a resonator input greater than 10 W.

CONNECTIONS

Yellow:	heater
White:	heater + cathode
Green:	i.c. (cathode)
Grey:	reflector
Maroon:	cavity

Net mass: 200 g

Mounting position: any

Mechanical tuning with bolt and nut

TUNING

Loosen both tuning nuts at socket side. Turn both nuts in centre in small steps to the left or to the right until required frequency is obtained. Then fix lower nuts again. Do not touch lock nut at reflector side.

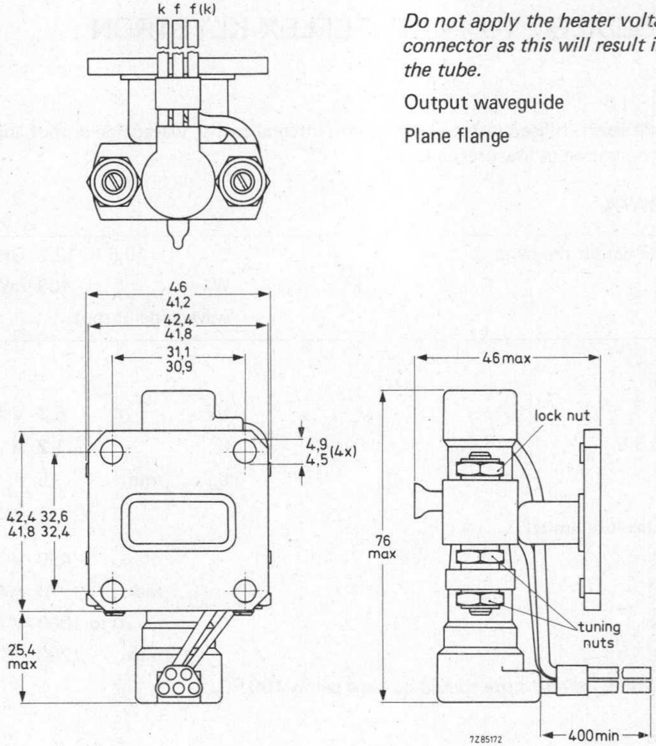
MECHANICAL DATA

Dimensions in mm

WARNING

Do not apply the heater voltage to the green connector as this will result in the destruction of the tube.

Output waveguide	RG-52/U (WR90)
Plane flange	UG-39/U



TYPICAL CHARACTERISTICS

Mechanical tuning range	10,5 to 12,2 GHz
Electronic tuning range between half-power points at any point in the mechanical tuning range at V_{res} = 400 V	> 30 MHz
Reflector modulation sensitivity at f = 10,5 to 12,2 GHz	0,8 to 2,0 MHz/V
Power output ay any frequency in the mechanical tuning range with reflector voltage optimized at V_{res} = 400 V	> 50 mW
Reflector voltage range for maximum power output over the mechanical tuning range	−120 to −370 V
Reflector voltage for maximum power output at centre frequency in principal mode at V_{res} = 400 V	−260 V

Frequency drift after first 5 minutes of operation			0,5	MHz
Temperature coefficient in the range T_{amb} = −10 to +40 °C		<	0,25	MHz/K
Frequency change with atmospheric pressure change equivalent to operation at				
0 to 20 km altitude	1	<	3	MHz
0 to 30 km altitude	2	<	10	MHz
Frequency modulation under vibration of 5 g applied to the flange (50 to 5000 Hz in three planes)		<	4	MHz

OPERATING CHARACTERISTICS

Frequency	10,5	11,5	12,2	GHz
Resonator voltage	400	400	400	V
Resonator current	65	65	65	mA
Reflector voltage	−190	−260	−315	V
Output power,				
matched load	150	270	370	mW
optimized load	320	400	420	mW
Electronic tuning range between half-power points	58	52	47	MHz
Reflector modulation coefficient	1,0	1,0	1,0	MHz/V

Frequency	10,5	11,5	12,2	GHz
Resonator voltage	200	200	200	V
Resonator current	23	23	23	mA
Reflector voltage	−60	−90	−110	V
Output power,				
matched load	10	22	27	mW
optimized load	25	30	27	mW
Electronic tuning range between half-power points	60	50	38	MHz

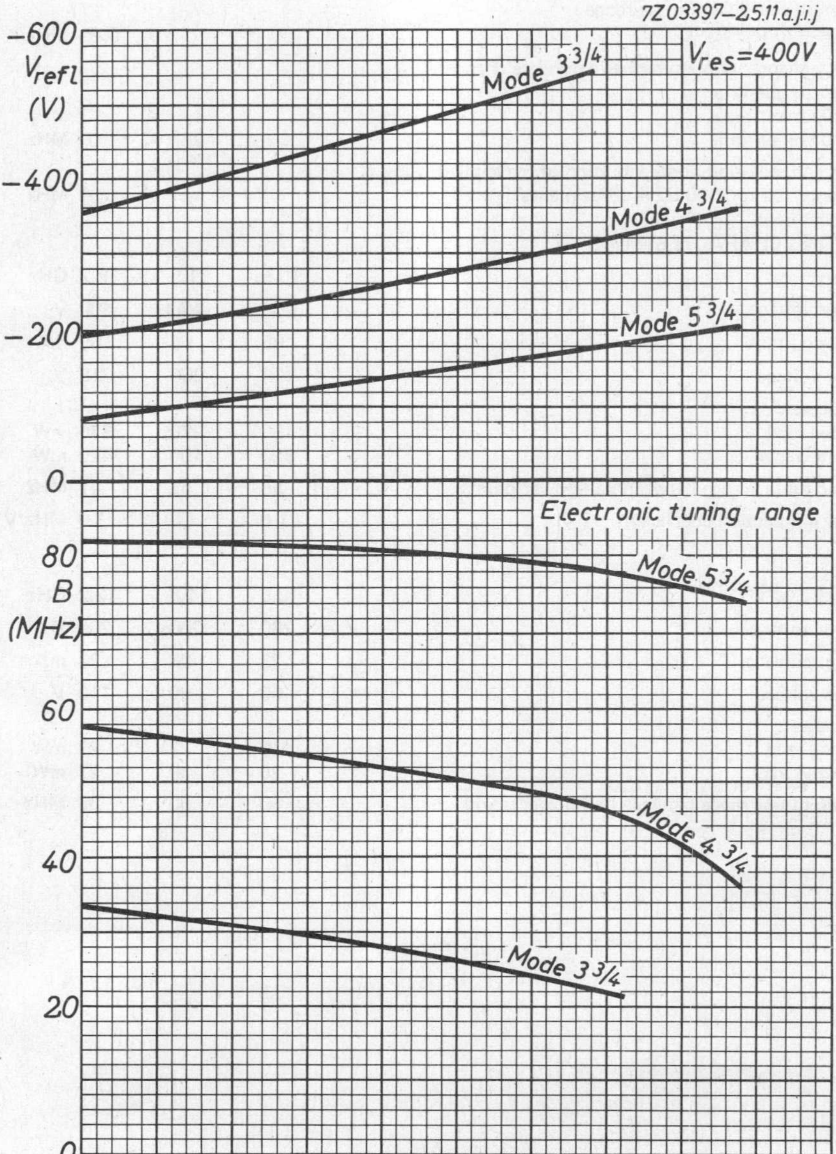

7Z03397–2.5.11.a.j.i.j
V_{res}=400V
−600
V_{refl}
(V)
−400
−200
0
Mode 3 3/4
Mode 4 3/4
Mode 5 3/4
Electronic tuning range
80
B
(MHz)
60
40
20
0
Mode 5 3/4
Mode 4 3/4
Mode 3 3/4
10,5
11
11,5
12 f(GHz)
12,5
13

Fig. 2.

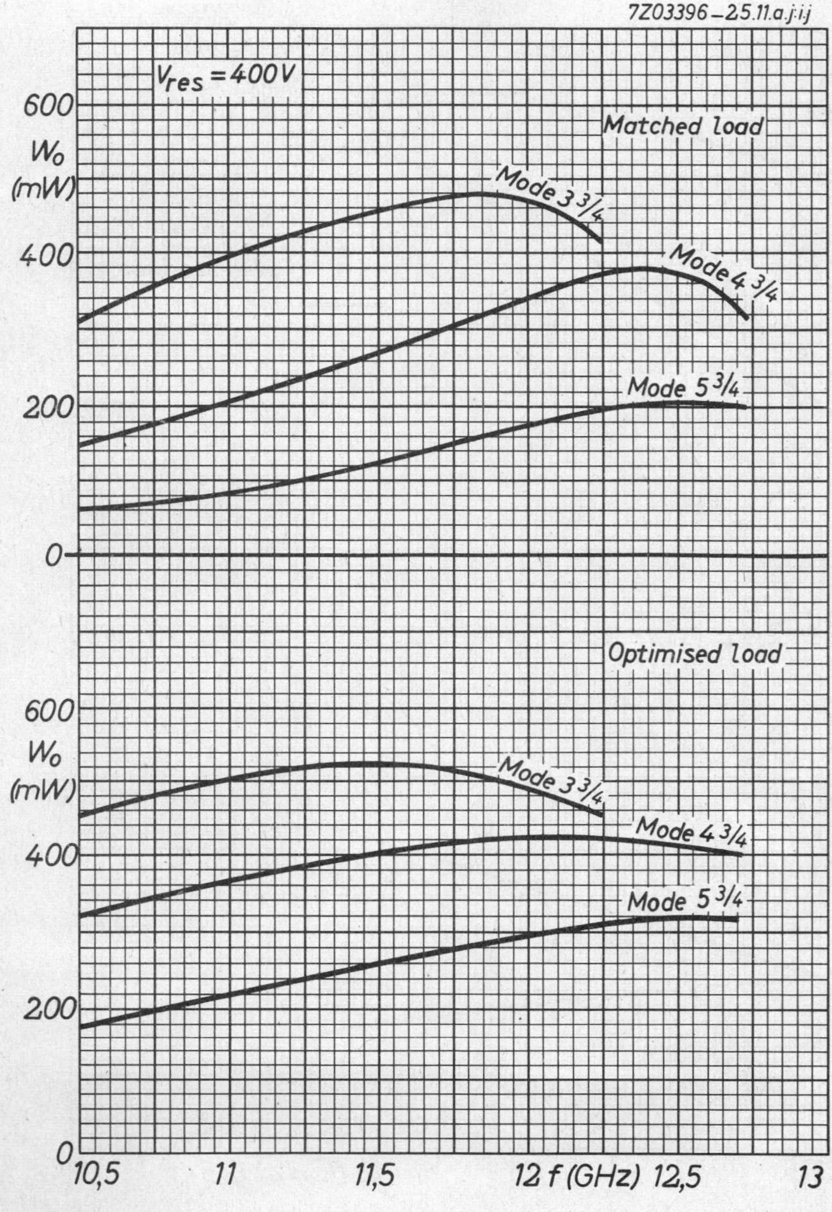

7Z03396-2.5.11.a.j·i.j
V_{res} = 400 V
600
W_o
(mW)
400
200
0
Matched load
Mode 3 3/4
Mode 4 3/4
Mode 5 3/4
Optimised load
600
W_o
(mW)
400
200
0
Mode 3 3/4
Mode 4 3/4
Mode 5 3/4
10,5
11
11,5
12 f (GHz)
12,5
13

Fig. 3.

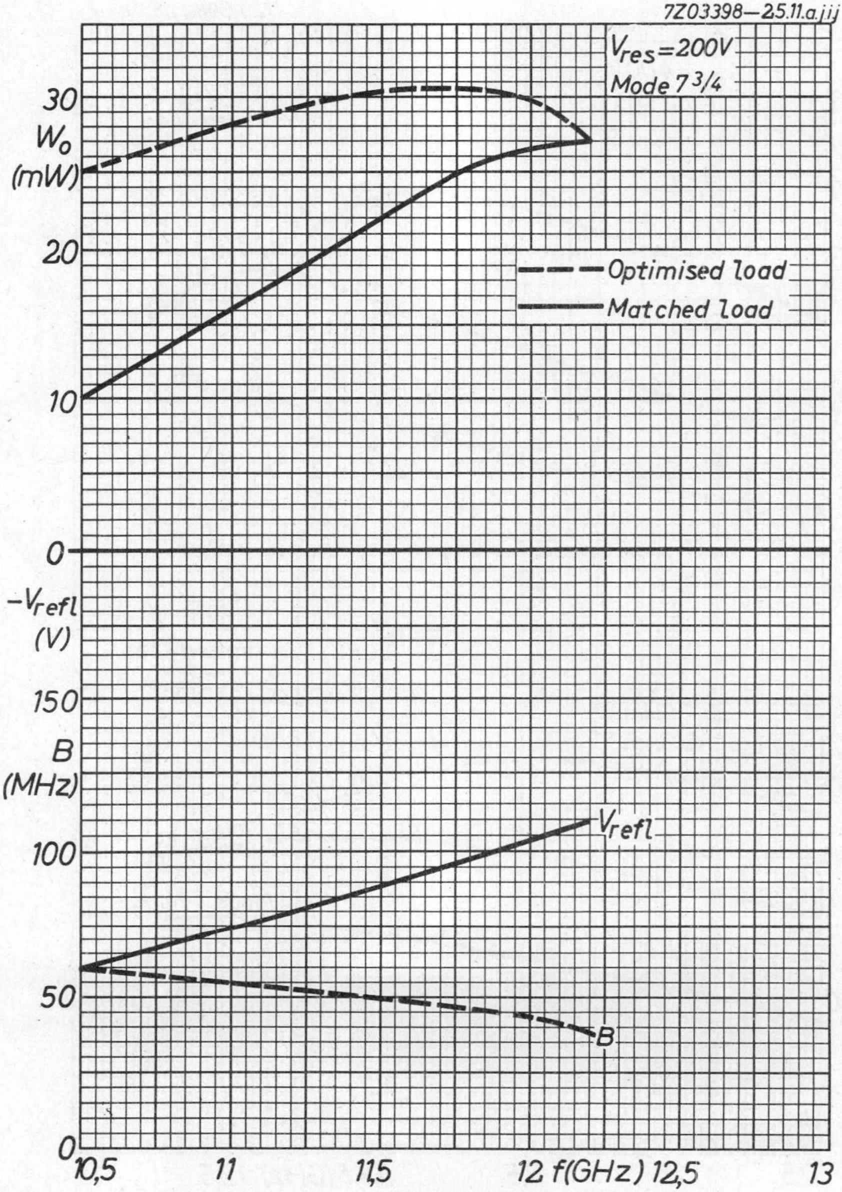

7Z03398—25.11.a.jij
V_{res}=200V
Mode 7 3/4
30
W_o
(mW)
20
10
0
$-V_{refl}$
(V)
150
B
(MHz)
100
50
0
Optimised load
Matched load
V_{refl}
B
10,5
11
11,5
12 f(GHz) 12,5
13

Fig. 4.

TUNABLE REFLEX KLYSTRON

Mechanically tunable lightweight reflex klystron with integral cavity and waveguide output.

QUICK REFERENCE DATA

Frequency range, tunable within the band	f	10,5 to 12,2 GHz
Power output	W_o	400 mW
Construction		waveguide output

HEATING: indirect

Heater voltage	V_f		6,3 V ± 10%
Heater current at V_f = 6,3 V	I_f		1,2 A
Cathode heating time	t_w	min.	15 s

LIMITING VALUES (Absolute limits)

Resonator voltage	max.	450 V
Resonator current	max.	70 mA
Negative reflector voltage		20 to 1000 V
Body temperature	max.	200 °C

For maximum life the body temperature should be kept below 100 °C.

COOLING: natural or forced air

Forced-air cooling is necessary for a resonator input greater than 10 W.

TUNING

Loosen both tuning nuts at socket side. Turn both nuts in centre in small steps to the left or to the right until required frequency is obtained. Then fix lower nuts again. Do not touch lock nut at reflector side.

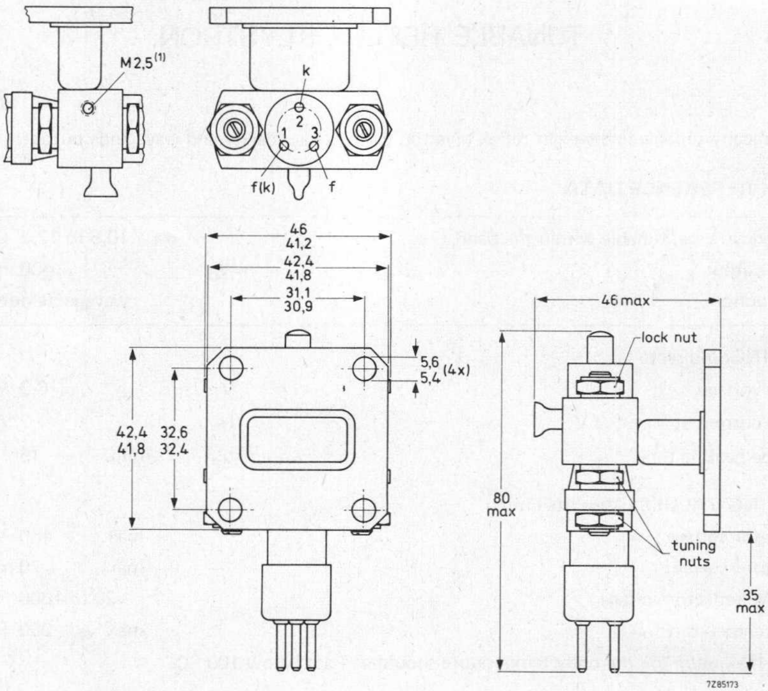
WARNING

Do not apply the heater voltage to the cathode pin as this will result in the destruction of the tube.

Output waveguide	RG-52/U (WR90)
Plain flange	UG-39/U
Net mass: 200 g	Mounting position: any
Base: Pee Wee 3 pin (A3-1)	
Socket: E2 555 37	Mechanical tuning with bolt and nut
Connector for reflector: 55316	

MECHANICAL DATA

Dimensions in mm



TYPICAL CHARACTERISTICS

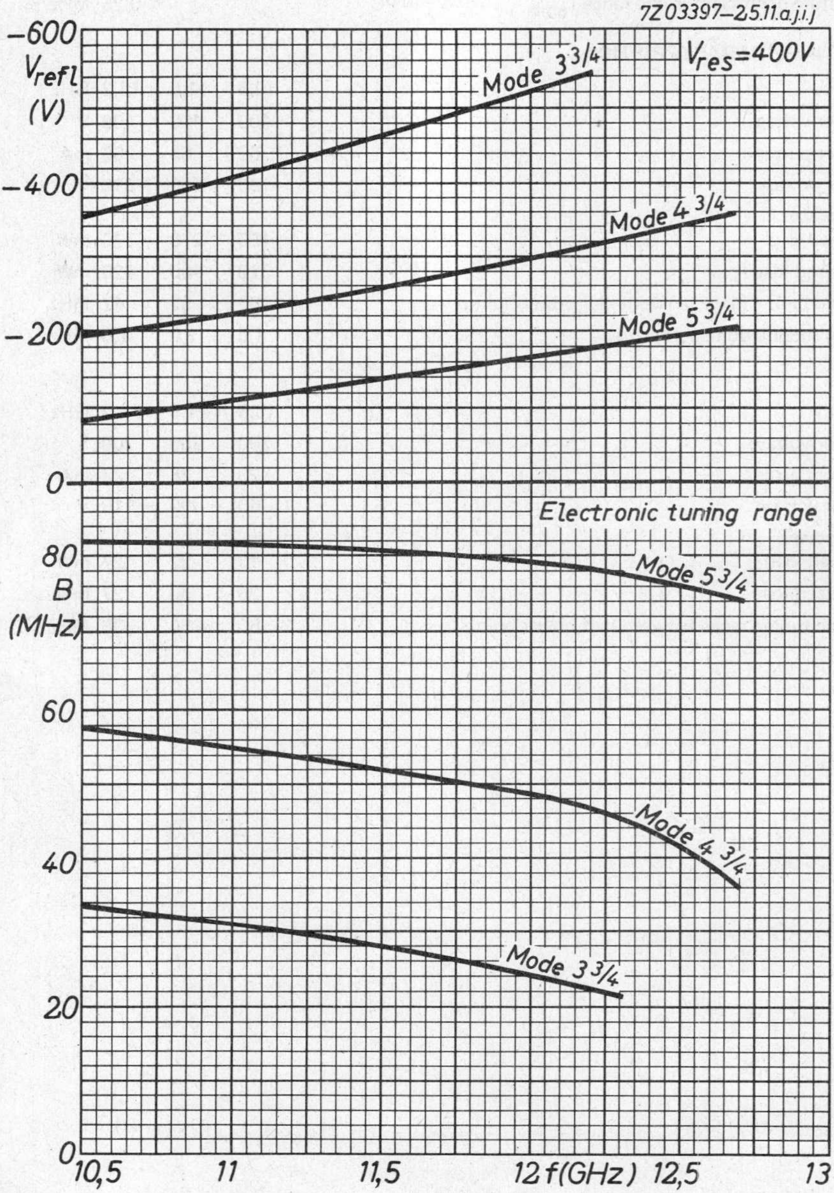
Mechanical tuning range	10,5 to 12,2 GHz
Electronic tuning range between half-power points at any point in the mechanical tuning range at V_{res} = 400 V	> 30 MHz
Reflector modulation sensitivity at f = 10,5 to 12,2 GHz	0,8 to 2,0 MHz per V
Power output at any frequency in the mechanical tuning range with reflector voltage optimized at V_{res} = 400 V	> 50 mW
Reflector voltage range for maximum power output over the mechanical tuning range	−100 to −400 V
Reflector voltage for maximum power output at centre frequency in principal mode at V_{res} = 400 V	−260 V

Frequency drift after first 5 minutes of operation			0,5	MHz
Temperature coefficient in the range T_{amb} = −10 to +40 °C			< 0,25	MHz/K

OPERATING CHARACTERISTICS

Frequency	10,5	11,5	12,2	GHz
Resonator voltage	400	400	400	V
Resonator current	65	65	65	mA
Reflector voltage	−190	−260	−315	V
Output power,				
matched load	150	270	370	mW
optimized load	320	400	420	mW
Electronic tuning range between half-power points	58	52	47	MHz
Reflector modulation coefficient	1,0	1,0	1,0	MHz/V

Frequency	10,5	11,5	12,2	GHz
Resonator voltage	200	200	200	V
Resonator current	23	23	23	mA
Reflector voltage	−60	−90	−110	V
Output power,				
matched load	10	22	27	mW
optimized load	25	30	27	mW
Electronic tuning range between half-power points	60	50	38	MHz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V_{res}=400V
-600
V_{refl}
(V)
-400
-200
0
Mode 3 3/4
Mode 4 3/4
Mode 5 3/4
Electronic tuning range
80
B
(MHz)
60
40
20
0
Mode 5 3/4
Mode 4 3/4
Mode 3 3/4
10,5
11
11,5
12 f(GHz)
12,5
13

Fig. 2.

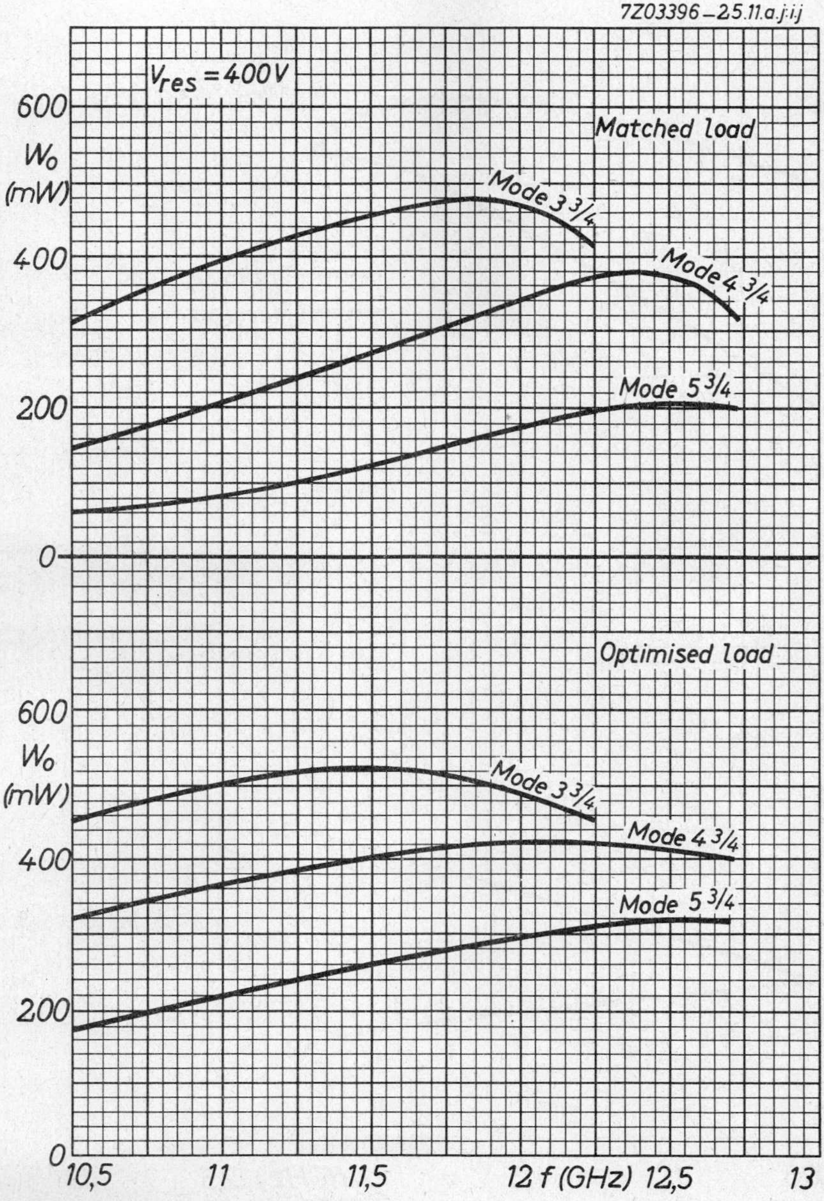

7Z03396–2.5.11.a.j:i.j
V_{res} = 400 V
Matched load
Mode 3 3/4
Mode 4 3/4
Mode 5 3/4
Optimised load
Mode 3 3/4
Mode 4 3/4
Mode 5 3/4
600
W_o (mW)
400
200
0
600
W_o (mW)
400
200
0
10,5
11
11,5
12 f (GHz)
12,5
13

Fig. 3.

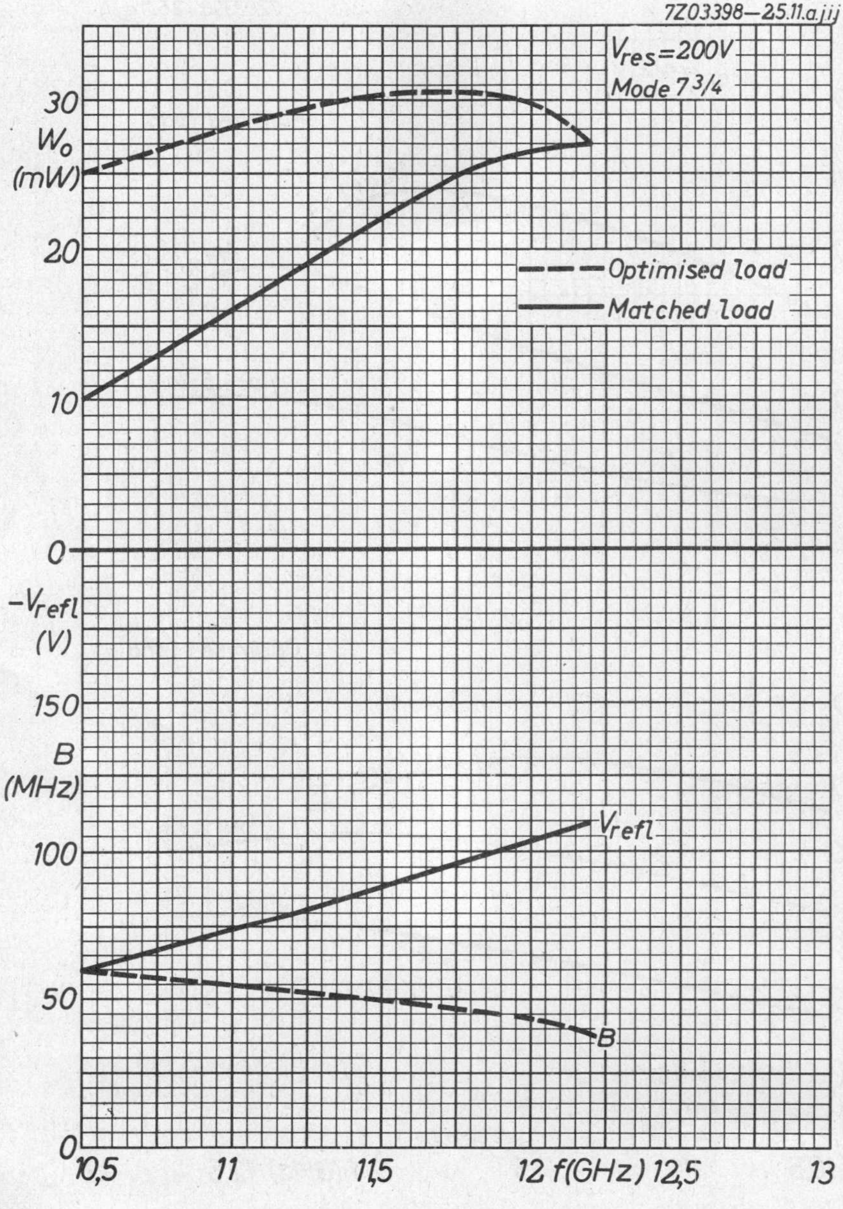

7Z03398—25.11.a.jij
V_{res}=200V
Mode 7 3/4
30
W_o
(mW)
20
10
0
$-V_{refl}$
(V)
150
B
(MHz)
100
50
0
Optimised load
Matched load
V_{refl}
B
10,5
11
11,5
12 f(GHz) 12,5
13

Fig. 4.

TRAVELLING-WAVE TUBES D

TRAVELLING-WAVE TUBE

6 GHz travelling-wave tube with a periodic permanent magnet mount intended for use in the power output stages of wideband microwave links.

QUICK REFERENCE DATA

Frequency range	f	5,925 to 6,425 GHz
Saturation output power	$W_{o\,sat}$	25 W
Gain	G	38 dB
Construction,		
tube		unpackaged
mount		periodic permanent magnet

CATHODE: dispenser type

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

Heater voltage	V_f		6,3 V ± 2%
Heater current	I_f		0,85 to 1,05 A
Waiting time	t_w	min.	2 min
for a new tube	t_w	min.	5 min

When operated on d.c. the heater must be negative with respect to cathode.

TEMPERATURE LIMITS AND COOLING

Absolute max. temperature at reference point on mount cooler	T	max.	140 °C

Ambient temperature range

		min.	max.	
Operation to full specification	T_{amb}	−10	+65	°C(note 1)
Operation without damage to tube	T_{amb}	−20	+65	°C
Storage	T_{amb}	−60	+85	°C (note 2)

Cooling

Tube installed in convection-cooled mount type P6L11

horizontally mounted	natural
vertically mounted	natural assisted by convection duct or low velocity air flow

A condition-cooled mount is available.

MECHANICAL DATA Dimensions in mm

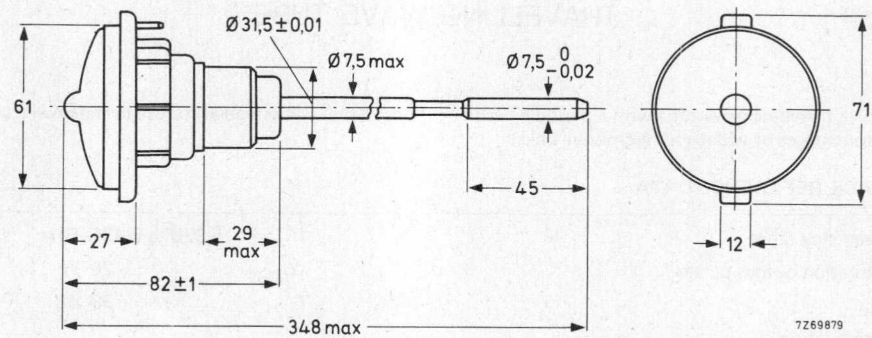


Fig. 1.

Mounting position: Any (but see "Cooling").

The barrel of the mount must be protected from strong magnetic fields such as from isolators, and should be several centimetres from steel plates.

Note that the tube is fragile. It should be inserted carefully into the mount and then pushed home axially. Rotation is also necessary to negotiate the withdrawal check lugs.

Mass

Net mass of tube: 0,15 kg

Net mass of mount: 4,9 kg

Accessories

Mount, convection-cooled, with 153 IEC-R70 waveguide input and output (34,85 mm x 15,799 mm) type P6L11, see Fig. 3.

Plug connections to mount

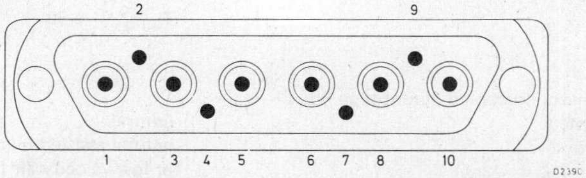
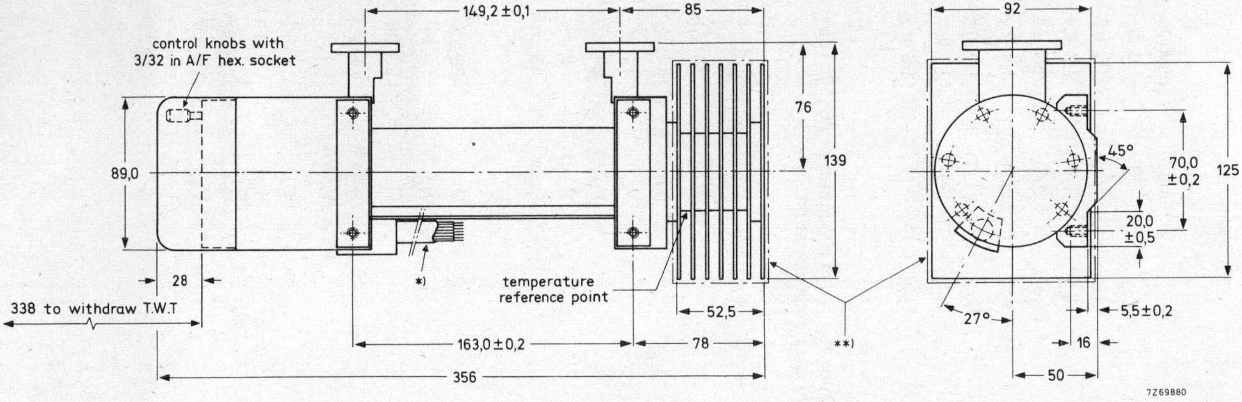
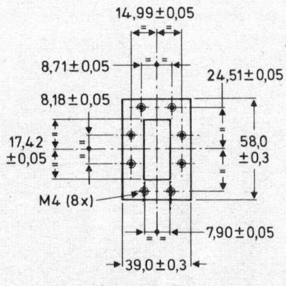


Fig. 2 Amphenol plug 17-801.

1 helix
2 collector (earth)
3 grid 2 (accelerator electrode)
4 –
5 grid 1 (focusing electrode)
6 cathode
7 safety circuit
8 heater
9 safety circuit
10 heater





special flange IEC-R70

* Screened cable 590 mm long with safety switch leads and Amphenol plug 17-801. Safety switch is operated by insertion and extraction of TWT.

** When mount is installed there must be a minimum clearance of 3 mm around the cooler.

Fig. 3 Dimensions of mount P6L11.

Note that the equipment should be designed so that the maximum misalignment moment at r.f. connectors is 19,6 Nm. The cooling fins are movable and require a minimum clearance of 3 mm. The mount should be handled with special care during installation to avoid damage to the cooling fins.

DESIGN RANGES FOR POWER SUPPLY

Voltages are specified with respect to cathode.

Normal operation.

		min.	max.		notes
Grid 1 voltage	V_{g1}	−20	0	V	3
Grid 1 current	I_{g1}		100	μA	
Grid 2 voltage	V_{g2}	1,9	2,7	kV	4,5
Grid 2 current	I_{g2}	−250	+250	μA	
Helix voltage	V_x	3,2	3,8	kV	
Helix current	I_x		1,5	mA	5,6
Collector voltage	V_{coll}	1,9	2,1	kV	7
Collector current	I_{coll}		50	mA	

TYPICAL OPERATION

As a power amplifier with the collector earthed and tube focused in a mount type P6L11. Tubes are fully interchangeable in mounts and tube replacement is a simple operation.
Voltages are specified with respect to cathode.

Conditions

Frequency	f	6	GHz
Heater voltage	V_f	6,3	V
Grid 1 voltage	V_{g1}	−15	V
Helix voltage	V_x	3,4	kV
Collector voltage (earth)	V_{coll}	2	kV
Collector current	I_{coll}	45	mA

Performance

Gain	G	38	dB
Output power	W_o	15	W
Noise factor (including gas noise)	F	28	dB
Hot input match	VSWR	1,2	
Hot output match	VSWR	1,4	
Grid 1 current	I_{g1}	1	μA
Grid 2 current	I_{g2}	5	μA
Helix current	I_x	0,5	mA
Grid 2 voltage	V_{g2}	2,2	kV

LIMITING VALUES (Absolute maximum rating system)
Voltages are specified with respect to cathode.

					notes
Grid 1 voltage	$-V_{g1}$	max.	250	V	
		min.	0	V	
Grid 2 voltage	V_{g2}	max.	3	kV	
Helix voltage	V_x	max.	4	kV	
Helix current	I_x	max.	1,3	mA	6
Collector voltage	V_{coll}	max.	2,2	kV	
		min.	1,9	kV	
Collector current	I_{coll}	max.	50	mA	
Collector dissipation	W_{coll}	max.	100	W	
R.F. input power	W_i	max.	250	mW	8

TEST CONDITIONS AND LIMITS
Tube focused in mount P6L11.

Conditions

Heater voltage	V_f	6,3	V	
Grid 1 voltage	V_{g1}	−15	V	
Grid 2 voltage	V_{g2}			6,9
Helix voltage	V_x			10
Collector voltage	V_{coll}	1,9	kV	
Collector current range	I_{coll}	40 to 50	mA	16
Output power	W_o	15	W	
Frequency range	f	5,925 to 6,425	GHz	11

Limits and characteristics

		min.	max.		
Gain at W_o = 15 W	G	37	40	dB	
Noise factor at W_o = 15 W, design test only	F		30	dB	
Saturation output power	$W_{o\,sat}$	23		W	12
Hot input match	VSWR		1,5		13
Hot output match	VSWR		2		13
Grid 2 voltage	V_{g2}	1,9	2,7	kV	
Helix voltage	V_x	3,2	3,8	kV	
Grid 1 current	I_{g1}		100	μA	
Grid 2 current	I_{g2}		250	μA	
Helix current	I_x		1,3	mA	6
A.M./P.M. conversion at W_o = 15 W (design test only)			2	°/dB	14
Attenuation					15

NOTES

1. The magnetic circuit is fully temperature-compensated in this range, and the operation of the tube will not change as the temperature is varied.
2. If the temperature of the mount is lowered below −60 °C the magnets will suffer an irreversible change.
3. V_{g1} is normally fixed at −15 V.
4. For adjustment of focus it is also necessary for the grid 2 voltage to be variable in the range 0 to 1,9 kV without stabilization. As an alternative the negative voltage on grid 1 may be increased within certain limits to reduce the collector current (see "Limiting Values").
5. The power supply should be designed so that any automatic switching allows the correct cathode preheating time (which may be reduced or eliminated for momentary breaks of 5 s), followed by establishment of all electrode voltages except V_{g2}. The V_{g2} may then be applied. All supplies should usually be stabilized to within ±2% except where otherwise stated. A protective device to reduce V_{g2} should operate if the helix current exceeds its limiting value (but see note 6).
6. During the focusing operation the helix current may (transiently) be allowed to reach 2 mA. It may be useful so set the focusing screws on a new mount 1,5 turns back from fully home before commencing the switch-on operation.
7. The collector voltage is usually fixed at 2 kV. This supply need not be stabilized provided that it remains in the range 1,9 to 2,1 kV when the tube is operating.
8. The output power reflected back into the tube by the load (for example the output isolator) should also not exceed this limit.
9. V_{g2} should be adjusted to give the specified collector current while cyclically adjusting focusing screws for minimum helix current.
10. V_x should be adjusted to give the maximum gain at the specified output power. Focusing should then be re-optimized.
11. The tube is tested at the centre and the extremes of the frequency range.
12. Measured pulsed at a duty ratio of 1:2. If necessary the helix voltage is readjusted to give maximum output power as the input power is increased and the focus re-optimized.
13. This is obtained without adjustment at each frequency ("plug-in" match).
14. The value given for A.M. to P.M. conversion is that obtained under the stated conditions. Improved values may be obtained with other settings of helix voltage and input power.
15. With electrode voltages not applied minimum attenuation is 60 dB.
16. Specified on data sheet enclosed with tube.

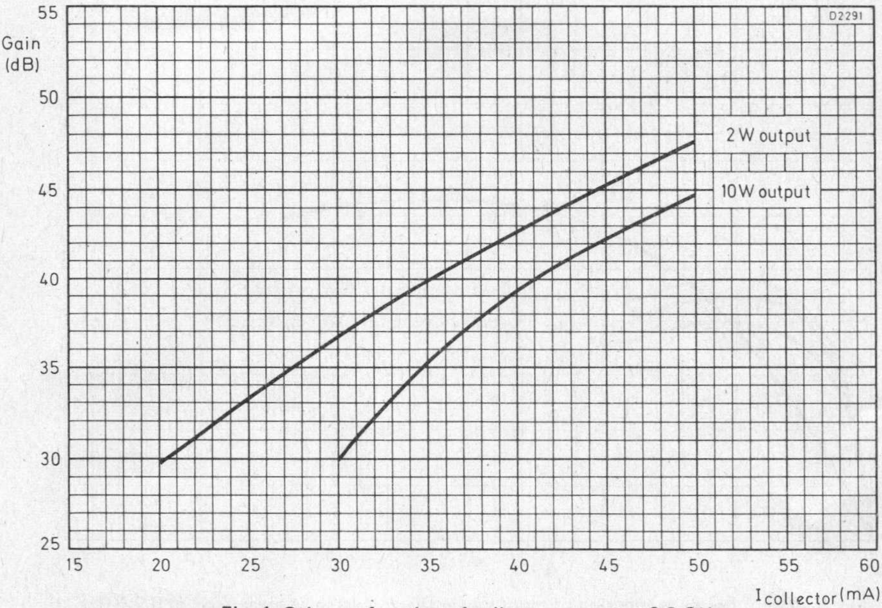


Fig. 4 Gain as a function of collector current at 6,2 GHz.

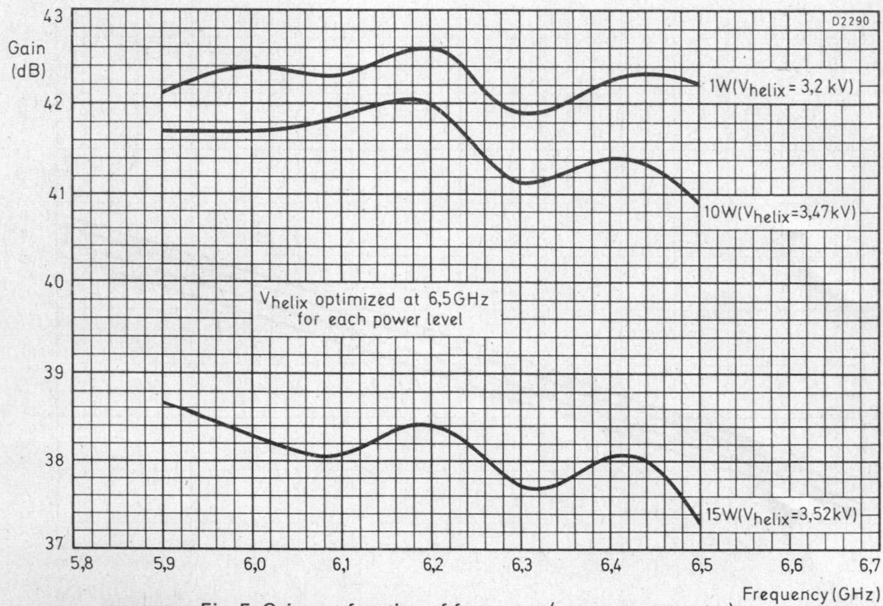


Fig. 5 Gain as a function of frequency (power as parameter).

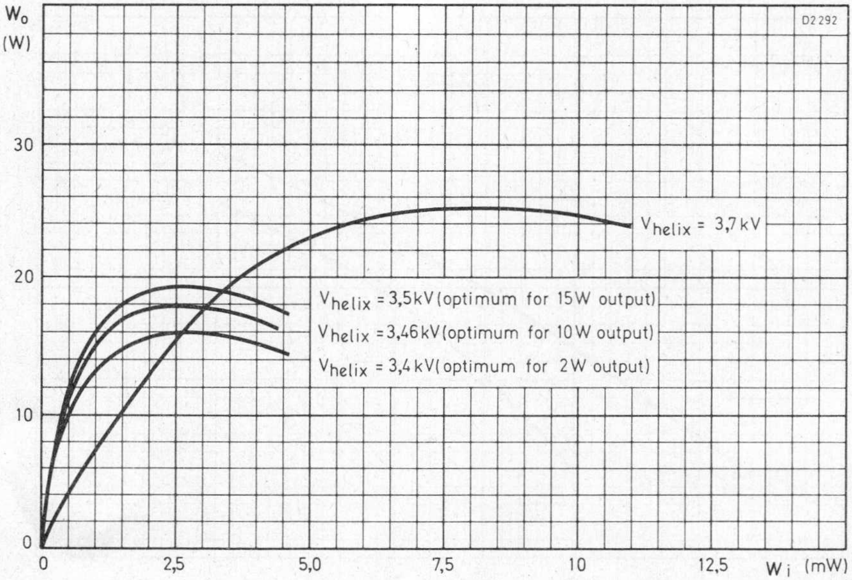


Fig. 6 Output power as function of input power (helix voltage as parameter) at 6,2 GHz).

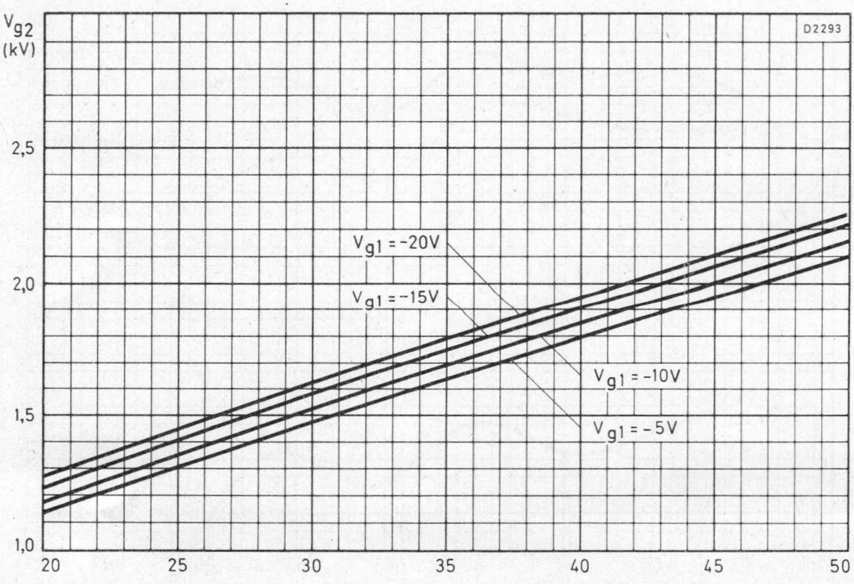


Fig. 7 Grid 2 voltage as a function of collector current.

TRAVELLING-WAVE TUBE

4 GHz travelling-wave tube with a periodic permanent magnet mount designed for wide-band microwave link applications.

QUICK REFERENCE DATA

Frequency range	3,4 to 4,2 GHz
Saturation output power at midband	25 W
Low-level gain	42 dB
Interchangeability	plug-in focus, plug-in match
Construction	unpackaged
tube	glass-metal envelope, metal-ceramic base
mount	periodic permanent magnet

CATHODE: dispenser type

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

When operated on d.c. the cathode must be connected to the positive side of the heater power supply.

Heater voltage	V_f		6,3 V ± 2%
Heater current at V_f = 6,3 V	I_f	approx.	1 A
Waiting time	t_w	min.	2 min

For shorter waiting time when the tube already has been in operation see "Application of voltages".

COOLING: Natural cooling
by convection with mount 55329 or
by conduction with mount 55332

MECHANICAL DATA Dimensions in mm

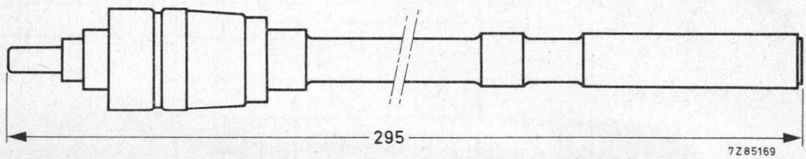


Fig. 1.

Mounting position: Any. See "Design and operating notes"

Mass

of tube	approx.	60 g
of mount	approx.	4,5 kg

ACCESSORIES (to be ordered separately)

PPM mount for convection cooling	type 55329
PPM mount for conduction cooling	type 55332
Waveguide taper (two required) to waveguide IEC-R40 (58,17 x 29,08 mm^2) with flange IEC-UER40	type 55330
Waveguide taper (two required) to waveguide IEC-F40 (58,17 x 7 mm^2) with flange IEC-UGF40	type 55333
Clamp for fastening of mount (two required)	type 55331

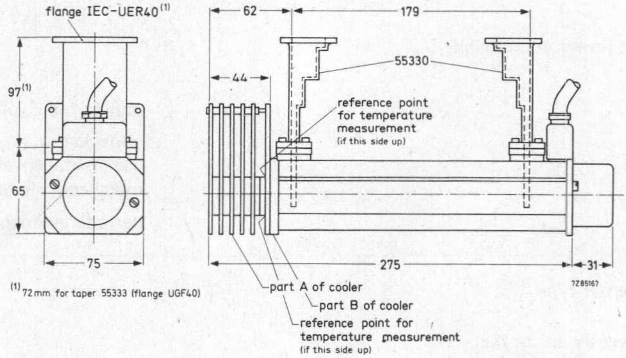


Fig. 2 Mount 55329 with convection cooling and waveguide tapers 55330.

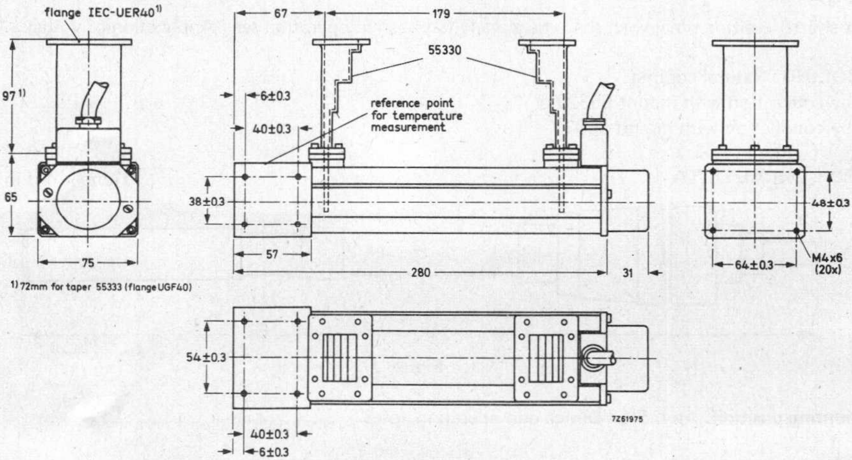


Fig. 3 Mount 55332 with conduction (heatsink) cooling and waveguide tapers 55330.

Connections

The mount is provided with flying leads, marked with colours

Heater, cathode	yellow
Heater	brown
Focusing electrode	green
Accelerator	blue
Helix	to be earthed via mount
Collector	red
Safety circuit (closed or opened, when putting on or taking off the mount cap)	two violet leads

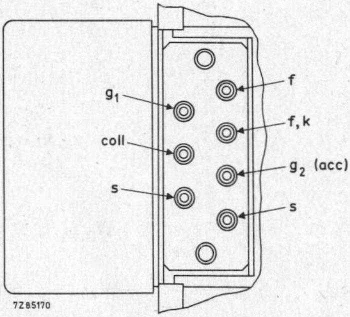


Fig. 4 Connections in cable housing.

GENERAL CHARACTERISTICS

Frequency range	f		3,4 to 4,2	GHz	
Saturation output power (CW)	W_{sat}		25	W	(note 1)
Low-level gain	G		42	dB	(note 2)
Gain at W_o = 15 W	G		38	dB	(note 3)
Thermal noise factor at W_o = 15 W	F		24	dB	(note 4)
AM to PM conversion at W_o = 15 W			3	^{o}/dB	(note 4)
Cold match at input and output (f = 3,4 to 4,2 GHz)	VSWR	max.	1,5		(note 5)

Notes

1. Typical value measured at f = 3,8 GHz, I_{coll} = 60 mA. W_i and V_x optimally adjusted for saturation output power.
2. Typical value measured at f = 3,8 GHz, I_{coll} = 60 mA. $W_o < 1$ W. V_x optimally adjusted for low-level gain.
3. Typical value measured at f = 3,8 GHz, I_{coll} = 60 mA. V_x adjusted for optimum gain.
4. Typical value measured at f = 4 GHz, I_{coll} = 60 mA. V_x adjusted for optimum gain.
5. Measured on the cold tube, i.e. with the beam switched off and without use of any matching device (plug-in match).

TYPICAL OPERATION

Voltages are specified with respect to the cathode

Frequency	f			3,6		GHz
Output power	W_o		15	10	5	W
Helix voltage (adjusted for optimum gain)	V_x	approx.	2250	2200	2150	V
Collector voltage	V_{coll}		1500	1300	1100	V
Focusing electrode voltage	V_{g1}		−5	−5	−5	V
Collector current	I_{coll}		60	60	60	mA
Gain	G		38	40	41	dB
Accelerator voltage*	V_{g2}	approx.	1550	1550	1550	V
Accelerator current	I_{g2}		<0,1	<0,1	<0,1	mA
Helix current (plug-in focus)	I_x		0,3	0,3	0,2	mA
Thermal noise factor	F		24	21,5	20,5	dB
AM to PM conversion			3	2,5	1,5	^{o}/dB

Frequency	f			4,0		GHz
Output power	W_o		15	10	5	W
Helix voltage (adjusted for optimum gain)	V_x	approx.	2150	2100	2050	V
Collector voltage	V_{coll}		1500	1300	1100	V
Focusing electrode voltage	V_{g1}		−5	−5	−5	V
Collector current	I_{coll}		60	60	60	mA
Gain	G		38	40	41	dB
Accelerator voltage*	V_{g2}	approx.	1550	1550	1550	V
Accelerator current	I_{g2}		<0,1	<0,1	<0,1	mA
Helix current (plug-in focus)	I_x		0,3	0,3	0,2	mA
Thermal noise factor	F		24	21,5	20,5	dB
AM to PM conversion			3	2,5	1,5	^{o}/dB

* To be adjusted for indicated collector current.

LIMITING VALUES (Absolute maximum rating system)

Voltages are with respect to the cathode unless otherwise specified.

Focusing electrode voltage	$-V_{g1}$	min.	0 V
		max.	50 V
Accelerator voltage	V_{g2}	max.	2000 V
Helix voltage	V_x	max.	2700 V
Collector to helix voltage	$V_{coll\text{-}x}$	max.	2500 V
Cathode current	I_k	max.	65 mA
Accelerator current	I_{g2}	max.	0,3 mA
Helix current	I_x	max.	3 mA
R.F. input level	W_i	max.	200 mW
Collector dissipation at T_{amb} = 65 °C	W_{coll}	max.	90 W
Power reflected from load (to avoid overheating of the helix)		max.	2 W
Cooler temperature at reference point			
mount type 55329	T	max.	140 °C
mount type 55332	T	max.	150 °C

DESIGN AND OPERATING NOTES

1. General design considerations

Equipment design should be oriented around the tube specifications given in these data sheets and not around one particular tube since due to normal production variations the design parameters will vary around the nominal values given.

2. Installation of the mount

Two main methods may be discerned:

a. Fixing the mount relative to the microwave circuit by only connecting the waveguide tapers to the input and output sides of the circuit.
b. Employing (a) and establishing additional support by fastening the mount to the rack with two clamps 55331. In this case it is recommended that a short piece of flexible waveguide be used at input and output side to prevent excessive strain on the mount via the tapers, unless very careful alignment of the waveguide components can be assured.

Possible forces on the waveguides must not produce a moment greater than 20 Nm at the flanges.

2.1 Mount type 55329

The cooler of the mount consists of the parts A and B (see Fig. 2). Part A is slightly movable and should be handled with special care. The mount should be installed in such a way, that it is not resting on the parts A or B of the cooler, and that part A always remains freely movable. When a tube is in the mount, no forces should be exerted on part A, since they would be directly transferred to the collector.

2.2 Mount type 55332

This mount has no movable parts. If clamps are used (method b) the slightly larger dimensions of the cooler with regard to the main part of the mount must be considered.

2.3 Magnetic shielding

The periodic permanent magnet mount is completely shielded. This implies that no additional measures need be taken to prevent the magnetic properties of the mount from being affected by external magnetic fields. The mount will not influence surrounding equipment which is susceptible to stray magnetic fields. Several mounts may be placed side by side without disturbance of the focusing qualities. Isolators may be installed quite near to the mount.

Warning

If any part of the shielding is removed, the magnetic properties of the mount may be disturbed. irreversibly.

3. Installation of the tube

Unlock the mount cap (see outline drawing) by turning it slightly counter-clockwise. The cap can then easily be removed, and the tube inserted by carefully pushing it in. Finally put the cap on the mount again, and lock by turning it clockwise. These instructions are also a guide for taking the tube out of the mount.

4. Safety

The supply voltages are fed to the tube via the mount cap. When the cap is unlocked all voltages are removed from the tube. The two violet leads can be incorporated into an additional safety circuit which switches the voltages off at the power supply if the cap is unlocked. Thus the voltages can also be removed from the mount. The mount should always be earthed.

5. Power supply

The design of the power supply depends on whether 5, 10 and/or 15 W operation is desired. An example of a supply circuit for 10 and 15 W operation is given in Fig. 5.

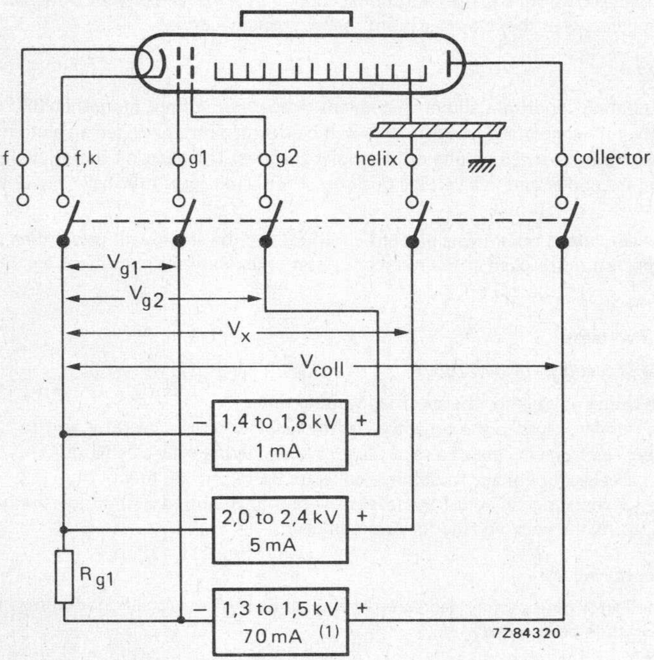


Fig. 5 For 5 W operation a minimum of 1,1 kV is required.

The design of the power supply should be so that V_{g2} can be varied between 1,4 and 1,8 kV. V_x can be varied between 2,0 and 2,4 kV. V_{g1} is –5 V at I_{coll} = 60 mA. The collector voltage must be 1,1 kV, 1,3 kV, or 1,5 kV at I_{coll} = 60 mA for a desired output of 5 W, 10 W, or 15 W respectively.

For measurements of saturation output power the collector voltage should be 1,7 kV (between 3,8 and 4,2 GHz) and 1,85 kV (between 3,4 and 3,8 GHz). The helix voltage may then reach 2,7 kV.

6. Cooling

Tube and mount need no artificial means of cooling. The natural cooling of the collector has been made possible of depression of the collector potential with respect to the helix and by ensuring adequate heat transfer from the collector to the environment.

6.1 Mount 55329

Under typical operating conditions and at an ambient temperature of not more than 65 °C, the cooler temperature at the reference point (see Fig. 2) is well below the limit, provided the tube is mounted horizontally, and free air circulation is possible.

Under less favourable conditions a slight additional cooling by a low-velocity air flow may be required. Checking the temperature at the reference point then is strongly advised.

6.2 Mount 55332

Under typical operating conditions and at an ambient temperature of not more than 65 °C, the cooler temperature at the reference point (see Fig. 3) is well below the limit, provided an aluminium heatsink of 300 x 300 x 6 mm is mounted on one of the cooler surfaces. The heatsink should be fixed with its centre contacting the cooler and in a vertical position. The mount itself may have any position in the equipment.

This is only an example and other heatsink configurations may be employed. It will then be necessary to check the temperatures reached at the reference point under extreme conditions e.g. 65 °C ambient temperature.

7. Application of voltages

7.1 Switching-on procedure for new tubes

7.1.1 Apply the heater voltage for the specified waiting time.
7.1.2 Apply the rated voltages to the collector, to the helix, to the accelerator and to the focusing electrode in case of a separate supply simultaneously (see Notes).
7.1.3 Adjust the accelerator voltage to obtain a collector current of 60 mA.
7.1.4 Apply the r.f. input signal, adjust the level to obtain the required output power while simultaneously adjusting the helix voltage for optimum gain.

7.2 Readjustment during life

During life the collector current may decrease. A readjustment of the accelerator voltage to obtain I_{coll} = 60 mA will then be necessary.

7.3 Switching-off procedure

All voltages may be switched off simultaneously (see Notes).

7.4 Switching-on procedure after interruption of voltage

7.4.1 Interruption of less than 40 s: All voltages may be switched on simultaneously.
7.4.2 Interruption of more than 40 s but less than 1 week: Apply the heater voltage for min. 40 s, then apply all other voltages simultaneously.
7.4.3 Interruption of more than 1 week: Apply the heater voltage for the specified waiting time of 2 min. Apply all other voltages simultaneously.

Notes

If the voltages cannot be switched simultaneously the possibility exists that all the cathode current is flowing to the accelerator or the helix. This condition may never last for more than 10 ms, otherwise it will cause permanent damage to the tube. This may be avoided by switching the accelerator voltage on after the other electrode voltages, or off before the other electrode voltages.

8. Input and output circuit and group delay

In order to avoid phase distortions due to long-line effect, the insertion of an isolator between tube and antenna, and between tube and pre-stage is strongly recommended. The isolators should be positioned as close to the tube as possible.

If isolators with a VSWR of less than 1,05 are used at a short distance from the tube, the reflections result in a variation of group delay of less than 0,2 nanoseconds over a band of 20 MHz.

It may be noted that the difference between the voltage reflection coefficients of the hot and cold (i.e. without beam) tube is less than 0,2 for the input as well as the output side.

9. Environmental conditions

Ambient temperature				
storage	T_{amb}	min.	−60	°C
		max.	+65	°C
operation	T_{amb}	min.	−30	°C
		max.	+65	°C
Relative humidity			0 to 95	%

The tube and mount resist fungus attack.

For changes in gain and helix current over the specified temperature range see Fig. 19.

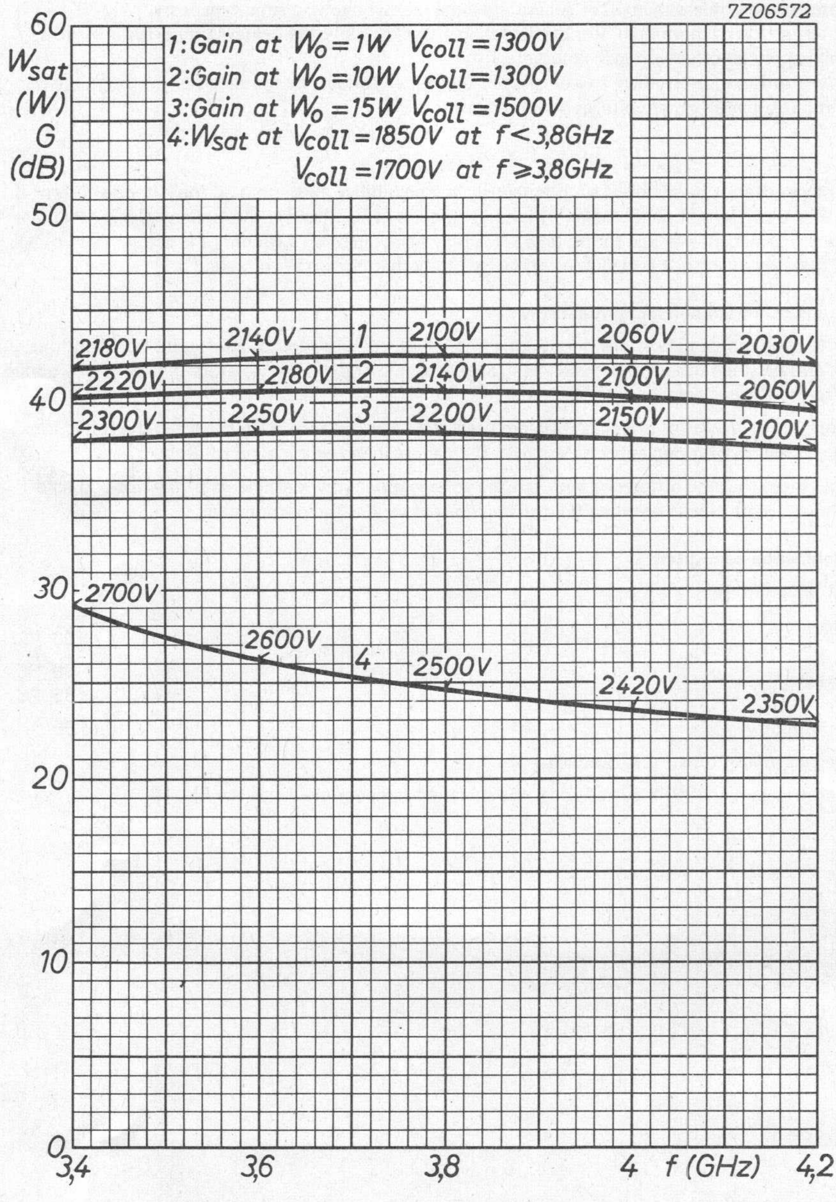


Fig. 6 Ratio of gain and saturation power to frequency.

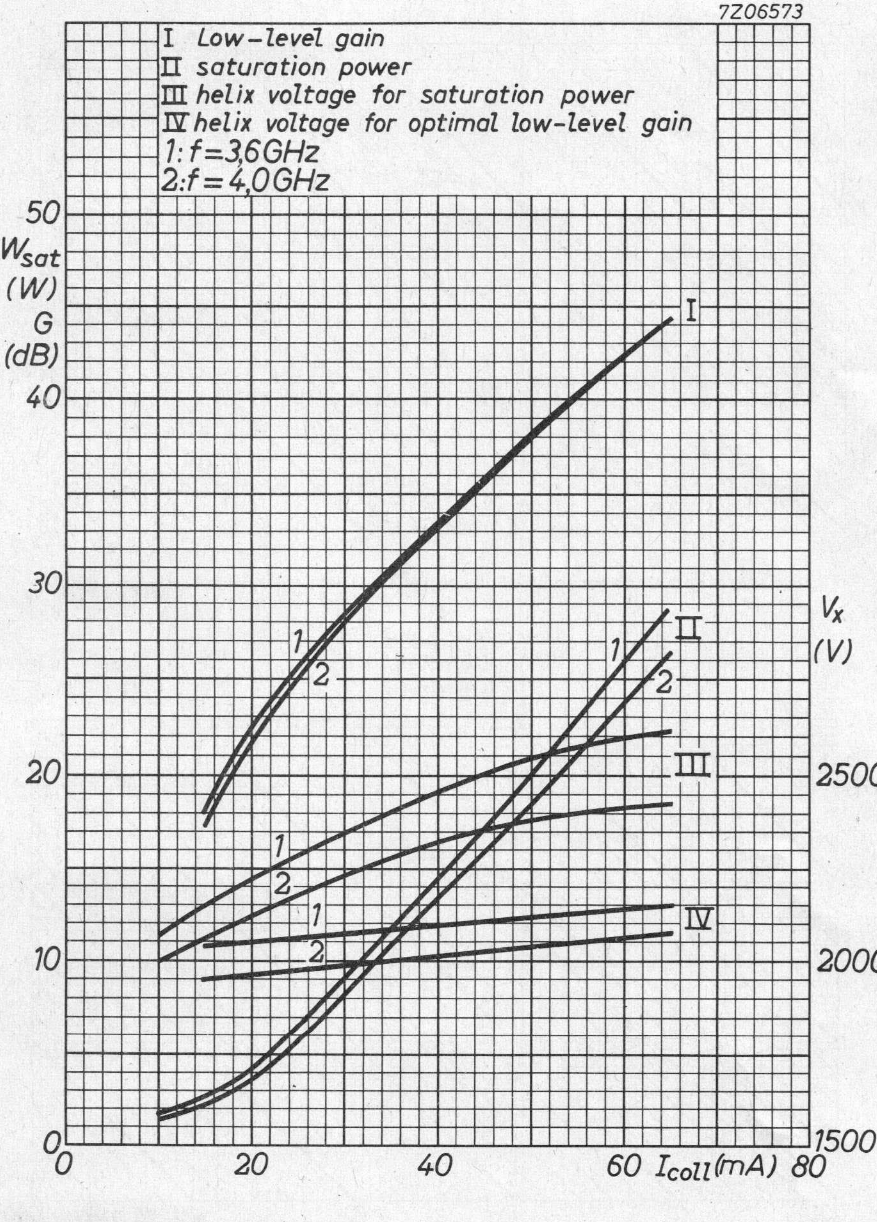


Fig. 7 Ratio of gain and saturation power to collector current.

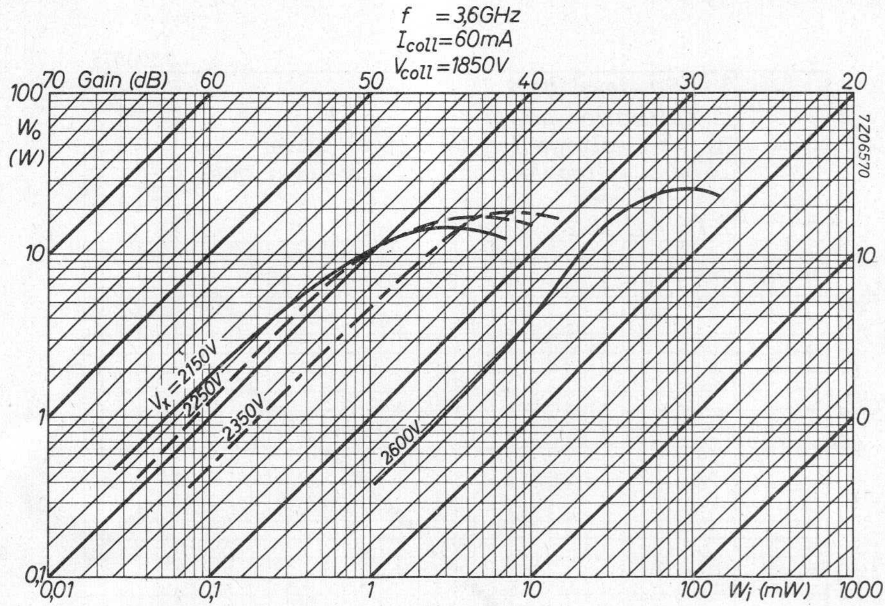


Fig. 8 Ratio of output power to input power. f = 3,6 GHz; I_{coll} = 60 mA; V_{coll} = 1850 V.

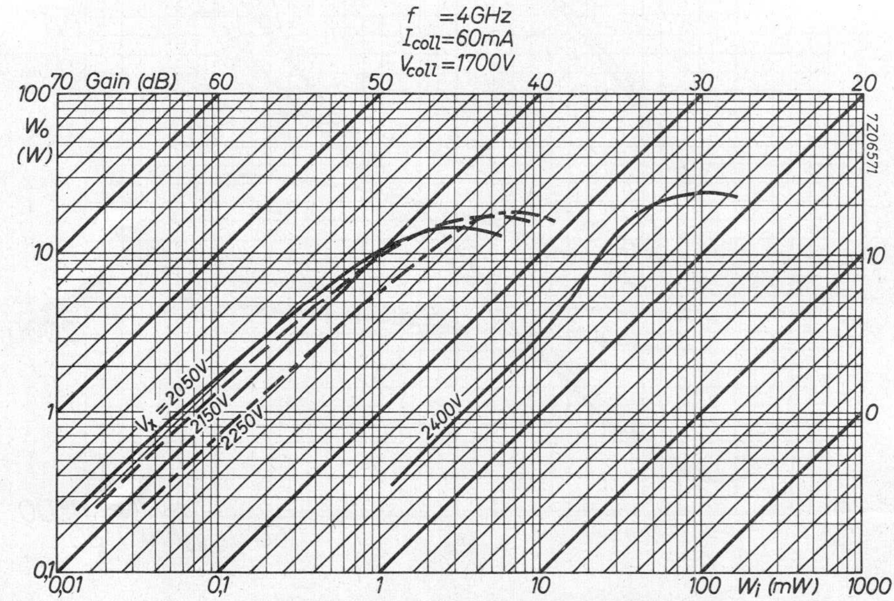


Fig. 9 Ratio of output power to input power. f = 4 GHz; I_{coll} = 60 mA; V_{coll} = 1700 V.

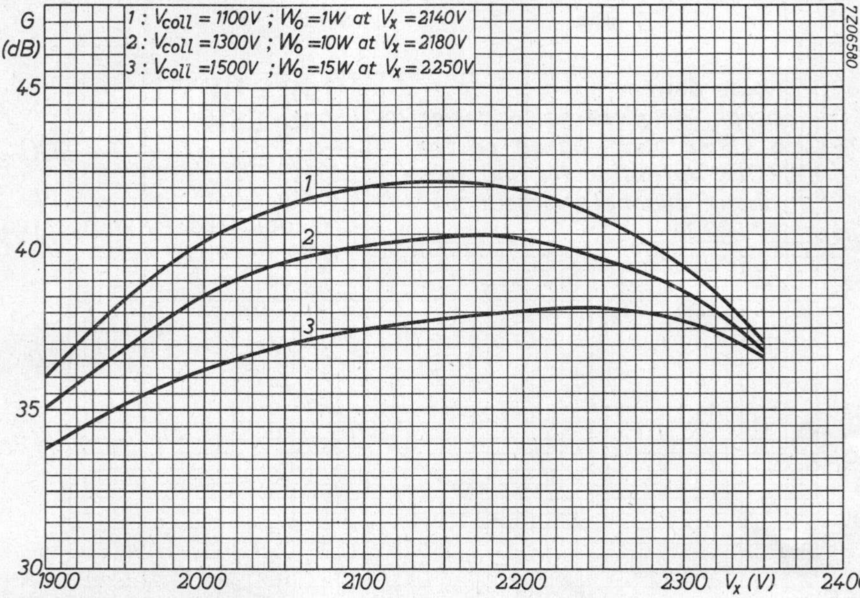


Fig. 10 Ratio of gain to helix voltage; f = 3,6 GHz.

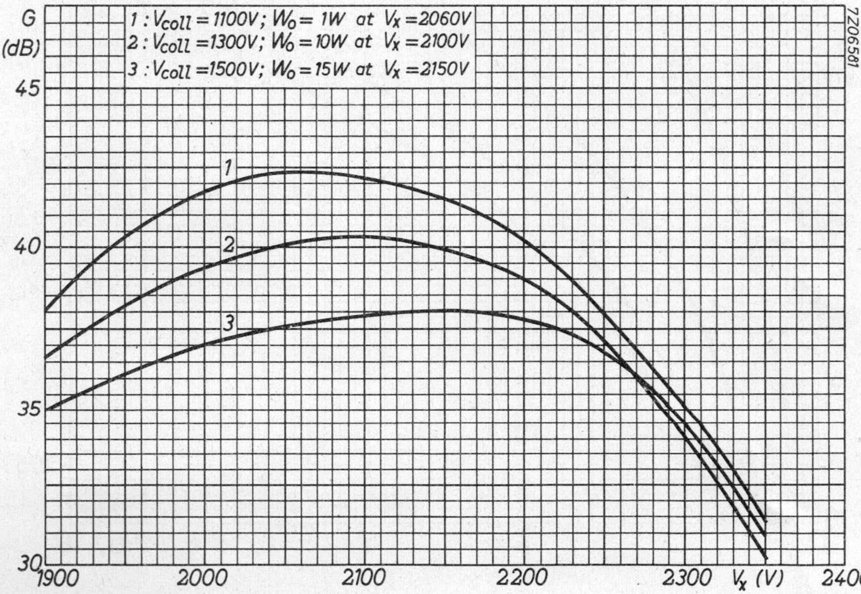


Fig. 11 Ratio of gain to helix voltage; f = 4 GHz.

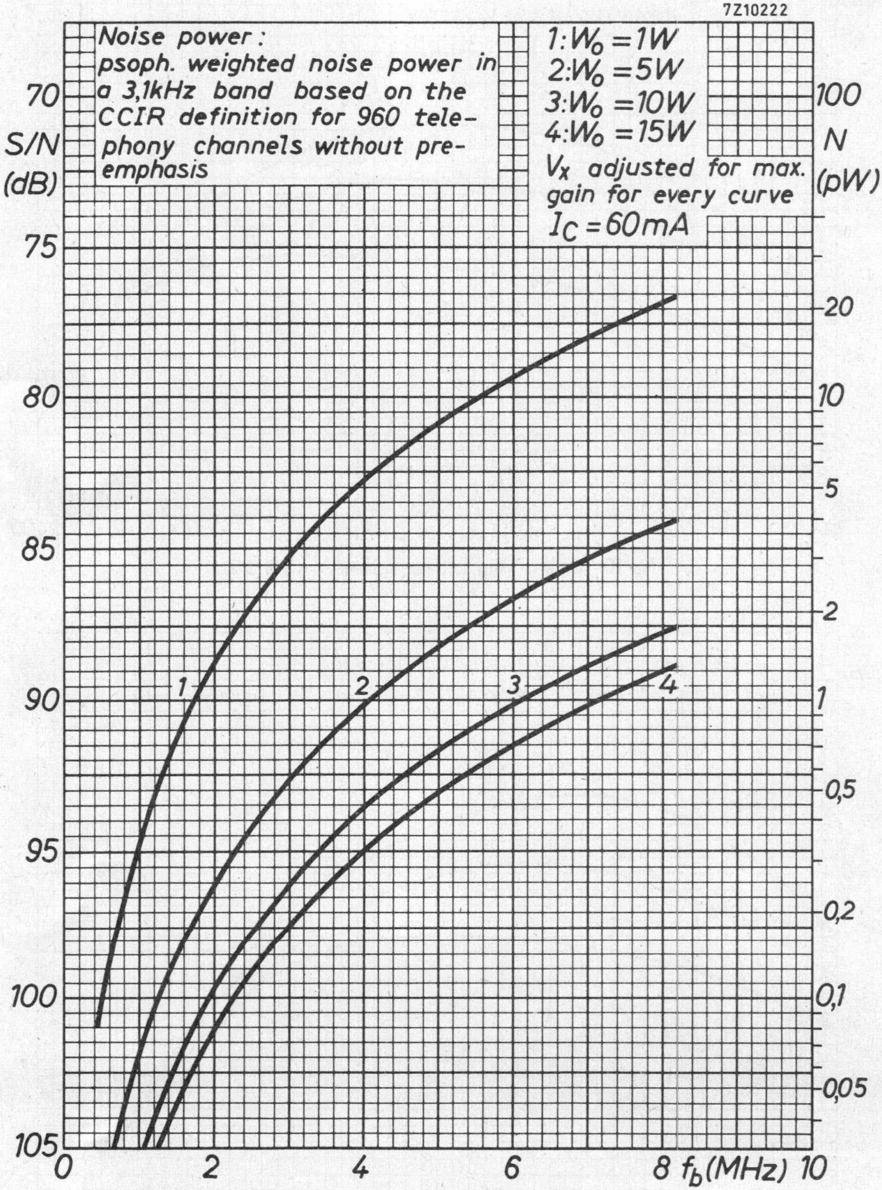


Fig. 12 Ratio of signal-to-noise ratio (FM) to baseband frequency; f = 4 GHz.

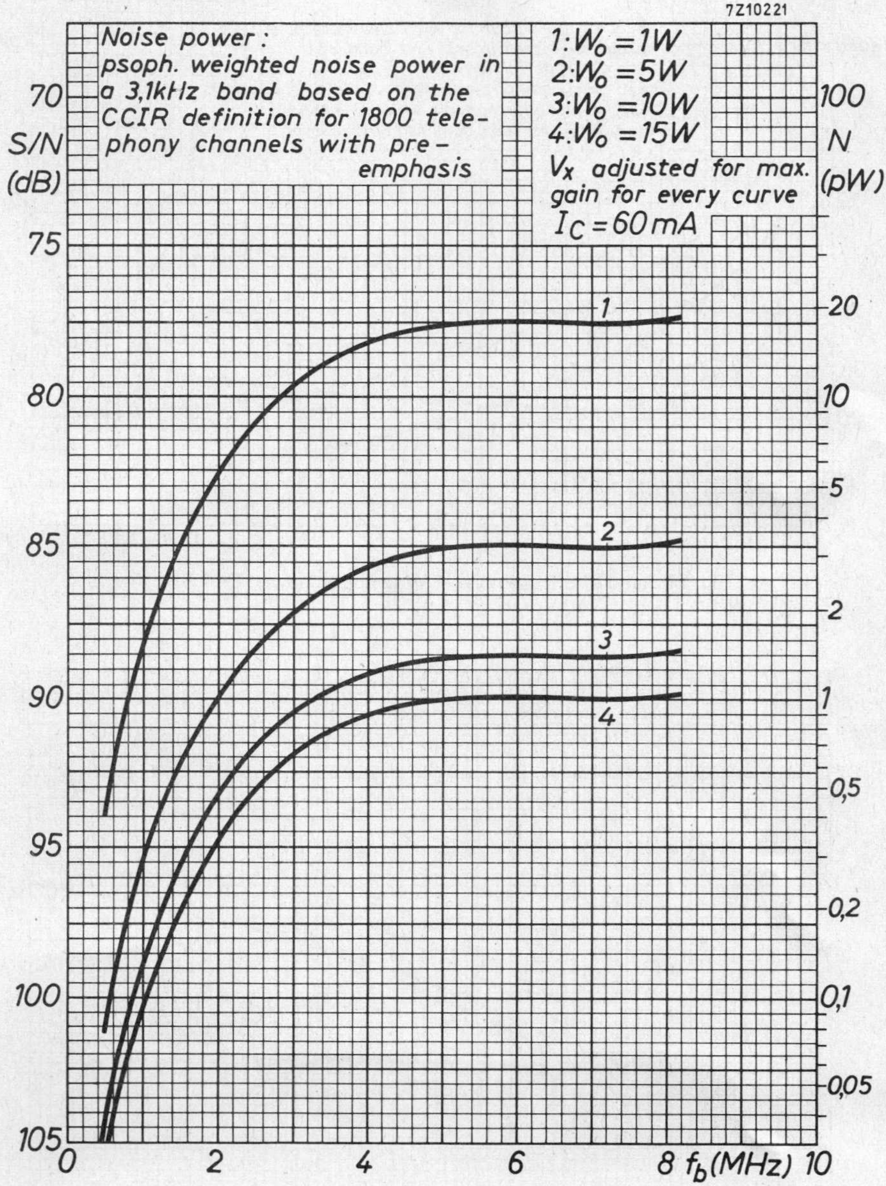


Fig. 13 Ratio of signal-to-noise ratio (FM) to baseband frequency; f = 4 GHz.

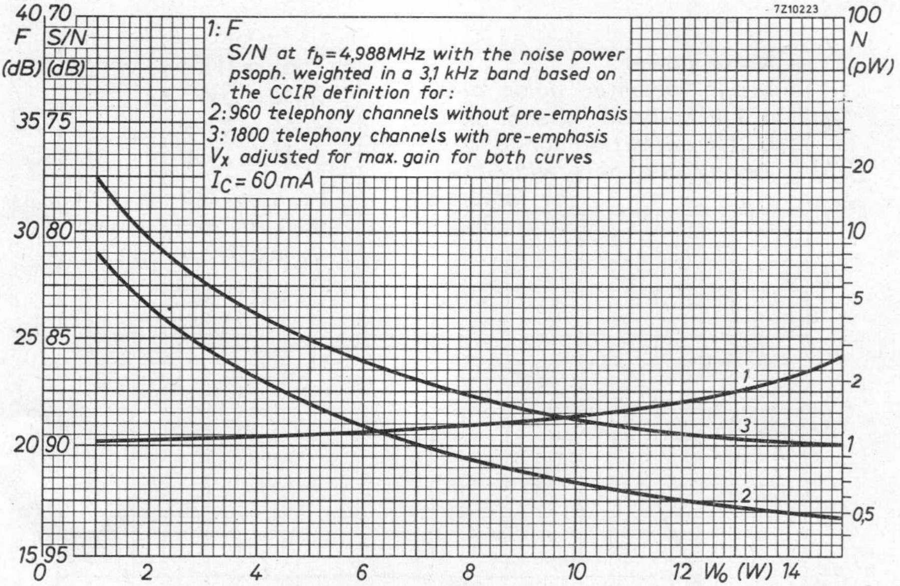


Fig. 14 Ratio of thermal noise (FM) to output power; f = 4 GHz.

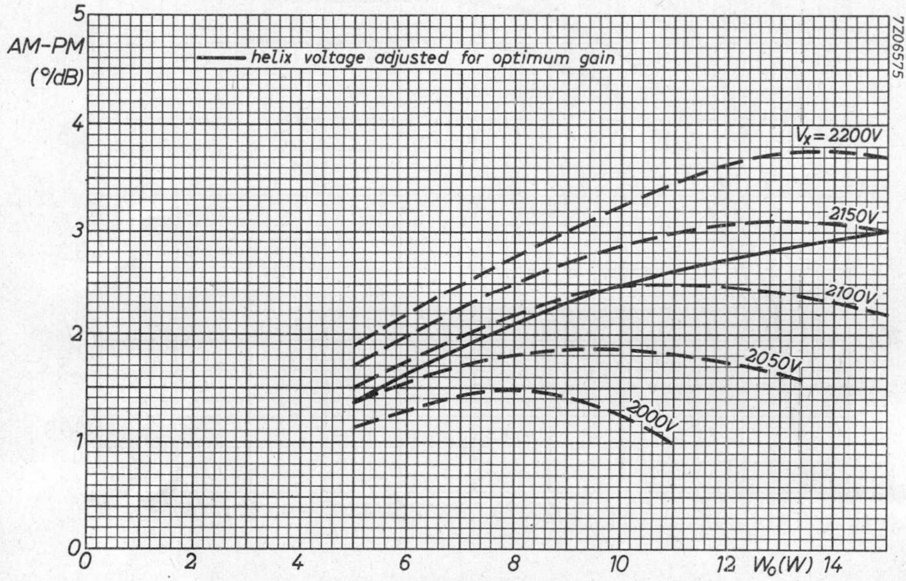


Fig. 15 Ratio of AM-to-PM conversion to output power; f = 4 GHz.

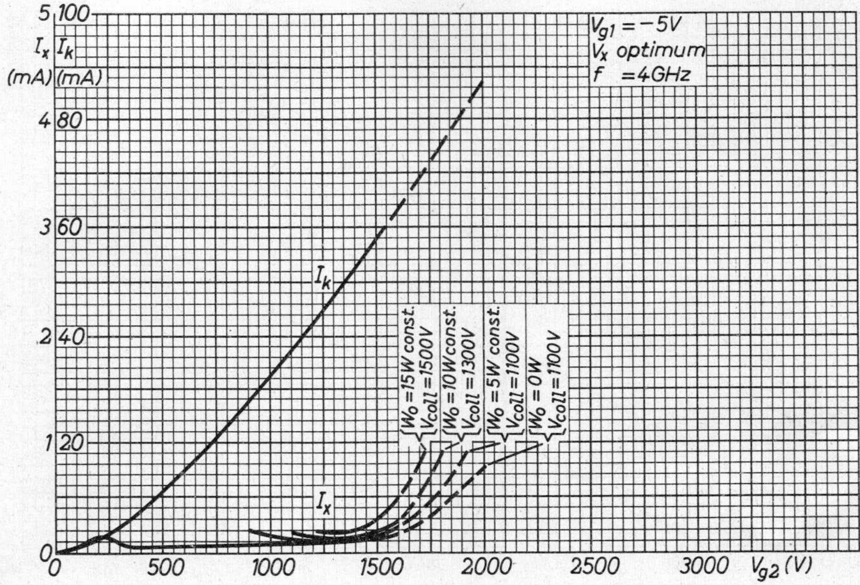


Fig. 16 Ratio of cathode current and helix current to accelerator voltage.

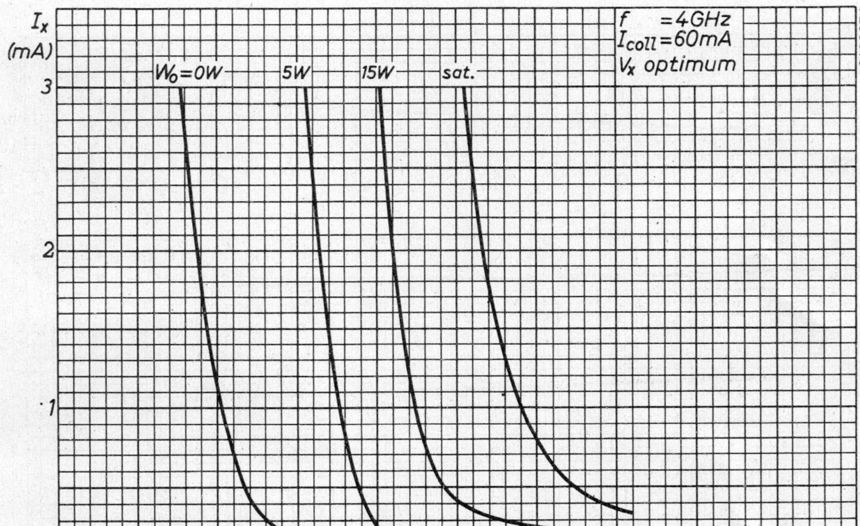


Fig. 17 Ratio of helix current to collector voltage.

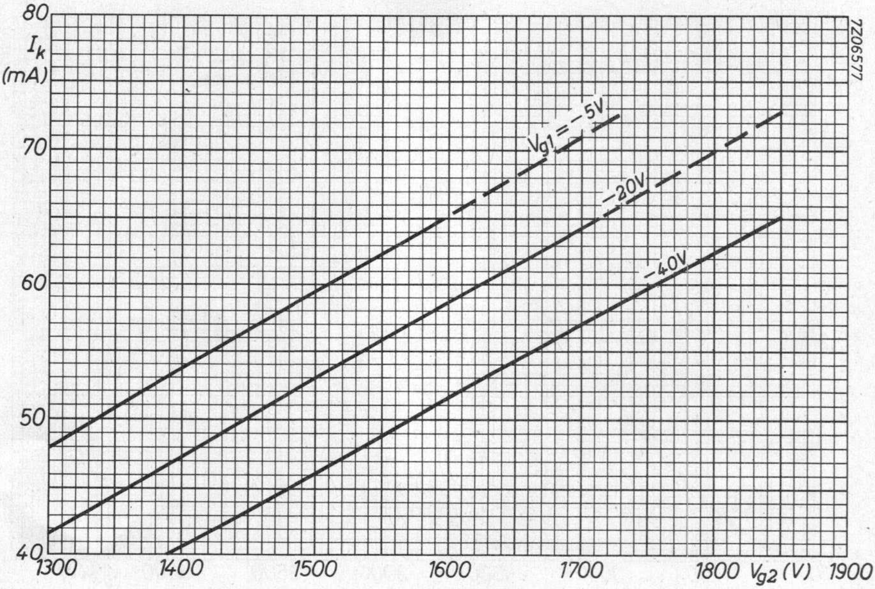


Fig. 18 Ratio of cathode current to accelerator voltage.

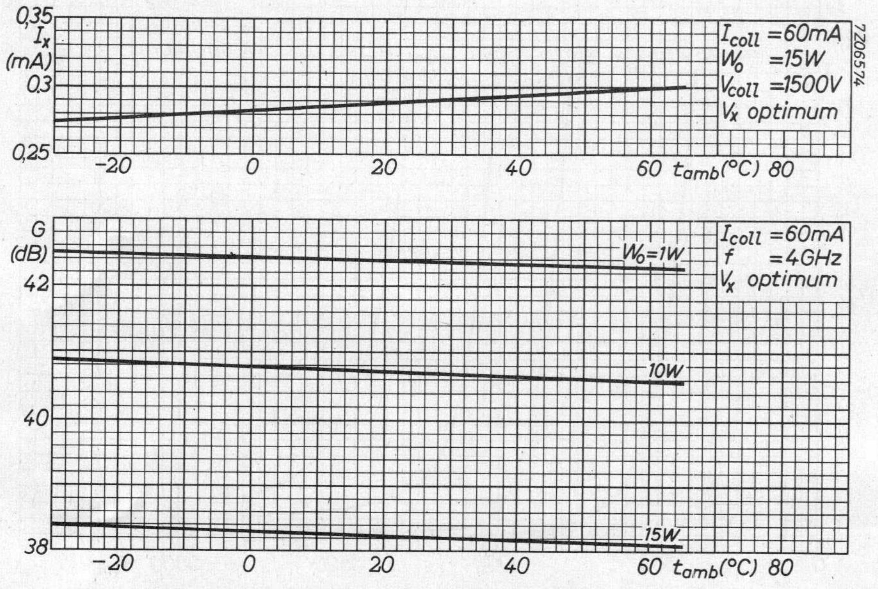


Fig. 19 Ratio of helix current and gain to ambient temperature.

TRAVELLING-WAVE TUBE

Travelling-wave tube with a periodic permanent magnet mount designed for wide-band microwave link applications.

QUICK REFERENCE DATA

Frequency range	5,8 to 8,5 GHz
Saturation output power at midband	20 W
Low-level gain at midband	45 dB
Interchangeability	plug-in focus, plug-in match
Construction	unpackaged
tube	glass-metal envelope, metal-ceramic base
mount	periodic permanent magnet

CATHODE: dispenser type

HEATER: indirect by a.c. or d.c.

When operated on d.c. the cathode must be connected to the positive side of the heater power supply.

Heater voltage	V_f		6,3 V ±2%
Heater current at V_f = 6,3 V	I_f	approx.	1 A
Waiting time	t_w	min.	2 min

For shorter waiting time when the tube already has been in operation see "Application of voltages".

COOLING: By conduction. See also "Design and operating notes", paragraph 6.

MECHANICAL DATA

Dimensions in mm

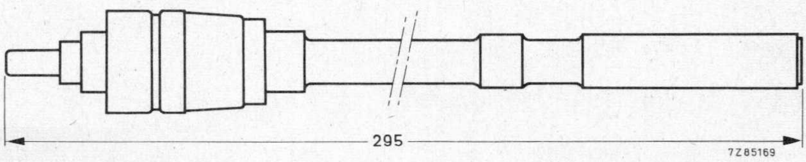


Fig. 1.

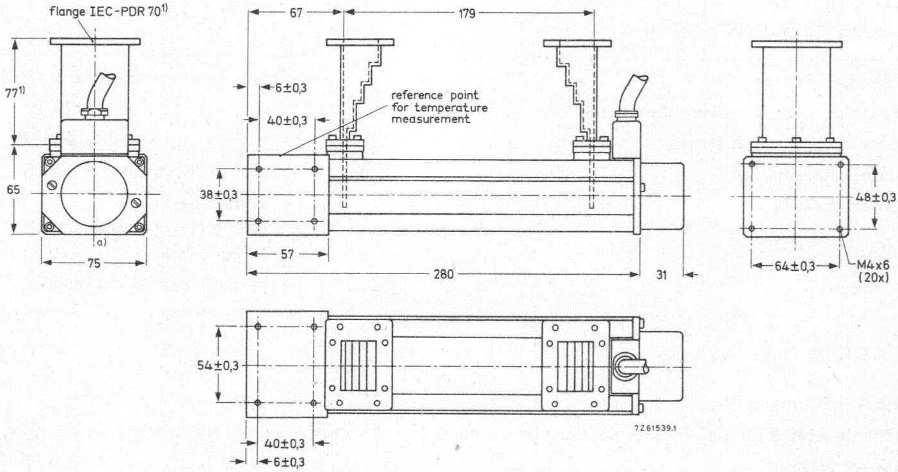
Mounting position: Any. See "Design and operating notes".

Mass

of tube	approx.	60 g
of mount	approx.	4,5 kg

ACCESSORIES (to be ordered separately)

PPM mount for conduction cooling	type 55337
Waveguide taper (two required) to waveguide IEC-R70 (34,85 x 15,80 mm^2) with flange mating IEC-PDR70	type 55338
Waveguide tapper (two required) to waveguide IEC-R84 (28,50 x 12,62 mm^2) with flange mating IEC-UER84	type 55342



(1) 37 mm for taper 55342 (flange UER-84).

Fig. 2 Mount with conduction (heatsink) cooling and waveguide tapers 55338.

Connections

The mount is provided with flying leads, marked with colours.

Heater, cathode	yellow
Heater	brown
Focusing electrode	green
Accelerator	blue
Helix	to be earthed via mount
Collector	red
Safety circuit (closed or opened, when putting on or taking off the mount cap)	two violet leads

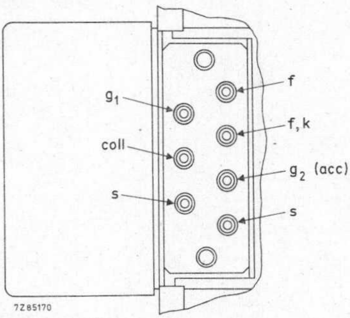


Fig. 3 Connections in cable housing.

GENERAL CHARACTERISTICS

Frequency range	f		5,8 to 8,5 GHz	
Saturation output power (CW)	W_{sat}		20 W	(note 1)
Low-level gain	G		45 dB	(note 2)
Gain at W_o = 15 W	G		39 dB	(note 3)
Thermal noise factor at W_o = 15 W	F		25 dB	(note 4)
AM to PM conversion at W_o = 15 W	k_p		3 ^{o}/dB	(note 4)
Cold match at input and output (f = 5,8 to 8,5 GHz)	VSWR	max.	1,5	

NOTES

1. Typical value measured at f = 7,2 GHz. I_{coll} = 55 mA, W_i and V_x optimally adjusted for saturation output power.
2. Typical value measured at f = 7,2 GHz. I_{coll} = 55 mA, $W_o < 1$ W, V_x optimally adjusted for low level gain.
3. Typical value measured at f = 7,2 GHz. I_{coll} = 55 mA, V_x adjusted for optimum gain.
4. Typical value measured at f = 6 GHz. I_{coll} = 55 mA, V_x adjusted for optimum gain.
5. Measured on the cold tube, i.e. with the beam switched off and without use of any matching device (plug-in match).

TYPICAL OPERATION

Voltages are specified with respect to the cathode.

Frequency	f		6,0		GHz
Output power	W_o	15	10	5	W
Helix voltage (adjusted for optimum gain)	V_x	approx. 2950	2900	2900	V
Collector voltage	V_{coll}	1500	1450	1300	V
Focusing electrode voltage	V_{g1}	−6	−6	−6	V
Collector current	I_{coll}	55	55	55	mA
Gain	G	41	43	45	dB
Accelerator voltage*	V_{g2}	approx. 2050	2050	2050	V
Accelerator current	I_{g2}	$<0,1$	$<0,1$	$<0,1$	mA
Helix current (plug-in focus)	I_x	0,8	0,8	0,5	mA
Thermal noise factor	F	25	23	22	dB
AM to PM conversion	k_p	3,0	2,5	1,5	°/dB

Frequency	f		7,0		GHz
Output power	W_o	15	10	5	W
Helix voltage (adjusted for optimum gain)	V_x	approx. 2850	2800	2800	V
Collector voltage	V_{coll}	1500	1450	1300	V
Focusing electrode voltage	V_{g1}	−6	−6	−6	V
Collector current	I_{coll}	55	55	55	mA
Gain	G	39	42	44	dB
Accelerator voltage*	V_{g2}	approx. 2050	2050	2050	V
Accelerator current	I_{g2}	$<0,1$	$<0,1$	$<0,1$	mA
Helix current (plug-in focus)	I_x	0,8	0,8	0,5	mA
Thermal noise factor	F	25	23	22	dB
AM to FM conversion	k_p	3,0	2,5	1,5	°/dB

* To be adjusted for indicated collector current.

Frequency	f		8,0		GHz
Output power	W_o		10	5	W
Helix voltage (adjusted for optimum gain)	V_x	approx.	2750	2750	V
Collector voltage			1540	1300	V
Focusing electrode voltage	V_{g1}		−6	−6	V
Collector current	I_{coll}		55	55	mA
Gain	G		38	40	dB
Accelerator voltage*	V_{g2}	approx.	2050	2050	V
Accelerator current	I_{g2}		<0,1	<0,1	mA
Helix current (plug-in focus)	I_x		0,8	0,5	mA
Thermal noise factor	F		23	22	dB
AM to PM conversion	k_p		2,5	1,5	°/dB

LIMITING VALUES (Absolute maximum rating system)

Voltages are with respect to the cathode unless otherwise specified.

Focusing electrode voltage	$-V_{g1}$	min.	0	V
		max.	50	V
Accelerator voltage	V_{g2}	max.	2700	V
Helix voltage	V_x	max.	3300	V
Collector to helix voltage	$V_{coll\text{-}x}$	max.	2500	V
Cathode current	I_k	max.	60	mA
Accelerator current	I_{g2}	max.	0,3	mA
Helix current	I_x	max.	3	mA
R.F. input level	W_i	max.	100	mW
Collector dissipation at T_{amb} = 65 °C	W_{coll}	max.	90	W
Power reflected from load (to avoid overheating of the helix)		max.	2	W
Cooler temperature at reference point	T	max.	150	°C

* To be adjusted for indicated collector current.

DESIGN AND OPERATING NOTES

1. Installation of the mount

Two main methods may be discerned:

(a) Fixing the mount relative to the microwave circuit by only connecting the waveguide tapers to the input and output sides of the circuit.

(b) Employing (a) and establishing additional support by fastening the mount to the rack with clamps. In this case it is recommended that a short piece of flexible waveguide be used at the input and output sides to prevent excessive strain on the mount via the tapers, unless very careful alignment of the waveguides can be assured.

Possible forces on the waveguides must not produce a moment greater than 20 Nm at the flanges.

1.1 Mount

The mount has no movable parts. If clamps are used (method b) the slightly larger dimensions of the cooler as compared to the main part of the mount must be considered.

1.2 Magnetic shielding

The periodic permanent magnet is completely shielded. This implies that no additional measures need be taken to prevent the magnetic properties of the mount from being affected by external magnetic fields. The mount will not influence surrounding equipment which is susceptible to stray magnetic fields. Several mounts may be placed side by side without disturbing the focusing qualities. Isolators may be installed quite near to the mount.

Warning

If any part of the shielding is removed, the magnetic properties of the mount may be disturbed irreversibly.

2. Installation of the tube

Unlock the mount cap (see outline drawing) by turning it slightly counter-clockwise. The cap can then easily be removed, and the tube inserted by carefully pushing it in. Finally put the cap on the mount again, and lock by turning it clockwise. These instructions also apply (in the reverse order) for taking the tube out of the mount.

3. Safety

The supply voltages are fed to the tube via the mount cap. When the cap is unlocked all voltages are removed from the tube. The two violet leads can be incorporated into an additional safety circuit which switches the voltages off at the power supply if the cap is unlocked. Thus the voltages can also be removed from the mount. The mount should always be earthed.

4. Power supply

An example of a supply circuit for 5, 10 and 15 W operation is given in Fig. 4.

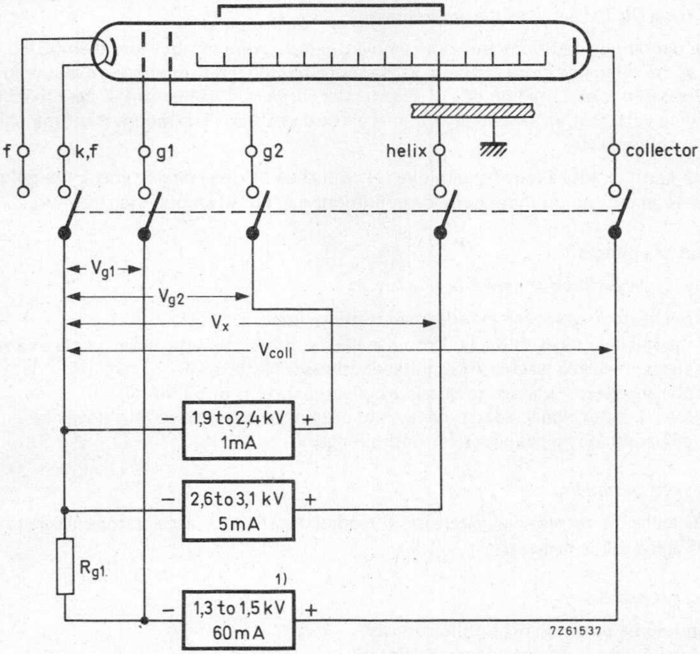


Fig. 4.

Design ranges for the power supply (electrode voltages with respect to cathode)

	min.	max.	
Accelerator voltage	1900	2400	V
Accelerator current		0,3	mA
Helix voltage*	2600	3100	V
Helix current		3	mA

The collector voltage is set at a fixed voltage dependent on the output power level.

Output power level	W_o	5	10	15	W_{sat}	W
Collector voltage	V_{coll}	1300	1450	1500	1700	V
Collector current	I_{coll}	55	55	55	55	mA
Focusing electrode voltage	V_{g1}	−6	−6	−6	−6	V

* At saturation the helix voltage may reach 3200 V.

5. Cooling

Tube and mount need no artificial means of cooling. Natural cooling of the collector has been made possible by depression of the collector potential with respect to the helix and by ensuring adequate heat transfer from the collector to the environment.

Under typical operating conditions and at an ambient temperature of not more than 65 ^{o}C, the cooler temperature at the reference point (see Fig. 2) is well below the limit, provided an aluminium heatsink of 300 x 300 x 6 mm is mounted on one of the coooler surfaces. The heatsink is best fixed with its centre coinciding with that of the cooler, and in a vertical position. The mount itself may have any position in the equipment.

Other heatsink configurations may be employed. It will then be necessary to check the temperatures reached at the reference point under extreme conditions e.g. 65 ^{o}C ambient temperature.

6. Application of voltages

6.1 Switching-on procedure for new tubes

6.1.1 Apply the heater voltage for the specified waiting time.
6.1.2 Apply the rated voltages to the collector, the helix, the accelerator (and in case of a separate supply to the focusing electrode) simultaneously (see Notes).
6.1.3 Adjust the accelerator voltage to obtain a collector current of 55 mA.
6.1.4 Apply the r.f. input signal, adjust the level to obtain the required output power while simultaneously adjusting the helix voltage for optimum gain.

6.2 Readjustment during life

During life the collector current may decrease. A readjustment of the accelerator voltage to obtain I_{coll} = 55 mA will then be necessary.

6.3 Switching-off procedure

All voltages should be switched off simultaneously.
If this is not feasible, do as described under "Notes".

6.4 Switching-on procedure after interruption of voltage (also see the Notes)

6.4.1 Interruption of less than 40 s: Switch on all voltages simultaneously.
6.4.2 Interruption of more than 40 s but less than 1 week: Apply the heater voltage for min. 40 s, then apply all other voltages simultaneously.
6.4.3 Interruption of more then 1 week: Apply the heater voltage for the specified waiting time of 2 min. Apply all other voltages simultaneously.

NOTES

When the voltages cannot be switched simultaneously all the cathode current may flow to the accelerator or the helix. If this condition lasts for more than 10 ms, it may cause permanent damage to the tube. The remedy is to switch the accelerator voltage on after the other electrode voltages, or off before the other electrode voltages.

7. Input and output circuit and group delay

In order to avoid phase distortions due to long-line effect, the insertion of an isolator between tube and antenna, and another between tube and pre-stage is strongly recommended. The isolators should be positioned as close to the tube as possible.

If isolators with a VSWR of less than 1,05 are used at a short distance from the tube, the reflections result in a variation of the group delay of less than 0,2 nanoseconds over a band of 20 MHz.

It may be noted that the difference between the voltage reflection coefficients of the hot and the cold tube (i.e. with respectively without electron beam) is less than 0,2 for the input as well as the output side, measured at an output power level of 5 W or more.

8. Environmental conditions

Ambient temperature			
storage	T_{amb}	min.	−60 °C
		max.	+65 °C
operation	T_{amb}	min.	−30 °C
		max.	+65 °C
Relative humidity			0 to 95 %

The tube and mount resist fungus attack.

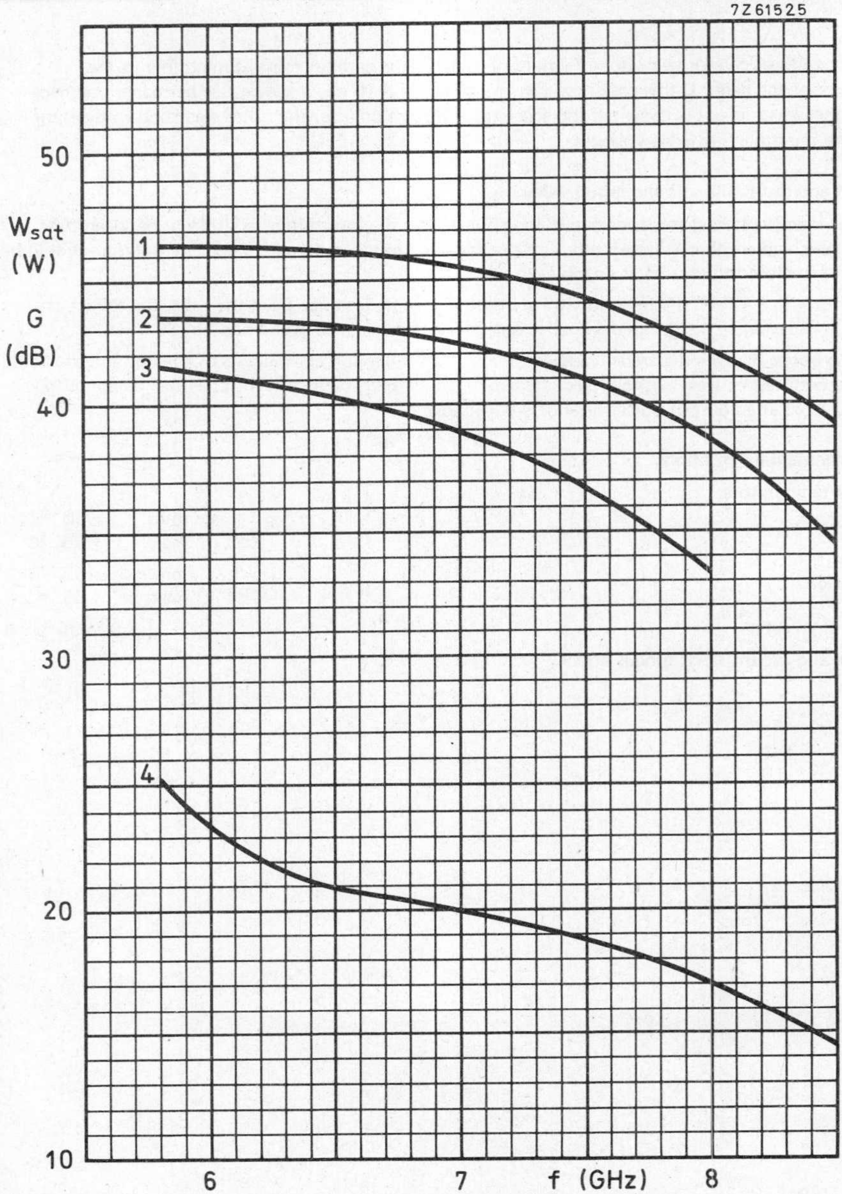


Fig. 5 Ratio of gain and saturation power to frequency.
1. Gain at W_o = 1 W; V_{coll} = 1300 V; V_f = 6,3 V
2. Gain at W_o = 10 W; V_{coll} = 1450 V; V_{g1} = –6 V
3. Gain at W_o = 15 W, V_{coll} = 1500 V; I_{coll} = 55 mA
4. W_o = W_{sat} V_{coll} = 1700 V; V_x = opt.

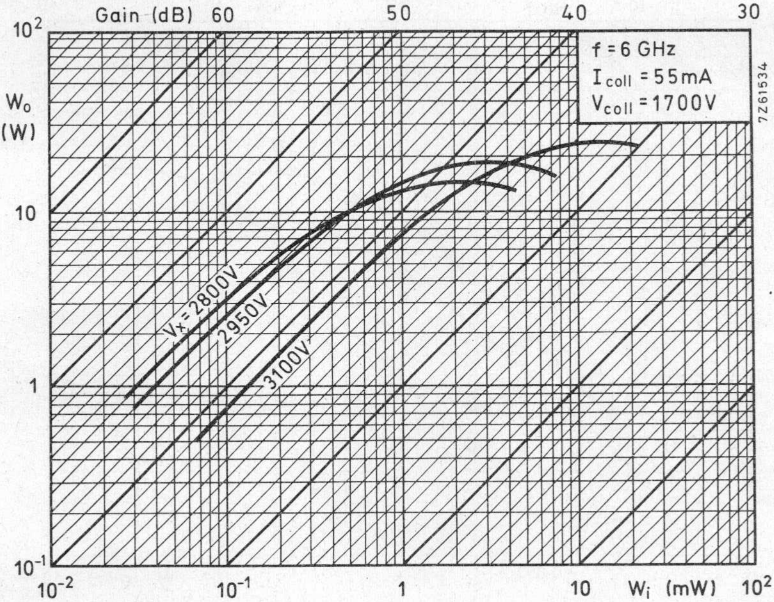


Fig. 6 Ratio of output power to input power; f = 6 GHz.

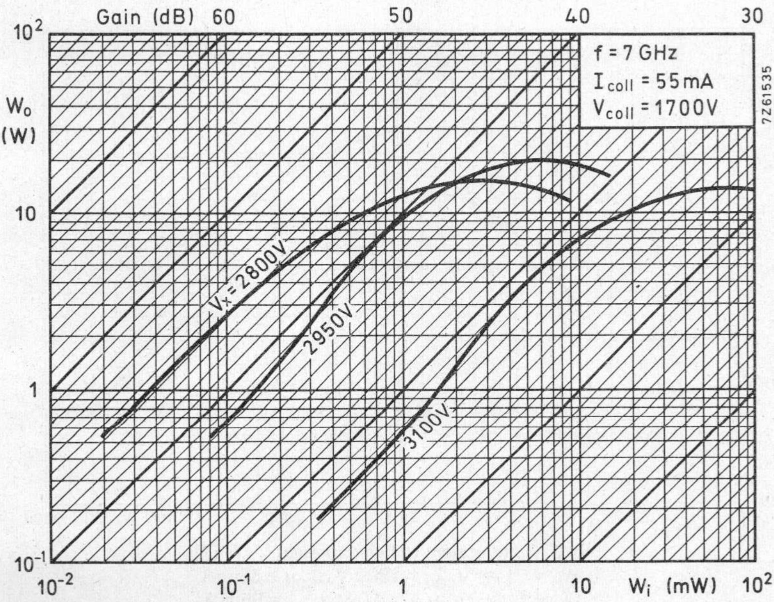


Fig. 7 Ratio of output power to input power; f = 7 GHz.

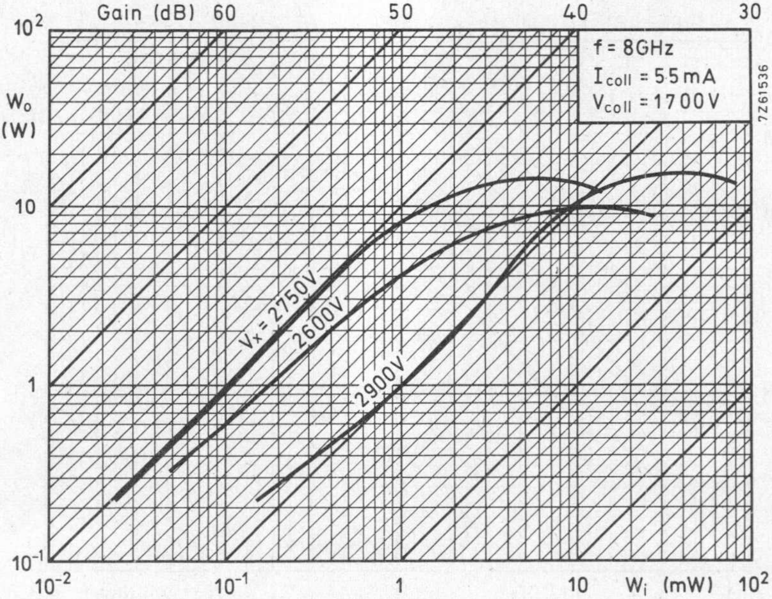


Fig. 8 Ratio of output power to input power.

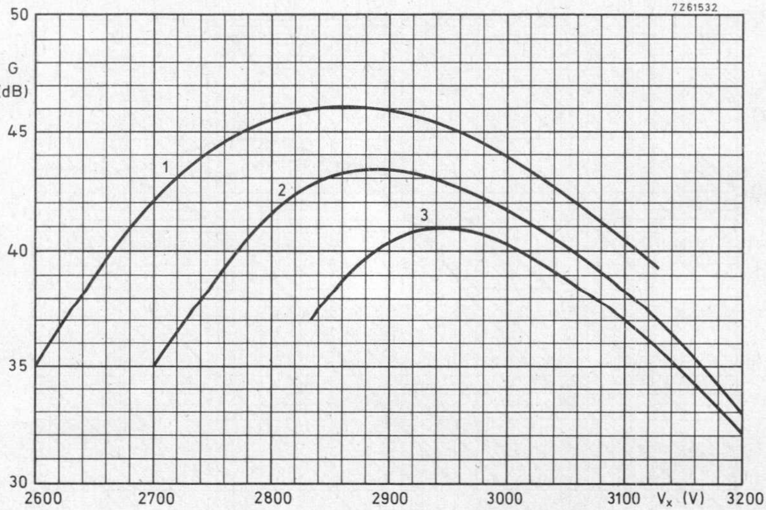


Fig. 9 Ratio of gain to helix voltage; f = 6 GHz.
1. W_o = 1 W; V_{coll} = 1300 V; I_{coll} = 55 mA.
2. W_o = 10 W; V_{coll} = 1450 V; I_{coll} = 55 mA.
3. W_o = 15 W; V_{coll} = 1500 V; I_{coll} = 55 mA.

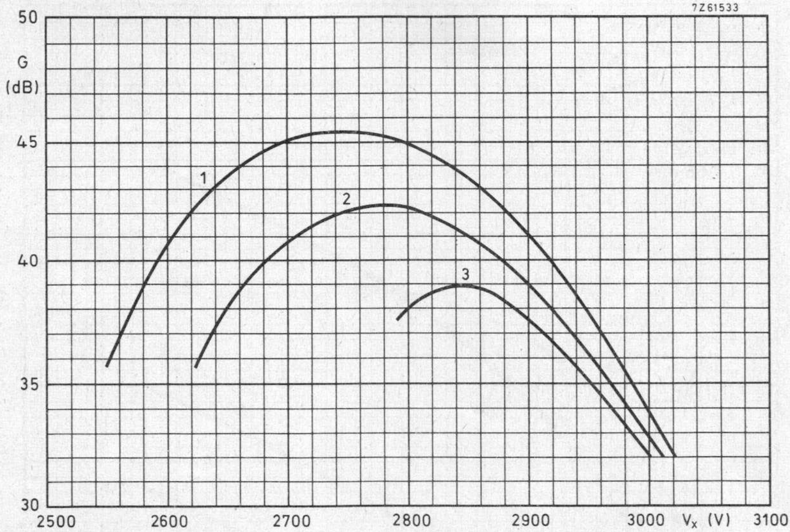


Fig. 10 Ratio of gain to helix voltage; f = 7 GHz.
1. W_o = 1 W; V_{coll} = 1300 V; I_{coll} = 55 mA
2. W_o = 10 W; V_{coll} = 1450 V; I_{coll} = 55 mA
3. W_o = 15 W; V_{coll} = 1500 V; I_{coll} = 55 mA.

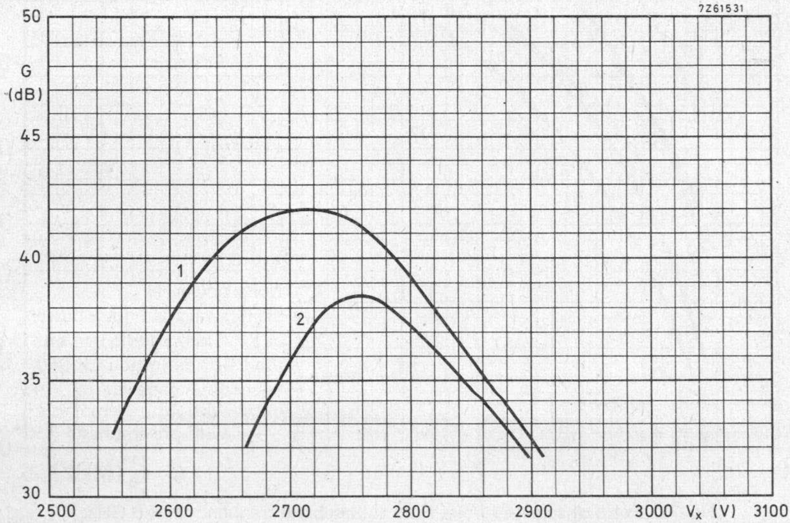


Fig. 11 Ratio of gain to helix voltage; f = 8 GHz.
1. W_o = 1 W; V_{coll} = 1300 V; I_{coll} = 55 mA
2. W_o = 10 W; V_{coll} = 1450 V; I_{coll} = 55 mA.

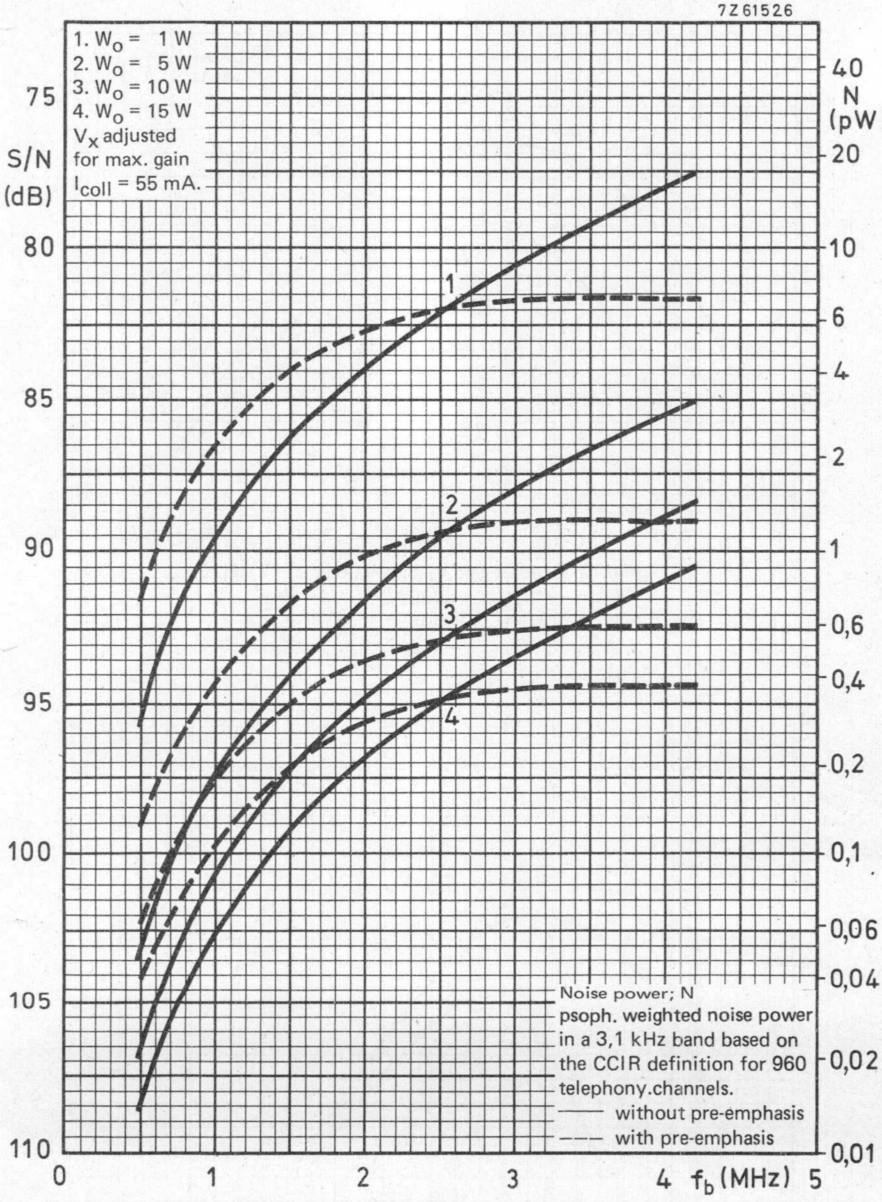


Fig. 12 Ratio of signal-to-noise ratio to baseband frequency; f = 6 GHz.

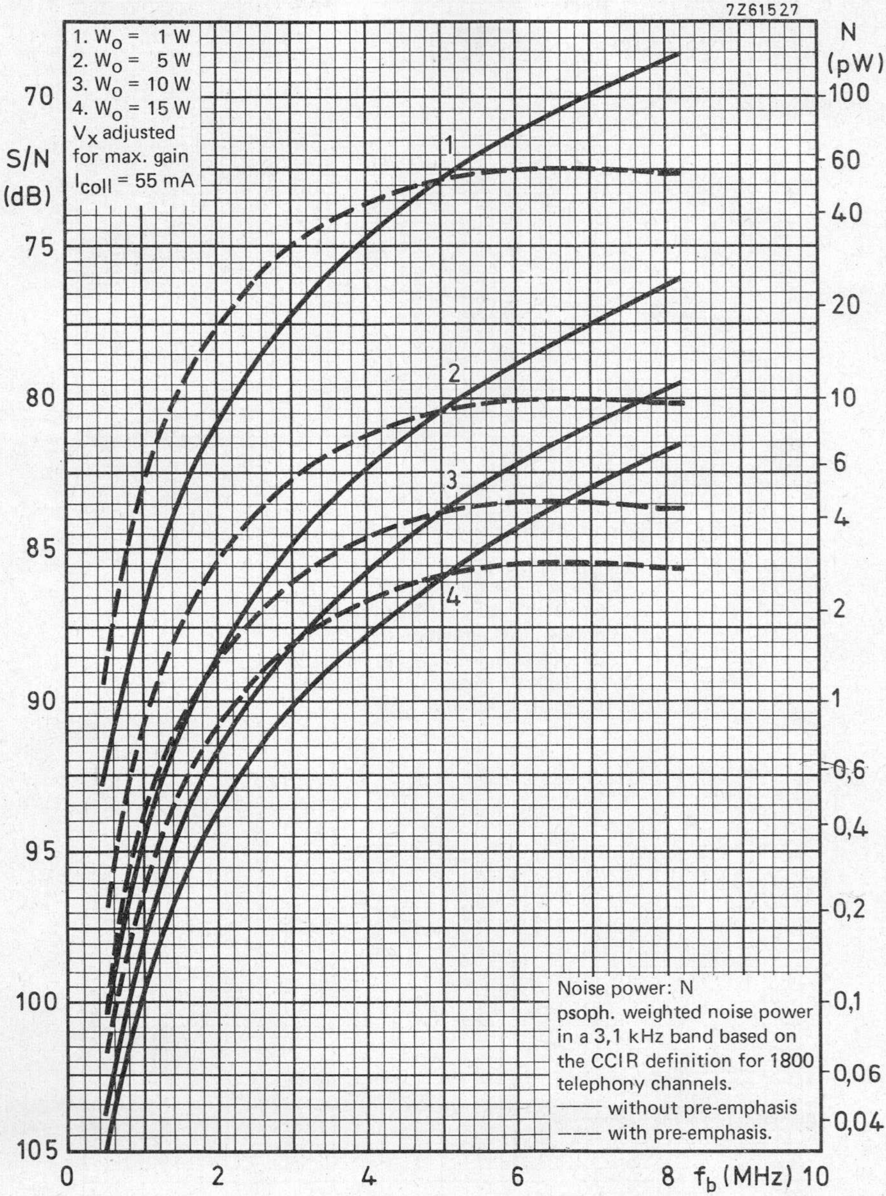


Fig. 13 Ratio of signal-to-noise ratio (FM) to baseband frequency; f = 6 GHz.

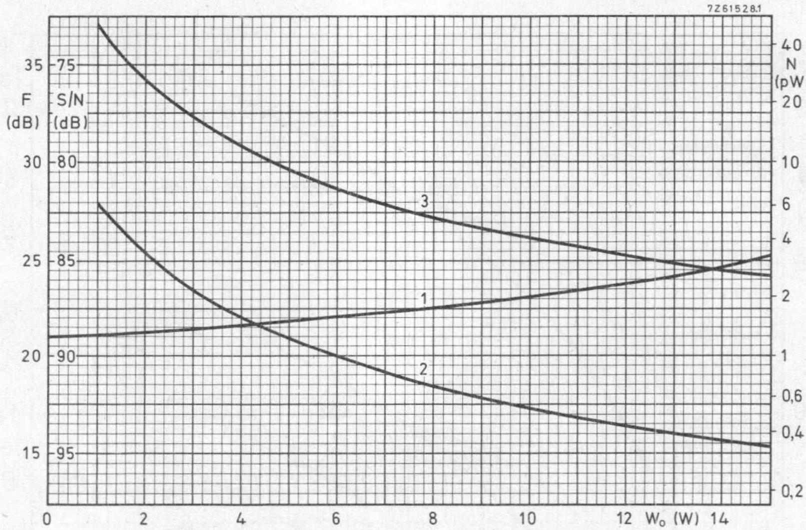


Fig. 14 Ratio of thermal noise (FM) to output power; f = 6 GHz.

1. F at I_{coll} = 55 mA
S/N with the noise psoph.
weighted in a 3,1 kHz band based
on the CCIR definition for:
2. 960 channels at f_b = 2,546 MHz
3. 1800 channels at f_b = 4,988 MHz
V_x adjusted for max. gain.

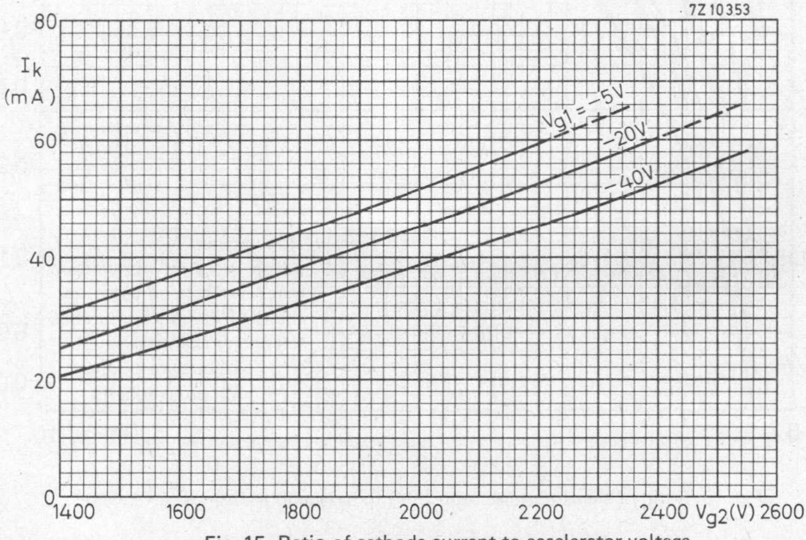


Fig. 15 Ratio of cathode current to accelerator voltage.

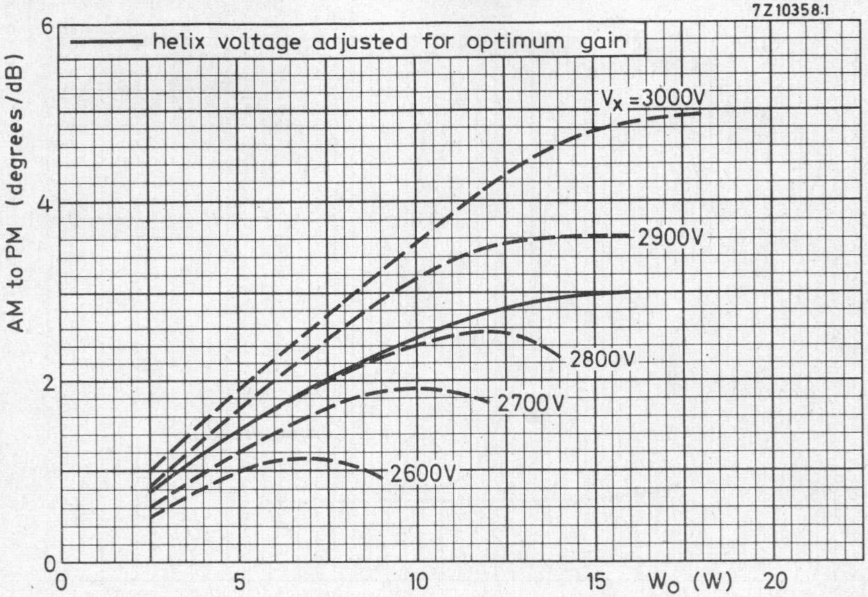


Fig. 16 Ratio of AM-to-PM conversion to output power; f = 6 GHz.

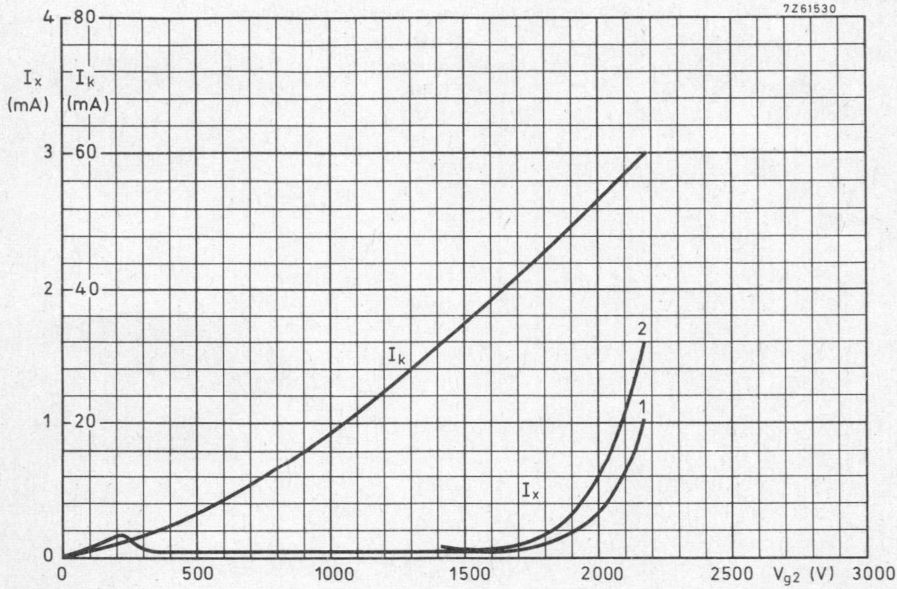


Fig. 17 Ratio of cathode current and helix current to accelerator voltage.

V_{g1} = −6 V
f = 6 GHz

1 { W_o = 0 W; V_{coll} = 1300 V; V_x = 2850 V }

2 { W_o = 10 W; V_{coll} = 1450 V; V_x = optimum }

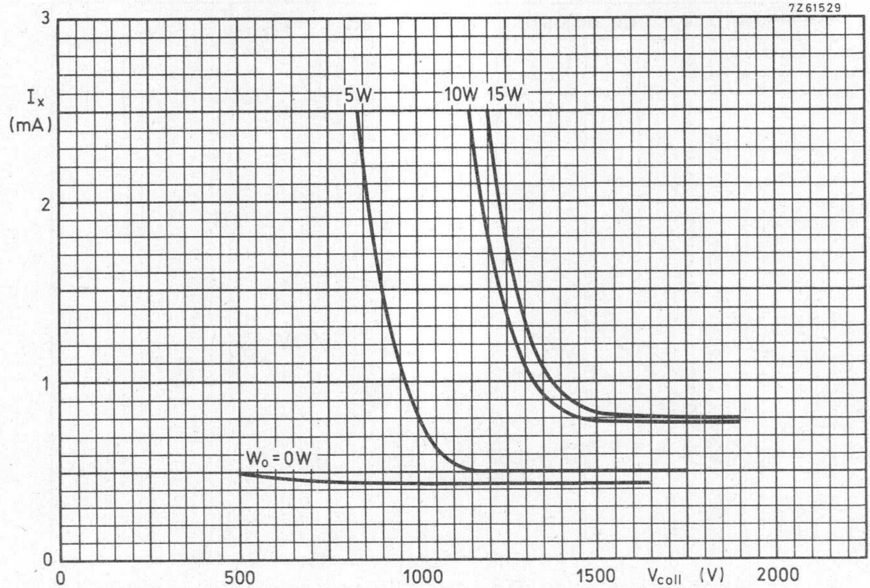


Fig. 18 Ratio of helix current to collector voltage.

$f = 6$ GHz
V_x = optimum
$I_{coll} = 55$ mA
$V_{g1} = -6$ V

TRAVELLING-WAVE TUBE

Travelling-wave tube with a periodic permanent magnet mount designed for wide-band microwave link applications.

QUICK REFERENCE DATA

Frequency range	7,0 to 8,0	8,0 to 8,5	GHz
Saturation output power at midband	22	17	W
Low-level gain at midband	45	42	dB
Interchangeability	plug-in focus, plug-in match		
Construction	unpackaged		
tube	glass-metal envelope, metal-ceramic base		
mount	periodic permanent magnet		

CATHODE: dispenser type

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

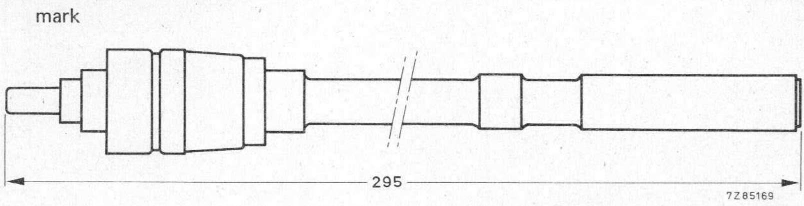
When operated on d.c. the cathode must be connected to the positive side of the heater power supply.

Heater voltage	V_f		6,3	V ± 2%
Heater current at V_f = 6,3 V	I_f	approx.	1	A
Waiting time	t_w	min.	2	min

For shorter waiting time when the tube already has been in operation see "Application of voltages".

COOLING: By conduction. See also "Design and operating notes", paragraph 6.

MECHANICAL DATA Dimensions in mm



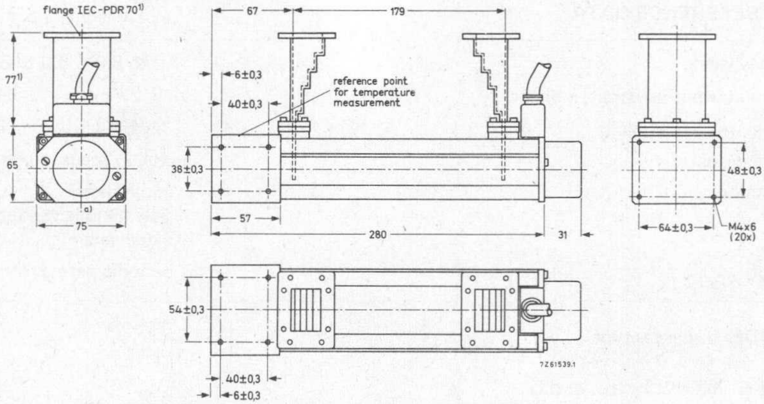
Mounting position: The tube is provided with a mark on the accelerator terminal. For optimum performance the tube must be inserted with this mark in line with the centre line a) of the cable housing on the mount. See Fig. 2.

Mass

of tube	approx.	60	g
of mount	approx.	4,5	kg

ACCESSORIES (to be ordered separately)

PPM mount for conduction cooling	type 55361
Waveguide taper (two required) to waveguide IEC-R70 (34,85 x 15,80 mm) with flange mating IEC-PDR70	type 55338
Waveguide taper (two required) to waveguide IEC-R84 (28,50 x 12,62 mm) with flange mating IEC-UER84	type 55342



(1) 37 mm for taper 55342 (flange UER84)

Fig. 2 Mount with conduction (heatsink) cooling and waveguide tapers type 55338.

Connections

The mount is provided with flying leads, marked with colours.

Heater, cathode	yellow
Heater	brown
Focusing electrode	green
Accelerator	blue
Helix	to be earthed via mount
Collector	red
Safety circuit (closed or opened, when putting on or off the mount cap)	two violet leads.

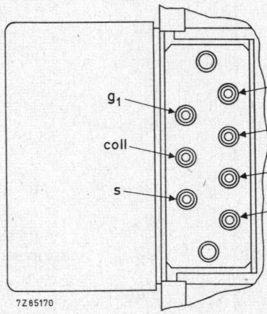


Fig. 3 Connections in cable housing.

GENERAL CHARACTERISTICS

Frequency range	f	7,0 to 8,0	8,0 to 8,5	GHz
Saturation output power (CW)	W_{sat}	22	17	W
Low-level gain	G	45	42	dB
Gain				
at W_o = 15 W	G	41		dB
at W_o = 10 W	G		39	dB
Thermal noise factor				
at W_o = 15 W	F	24		dB
at W_o = 10 W	F		24	dB
AM to FM conversion at W_o = 15 W	k_p	3		°/dB
Cold match at input and output (f = 7,0 to 8,5 GHz)	VSWR		max. 1,5	

Notes

1. Typical values measured at f = 7,5 GHz, I_{coll} = 55 mA, or f = 8,3 GHz, I_{coll} = 52,5 mA respectively, W_i and V_x optimally adjusted for saturation output power.
2. Typical values measured at f = 7,5 GHz, I_{coll} = 55 mA, or f = 8,3 GHz, I_{coll} = 52,5 mA respectively, $W_o < 1$ W, V_x optimally adjusted for low level gain.
3. Typical value measured at f = 7,5 GHz, I_{coll} = 55 mA, or f = 8,3 GHz, I_{coll} = 52,5 mA respectively, V_x adjusted for optimum gain.
4. Measured on the cold tube, i.e. with the beam switched off and without use of any matching device (plug-in match).

TYPICAL OPERATION

Voltages are specified with respect to the cathode.

Frequency	f			7,0		GHz
Output power	W_o		15	10	5	W
Helix voltage (adjusted for optimum gain)	V_x	approx.	3100	3000	2950	V
Collector voltage	V_{coll}		1500	1450	1300	V
Focusing electrode voltage	V_{g1}		−6	−6	−6	V
Collector current	I_{coll}		55,0	52,5	52,5	mA
Gain	G		42	43	45	dB
Accelerator voltage*	V_{g2}	approx.	2050	2000	2000	V
Accelerator current	I_{g2}		$<0,1$	$<0,1$	$<0,1$	mA
Helix current (plug-in focus)	I_x		1,0	0,7	0,5	mA
Thermal noise factor	F		24	24	22	dB
AM to FM conversion	k_p		3,0	2,5	1,5	°/dB

Frequency	f			8,0		GHz
Output power	W_o		15	10	5	W
Helix voltage (adjusted for optimum gain)	V_x	approx.	3050	2950	2900	V
Collector voltage	V_{coll}		1500	1450	1300	V
Focusing electrode voltage	V_{g1}		−6	−6	−6	V
Collector current	I_{coll}		55,0	52,5	52,5	mA
Gain	G		39	40	43	dB
Accelerator voltage*	V_{g2}	approx.	2050	2000	2000	V
Accelerator current	I_{g2}		$<0,1$	$<0,1$	$<0,1$	mA
Helix current (plug-in focus)	I_x		1,0	0,7	0,5	mA
Thermal noise factor	F		24	24	22	dB
AM to PM conversion	k_p		3,0	2,5	1,5	°/dB

* To be adjusted for indicated collector current.

Frequency	f		8,5		GHz
Output power	W_o		10	5	W
Helix voltage (adjusted for optimum gain)	V_x	approx.	2900	2900	V
Collector voltage	V_{coll}		1450	1300	V
Focusing electrode voltage	V_{g1}		–6	–6	V
Collector current	I_{coll}		52,5	52,5	mA
Gain	G		37	40	dB
Accelerator voltage*	V_{g2}	approx.	2000	2000	V
Accelerator current	I_{g2}		$<0,1$	$<0,1$	mA
Helix current (plug-in focus)	I_x		0,7	0,5	mA
Thermal noise factor	F		24	22	dB
AM to PM conversion	k_p		2,5	1,5	°/dB

LIMITING VALUES (Absolute maximum rating system)

Voltages are with respect to the cathode unless otherwise specified.

Focusing electrode voltage	V_{g1}	min.	0	V
		max.	50	V
Accelerator voltage	V_{g2}	max.	2700	V
Helix voltage	V_x	max.	3300	V
Collector to helix voltage	$V_{coll\text{-}x}$	max.	2500	V
Cathode current	I_k	max.	58	mA
Accelerator current	I_{g2}	max.	0,3	mA
Helix current	I_x	max.	3	mA
R.F. input level	W_i	max.	100	mW
Collector dissipation at T_{amb} = 65 °C	W_{coll}	max.	90	W
Power reflected from load (to avoid overheating of the helix)		max.	2	W
Cooler temperature at reference point	T	max.	150	°C

* To be adjusted for indicated collector current.

DESIGN AND OPERATING NOTES

1. Installation of the mount

Two main methods may be discerned:

a. Fixing the mount relative to the microwave circuit by only connecting the waveguide tapers to the input and output sides of the circuit.
b. Employing (a) and establishing additional support by fastening the mount to the rack with clamps. In this case it is recommended to use a short piece of flexible waveguide at the input and output sides to prevent excessive strain on the mount via the tapers, unless very careful alignment of the waveguides can be assured.

Possible forces on the waveguides must not produce a moment greater than 20 Nm at the flanges.

1.1 Mount

The mount has no movable parts. If clamps are used (method b) the slightly larger dimensions of the cooler as compared to the main part of the mount must be considered.

1.2 Magnetic shielding

The periodic permanent magnet is completely shielded. This implies that no additional measures need be taken to prevent the magnetic properties of the mount from being affected by external magnetic fields. The mount will not influence surrounding equipment which is susceptible to stray magnetic fields. Several mounts may be placed side by side without disturbing the focusing qualities. Isolators may be installed quite near to the mount.

Warning

If any part of the shielding is removed, the magnetic properties of the mount may be disturbed irreversible.

2. Installation of the tube

Unlock the mount cap (see outline drawing) by turning it slightly counter-clockwise. The cap can then easily be removed, and the tube inserted by carefully pushing it in. The tube is provided with a mark on the accelerator terminal. For optimum performance the tube must be inserted with this mark in line with the centre line a) of the cable housing on the mount. (See Fig. 2). Finally put the cap on the mount again, and lock by turning it clockwise. These instructions also apply (in the reverse order) for taking the tube out of the mount.

3. Safety

The supply voltages are fed to the tube via the mount cap. When the cap is unlocked all voltages are removed from the tube. The two violet leads can be incorporated into an additional safety circuit which switches the voltages off at the power supply if the cap is unlocked. Thus the voltages can also be removed from the mount. The mount should always be earthed.

4. Power supply

An example of a supply circuit for 5, 10 and 15 W operation is given in Fig. 4.

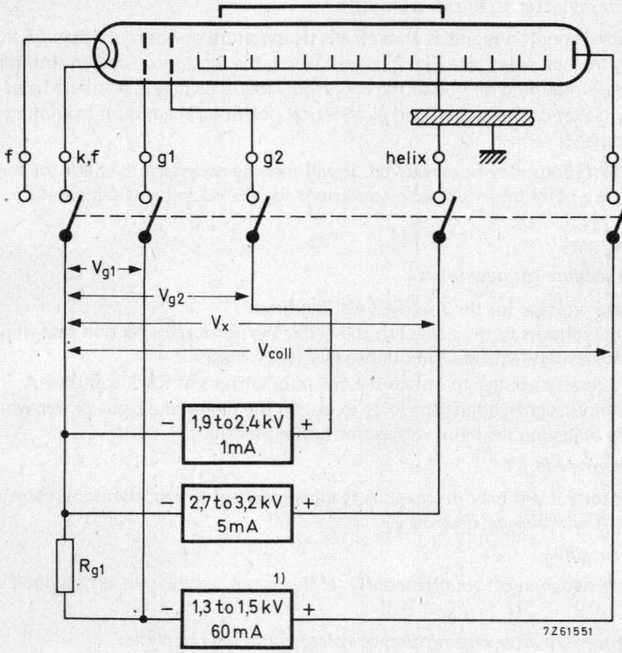


Fig. 4.

Design ranges for the power supply (electrode voltages with respect to cathode).

	min.	max.	
Accelerator voltage	1900	2400	V
Accelerator current		0,3	mA
Helix voltage*	2700	3200	V
Helix current		3	mA

The collector voltage is set at a fixed voltage dependent on the output power level.

Output power level	W_o	5	10	15	W_{sat}	W
Collector voltage	V_{coll}	1300	1450	1500	1700	V
Collector current	I_{coll}	52,5	52,5	55,0	52,5/55,0	mA
Focusing electrode voltage	V_{g1}	–6	–6	–6	–6	V

* At saturation the helix voltage may reach 3300 V.

5. Cooling

Tube and mount need no artificial means of cooling. Natural cooling of the collector has been made possible by depression of the collector potential with respect to the helix and by ensuring adequate heat transfer from the collector to the environment.

Under typical operating conditions and at an ambient temperature of not more than 65 °C, the cooler temperature at the reference point (see Fig. 2) is well below the limit, provided an aluminium heatsink of 300 x 300 x 6 mm is mounted on one of the cooler surfaces. The heatsink is best fixed with its centre coinciding with that of the cooler, and in a vertical position. The mount itself may have any position in the equipment.

Other heatsink configurations may be employed. It will then be necessary to check the temperatures reached at the reference point under extreme conditions e.g. 65 °C ambient temperature.

6. Application of voltages

6.1 Switching-on procedure for new tubes

6.1.1 Apply the heater voltage for the specified waiting time.

6.1.2 Apply the rated voltages to the collector, the helix, the accelerator (and in case of a separate supply to the focusing electrode) simultaneously (see Notes).

6.1.3 Adjust the accelerator voltage to obtain the collector current of 52,5 or 55,0 mA.

6.1.4 Apply the r.f. input signal, adjust the level to obtain the required output power while simultaneously adjusting the helix voltage for optimum gain.

6.2 Readjustment during life

During life the collector current may decrease. A readjustment of the accelerator voltage to obtain I_{coll} = 52,5 (55,0) mA will then be necessary.

6.3 Switching-off procedure

All voltages should be switched off simultaneously. If this is not feasible, do as described under "Notes".

6.4 Switching-on procedure after interruption of voltage (also see the Notes)

6.4.1 Interruption of less than 40 s: Switch on all voltages simultaneously.

6.4.2 Interruption of more than 40 s but less than 1 week: Apply the heater voltage for min. 40 s, then apply all other voltages simultaneously.

6.4.3 Interruption of more than 1 week: Apply the heater voltage for the specified waiting time of 2 min. Apply all other voltages simultaneously.

Notes

When the voltages cannot be switched simultaneously all the cathode current may flow to the accelerator or the helix. If this condition lasts for more than 10 ms, it may cause permanent damage to the tube. The remedy is to switch the accelerator voltage on after the other electrode voltages, or off before the other electrode voltages.

7. Input and output circuit and group delay

In order to avoid phase distortions due to long-line effect, the insertion of an isolator between tube and antenna, and another between tube and pre-stage is strongly recommended. The isolators should be positioned as close to the tube as possible.

If isolators with a VSWR of less than 1,05 are used at a short distance from the tube, the reflections result in a variation of the group delay of less than 0,2 nanoseconds over a band of 20 MHz.

It may be noted that the difference between the voltage reflection coefficients of the hot and the cold (i.e. with respectively without electron beam) tube is less than 0,2 for the input as well as the output side, measured at an output power level of 5 W or more.

8. Environmental conditions

Ambient temperature,

storage	T_{amb}	min	−60	°C
		max.	+65	°C
operation	T_{amb}	min.	−30	°C
		max.	+65	°C
Relative humidity			0 to 95	%

The tube and mount resist fungus attack.

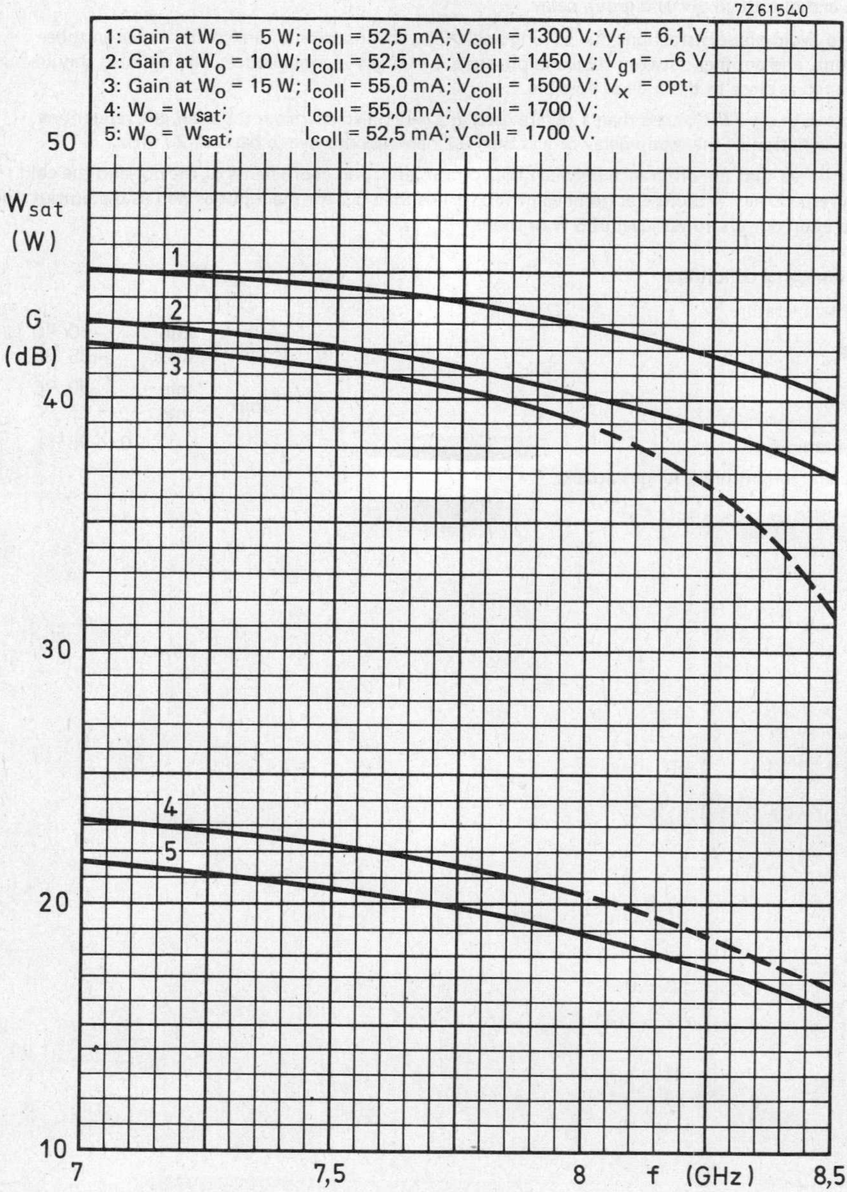


Fig. 5 Ratio of gain and saturation power to frequency.

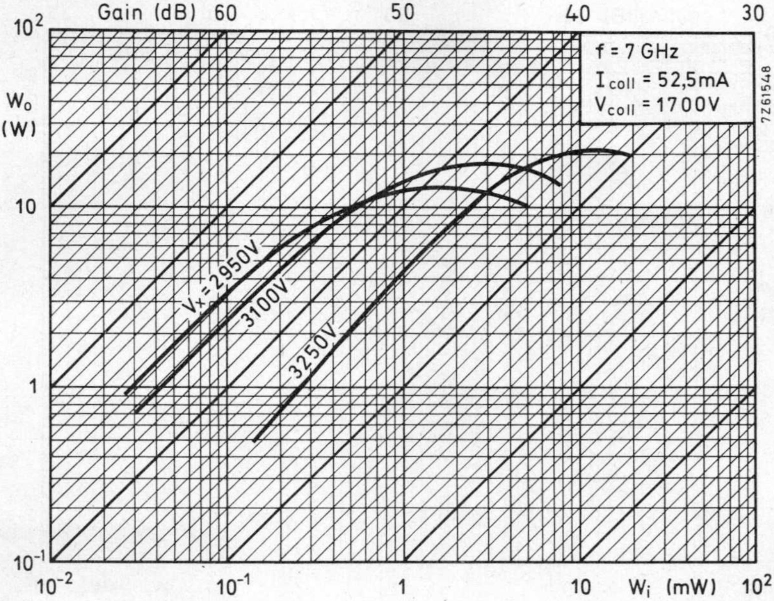


Fig. 6 Ratio of output power to input power.

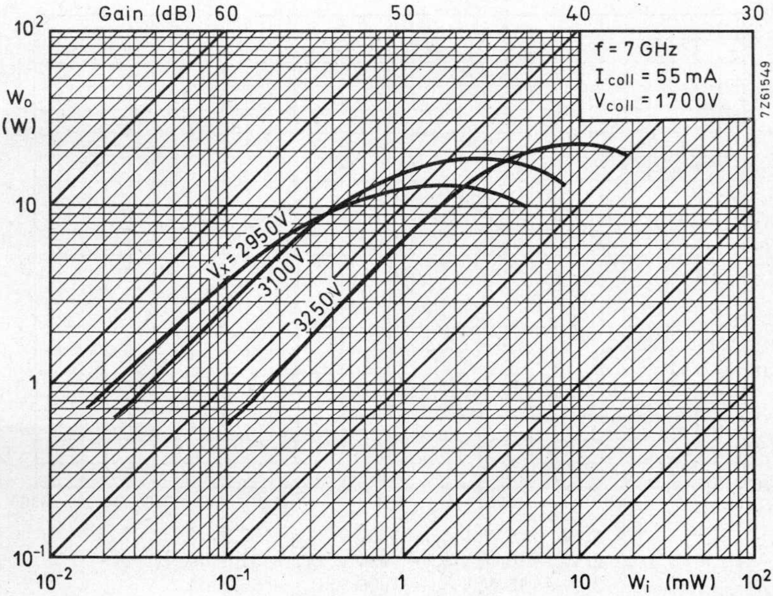


Fig. 7 Ratio of output power to input power.

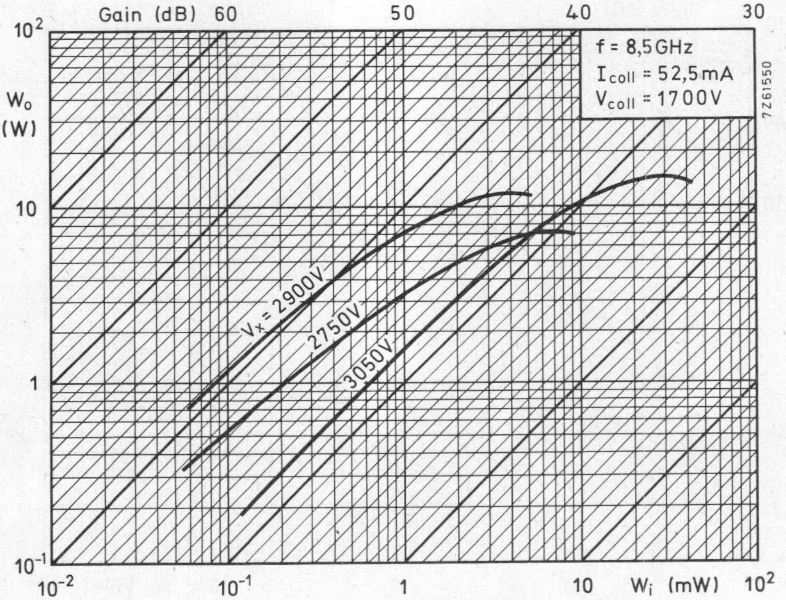
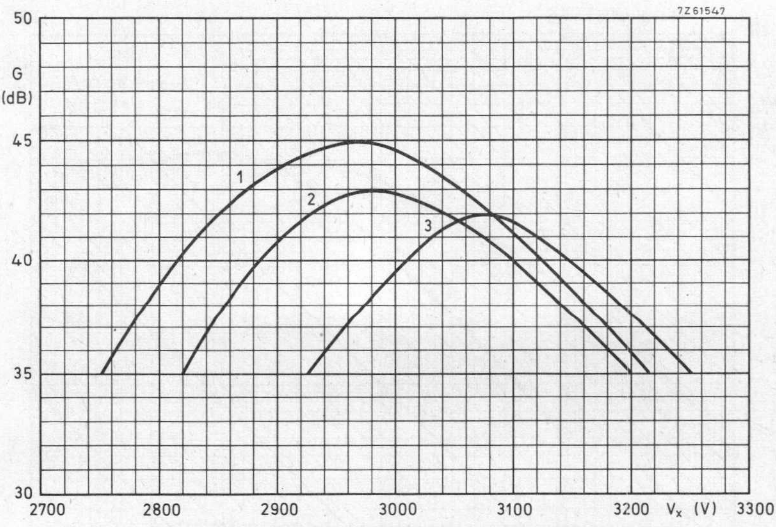
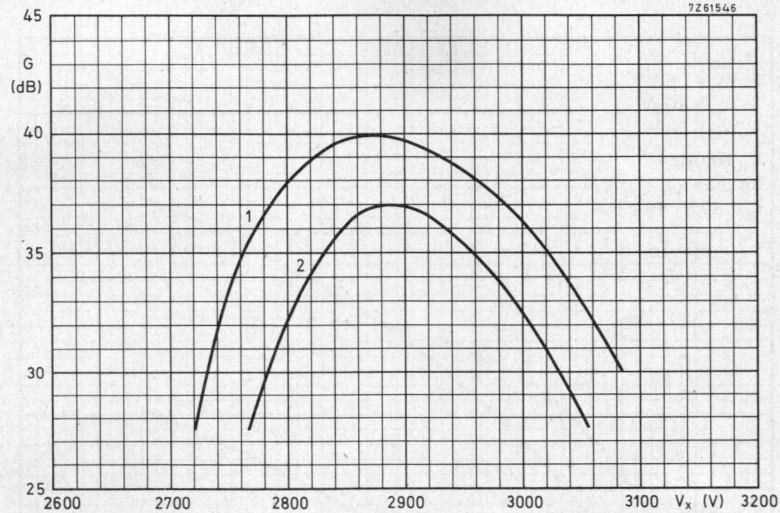


Fig. 8 Ratio of output power to input power.



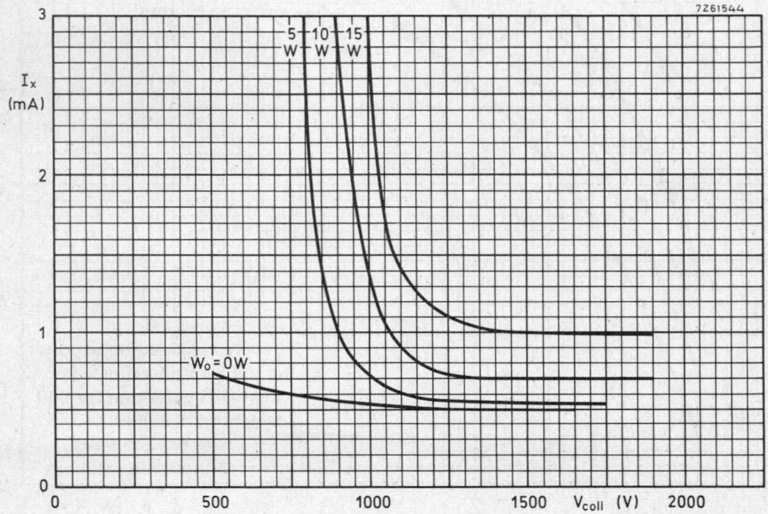
1: W_o = 5 W; V_{coll} = 1300 V; I_{coll} = 52,5 mA
2: W_o = 10 W; V_{coll} = 1450 V; I_{coll} = 52,5 mA
3: W_o = 15 W; V_{coll} = 1500 V; I_{coll} = 55,0 mA

Fig. 9 Ratio of gain to helix voltage; f = 7,0 GHz.



1: W_o = 5 W; V_{coll} = 1300 V; I_{coll} = 52,5 mA
2: W_o = 10 W; V_{coll} = 1450 V; I_{coll} = 52,5 mA

Fig. 10 Ratio of gain to helix voltage; f = 8,5 GHz.



f = 8 GHz	I_{coll} = 55,0 mA		I_{coll} = 52,5 mA
V_x = optimum	at W_o = 0 W		at W_o = 5 W
	W = 15 W		W = 10 W

Fig. 11 Ratio of helix current to collector voltage.

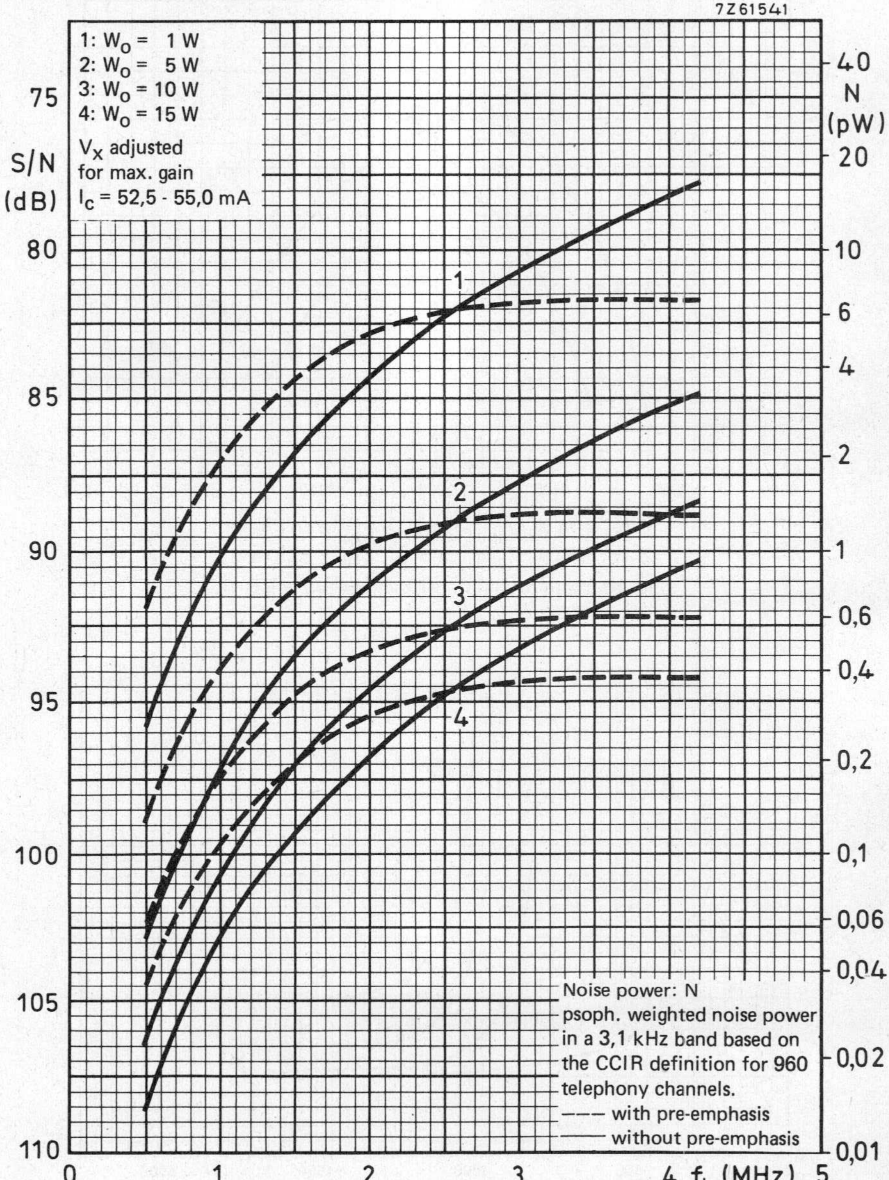


Fig. 12 Ratio of signal-to-noise ratio (FM) to baseband frequency; f = 7 GHz.

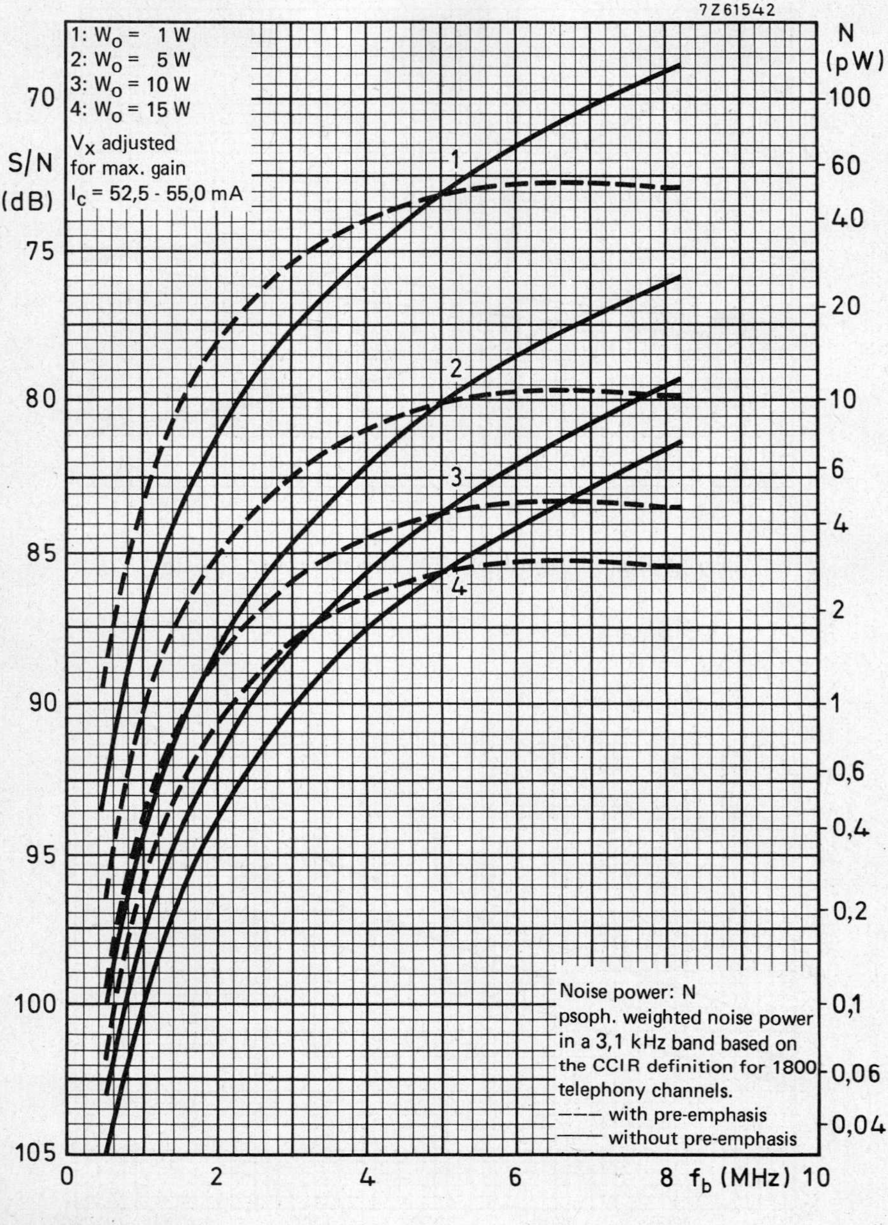


Fig. 13 Ratio of signal-to-noise ratio (FM) to baseband frequency; f = 7 GHz.

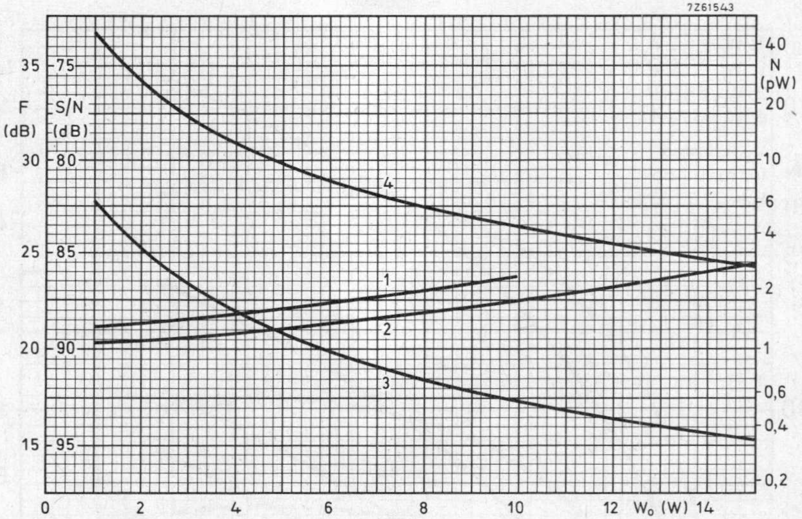


Fig. 14 Ratio of thermal noise (FM) to output power; f = 7 GHz.

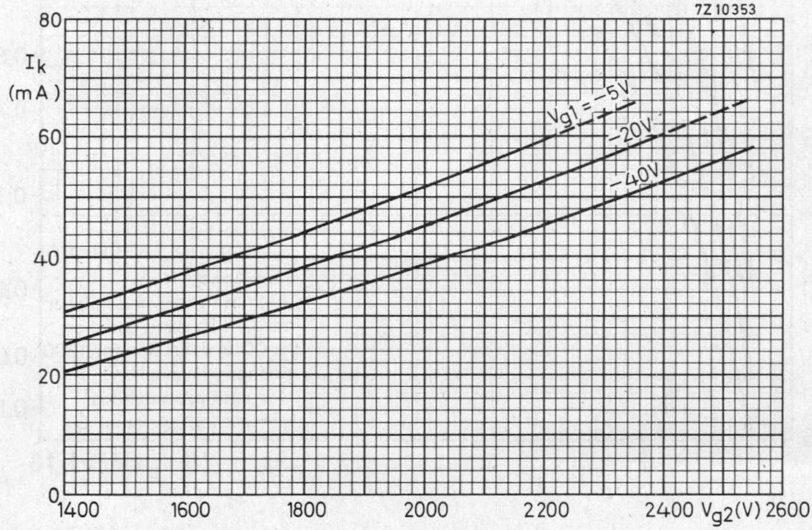


Fig. 15 Ratio of cathode current to accelerator voltage.

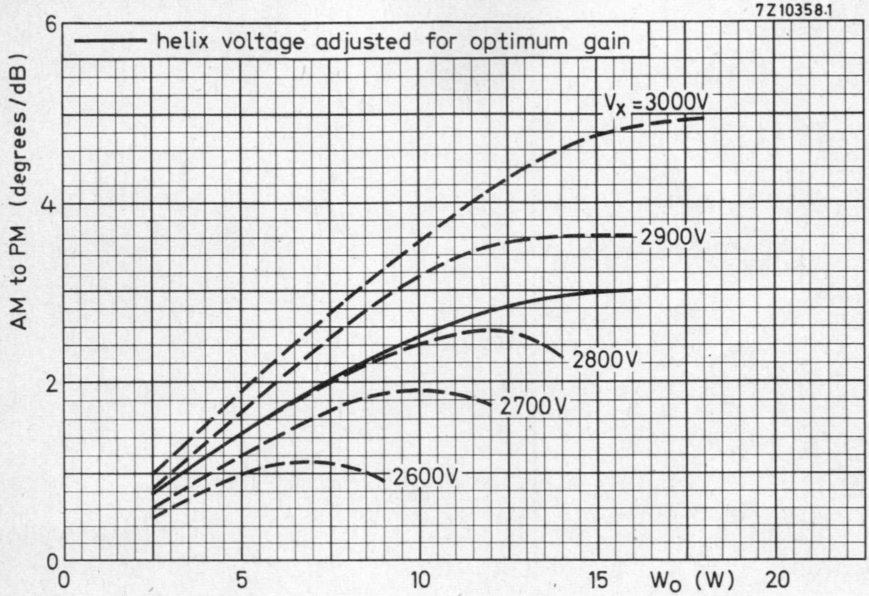


Fig. 16 Ratio of AM-to-PM conversion to output power; f = 7 GHz.

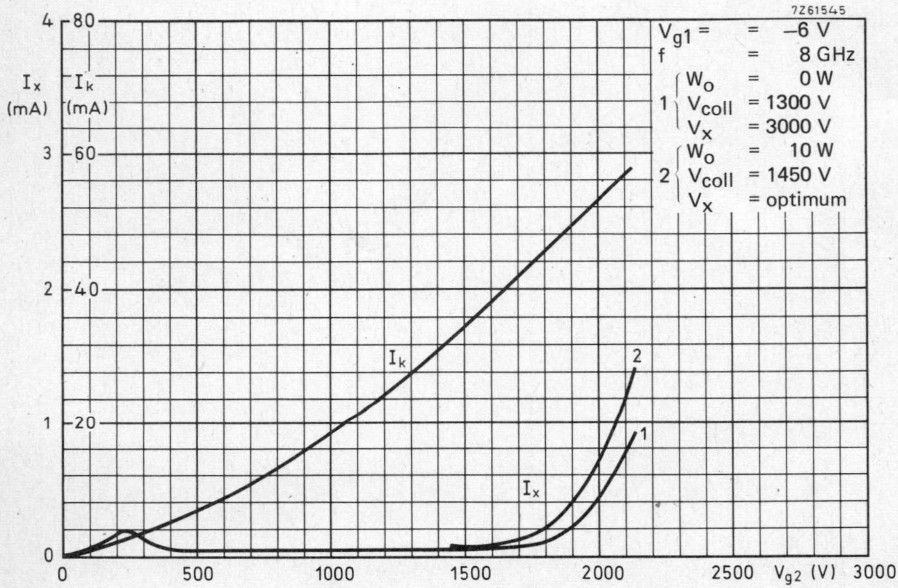


Fig. 17 Ratio of cathode current and helix current to accelerator voltage.

TRAVELLING-WAVE TUBE

QUICK REFERENCE DATA

Frequency range	f		4,4 to 5,0	GHz
Low level gain at 5,0 GHz	G	>	36	dB
Saturated output power	W_o	>	6	W
Construction	unpackaged with uniform field permanent magnet focusing			

DESCRIPTION

The wave propagating structure is of the helical type. The separate mount for the tube with r.f. conductors for coupling to the input and output waveguides contains a permanent magnet of the uniform field type, which is completely shielded by means of the surrounding box.
The tube is designed for plug-in match in the waveguide circuit. This gives the advantage that, after changing tubes, no tuning will be necessary, nor will the voltages on the tube have to be re-established, apart from the starting procedure. Only a slight adjustment of the tube in the magnetic field will be required.

HEATING: indirect; dispenser type cathode

Heater voltage	V_f		6,3	V
Heater current	I_f		800	mA
Waiting time	t_w	min.	5	min

GENERAL CHARACTERISTICS

Magnetic field strength	H		48	kA/m
Cold transmission loss (f = 4,4 to 5,0 GHz)		>	55	dB
Saturated output power (I_{coll} = 50 mA)	W_o	>	6	W
Frequency	f		5,0	GHz
Helix voltage	V_x		optimal	
Collector current	I_{coll}		50	mA
Output power	W_o		100	mW
Low level gain	G	>	36	dB

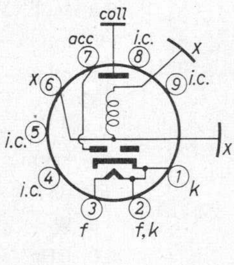
MECHANICAL DATA

Dimensions in mm

Net mass	0,5 kg
Net mass of mount	30 kg
Input and output waveguides	RG-49/U

Connections of the plug of the mount

1, 2 Helix (x)
3 –
4 Collector (coll)
5 Accelerator (acc)
6 Heater (f)
7 Heater and cathode (f, k)



Tube base (Noval)

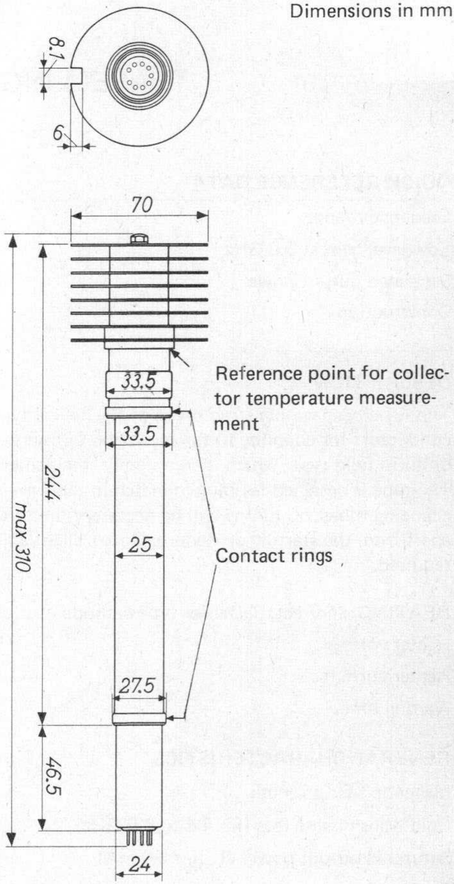
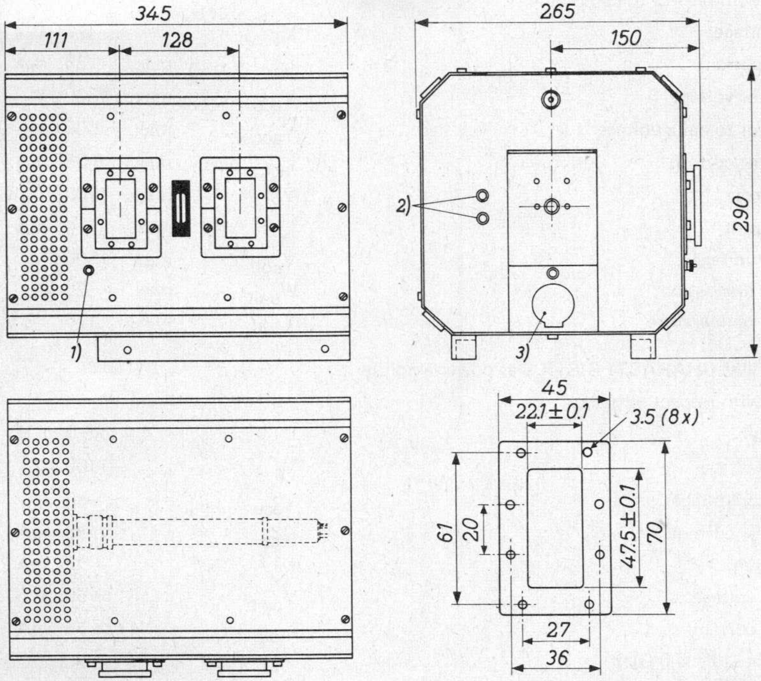


Fig. 1.

Mounting position: arbitrary, see "Cooling".



(1) Earth connection.

(2) Alignment screws.

(3) Connector to power supply.

Fig. 2 Mount 55310

WARNING

Do not apply voltages to the tube when the door is open.
Do not remove any part of the shielding box, nor introduce ferro-magnetic materials into the mount.

NOTE

A socket wrench for the alignment screws is fixed near the fastener on the door.

LIMITING VALUES (Absolute maximum rating system)

Voltages with respect to cathode.

Heater voltage	V_f		6,3	V ± 2%
Cathode current	I_k	max.	55	mA
Accelerator voltage	V_{acc}	max.	1500	V
Accelerator to helix voltage	$V_{acc\text{-}x}$	max.	500	V
Accelerator current	I_{acc}	max.	0,35	mA
Helix voltage	V_x	max.	1500	V (note 1)
Helix current	I_x	max.	4	mA
Collector voltage	V_{coll}	max.	1500	V
Collector dissipation	W_{coll}	max.	70	W
Collector temperature	T_{coll}	max.	175	^oC (note 2)

OPERATING CHARACTERISTICS as power amplifier

Voltages with respect to helix.

Frequency	f		4,4 to 5,0	GHz
Cathode voltage	V_k		−1100	V
Accelerator voltage	V_{acc}		−30	V
Accelerator current	I_{acc}	<	0,35	mA
Helix current	I_x	<	3	mA
Collector voltage	V_{coll}		+50	V
Collector current	I_{coll}		47 to 53	mA
Power gain at f = 5,0 GHz				
at W_o = 100 mW	G	>	34	dB
at W_o = 2,5 W	G	>	32	dB
Voltage standing-wave ratio		<	1,5	(note 3)
Noise figure	F	<	30	dB

NOTES

1. The helix is galvanically connected to the mount.
2. For reference point of the collector temperature see Fig. 1.
3. For input and output. Measured cold, i.e. with beam switched off. For further particulars see paragraph "Transmission line".

Cooling

The tube is convection cooled by natural air circulation. Under normal operating conditions and at $T_{amb} < 55\ ^oC$ no forced air cooling is required to keep the collector temperature below the maximum permissible value of 175 ^oC, provided the tube is mounted horizontally and no obstructions are offered for the air circulation through the ventilation holes in the mount. For less favourable conditions a slight additional air flow will be necessary.

Shielding

Nowhere along the box surface a magnetic field strength of 160 kA/m close to the shielding plates extended over a cross-sectional area of 30 cm^2 and directed perpendicular to the box surface, causes a change, worth mentioning, in the focus quality. Several mounts may be placed on top of or next to each other, without mutual disturbance of focusing qualities.

The stray field of the mount, measured at a distance of 1 cm from the box, is in general less than 800 A/m. At a few spots, e.g. near the ventilation holes and the alignment screws this value is exceeded with maximum 1,6 kA/m, but then the 800 A/m value is still reached within a distance of 4 cm from the box.

Transmission line

To obtain the full benefit of the broadband characteristics of the tube, the insertion of an isolator between the tube and the pre-stage and between the tube and the antenna is strongly recommended. The isolators should be positioned as close as possible to the tube. By these provisions phase distortion by long line effects is avoided.

The difference between the reflection coefficients at input and output sides of the cold tube (i.e. without beam) and the warm tube is less than 0,2. Provided an isolator with a VSWR of less than 1,05 is placed at a short distance (10 to 20 cm) at either side of the tube, the reflections result in a variation of group delay of less than 0,1 ns over a band of 20 MHz.

Operating instructions

The mount is provided with an alignment device for the proper positioning of the tube with respect to the magnetic field in the mount. For alignment screws see drawing of the mount.

As the helix current depends on the position of the tube with respect to the magnetic field, special attention must be given to the proper alignment of the tube during steps c and d of the starting procedure given below. To prevent tube damage it is essential to observe the 4 mA maximum limit on the helix current.

1. Starting procedure

1.1 Remove the plug, loosen the fastener and open the door.

1.2 Insert the tube into the mount as shown in the drawing of the mount (take care, the tube is subject to magnetic forces). If the tube is obstructed by some parts of the mount, a small correction in the position of the tube will be sufficient to avoid the obstacles.

1.3 Close the door, lock the fastener and put on the plug.

1.4 Switch on the supply voltages in the following sequence (the voltages mentioned below are with respect to the helix, which is normally at ground potential):
  a. Apply the rated heater voltage for at least 5 minutes.
  b. Apply +50 V to the collector and −30 V to the accelerator. These voltages may be applied simultaneously.
  c. Apply the cathode voltage gradually, adjusting the alignment of the tube in order not to exceed 4 mA helix current.
  d. Apply the h.f. signal to the input of the tube and adjust the alignment of the tube until the helix current reaches a minimum.

2. Switching procedure after interruption of voltages

2.1 *Interruption less than 1 s.* All voltages can be applied simultaneously. The output will reach 95% of the stable end value within 0,2 s after the application of the voltages.

2.2 *Interruption 1 s or more.* The voltages must be applied in the following sequence:
  a. Apply the rated heater voltage for at least 40 s.
  b. Apply +50 V to the collector and −30 V to the accelerator. These voltages may be applied simultaneously.
  c. Apply the rated cathode voltage. Voltages mentioned under b and c can be applied simultaneously.

The h.f. voltage can be applied at any time.
The output will reach 95% of the stable end value within 60 s after the application of the heater voltage.

Note

The procedure described under 2.2 can be followed without any risk of disturbing the properties of the tube. It should be noted, however, that normally about 5 minutes cathode heating time is required to obtain completely stable operation of the tube.

3. Switching off procedure

3.1 a. Switch off all voltages simultaneously.
  b. Remove plug, open the door and pull out the tube.

3.2 a. Bring accelerator voltage to helix potentional.
  b. Switch off the cathode voltage.
  c. Switch off the accelerator, collector and heater voltages.
  d. Remove plug, open the door and pull out the tube.

The methods 3.1 and 3.2 are optional.

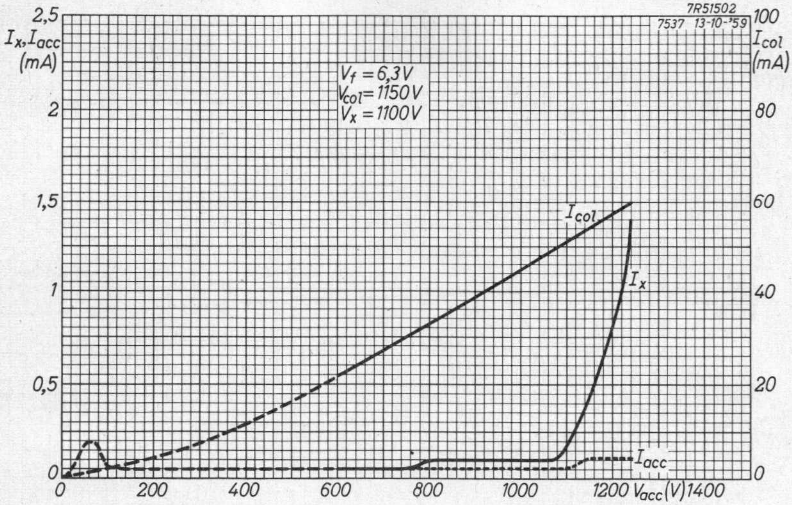

7R51502
7537 13-10-'59
2,5
I_x, I_{acc}
(mA)
2
1,5
1
0,5
0
100
I_{col}
(mA)
80
60
40
20
0
$V_f = 6,3V$
$V_{col} = 1150V$
$V_x = 1100V$
I_{col}
I_x
I_{acc}
0
200
400
600
800
1000
1200
V_{acc}(V)
1400

Fig. 3.

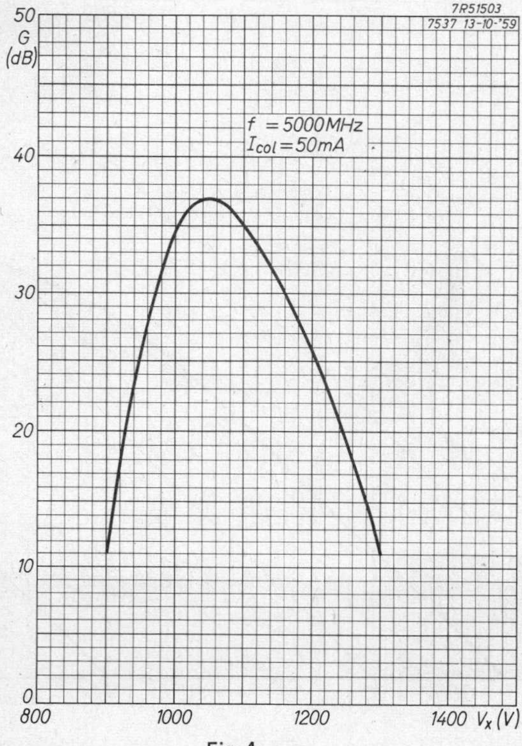

7R51503
7537 13-10-'59
50
G
(dB)
40
30
20
10
0
f = 5000MHz
I_{col} = 50mA
800
1000
1200
1400
V_x (V)

Fig. 4.

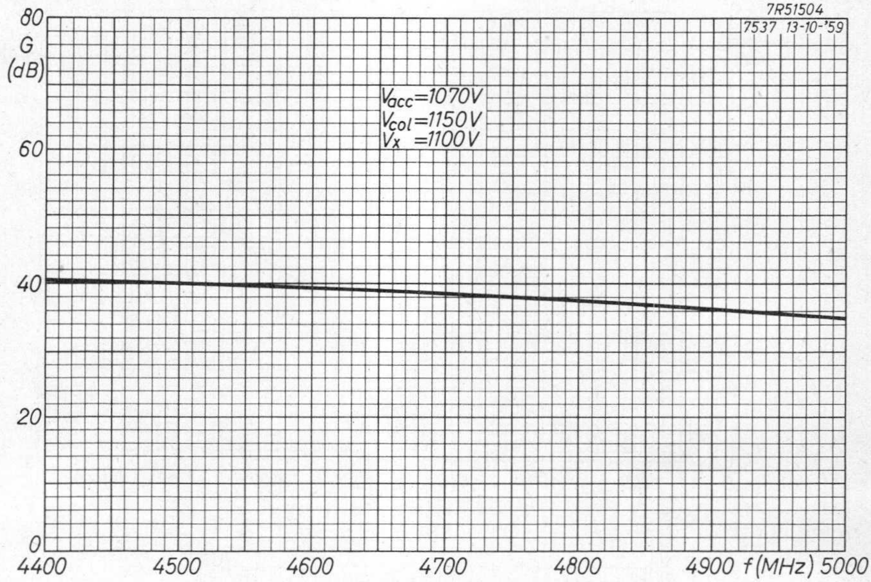

7R51504
7537 13-10-'59
80
G
(dB)
60
40
20
0
V_{acc}=1070V
V_{col}=1150V
V_x =1100V
4400
4500
4600
4700
4800
4900 f(MHz) 5000

Fig. 5.

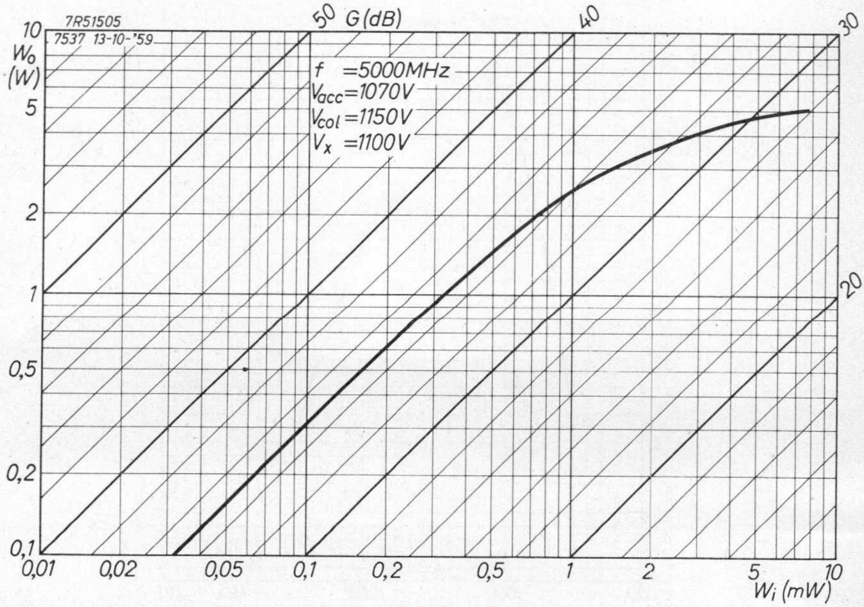

7R51505
7537 13-10-'59
50 G(dB)
40
30
20
10
W_o
(W)
5
2
1
0,5
0,2
0,1
f =5000MHz
V_{acc}=1070V
V_{col}=1150V
V_x =1100V
0,01
0,02
0,05
0,1
0,2
0,5
1
2
5
10
W_i (mW)

Fig. 6.

TRAVELLING-WAVE TUBE

QUICK REFERENCE DATA

Frequency range	f		3,8 to 4,2 GHz
Low level gain at 4,2 GHz	G	>	39 dB
Saturated output power	W_o	>	8 W
Construction	unpackaged with uniform field permanent magnet focusing		

DESCRIPTION

The wave propagating structure is of the helical type. The separate mount for the tube with r.f. conductors for coupling to the input and output waveguides contains a permanent magnet of the uniform field type, which is completely shielded by means of the surrounding box.

The tube is designed for plug-in match in the waveguide circuit. This gives the advantage that, after changing tubes, no tuning will be necessary, nor will the voltages on the tube have to be re-established, apart from the starting procedure. Only a slight adjustment of the tube in the magnetic field will be required.

HEATING: indirect; dispenser type cathode.

Heater voltage	V_f		6,3 V
Heater current	I_f		800 mA
Waiting time	t_w	min.	5 min

GENERAL CHARACTERISTICS

Magnetic field strength	H		48 kA/m
Cold transmission loss (f = 3,8 to 4,2 GHz)		>	60 dB
Saturated output power (I_{coll} = 50 mA)	W_o	>	8 W
Frequency	f		4,2 GHz
Helix voltage	V_x		optimal
Collector current	I_{coll}		50 mA
Output power	W_o		100 mW
Low level gain	G	>	39 dB

MECHANICAL DATA

Dimensions in mm

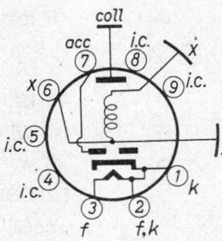
Net mass 0,5 kg

Net mass of mount 30 kg

Input and output waveguides WR229

Connections of the plug of the mount

1, 2 } Helix (x)
3 –
4 Collector (coll)
5 Accelerator (acc.)
6 Heater (f)
7 Heater and cathode (f, k)



Tube base (Noval)

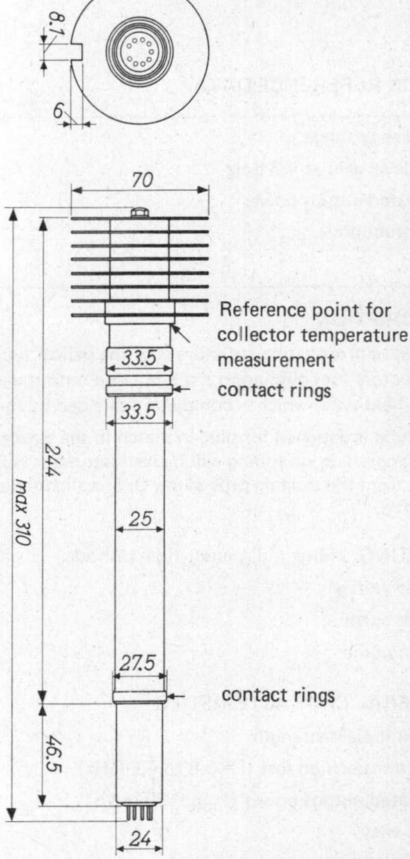
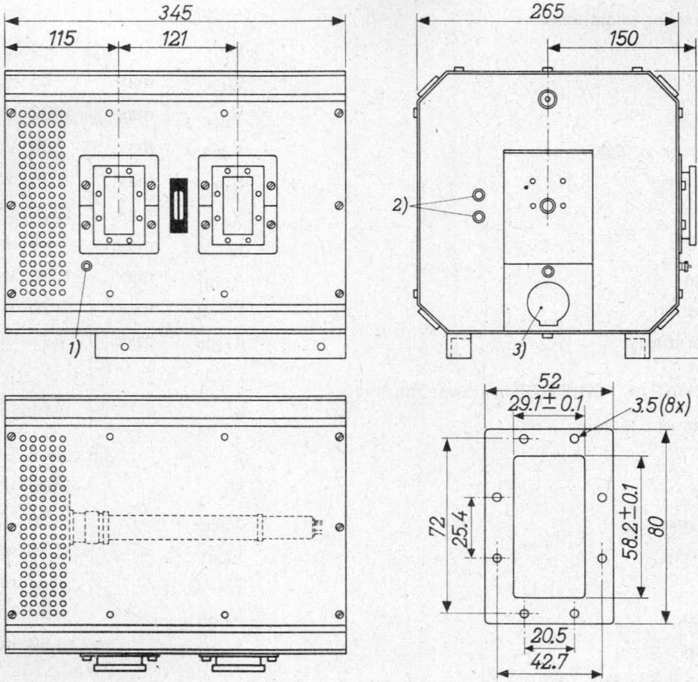


Fig. 1.

Mounting position: arbitrary, see "Cooling".



(1) Earth connection.
(2) Alignment screws.
(3) Connector to power supply.

Fig. 2 Mount 55309.

WARNING

Do not apply voltages to the tube when the door is open.
Do not remove any part of the shielding box, nor introduce ferro-magnetic materials into the mount.

NOTE

A socket wrench for the alignment screws is fixed near the fastener on the door.

LIMITING VALUES (Absolute maximum rating system)

Voltages with respect to cathode.

Heater voltage	V_f		6,3 V ± 2	%
Cathode current	I_k	max.	55	mA
Accelerator voltage	V_{acc}	max.	1500	V
Accelerator to helix voltage	$V_{acc\text{-}x}$	max.	500	V
Accelerator current	I_{acc}	max.	0,35	mA
Helix voltage	V_x	max.	1500	V (note 1)
Helix current	I_x	max.	4	mA
Collector voltage	V_{coll}	max.	1500	V
Collector dissipation	W_{coll}	max.	70	W
Collector temperature	T_{coll}	max.	175	°C (note 2)

OPERATING CHARACTERISTICS as power amplifier

Voltages with respect to helix

Frequency	f		3,8 to 4,2	GHz
Cathode voltage	V_k		−1100	V
Accelerator voltage	V_{acc}		−30	V
Accelerator current	I_{acc}	<	0,35	mA
Helix current	I_x	<	3	mA
Collector voltage	V_{coll}		+50	V
Collector current	I_{coll}		47 to 53	mA
Power gain at f = 4,2 GHz				
at W_o = 100 mW	G	>	37	dB
at W_o = 3,0 W	G	>	35	dB
Voltage standing wave ratio		<	1,5	(note 3)
Noise figure	F	<	30	dB

Notes

1. The helix is galvanically connected to the mount.
2. For reference point of the collector temperature see Fig. 1.
3. For input and output. Measured cold, i.e. with beam switched off. For further particulars see paragraph "Transmission line".

Cooling

The tube is convection cooled by natural air circulation. Under normal operating conditions and at $T_{amb} < 55$ °C no forced air cooling is required to keep the collector temperature below the maximum permissible value of 175 °C, provided the tube is mounted horizontally and no obstructions are offered for the air circulation through the ventilation holes in the mount. For less favourable conditions a slight additional air flow will be necessary.

Shielding

Nowhere along the box surface a magnetic field strength of 160 kA/m close to the shielding plates extended over a cross sectional area of 30 cm^2 and directed perpendicular to the box surface, causes a change, worth mentioning, in the focus quality. Several mounts may be placed on top of or next to each other, without mutual disturbance of focusing qualities.

The stray field of the mount, measured at a distance of 1 cm from the box, is in general less than 800 A/m. At a few spots, e.g. near the ventilation holes and the alignment screws this value is exceeded with maximum 1,6 kA/m, but then the 800 A/m value is still reached within a distance of 4 cm from the box.

Transmission line

To obtain the full benefit of the broadband characteristics of the tube, the insertion of an isolator between the tube and the pre-stage and between the tube and the antenna is strongly recommended. The isolators should be positioned as close as possible to the tube. By these provisions phase distortion by long line effects is avoided.

The difference between the reflection coefficients at input and output sides of the cold tube (i.e. without beam) and the warm tube is less than 0,2. Provided an isolator with a VSWR of less than 1,05 is placed at a short distance (10 to 20 cm) at either side of the tube, the reflections result in a variation of group delay of less than 0,1 ns over a band of 20 MHz.

Operating instructions

The mount is provided with an alignment device for the proper positioning of the tube with respect to the magnetic field in the mount. For alignment screws see drawing of the mount.

As the helix current depends on the position of the tube with respect to the magnetic field, special attention must be given to the proper alignment of the tube during steps c and d of the starting procedure given below. To prevent tube damage it is essential to observe the 4 mA maximum limit on the helix current.

1. Starting procedure

1.1 Remove the plug, loosen the fastener and open the door.

1.2 Insert the tube into the mount as shown in the drawing of the mount (take care, the tube is subject to magnetic forces). If the tube is obstructed by some parts of the mount, a small correction in the position of the tube will be sufficient to avoid the obstacles.

1.3 Close the door, lock the fastener and put on the plug.

1.4 Switch on the supply voltages in the following sequence (the voltages mentioned below are with respect to the helix, which is normally at ground potential):

a. Apply the rated heater voltage for at least 5 minutes.
b. Apply +50 V to the collector and −30 V to the accelerator. These voltages may be applied simultaneously.
c. Apply the cathode voltage gradually, adjusting the alignment of the tube in order not to exceed 4 mA helix current.
d. Apply the h.f. signal to the input of the tube and adjust the alignment of the tube until the helix current reaches a minimum.

2. Switching procedure after interruption of voltages

2.1 *Interruption less than 1 s.* All voltages can be applied simultaneously. The output will reach 95% of the stable end value within 0,2 s after the application of the voltages.

2.2 *Interruption 1 s or more.* The voltages must be applied in the following sequence:

a. Apply the rated heater voltage for at least 40 s.
b. Apply +50 V to the collector and −30 V to the accelerator. These voltages may be applied simultaneously.
c. Apply the rated cathode voltage. Voltages mentioned under b and c can be applied simultaneously.

The h.f. voltage can be applied at any time.
The output will reach 95% of the stable end value within 60 s after the application of the heater voltage.

Note

The procedure described under 2.2 can be followed without any risk of disturbing the properties of the tube. It should be noted, however, that normally about 5 minutes cathode heating time is required to obtain completely stable operation of the tube.

3. Switching off procedure

3.1 a. Switch off all voltages simultaneously.
b. Remove plug, open the door and pull out the tube.

3.2 a. Bring accelerator voltage to helix potential.
b. Switch off the cathode voltage.
c. Switch off the accelerator, collector and heater voltages.
d. Remove plug, open the door and pull out the tube.

The methods 3.1 and 3.2 are optional.

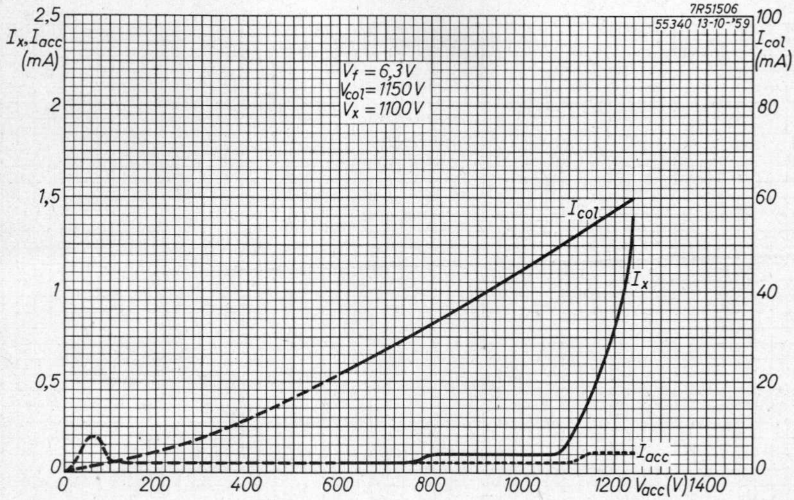

7R51506
55340 13-10-'59
2,5
I_x, I_{acc}
(mA)
2
1,5
1
0,5
0
100
I_{col}
(mA)
80
60
40
20
0
V_f = 6,3V
V_{col} = 1150V
V_x = 1100V
I_{col}
I_x
I_{acc}
0
200
400
600
800
1000
1200
V_{acc}(V)
1400

Fig. 3.

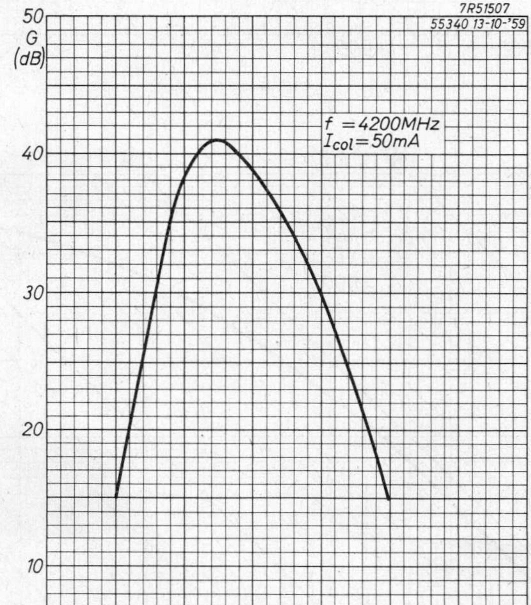

7R51507
55340 13-10-'59
50
G
(dB)
40
30
20
10
0
f = 4200MHz
I_{col} = 50mA
800
1000
1200
1400
V_x(V)

Fig. 4.

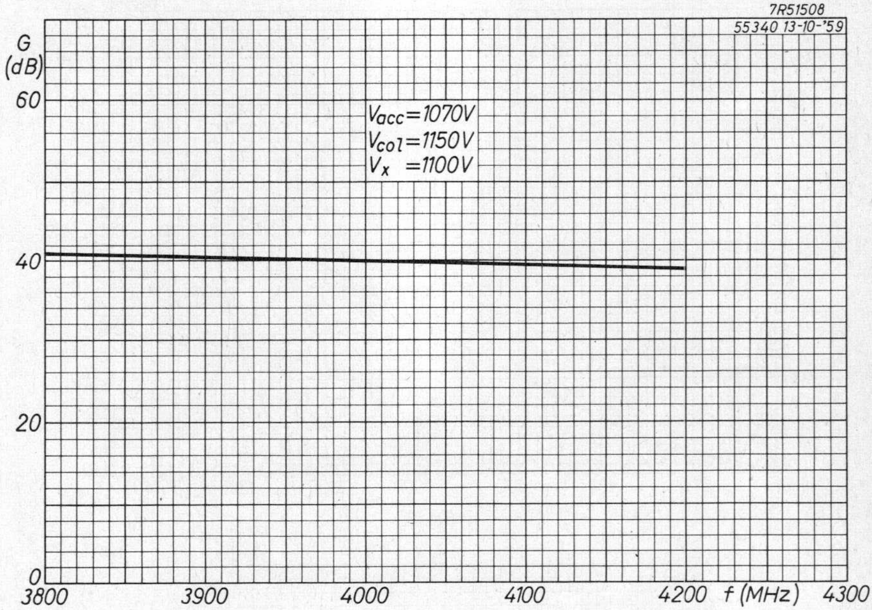

7R51508
55340 13-10-'59
G
(dB)
60
40
20
0
V_{acc}=1070V
V_{col}=1150V
V_x =1100V
3800
3900
4000
4100
4200
f (MHz)
4300

Fig. 5.

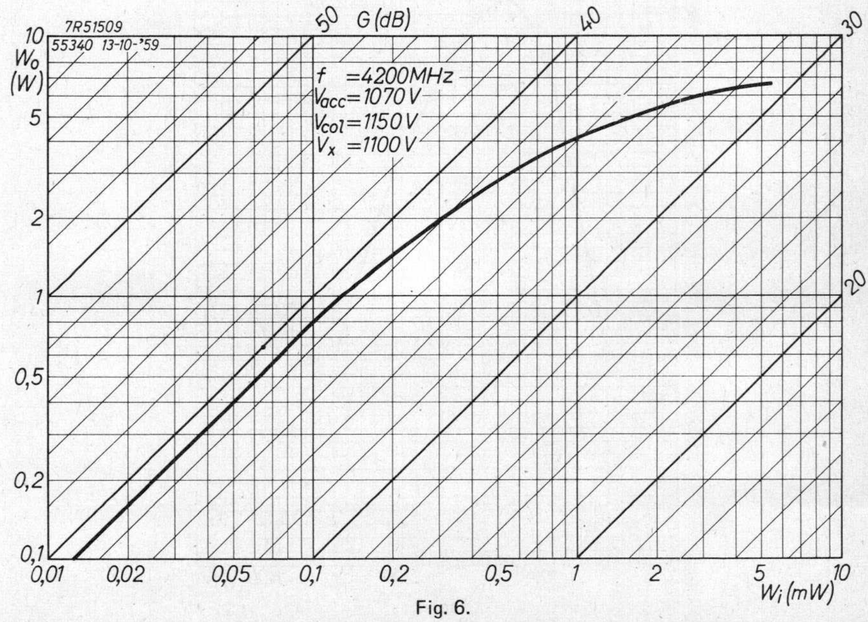

7R51509
55340 13-10-'59
10
W_o
(W)
5
2
1
0,5
0,2
0,1
50
G (dB)
40
30
20
f =4200MHz
V_{acc}=1070 V
V_{col}=1150 V
V_x =1100 V
0,01
0,02
0,05
0,1
0,2
0,5
1
2
5
10
W_i (mW)

Fig. 6.

DIODES E

MEASURING DIODE

QUICK REFERENCE DATA

Frequency	f		1000	MHz
Peak inverse voltage	$V_{d\,inv\,p}$	max.	1000	V

HEATING: indirect by a.c. or d.c.; series or parallel supply

Heater voltage	V_f		6,3	V
Heater current	I_f		300	mA

CAPACITANCE

Anode to cathode	C_d	max.	0,5	pF

TYPICAL CHARACTERISTICS

Diode current	I_d		0,5	mA
Diode voltage	V_d	max.	3	V

LIMITING VALUES (Absolute maximum rating system)

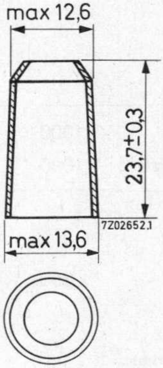
Peak inverse voltage at $f < 100$ MHz	$V_{d\,inv\,p}$	max.	1000	V
at $f > 100$ MHz	$V_{d\,inv\,p}$	max.	$\frac{100}{f} \times 1000$	V*
Cathode current, V_f from 5,6 to 7,0 V	I_k	max.	0,3	mA
Peak cathode current, V_f from 5,6 to 7,0 V	I_{kp}	max.	5	mA**
Voltage between heater and cathode	V_{kf}	max.	50	V
External resistance between heater and cathode	R_{kf}	max.	20	kΩ
Heater voltage	V_f	max.	7,0	V
		min.	5,6	V

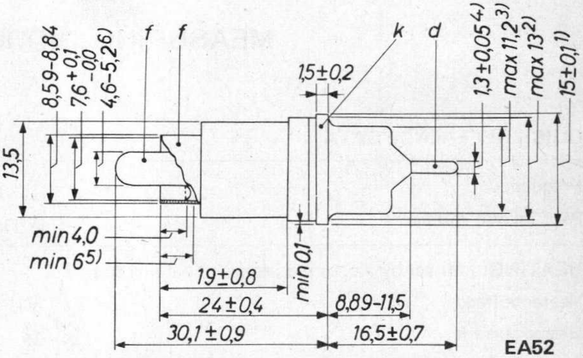
* f in MHz.

** For frequencies < 100 Hz: I_{kp} max. 0,3 + 0,047 f mA (f in Hz).

MECHANICAL DATA

Dimensions in mm

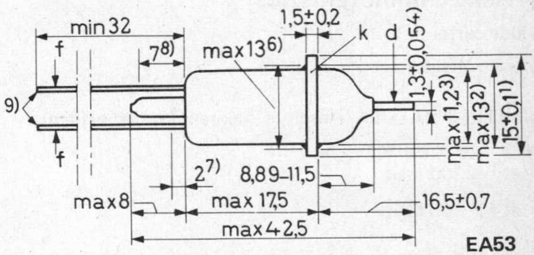




EA52

Protective cap for EA52

For protection during transport the EA52 is fitted with a plastic cap which should preferably be removed when the tube is mounted into position. If the cap is not removed, make sure that its temperature never exceeds 100 °C.



EA53

Fig. 1.

Notes

(1) In order to avoid strain, the connection to the cathode disc should be sufficiently flexible.
(2) Maximum diameter of the glass seal.
(3) Eccentricity with respect to the cathode disc max. 0,35 mm.
(4) Eccentricity with respect to the cathode disc max. 0,25 mm.
(5) This dimension defines the length of the cylindrical section.
(6) The max. dimension includes the eccentricity.
(7) This part of the leads should not be bent.
(8) This part of the leads should not be soldered.
(9) Gold plated leads, 0,4 mm diameter.

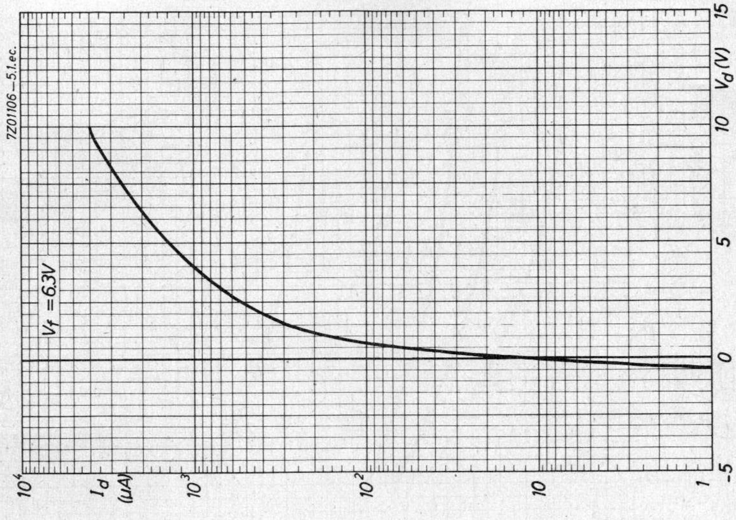

7Z01106—5.1.ec.
V_f = 6.3V
V_d (V)
15
10
5
0
-5
10^4
I_d (µA)
10^3
10^2
10
1

Fig. 2.

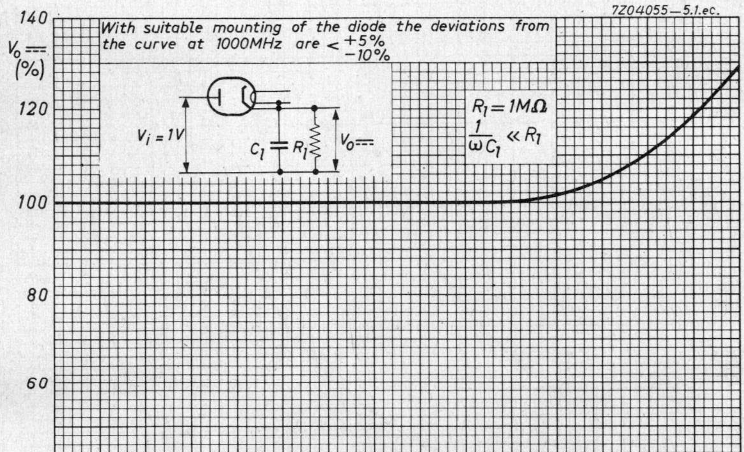

7Z04055—5.1.ec.
With suitable mounting of the diode the deviations from the curve at 1000MHz are < +5% −10%
V_o (%)
V_i = 1V
C_1
R_1
V_o
R_1 = 1MΩ
$\frac{1}{\omega C_1} \ll R_1$
140
120
100
80
60
40
0
200
400
600
800
1000
1200
1400
f (MHz)

Fig. 3.

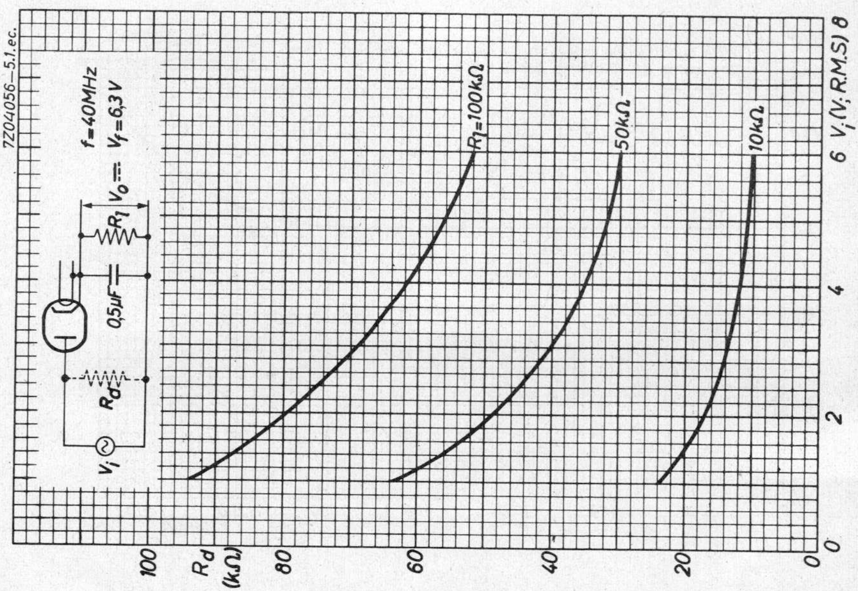

7Z04056—5.1.ec.
f=40MHz
Vf=6,3V
Vi
Rd
0,5μF
Rl
Vo
Rl=100kΩ
50kΩ
10kΩ
Rd
(kΩ)
100
80
60
40
20
0
0
2
4
6 Vi (V; R.M.S) 8

Fig. 4.

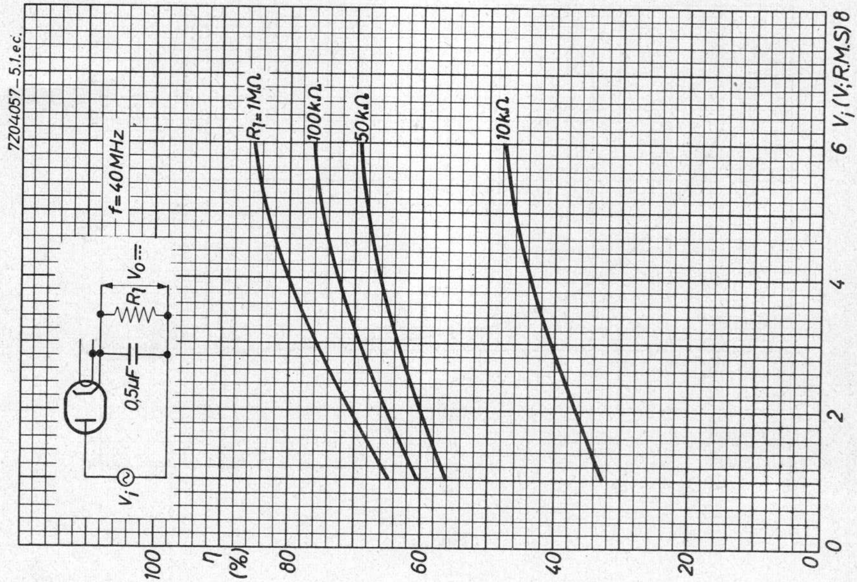

7Z04057—5.1.ec.
f=40MHz
Vi
0,5μF
Rl
Vo
Rl=1MΩ
100kΩ
50kΩ
10kΩ
η
(%)
100
80
60
40
20
0
0
2
4
6 Vi (V; R.M.S) 8

Fig. 5.

NOISE DIODE

Rare gas-filled noise diode for use in waveguide systems in the 3 cm waveband.

QUICK REFERENCE DATA

Noise level above 290 K	F		18,75	dB
Ignition voltage	V_{ign}	min.	6000	V
Anode current	I_a	max.	150	mA

HEATING: direct, parallel supply

Filament voltage	V_f		2	V ± 10%
Filament current	I_f		2	A
Heating time	t_w	min.	15	s

TYPICAL CHARACTERISTICS

Anode voltage	V_a		165	V
Anode current	I_a		125	mA
Noise temperature	T_F		21 700	K ± 5%
Noise level above 290 K*	F		18,75	± 0,2 dB
Ignition voltage	V_{ign}	min.	6000	V

LIMITING VALUES (Absolute maximum rating system)

Anode current	I_a	max.	150	mA
		min.	50	mA
Ambient temperature	T_{amb}		−55 to +75	°C

NOTES

It is recommended that the noise diode and the microwave part of the mount are not touching (minimum diameter of pipe 7,5 mm).

The VSWR in the test mount with the noise diode in operation should not be more than 1,1.

* Change in noise level over 200 hours of operation is negligible.

MECHANICAL DATA Dimensions in mm

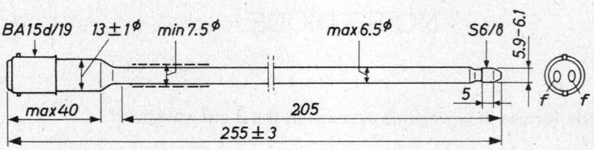


Fig. 1.

MOUNTING POSITION: Cathode at receiver side

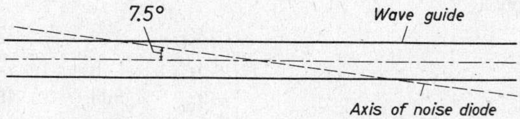


Fig. 2.

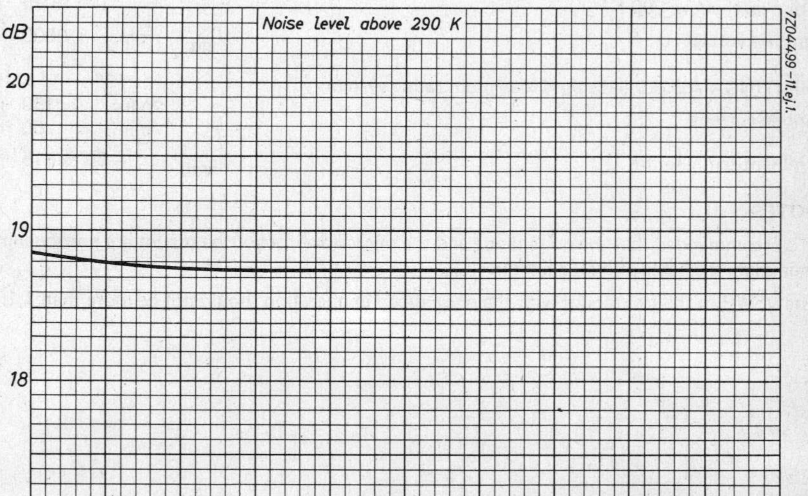


Fig. 3.

NOISE DIODE

Rare gas-filled noise diode for use in waveguide systems in the 10 cm waveband.

QUICK REFERENCE DATA

Noise level above 290 K	F		17,58	dB
Ignition voltage	V_{ign}	min.	6000	V
Anode current	I_a	max.	300	mA

HEATING: direct, parallel supply

Filament voltage	V_f		2	V ± 10%
Filament current	I_f		3,5	A
Heating time	t_w	min.	15	s

TYPICAL CHARACTERISTICS

Anode voltage	V_a		140	V
Anode current	I_a		200	mA
Noise temperature	T_F		16 600	K ± 5%
Noise level above 290 K*	F		17,58	± 0,2 dB
Ignition voltage	V_{ign}	min.	6000	V

LIMITING VALUES (Absolute maximum rating system)

Anode current	I_a	max.	300	mA
		min.	100	mA
Ambient temperature	t_{amb}		−55 to +75	°C

NOTES

It is recommended that the noise diode and the microwave part of the mount are not touching (minimum diameter of pipe 17 mm).

The VSWR in the test mount with the noise diode in operation should not be more than 1,1.

* Change in noise level over 200 hours of operation is negligible.

MECHANICAL DATA Dimensions in mm

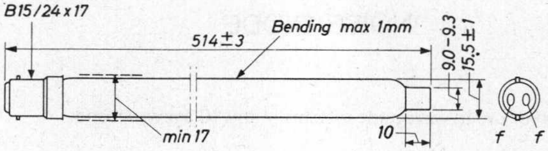


Fig. 1.

MOUNTING POSITION: Cathode at receiver side

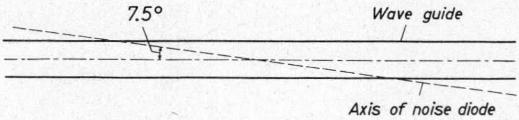


Fig. 2.

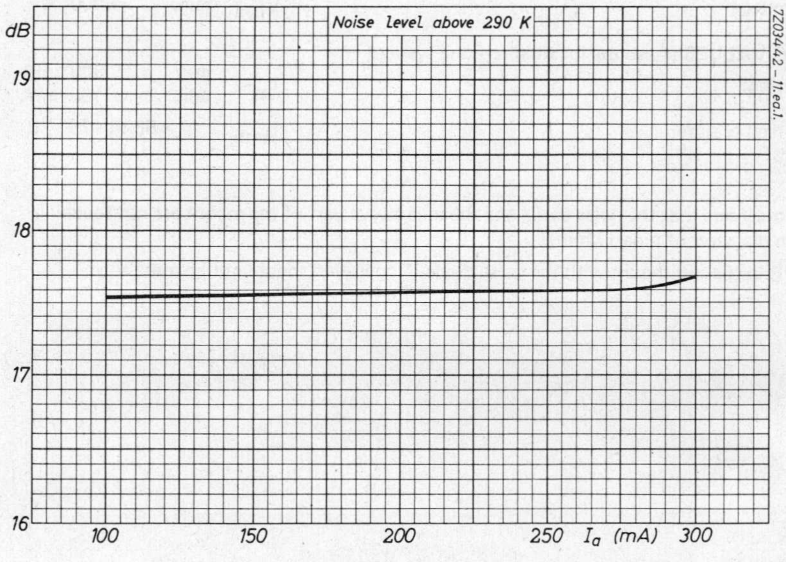


Fig. 3.

HIGH-VACUUM, HIGH-VOLTAGE DIODE

Half-wave vacuum rectifier diode for high-voltage rectifying and surge limiting purposes.

QUICK REFERENCE DATA

Tube voltage drop at I_a = 100 mA	V_a		200	V
Peak current at V_{ap} = 10 kV	I_{ap}	>	2	A
Maximum permissible peak inverse voltage	$V_{a\,inv\,p}$	max.	40	kV
Maximum permissible rectified current	I_a	max.	100	mA

APPLICATION

In radar equipment for protection of the modulator circuit and the magnetron against excessive voltages, as high-voltage rectifier, charging diode, etc. and in dust precipitation equipment.

HEATING: direct; thoriated tungsten filament

Filament voltage	V_f		5 V ± 5%
Filament current	I_f	min.	6 A ± 0,5 A
Waiting time	t_w	min.	5 s

CAPACITANCE

Anode to filament	C_{af}	1,4 pF

TYPICAL CHARACTERISTICS

Tube voltage drop at I_a = 100 mA	V_a	200 V

OPERATING CHARACTERISTICS as surge limiter

Heater voltage	V_f		5,5 V
Peak forward anode voltage	V_{ap}		10 kV
Peak anode current	I_{ap}	>	2 A

MECHANICAL DATA

Dimensions in mm

Net mass: 90 g

Base: Medium 4p. with bayonet

Cap: Medium

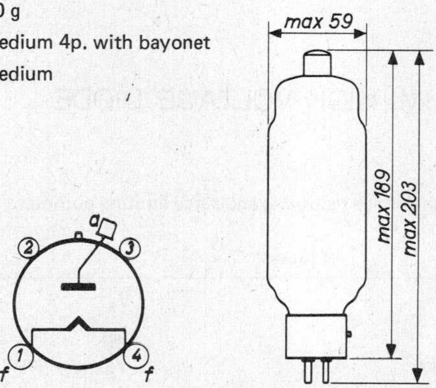


Fig. 1.

Mounting position: vertical with base down

ACCESSORIES

Anode clip 40619

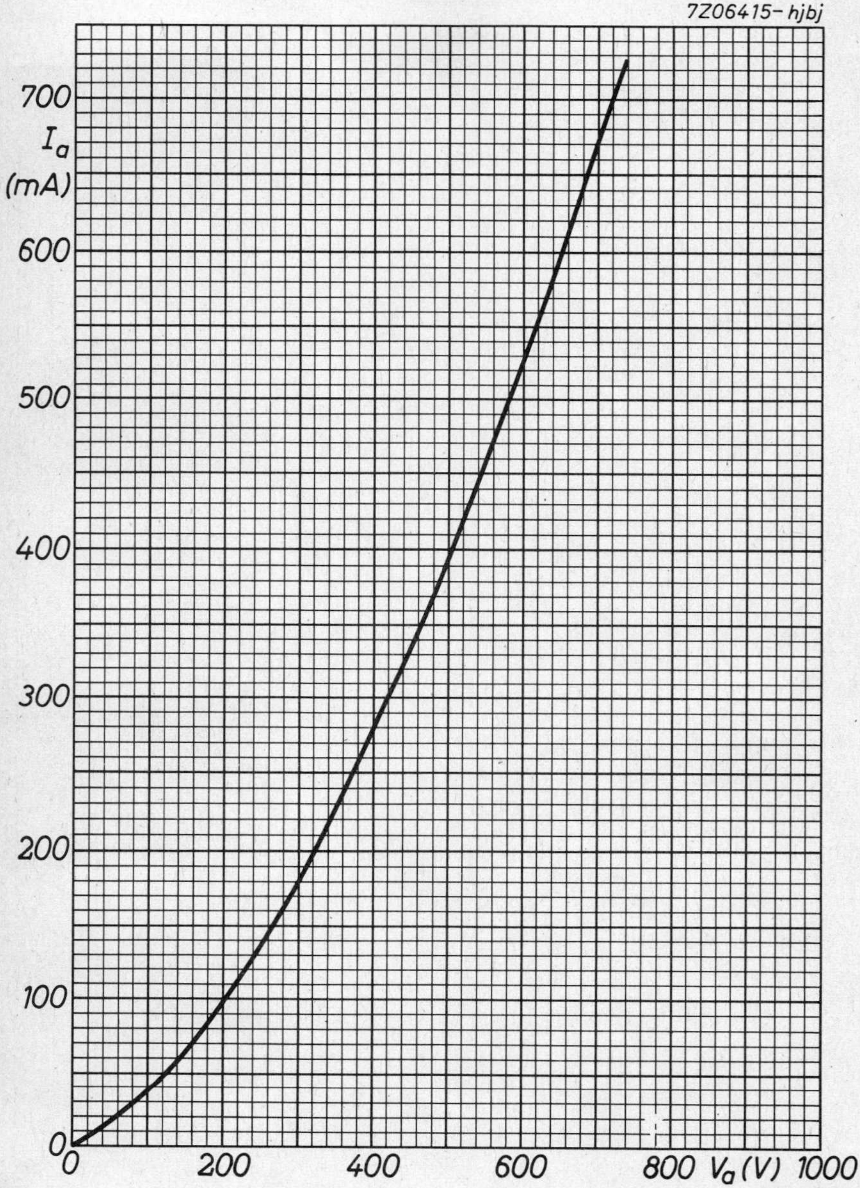
At voltages above 2 kV the socket must be insulated from the chassis.

LIMITING VALUES as surge limiter (Absolute maximum rating system)

Filament voltage	V_f	=	max.	5,8	V
Peak forward anode voltage	V_{ap}	=	max.	12,5	kV
Peak inverse anode voltage	$V_{a\ invp}$	=	max.	40	kV
Anode dissipation	W_a	=	max.	75	W

LIMITING VALUES as rectifier (Absolute maximum rating system)

Peak inverse anode voltage	$V_{a\ invp}$	=	max.	40	kV
Peak anode current	I_{ap}	=	max.	750	mA
Average rectified current	I_a	=	max.	100	mA


7Z06415-hjbj
700
I_a
(mA)
600
500
400
300
200
100
0
0
200
400
600
800
V_a (V)
1000

T-R SWITCHES F

DUAL T-R SWITCH

Broad-band gas-filled dual T-R switch covering the 8,490 to 9,580 GHz frequency band. It consists basically of two single switches forming one unit with a common flange arrangement. The 56032 is designed for operation in slot-hybrid duplexers, based on waveguide RG-52/U (WR90).

ELECTRICAL DATA

LIMITING VALUES (Absolute maximum rating system) AND CHARACTERISTICS

Peak power	max.	250	kW
	min.	3	kW
Ignitor d.c. supply voltage *	min.	−600	V
Ignitor current	max.	200	μA
Ignitor voltage drop at an	max.	300	V
ignitor current of 100 μA	min.	170	V

Low-level characteristics

Voltage standing wave ratio**			
at 8490 MHz	<	1,4	
at 9580 MHz	<	1,4	
at 8560 to 9490 MHz	<	1,2	
Duplexer loss ▲			
at 8490 MHz	<	1,1	dB
at 9580 MHz	<	1,1	dB
at 8560 to 9490 MHz	<	1,0	dB

High-level characteristics ▲

Flat leakage power	<	15	mW
Spike leakage energy	<	15	nJ
Arc loss	<	1	dB
Recovery time	<	7	μs

* The ignitor voltage shall be applied to each electrode via a suitable resistor giving 80 to 150 μA ignitor current.

** When measuring the v.s.w.r. the short-slot hybrids used shall have a v.s.w.r. of 1,1 max over the specified frequency band. Each hybrid shall split the power evenly to within 0,25 dB and shall have a minimum isolation of 25 dB.

▲ 100 μA (d.c.) through each ignitor electrode.

MECHANICAL DATA

Dimensions in mm

Mounting position: any

Net mass: 175 g

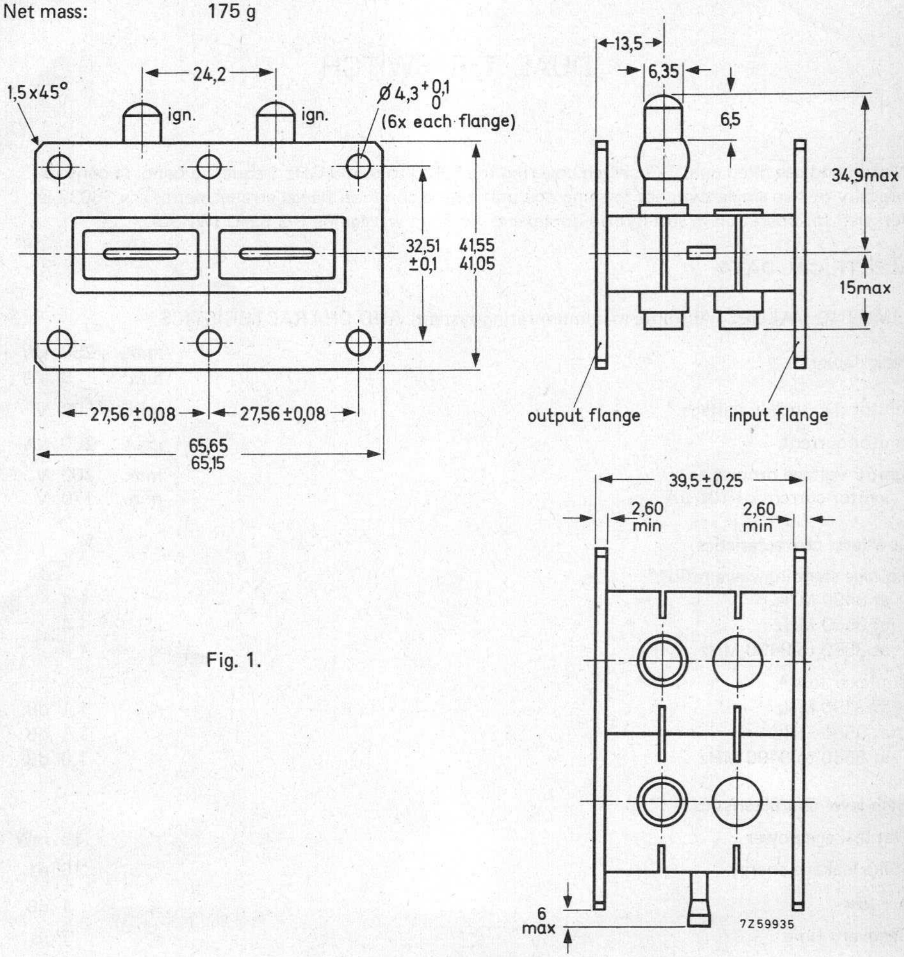


Fig. 1.

Accessories (supplied with switch)	2 gaskets, Fig. 3
Mating flange	See Fig. 2

A gasket should be placed between each flange and the mating flanges of the short-slot hybrid junctions. See Figs 2 and 3.

Pressurization	max.	350 kPa
	min.	50 kPa
Altitude	max.	3000 in

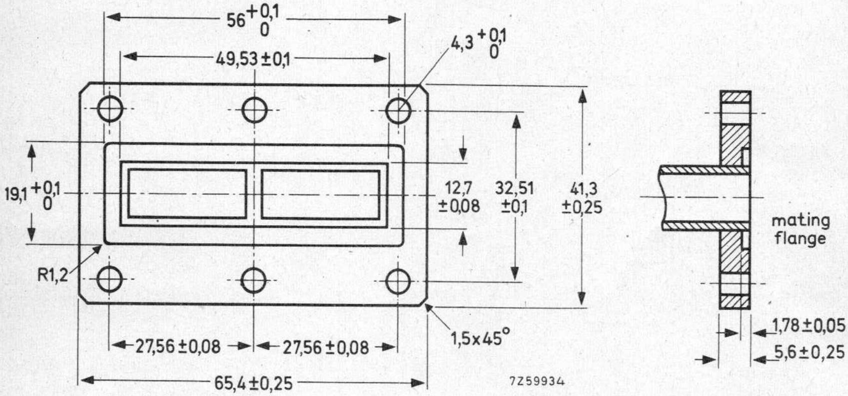


Fig. 2 Gasket assembly.

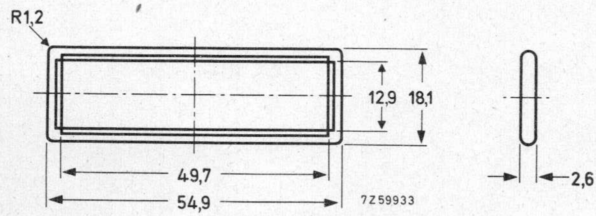


Fig. 3 Gasket.

INDEX G

INDEX OF TYPE NUMBERS

KLYSTRONS, TWTs, MICROWAVE DIODES

Mullard

technical handbook

Book 2

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