Mullard

technical handbook

Book 2

Valves and tubes

Part 4d

Magnetrons for microwave heating

1985

MAGNETRONS FOR MICROWAVE HEATING

Book 2 Part 4d

Valves and tubes

Magnetrons for microwave heating

MULLARD LTD., MULLARD HOUSE, TORRINGTON PLACE,
LONDON, WC1E 7HD

Telephone 01-580 6633 Telex: 264341

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 1c	Monochrome tubes and deflection units
Part 2a	Camera tubes and image intensifiers
Part 2b	Geiger-Muller tubes
Part 3	Photo and electron multipliers
Part 4a	Tubes for r.f. heating
Part 4b	Transmitting tubes for communications
Part 4c	Klystrons, TWTs and microwave vacuum 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.

Because the Technical Handbook system forms a comprehensive data reference library the current Mullard Quick Reference Guides should always be consulted for details of the Mullard preferred range.

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.

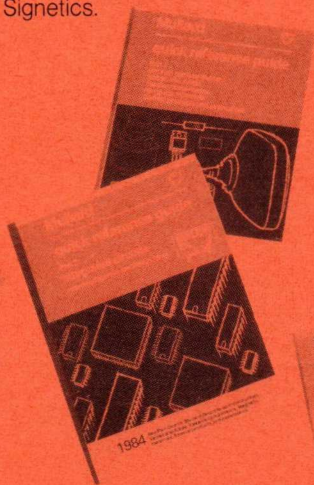
Prices and availability information for Mullard components should be obtained from Mullard House, or from one of the Mullard Distributors listed on the back cover.

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.



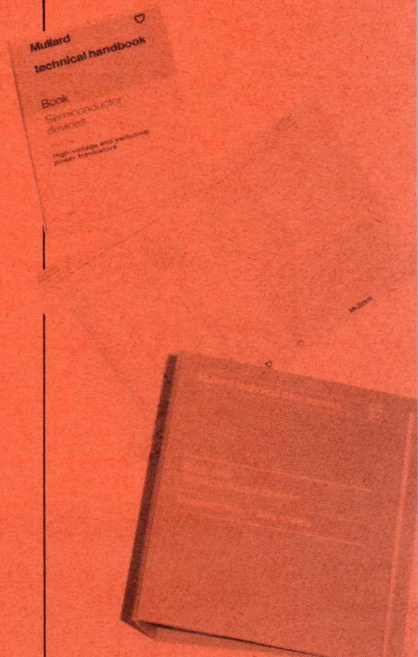
Technical Data Service

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

Subscribers to any or all of the four handbook sections receive all relevant handbooks, looseleaf binders, monthly mailings of new data sheets, and new handbook parts as they are published.

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

1. GENERAL

When properly used and handled, electronic tubes 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 may indicate if any of the specific hazards given in sections 2 to 9 are likely to be present.

1.1 Breakage

If a 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 United Kingdom the Deposit of Poisonous Waste Act 1972 and the Control of Pollution Act 1974 apply. Most electronic tubes contain toxic materials, therefore, particularly when disposing of large quantities, the advice of the manufacturer's 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 1 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 wave-guide, 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 TELEVISION PICTURE AND 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 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 move the bonded faceplate or integral implosion protection band when fitted to a tube.

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

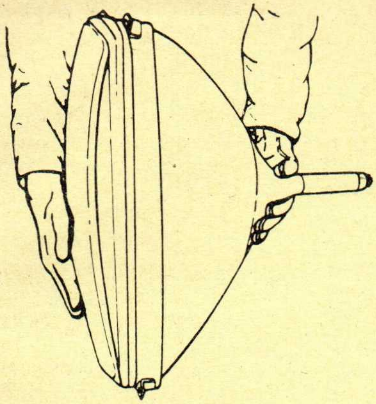


Fig.1 – Lifting tube from edge-down position.

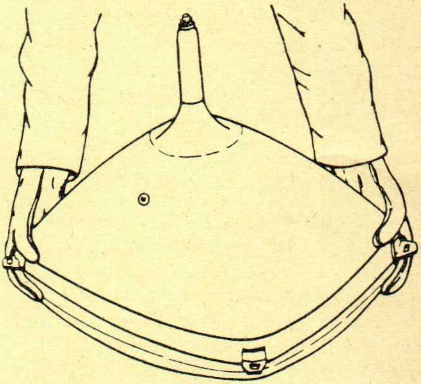


Fig.2 – Lifting tube from face-down position.

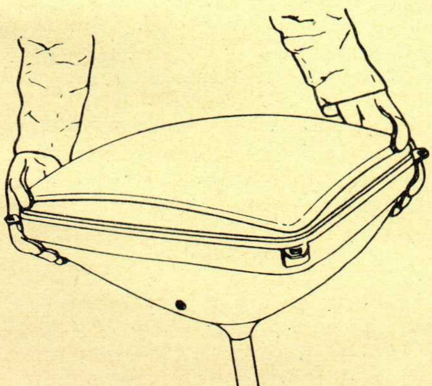


Fig.3 – Lifting tube from face-up position.

Tube on one edge

To lift a tube from the edge-down position, one hand should be placed around the parabolic 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 the 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 – TELEVISION PICTURE AND CATHODE RAY TUBES

Attention is called to the fact that a high voltage may be carried by the internal coductive 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. values (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 are used during installation, such as non-magnetic stainless steel, brass, beryllium copper and aluminium. Furthermore, the usér should be aware of the detrimental influence of the strong magnetic field around the magnet on compass, 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
TELEVISION PICTURE AND 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.

SELECTION GUIDE

TYPES RECOMMENDED FOR NEW EQUIPMENT DESIGN

Wo kW	type of magnet	Va kV	Ia A	cooling	frequency MHz	type	page
0,31	perm. magnet	3,0	0,15	forced air	2460	YJ1511	123
0,31	electromagnet	3,0	0,15	forced air	2460	YJ1530	131
1,26	perm. magnet	3,0	0,40	forced air	2460	YJ1540	139
5,0	electromagnet	4,5	0,95	water	2460	YJ1600	147

MAINTENANCE TYPES (types still in current production but not recommended for new equipment design)

Wo kW	type of magnet	Va kV	Ia A	cooling	frequency MHz	type	page
0,265	perm. magnet	3,0	0,15	forced air	2455	YJ1510	115
1,1	perm. magnet	4,0	0,38	forced air	2450	YJ1500	107
3,0	perm. magnet	5,8	0,8	water	2425–2475	YJ1442	87
6,0	perm. magnet	7,2	1,25	water	2430–2470	YJ1191*	40
6,0	perm. magnet	7,2	1,25	water	2430–2470	YJ1193	41
6,0	perm. magnet	7,2	1,25	water	2430–2470	YJ1195**	41
6,0	perm. magnet	7,2	1,25	water	2400–2350	YJ1194	68
6,0	electromagnet	7,2	1,25	water	2430–2470	YJ1193E	55
6,0	electromagnet	7,2	1,25	water	2430–2470	YJ1195E**	55

OBSOLESCENT TYPES (types no longer in production but available as long as stocks last)

type	page
YJ1160	31
YJ1162	38
YJ1280	69
YJ1441	77
YJ1481	97
7090	157

* Type without R.F. filter box.

** R.F. filter box turned 90° with respect to types YJ1193 and YJ1193E.

GENERAL

LIST OF SYMBOLS

a	Anode
B	Bandwidth
C_{ak}	Capacitance between anode and cathode (all other elements being earthed)
d	Distance of voltage standing wave minimum
$\frac{dV_a}{dt}$, $\frac{\Delta V}{\Delta t_{rv}}$	Rate of rise voltage
f	Filament or heater or frequency
f_{imp}	Pulse repetition rate
H	Magnetic field strength
I_a	Anode current
I_{ap}	Peak anode current
I_f	Filament or heater current
I_{fo}	Filament or heater starting current
I_{fp}	Peak filament or heater starting current
p	Pressure
p_i	Pressure drop of cooling air or cooling water
q	Required air flow or water flow for cooling
T	Temperature
T_a	Temperature of anode or anode block
T_{amb}	Ambient temperature
T_i	Inlet temperature of cooling air or cooling water
t_{imp}	Pulse duration
T_o	Outlet temperature of cooling air or cooling water
t_w	Cathode preheating time
V_a	Anode voltage
V_{ap}	Peak anode voltage
V_f	Filament or heater voltage
V_{fo}	Filament or heater starting voltage
VSWR	Voltage standing-wave ratio
W_{ia}	D.C. anode supply power
W_{ip}	Peak input power
W_o	Output power
W_{op}	Peak output power
δ	Duty factor

$\frac{\Delta f}{\Delta I_a}$	Pushing figure of a magnetron
$\frac{\Delta f}{\Delta T}$	Frequency temperature coefficient
Δf_p	Pulling figure of a magnetron
η	Efficiency
λ	Wavelength

DEFINITIONS

f — The frequency f is measured at maximum instantaneous output power when the tube is coupled into a matched load (VSWR $\leqslant$ 1,05).

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.

I_a — The mean anode current I_a is the average anode current through the magnetron as measured with a moving-coil instrument (or equivalent method).

I_{ap} — The peak anode current I_{ap} is the maximum instantaneous anode current value during the current pulse.

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).

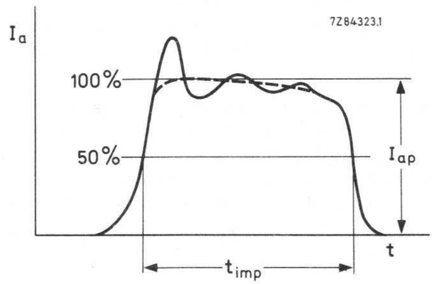


Fig. 1 Current pulse.

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_w — The cathode preheating time t_w, also called waiting time, is the minimum period of time during which the heater or filament voltage should be applied before the application of electrode voltages.

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).

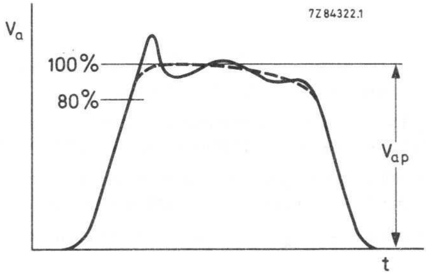


Fig. 2 Voltage pulse.

V_a — The published anode voltage V_a is generally the value measured under d.c. power supply and matched load conditions. When a special type of power is published, then the peak anode voltage value V_{ap} is quoted under matched load conditions (or other conditions of matching where applicable).

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.

W_{ia} — The mean anode input power into the magnetron W_{ia} can be computed approximately from:

(a) mains input power measurements and correcting for losses in transformer, capacitor, etc.

(b) mean anode current times peak anode voltage.

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

$$\delta = t_{imp}\ (s) \times \bar{f}_{imp}\ (Hz).$$

RECTANGULAR WAVEGUIDE DATA AND DESIGNATIONS

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

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

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

FLANGE DESIGNATIONS

FOR WAVEGUIDE 153 - IEC*	FLANGE DESIGNATION					
	PLAIN FLANGE			CHOKE FLANGE		
	154 - IEC	JAN UG /U 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					

GENERAL OPERATIONAL RECOMMENDATIONS MAGNETRONS

1. GENERAL

1.1 General note

The following directions apply in general to all types of magnetrons. Any deviations for a particular type has been indicated in the relevant data.

1.2 Magnetron definition

A magnetron is a cylindrical high-vacuum diode with a cavity resonator system embedded in the anode. In the presence of suitable crossed electric and magnetic fields the magnetron can be used for the generation of continuous-wave and pulsed signals in the higher frequency bands. The energy available within the cathode/anode zone is coupled out and launched in a coaxial line or waveguide by means of the output probe or antenna.

The magnetron should not be regarded as an independent device, but rather as an integral part of the complete circuit. It follows that the operation of the equipment depends on the degree the various components are matched to each other.

1.3 Magnetrons for communications

In practice the communication magnetrons comprise the pulsed type of magnetrons used as radar transmitters either at a fixed frequency or tunable over a frequency range.

1.4 Magnetrons for microwave heating

Magnetrons for microwave heating are designed for c.w. operation at a frequency of either 2,450 GHz or 2,375 GHz.

1.5 General design considerations

Equipment should be designed around the tube specifications given in the data and not around one particular tube since, due to normal production variations, the electrical and mechanical design parameters may vary around the nominal values.

2. OPERATING CONDITIONS

2.1 Operating characteristics

The values published for these characteristics must be considered as the outcome of measurements on an average magnetron. Individual magnetrons may show a certain spread around the published values, whereas during life the values may be subject to variation.

In the published data the spread and variation during life have in many cases be accounted for by mentioning maximum and/or minimum values of the characteristics.

As the performance of a magnetron is greatly influenced by its load and by the characteristics of the power supply, it is strongly recommended that the magnetron be operated at the published operating conditions only. Whenever it is considered to operate the magnetron at conditions substantially different from those indicated, the tube manufacturer should be consulted.

2.2 Typical characteristics

The characteristics tabulated under this heading give general information on the magnetron independent of any specific kind of operation. The data should be regarded as pertaining to an average magnetron representative of the particular type. When necessary maximum and/or minimum values of the characteristics have been given to include the spread shown by individual samples and the variation which may occur during life.

2.3 Typical operation (recommended operation)

As the performance and lifetime of a magnetron are greatly influenced by the operating conditions (kind of anode supply, load, cooling, etc.), it is recommended that the magnetron be operated under the conditions "Typical Operation". Designers can consult the manufacturer whenever they consider it necessary to operate a certain tube under conditions different from those stated under "Typical Operation".

3. LIMITING VALUES

3.1 Rating system

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

3.2 Absolute maximum rating system

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

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

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

3.3 Anode voltage, positive and negative

In some cases (e.g. when the filament is not energized) the anode voltage across the tube may be higher than the nominal operating condition, due to the type of power supply employed. The maximum voltage is specified for individual tubes. It is recommended that a suitable spark gap be connected between the filament connectors and the anode (earth) to prevent this maximum rating being exceeded.

4. CATHODE

4.1 A cathode temperature either too high or too low may lead to unsatisfactory operation such as moding and arcing, involving short life and loss of efficiency. During operation the heater voltage should, therefore, be set as near as possible at the prescribed value. Temporary fluctuations should not exceed the tolerances mentioned in the published data of the individual types. The heater voltage should be measured directly on the terminals of the tube.

4.2 Types of cathode

There are two types of cathode in use and each individual tube data specifies which cathode it uses.

(a) *Indirectly heated cathode*
A cathode heated by an element, the heater.

A special construction is the *dispenser cathode,* which is not coated but continuously supplied with suitable emission material from a separate element associated with it.

(b) *Directly heated cathode,* or filamentary cathode.

A hot cathode usually in the form of a thoriated tungsten wire which is heated by current flowing in it.

4.3 Heater supply

The heater should be operated from a.c. (50 Hz or 60 Hz); d.c. may be used when specified in the data of a particular type.

4.4 Heater transformer

It is usual that the magnetron will be operated with the anode at earth potential. Therefore, the heater will be at high potential with respect to earth. Care must be taken to ensure that the secondary winding of this transformer is sufficiently well insulated from the earth and the primary winding.

4.5 Heater/cathode connectors

The connectors specified in the individual data have been designed to give the required electrical and mechanical contact and should be used with the specified magnetron.

The heater voltage should be measured on these connectors.

A coating of high temperature resistant silicone grease is recommended to prevent oxidation. The electrical conductors to the heater/cathode connectors should be flexible to eliminate undue stress on their respective terminals.

4.6 Heater voltage, starting

This is the voltage that should be applied to the heater when the tube is switched on from cold and before the anode voltage is applied.

4.7 Waiting time, or HT delay time

This is the minimum time which must elapse after the heater starting voltage is switched on and before the anode voltage is applied. This is to enable the cathode to reach the operating temperature.

4.8 Heater voltage, operating

This is the voltage at which the heater should be set immediately after applying the anode voltage. For some types information is given of the heater operating voltage related to the mean anode current.

4.9 Heater current

The heater current mentioned in the data is the nominal (typical) value measured when only the starting voltage is applied to the tube and when (thermal) equilibrum is reached. In addition the maximum value of the heater current at the starting voltage is given to assist in transformer design.

4.10 Heater current, peak starting

During switch-on when the heater starting voltage is applied, the peak current through the heater shall not exceed (at any time) the specified value under any condition of supply voltage waveform. In order to assist in the design of the heater transformer, information is also given in the individual data about the cold filament resistance at room temperature.

4.11 Precautions

Filtering of r.f. interference

There are national and international regulations concerning r.f. interference emanating from equipment. Filtering of this interference by capacitive and inductive components associated with the heater connections may be necessary. For tubes having no integral filter these components can influence the proper operation of the magnetron and the tube manufacturer should be consulted for advice and approval.

Fluctuations in supply voltage

Care should be taken to ensure that fluctuations in the supply voltage to the heater do not exceed the published tolerances for the particular type since too high or too low cathode operating temperatures can result in unsatisfactory magnetron operation e.g. moding, arcing, short life, etc.

5. ANODE POWER SUPPLY AND MODULATORS

5.1 General

The dynamic impedance of magnetrons is in general low; thus small variations in the applied voltage can cause appreciable changes in operating current. In the equipment design it is necessary to ensure that such variations in operating current do not lead to operation outside the published limits.

Current changes result in variation of power, frequency and frequency spectrum quality and consequent deterioration of equipment performance. This factor should determine the maximum current change inherent in the equipment design under the worst operating conditions.

For some magnetrons, a special type of power supply is published which is recommended for that tube. Design information of these power supplies may be obtained from the tube manufacturer.

5.2 Pulse type magnetrons

5.2.1 General

To ensure a constant operating condition with a pulsed magnetron the modulator design must provide a pulse, the amplitude of which does not vary to any significant extent from pulse to pulse. Moreover, the energy per pulse delivered to the magnetron, if arcing occurs, should not considerably exceed the normal energy per pulse. Further design precautions depend on the type of modulator employed, and cannot be generalized.

The performance of a magnetron is often a sensitive function of the shape of the voltage pulse that it receives and it is necessary to control four distinct aspects: rate of rise, spike, flatness and rate of fall. In this connection it is important that any observation of the shape of the pulse, either of voltage or of current, supplied by the modulator should be made with a magnetron load and not with a dummy load, because a magnetron acts as a non-linear impedance. Furthermore, a magnetron is likely to be sensitive to a mismatched load.

5.2.2 Rate of rise of voltage

Both maximum and minimum rate of rise of voltage (and sometimes of current) may be specified. The most critical value is that just before and during the initiation of oscillation. Too high or low a rate of rise may accentuate the tendency to moding.

Too high a rate of rise may cause operation in the wrong mode or even failure to oscillate, and either of these conditions may lead to arcing resulting in overheating or to excessive voltages.

Operation at too low a rate of rise of voltage may also cause oscillation in the wrong mode or oscillation in the normal mode at less than full current for an appreciable period and this will cause frequency pushing leading to a broad frequency spectrum.

Generally the rate of rise of voltage between the 20% and 80% points of the peak voltage is nearly linear and provides a good impression of the rate of rise at the onset of oscillation. In other cases, however, it may be necessary to measure the rate of rise above the 80% point.

For accuracy it is advisable to measure the rate of rise by means of a differentiating circuit or an oscilloscope. The total capacitance of the removable measuring device should be small with respect to the total stray capacitance of the modulator output circuit and in most cases not exceed 6 pF.

5.2.3 Spike

It is important that the voltage pulse should not have a high spike on the leading edge. Such a spike may cause the magnetron to start in an undesired mode. Although this operation may not be sustained, the transient condition may lead to destructive arcing. Measures taken to reduce the spike must not also reduce the rate of rise below the specified minimum.

5.2.4 Flat

The top of the voltage pulse should be free from ripple or droop since small changes in voltage cause large current variations resulting in frequency pushing. This leads to frequency modulation of the r.f. pulse and consequent broadening of the spectrum or instability.

5.2.5 Rate of fall

The fall of voltage must be rapid at least to the point where oscillation ceases, to avoid appreciable periods of operation below full current, with the attendent frequency pushing. This point is normally reached when the voltage has fallen to about 80% of the peak value.

Beyond this point a lower rate of fall is generally permissible, but a significant amount of noise will be generated, which may be detrimental to radar systems with a very short minimum range. To prevent noise being generated especially in short-wave radars the voltage tail must decay to zero before the radar receiver recovers.

A fast rate of fall is also important where a magnetron is operated at a high pulse repetition frequency since any diode current which occurs after oscillations have ceased will add appreciably to the mean current and dissipation of the tube.

In certain applications it is desirable to return the cathode to a positive d.c. bias in order to speed up the rate of fall and to prevent diode current being passed during the inter-pulse period.

5.3 C.W. type magnetrons

5.3.1 General

For c.w. types the amount of smoothing required in the h.t. supply depends on the amount of modulation, resulting from operating current variation, that can be tolerated.

5.3.2 Power supplies

General information on power supply design and possibly component design, e.g. transformer design, capacitor, etc. may be supplied by the tube manufacturer. The following power supply types are in use for different tubes:

(a) unfiltered three-phase
(b) single-phase full-wave rectification
(c) unfiltered three-phase half-wave rectification
(d) unfiltered three-phase full-wave rectification
(e) LC stabilized
(f) half-wave doubler, LC stabilized.

6 MICROWAVE PERFORMANCE

6.1 General

The magnetron oscillates in the specified frequency range and the power is coupled out from the anode zone into a waveguide or coaxial line by means of the output probe or antenna. The coupling of the transmission line to the cavity in which the material is being treated has to be carefully designed to ensure that the magnetron operates correctly.

6.2 Load or Rieke diagram

In general the published data include a load diagram, a circle diagram in which, for fixed input conditions, the output power and the frequency change of the magnetron are plotted against the magnitude and the phase (varied over 180 electrical degrees) of the voltage standing-wave ratio representing the load as seen by the magnetron.

In some cases the magnitude of the voltage standing-wave ratio (VSWR) has been replaced by the magnitude of the reflection coefficient (γ) these magnitudes being related by the formulae:

$$\mathrm{VSWR} = \frac{1+\gamma}{1-\gamma} \qquad \gamma = \frac{\mathrm{VSWR}-1}{\mathrm{VSWR}+1}$$

The load diagram provides information on the behaviour of the magnetron to load conditions.

With a load of bad mismatch and at a particular phase there is a region on the load diagram which is characterized by high power output and convergence of the frequency contours. This region is known as "the sink" and the phase of the load at which the magnetron behaves in this manner is known as "the phase of sink". It is recommended that a tube be operated in the direction of sink. A tube should not be operated in the direction of anti-sink.

6.3 Reference plane

This is the plane from which measurements on microwave phase of the VSWR are made. The reference plane corresponds with the zero λ line in the load diagram. The distance d of an operating point in the diagram gives the position of the minimum of the VSWR with respect to the reference plane. This distance is specified in terms of guide wavelength.

6.4 Voltage standing-wave ratio (VSWR)

6.4.1 VSWR for pulse magnetrons

The anode current range shown in the individual data is related to a VSWR of maximum 1,5 as seen by the magnetron. Operation of the magnetron with a VSWR in excess of 1,5 is not recommended as this may reduce the current range for stable operation and can cause arcing and moding. A ratio near unity will benefit tube life and reliability.

When the length of the transmission line between the magnetron and the load is large compared with the wavelength the maximum permissible value of the VSWR may be reduced due to the occurrence of so-called long line effects. When a long transmission line can not be avoided a load isolator must be inserted between the magnetron and the line.

6.4.2. VSWR for c.w. magnetrons

Under typical operating conditions the tube is operated under specified VSWR and phase conditions. It is most unlikely that these VSWR and phase conditions will be constant and therefore there are two types of VSWR conditions:

(a) Maximum continuous voltage standing-wave ratio
This value shall not be exceeded under any conditions of loading, except those specified in para. 6.4.2.(b). The value for certain equipment may be measured with standard cold measuring techniques (perhaps using a specified measuring probe). In some instances this VSWR value may be limited to particular phase regions of operation and outside these regions a lower VSWR value may be specified. This value shall not be exceeded. Incorrect loading of the tube may cause unstable operation.

(b) Instantaneous maximum voltage standing-wave ratio
Some equipments use a device for varying the field pattern to produce a more uniform energy distribution in the applicator. This introduces instantaneous VSWR conditions which may exceed the continuous value. With those tubes where it is permissible to exceed the continuous value, the instantaneous value may be up to the specified value for a time of 0,02 s and maximum 20% of the time. It must be foolowed by a period four times as long during which the VSWR is less than the continuous maximum value.

Under no circumstances should the magnetron be permitted to mode. Amongst other conditions, the moding stability of a magnetron depends on the r.f. loading conditions such as VSWR, phase of reflection and coupling section. It also depends on peak anode current, mean anode current waveform. See para. 7.2.5.

6.5 Fixed relfection elements

Fixed reflection elements are used to alter the operating position of a magnetron concerning magnitude of VSWR and phase. It may be that an equipment is set up for optimum operation at matched load. A fixed reflection element can alter the operating position to the more efficient position of the phase of sink.

6.6 Microwave accessories

6.6.1 Antenna

In some cases the tube manufacturer can supply data on antennae which can be attached to the output of the tube in order to facilitate coupling into a specific waveguide type. In addition, drawings may be available on specific waveguide coupling assemblies.

6.6.2 R.F. gasket or soft copper washer

Gaskets and washers are provided to ensure adequate and proper electrical and r.f. contact between the tube output structure and the coupling section. When a new tube is installed in an equipment new gaskets and washers must be installed at the same time.

6.6.2 Microwave coupling or launching section

In some instances the coupling section for a certain tube is published. It is recommended that that coupling section be used with that tube. In other cases no specific publication of coupling section is given and the tube manufacturer should be consulted, since drawings of a particular coupling section for a particular waveguide may be available. In some instances a transition to approximately 53,4 Ω coaxial line is published.

7 MEASUREMENTS

7.1 Cold measurements

Cold measurements are carried out to determine the VSWR and phase offered to the magnetron. These measurements should already have been carried out during the development of the applicator.

A measuring probe is available for those magnetrons having an antenna output. This probe replaces the tube in cold measurements. For tubes with a coaxial output structure VSWR measurements can be done with available standard equipment.

The coaxial input of either the measuring probe or applicator can be directly connected to a network analyser to observe VSWR and phase. The reference plane for the load diagram is fixed to the input of the measuring probe or to the coaxial output structure of the tube (see drawings in the respective data publications). Design information for a network analyser for the microwave-heating band is available from the tube manufacturer.

7.2 Hot measurements

Hot measurements are carried out during development, production and servicing of microwave equipment.

7.2.1 Power output in a load

An output power measurement can be made using a defined quantity of water which is heated during a defined time. This check can also be done during production line control and servicing. The power into a cavity is given by the following equation:

$$P_o = q \frac{\Delta T}{14,4} \text{ W}$$

in which q is the quantity of water being heated (cm^3) and ΔT is the temperature rise per minute of the water (K).

7.2.2 Peak heater current

This value must be checked. A suggested method is shown in the following diagram.

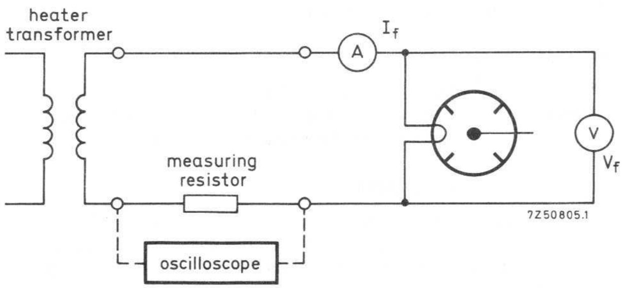


Fig. 1.

7.2.3 *Heater voltage*

The heater voltage — both starting and stand-by — shall be checked under all possible conditions of mains voltage fluctuations. The values shall remain within the published limits.

7.2.4 *Anode current/anode voltage*

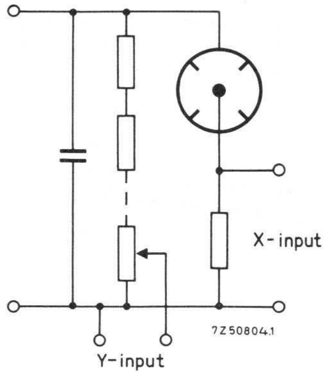


Fig. 2.

The circuit shown above enables the peak anode current I_a, the peak anode voltage V_a and the V_a to I_a characteristic to be displayed on an oscilloscope. The waveforms show whether the peak values are in accordance with the published data and whether under certain load conditions, the magnetron can mode.
In addition the X-input signal can be read on a moving-coil voltmeter and calibrated in mean current.
For measurement of peak anode voltage the following circuit is recommended.

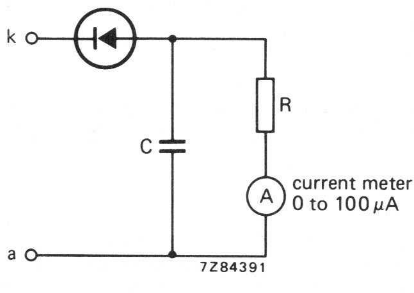


Fig. 3 For 50 Hz operation the RC time is fixed to 1 s.

7.2.5 V_a to I_a characteristic

Excessive VSWR and/or current values may lead to moding of the magnetron which can be detected by displaying the V_a to I_a characteristic on an oscilloscope for the various load conditions. This should be part of production line inspection but should also be checked during field inspection and after tube replacement. The normal V_a to I_a characteristic should be similar to the normal magnetron characteristic as drawn below. The appearance of a second line or parts thereof distinctly above the first line indicates undesired modes of oscillation that can rapidly lead to failure of the tube.

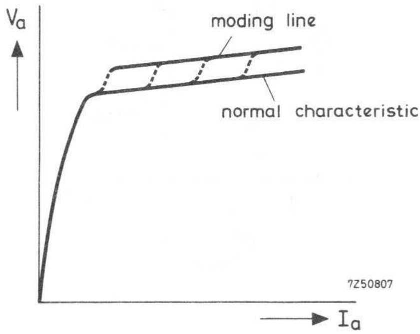


Fig. 4 X-Y display of magnetron characteristic (unfiltered supply).

In such cases the operating conditions, including the VSWR, must be checked and the tube replaced if, under correct operating conditions, moding still occurs.

7.2.6 Seal temperature

The temperature of the specified points shall not exceed the published ratings. If the flow of coolant is reduced or blocked, the thermoswitch must switch off the equipment before the maximum seal temperature is reached.

7.2.7 Stray magnetic fields

During development, the proximity of other magnetic materials should be checked concerning the influence on the magnetic field of the operating magnetron. This can be detected with the circuit for peak anode voltage (see 7.2.4).

7.2.8 Stray microwave leakage

During development, production and servicing care should be taken to ensure that the microwave leakage from the equipment is below the standards for particular countries concerned. Generally this is a cavity design problem but sometimes energy can leak from the r.f. couplings associated with the tube.

8 HANDLING AND MOUNTING

8.1 General

The magnetron is a delicate electronic tube and has parts made of glass and/or ceramic. Care must be taken in handling, installation, carriage (transport), storage, etc.

8.2 Handling and storage

The original packing should be used for transporting and storing the tube. Shipment of the tube mounted in equipment is not permitted unless specifically authorized by the tube manufacturer.

The strong magnetic field necessary for the operation of the tube must not be weakened permanently. Therefore the tube should NEVER be placed directly on any piece of ferromagnetic material (steel shelfs, etc.). When the tubes have to be unpacked, e.g. at an assembly line or for measuring purposes, care should be taken that the tubes are not placed closer to each other than they would be placed when still packed. The storage area may be at normal room temperature and average humidity. Since the heater/filament is sensitive to shocks and vibration, care should be taken when handling and storing tubes such that shocks and vibrations are avoided. The best protection for the tube is the original pack.

8.3 Mounting position

There is a specified mounting position in the individual data. This mounting position normally refers to a certain axis. The specified axis is usually quoted on the outline drawing of the relevant magnetron.

8.4 Fixing or holding points

The fixing/holding/supporting points are generally specified on the outline drawing. The r.f. output coupling of the tube should not be used as the only means of supporting the tube. Adjustment should be available in the supporting brackets in the three directions of freedom to allow for manufacturing tolerances.

8.5 Electrical connections

The individual electrode connections to the tube should be flexible. Special places for the anode (earth) connection are indicated. These places are unpainted and therefore direct earth connections. Other places might not be electrically satisfactory.

8.6 Proximity of other magnets or ferromagnetic materials

The influence of other magnets or ferromagnetic materials on the magnetron magnetic field can result in degraded performance of the tube.Therefore magnets and stray magnetic field generators, either constant or varying, e.g. transformer cores, should be kept away at the specified distance from the magnetron in question.

8.7 Tools and instruments

All tools such as screwdrivers, wrenches, etc. used close to or in contact with the magnetron should be made of non-magnetic materials such as beryllium copper, brass or plastics to avoid unwanted attraction and possible mechanical damage to glass or ceramic parts as well as short-circuiting of the magnetic flux. Sensitive instruments may be influenced or damaged by being positioned too close to the magnetron.

8.8 General precautions

The tube, and particularly the r.f. output coupling, should be kept clean and should be inspected before installation. Any foreign matter, especially metal particles inside the coaxial line and dirt on the ceramic insulation may cause electrical breakdown during operation.

The magnetron should never be held by the cathode radiator because this might result in mechanical damage to the tube. When a magnetron is removed from service every effort should be made to put it back into its original packing.

8.9 Tube cleanliness

The ceramic parts of the input and output structures of the tube must be kept clean during operation. A protective cover of suitable material should be placed over the tube output if the output if the tube is inserted directly into a microwave cavity.

9 COOLING

9.1 General

In general, cooling of the filament terminals, anode block and output is necessary and individual data specify the extent to which cooling by air, forced air or water is required. Overheating of the tube due to insufficient cooling may damage the tube. The coupling requirements stated in the individual data refer to magnetrons operated under open bench conditions. In order to keep within the limiting temperatures for anode block, cathode terminal assembly and output seal, where appropriate, it may be necessary in the practical equipment to provide additional coolant on account of high environmental temperatures due to restrictions imposed by the cabinet and to high ambient temperatures at the equipment location.

The residual heat of the cathode on switch-off may raise the seal temperature above its permitted maximum. This danger can be avoided either by continuing the air flow after removal of cathode heater power or by using sufficient air during operation to keep the temperature of the cathode so low that the rise in seal temperature on switch-off can be accommodated.

9.2 Air cooling

Forced air cooling, when required, shall be in accordance with the information given under typical cooling air requirements. In addition a cooling air diagram (if available) indicates the variation of temperature at a certain point and the air pressure drop as a function of air flow rate. It is recommended that the cooling air temperature at the entrance to the tube cooling radiator does not exceed 40 °C. Care should be taken that air filters do not become blocked so that the flow rate is inhibited and the cooling air is heated to a too high temperature by surrounding dissipative components such as mains high-voltage transformer. It is important that the air should not contain dust, moisture and oil. If an air filter is incorporated in the system, allowance must be made for the pressure drop across the filter and ducting when choosing a blower.

9.3 Water cooling

Water cooling in accordance with the specified flow rate should be supplied to the tube. The cooling diagram specifies the inlet water temperature and pressure drop as a function of water flow rate. Closed or open water circuits may be used and the minimum water inlet temperature is 4 °C. Re-circulating systems are preferred, since, apart from saving water, they help to ensure a high standard of purity.

Some of the requirements for satisfactory cooling water are that it should not be corrosive or deposit scale, should not contain insoluble material that might cause blockages and should have a high electrical resistance to prevent electrolysis. Its mineral content and electrical conductivity should therefore be periodically checked, especially when it is not drawn from a circulating system. A non-corrosive water should be low in chlorides, oxygen and carbon dioxide.

Scale formation may be avoided by maintaining a low amount of silica and bicarbonates, especially calcium bicarbonate. The total carbonate hardness should not exceed a value of 6° dH. No exact figures can be given for impurities as they are interdependent. However, in a circulating system the water should be as free as possible from all solid matter, and the dissolved oxygen content should be low. Whenever possible a closed water system using destilled or demineralized water should be employed. In this case the following should be added:

1. 700 mg of a 24% solution hydrazin hydrate (approx. 0,7 ml per litre of water) to avoid corrosion.
2. Approximately 700 mg sodium silicate per litre of water to increase the pH value (hydrogen ion concentration).

The additives will reduce the electrical conductivity of the water to below 300 $\mu\Omega^{-1}$ cm^{-1} (resistivity > 3,3 kΩ per cm^3) and also increase the pH value. A pH value of 7 to 9 is recommended). It is also recommended that the quality of the cooling water be checked after starting operations, and at regular intervals thereafter.

The cooling water must also be free from all traces of greasy substances since a small amount may form a dangerous heat barrier on the anode cooler, causing excessive anode temperature despite an apparently adequate water flow. These greasy or oily films may be removed by repeated flushing of the cooling channels with a domestic liquid detergent or slight soapy water to which a small quantity of industrial alcohol and 33% ammonia has been added (approx. 10 cc/l of each). The cleaning process should be completed by repeated flushing with demineralized water. The cause of such greasy deposits will usually be found elsewhere in the cooling system as the result of, for example, leaky pump glands. After the necessary repairs have been carried out, the whole system must be cleaned in a similar manner to prevent deposits forming again. The cooling water system must be interlocked with all electrical supplies to the tube. As an added safeguard, the interlocks should be activated if the water outlet temperature exceeds the indicated upper limit. To prevent the tube from running dry in the event of minor leakages in the system, the reservoir should always be above the level of the tube.

9.4 Thermoswitches

A thermoswitch must be used with each magnetron to protect the tube from overheating as a result of failure of the cooling system. The thermoswitch is normally 'closed' and opens when the temperature at the particular reference point exceeds the specified limit. The thermoswitch controls the power supply via a protection circuit and switches it off in the event of overheating.

A thermoswitch must be chosen which opens at the particular specified temperature when mounted at the specified place. In specifying the operating (opening) temperature, the temperature drop across the thermoswitch holder should be taken into account with respect to the temperature limit; under typical conditions this is about 5 K. Details of suggested thermoswitches can be supplied on request.

9.5 Temperature limits

Temperature reference points and maximum temperature limits are specified in the data. Under no circumstances shall these limits be exceeded. As for the limiting temperatures, measurements should be made in the development stage of the equipment, using suitable measuring methods.

9.6 Cooling during stand-by

Some forced-air or water cooling may be necessary during stand-by or starting filament heater voltage operation only. Tests should be carried out during the development of the equipment to ensure that sufficient cooling, even under extreme conditions, is available to keep the temperature of specified places below the maximum limit.

10 ACCESSORIES

10.1 General

The accessories recommended for use with relevant magnetrons should be used whenever possible. If an equipment maker considers it necessary to use other accessories he should ask the opinion of the tube manufacturer.

10.2 Fixed reflection elements

Fixed reflection elements are designed to adapt the operating position (in phase and VSWR) of the magnetron to a better position in the Rieke diagram (load diagram) to obtain more useful results, particularly with respect to power output. These accessories are not supplied by the tube manufacturer but drawings are given to facilitate manufacture if the use of these fixed reflection elements is recommended.

10.3 Gaskets and washers

Gaskets and washers are provided to ensure adequate and proper electrical and r.f. contact between the elements concerned. Generally, when a tube is installed, or re-installed, new gaskets and washers must be used.

10.4 Measuring probe

When available, the measuring probe should be used in place of the tube in development, production and servicing to ensure that the correct microwave impedance (phase and VSWR) is presented to the tube. See 7.1.

RATING SYSTEM

(in accordance with IEC Publication 134)

ABSOLUTE MAXIMUM RATING SYSTEM

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

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

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

MAGNETRONS FOR MICROWAVE HEATING

CONTINUOUS-WAVE MAGNETRON

Continuous-wave water-cooled packaged magnetron intended for microwave heating applications.

QUICK REFERENCE DATA

Frequency, fixed with the band	f	2,425 to 2,475 GHz
Output power	W_o	2,0 to 2,5 kW
Construction		packaged
Anode supply		unfiltered single-phase full-wave, or three-phase half-wave rectification

CATHODE: Dispenser type

HEATING: Indirect by a.c. (50 to 60 Hz) or d.c. See also page C7.

Heater voltage, starting	V_f		5 V $^{+5\%}_{-10\%}$
Heater voltage, stand-by	V_f		4,8 V $^{+5\%}_{-10\%}$
Heater current at V_f = 5 V	I_f	≈ <	35 A 38 A
Heater current, peak starting	I_{fp}	max.	100 A
Cold heater resistance	R_{fo}	≈	20 mΩ
Waiting time (time before application of high voltage at V_f = 5 V	t_w	min.	120 s

TYPICAL CHARACTERISTICS measured under matched load conditions (VSWR ⩽ 1,05) and a d.c. power supply

Frequency, fixed within the band	f	2,425 to 2,475 MHz
Anode voltage at I_a = 750 mA	V_a	4,45 to 4,85 kV

LIMITING VALUES AND OPERATING CHARACTERISTICS

Anode voltage obtained from a single-phase full-wave, or three-phase half-wave, rectifier without smoothing filter.

A. OPERATION WITH W_o = 2 kW

LIMITING VALUES (Absolute maximum rating system)

Anode current, mean	I_a	max. min.	0,8 A 0,1 A
Anode current, peak	I_{ap}	max.	2,1 A
Voltage standing-wave ratio at $0{,}37\ \lambda < d < 0{,}44\ \lambda$	VSWR	max.	4
remaining region	VSWR	max.	5

TYPICAL OPERATION (into a matched load)

Heater voltage, running	V_f		2 V
Anode current, mean	I_a		0,75 A
Anode current, peak	I_a		2 A
Anode voltage (measured with d.c.)	V_a		4,75 kV
Output power	W_o	 $>$	2 kW 1,85 kW
Efficiency	η		55 %

B. OPERATION WITH W_o = 2,5 kW

A fixed reflection element with a VSWR of 1,5 and a phase position of 0,41 λ should be inserted between magnetron and load.

LIMITING VALUES (Absolute maximum rating system)

Anode current	I_a	max. min.	0,9 A 0,1 A
Anode current, peak	I_{ap}	max.	2,1 A
Voltage standing-wave ratio at 0,37 λ $<$ d $<$ 0,44 λ	VSWR	max.	2,5
remaining region	VSWR	max.	4

TYPICAL OPERATION (into a matched load) *

Heater voltage, running	V_f		1,5 V
Anode current, mean	I_a		0,85 A
Anode current, peak	I_{ap}		2 A
Anode voltage (measured with d.c.)	V_a		4,8 kV
Output power	W_o	 $>$	2,5 kW 2,3 kW
Efficiency	η	$\approx$	60 %

C. OPERATION WITH W_o = 2,5 kW FOR MICROWAVE OVENS

The average VSWR should be 3 at d = 0,41 λ.

LIMITING VALUES (Absolute maximum rating system)

Anode current, mean	I_a	max. min.	0,85 A 0,1 A
Anode current, peak	I_{ap}	max.	2,1 A
Voltage standing-wave ratio at 0,3 λ $<$ d $<$ 0,5 λ	VSWR	max.	4
intermittent (t = max. 0,02 s and max. 20% of the time)	VSWR	max.	10 **
remaining region	VSWR	max.	4

* With respect to reference plane B of fixed reflection element.

** The average reflected power for any one-second period must not exceed the reflected power equivalent to a VSWR of 4. When operating under these conditions, the tube should not be permitted to mode.

TYPICAL OPERATION

Heater voltage, running	V_f		1,8	V
Anode current, mean	I_a		0,8	A
Anode current, peak	I_{ap}		2	A
Anode voltage	V_a		4,95	kV
Voltage standing-wave ratio at $0{,}3\,\lambda < d < 0{,}5\,\lambda$	VSWR		3	
Output power	W_o		2,5	kW
		>	2,3	kW
Efficiency	η	≈	60	%

COOLING

Anode block	water
Required quantity of water	see cooling curve
Cathode radiator, via air duct	low-velocity air flow $> 0{,}2\ m^3/min$

TEMPERATURE LIMITS (Absolute maximum rating system)

Anode temperature at reference point for temperature measurement	T_a	max.	125	^oC
Cathode radiator temperature	T	max.	180	^oC

To safeguard the magnetron from overheating if the cooling fails, provision is made for mounting a thermoswitch. This switch should become operative at a temperature of 120 ^oC to 125 ^{o} at the mounting plate.

MECHANICAL DATA

Net mass: ≈ 4,7 kg

Mounting position: any

ACCESSORIES

Cap nut	type	55312
Spring ring	type	55313
Heater connector	type	40634
Heater/cathode connector	type	40649

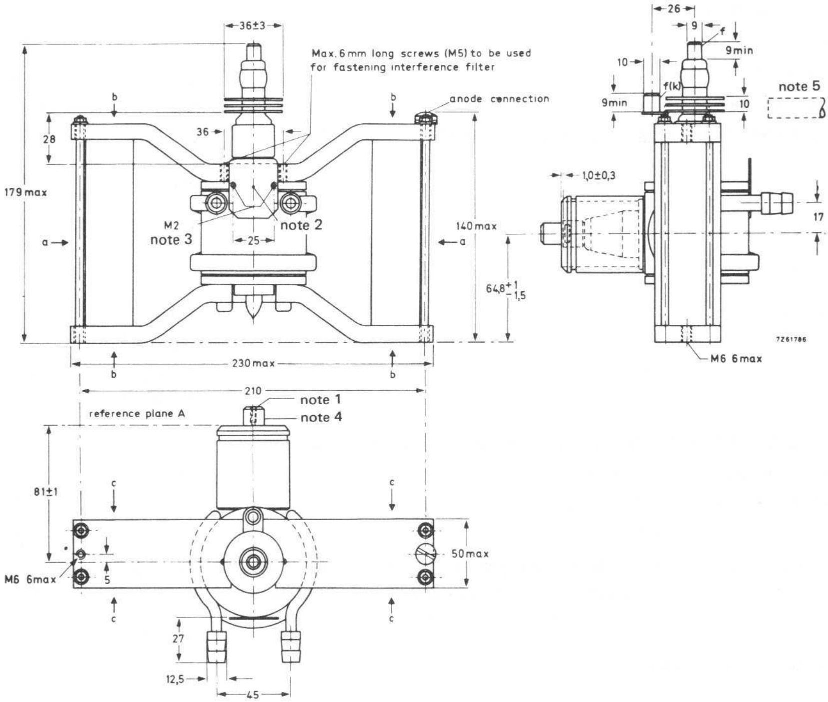


Fig. 1.

Notes
1. Axial hole for short antenna: M4, depth 9 mm minimum.
2. Reference point for temperature measurements.
3. Mounting holes for thermoswitch.
4. Eccentricity of inner conductor with respect to the outer conductor max. 0,4 mm.
5. Non-metallic air duct, inner diameter 13 mm.

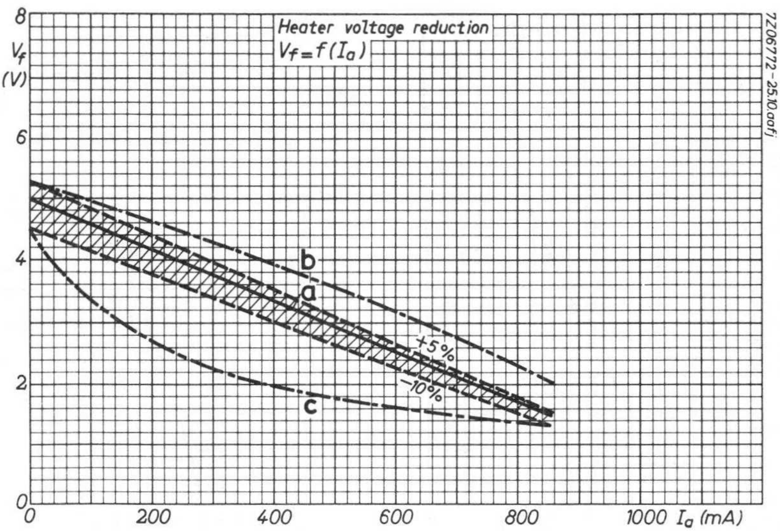


Fig. 2.

Immediately after applying the anode voltage the heater voltage must be reduced as a function of the anode current according to the diagram above. The life of the magnetron will be greatest if the heater voltage is reduced to a value given by the fully drawn line a. The heater voltage should be adjusted within +5 and −10% as given by the dashed lines which border the hatched area.

If the equipment has been designed for a predetermined number of steps of output power level, the reduced heater voltage for each step must be set to a value within the area bordered by the lines b and c, and preferably within or close to the hatched area. In no circumstances should the heater voltage reach a value outside the limits given by the curves b and c.

The limits V_f = 5 V −10% and t_w = 120 s should not be used simultaneously. With V_f below the nominal value, t_w should be increased in linear proportion up to min. 180 s at V_f = 5 V −10%. It is also possible to preheat the tube at stand-by conditions if the waiting time is extended to at least 10 minutes.

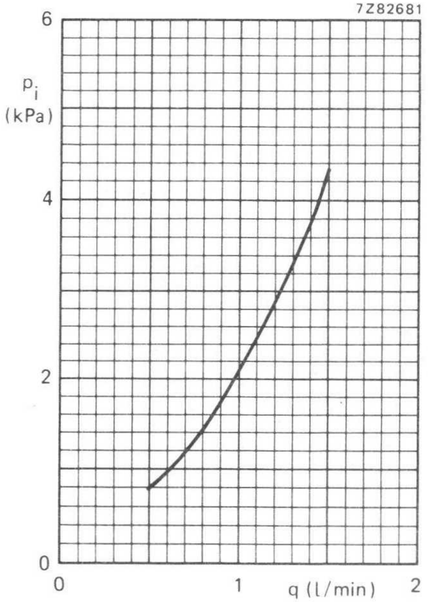


Fig. 3.

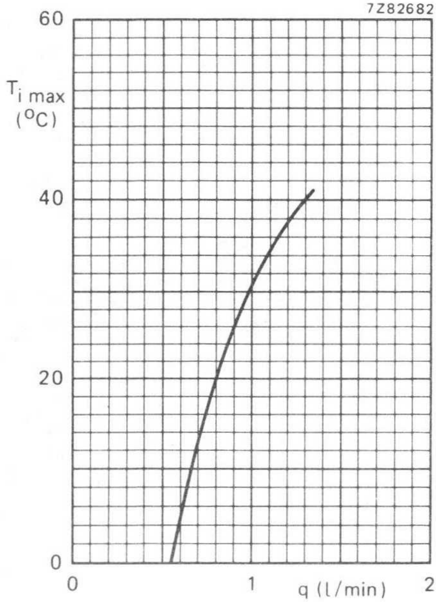
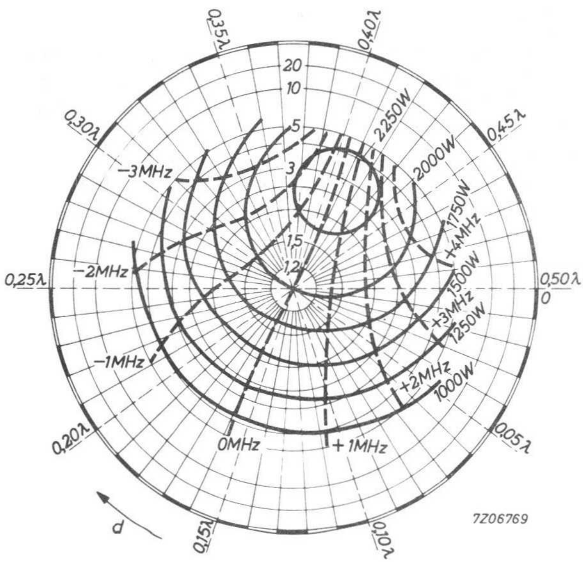


Fig. 4.

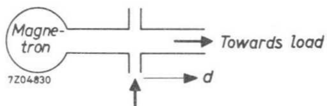


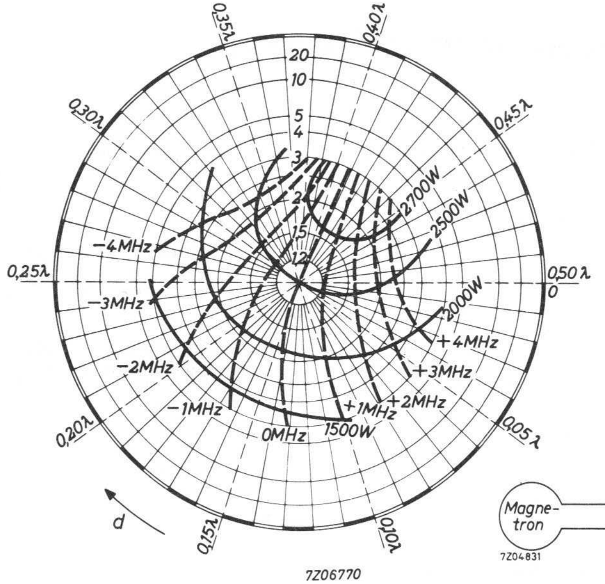
Load diagram Operation A

Fig. 5 Mean anode current 0,75 A
Peak anode current 2 A

d = distance of standing wave minimum from reference plane A towards load

Temperature at reference point 85 °C



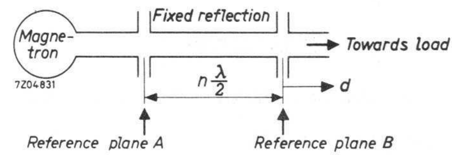


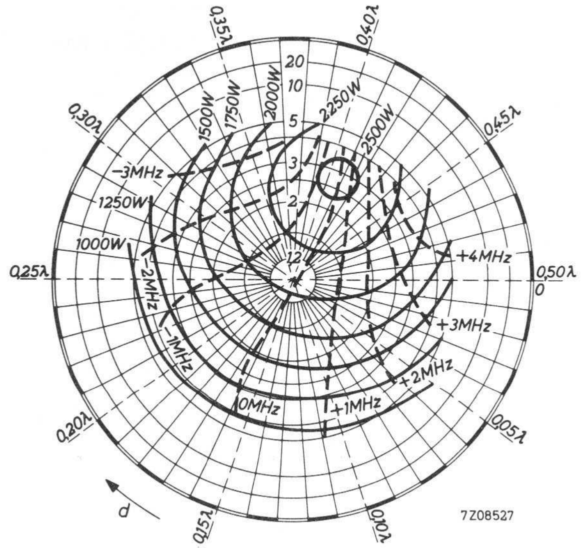
Load diagram Operation B

Fig. 6 Mean anode current 0,85 A
Peak anode current 2 A
Fixed reflection VSWR = 1,5
d = 0,41 λ

d = distance of standing wave minimum from reference plane B towards load

Temperature at reference point 85 °C



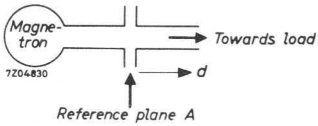


Load diagram Operation C

Fig. 7 Mean anode current 0,8 A
Peak anode current 2 A

d = distance of standing wave minimum from reference plane A towards load

Temperature at reference point 85 °C



CONTINUOUS-WAVE MAGNETRON

Continuous-wave air-cooled packaged magnetron intended for microwave heating applications.

QUICK REFERENCE DATA

Frequency, fixed within the band	f	2,425 to 2,475 GHz
Output power	W_o	2,0 to 2,5 kW
Construction	packaged	
Anode supply	unfiltered single-phase full-wave, or three-phase half-wave rectified	

CATHODE

HEATING

TYPICAL CHARACTERISTICS

LIMITING VALUES AND OPERATING CONDITIONS

TEMPERATURE LIMITS

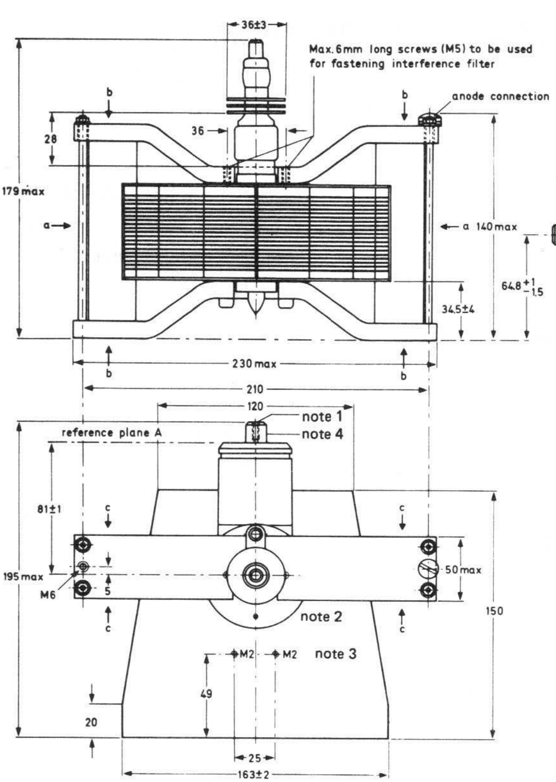
See YJ1160

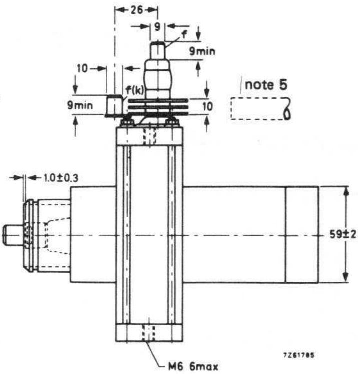
COOLING

Anode block	forced air
Required quantity of air	see cooling curve
Cathode radiator, via air duct	low-velocity air flow (> 0,2 m^3/min)

MECHANICAL DATA

Dimensions in mm





1. Axial hole for short antenna: M4, depth ⩾ 9 mm.
2. Reference point for temperature measurements.
3. Mounting holes for thermoswitch.
4. Eccentricity of inner conductor with respect to the outer conductor max 0,4 mm.
5. Non-metallic air duct, inner diameter 13 mm.

Fig. 1.

CONTINUOUS-WAVE MAGNETRON

QUICK REFERENCE DATA

Frequency, fixed within the band	f	2,430 to 2,470 GHz
Output power	W_o	6 kW
Construction	packaged, metal ceramic	
Cathode	quick heating	

The YJ1191 is equivalent to YJ1193 but has no filter box.

CONTINUOUS-WAVE MAGNETRONS

Packaged, water-cooled continuous-wave magnetron with integral r.f. filter and permanent magnets, intended for industrial microwave heating applications. The tube features a quick-heating cathode, high efficiency, and has a typical output power of 6 kW. Types YJ1193 and YJ1195 are only mechanically different.

QUICK REFERENCE DATA

Frequency, fixed within the band	f	2,430 to 2,470	GHz
Output power	W_o	6	kW
Construction	packaged, metal ceramic		
Cathode	quick heating		
Cooling	water and air		
R.F. filter	integral		

TYPICAL OPERATION

Conditions

Filament voltage, starting	V_f	5,5	V
Waiting time	t_w	10	s ←
Filament voltage, operating	V_f	1,0	V
Anode supply	three-phase full-wave rectifier		
Anode current, mean	I_a	1,25	A
Anode current, peak	I_{ap}	1,5	A
Load impedance			
Voltage standing-wave ratio	VSWR	1,5	
Phase, in direction of load with respect to reference plane	d	0,42	λ
Cooling	see relevant paragraph		

Performance

Filament current at V_f = 1,0 V	I_f	5	A
Anode voltage, mean	V_a	7,3	kV
Output power	W_o	6	kW
	W_o	> 5,4	kW
Efficiency	η	65	%

For other load impedance and anode current conditions see pages 11 and 12 and "Design and operating notes".

CATHODE: thoriated tungsten

HEATING: direct by a.c. (50 Hz or 60 Hz) or d.c.

With d.c. the filament terminal (f) must have positive polarity.

Filament voltage, starting and stand-by	V_f		5,5 V ± 10%
operating at $I_{a\,mean}$ = 1,25 A	V_f		1,0 V ± 10%
Filament current at V_f = 5,5 V; I_a = 0	I_f	<	44 A 48 A
at V_f = 1,0 V; $I_{a\,mean}$ = 1,25 A	I_f		5 A
Filament starting current, peak	I_{fp}	max.	150 A
Cold filament resistance	R_{fo}		17 mΩ
→ Waiting time (time before application of high voltage)	t_w	min.	10 s

Immediately after applying the anode voltage the filament voltage must be reduced to the operating value.

If it is intended to design the equipment for a variable output power, either continuously adjustable or stepped, the filament voltage must be reduced as a function of the anode current (see graph below). The reduced filament voltage may be set to a value within the area bordered by the lines b and c, but for longest life it should be within the hatched area. In no circumstances should the filament voltage reach a value outside the limits given by the lines b and c.

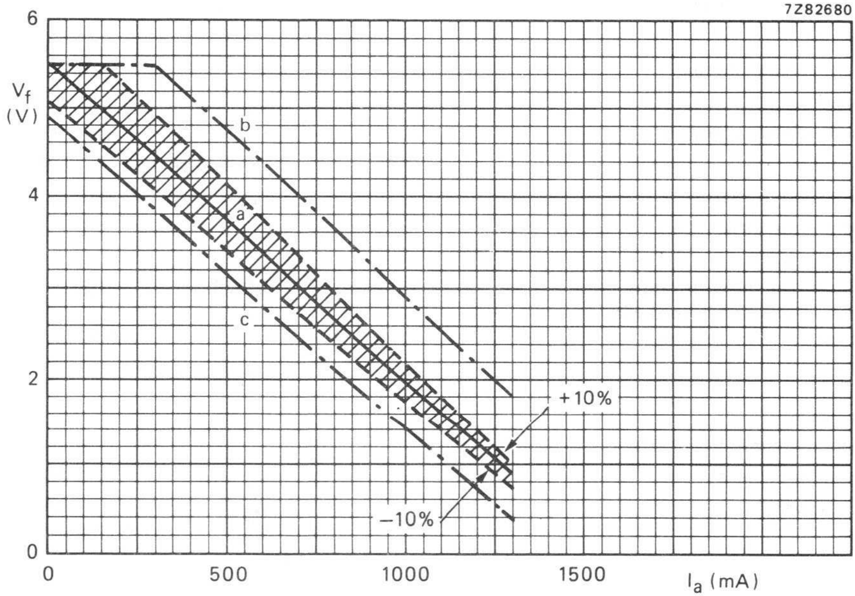


Fig. 1 Filament voltage reduction curve.

TYPICAL CHARACTERISTICS

Measured under matched load conditions (VSWR ≤ 1,05) and three-phase full-wave rectified supply. (See "Design and operating notes".)

Frequency, fixed within the band	f	2,430 to 2,470	GHz
Anode voltage, mean	V_a	7,2	kV
Anode current, mean	I_a	1,25	A
Output power	W_o	5,5	kW

LIMITING VALUES (Absolute maximum rating system)

Anode current, mean	I_a	max.	1,3	A
Anode current, peak	I_{ap}	max.	1,7	A
Anode input power	W_{ia}	max.	9,6	kW
Temperature at reference point,				
closed cooling circuit	T_a	max.	85	°C
open cooling circuit	T_a	max.	70	°C
Cooling water outlet temperature,				
closed cooling circuit	T_o	max.	75	°C
open cooling circuit	T_o	max.	65	°C
Voltage standing-wave ratio	VSWR	max.	2,5	

COOLING

Anode block	water			
Minimum required rate of flow and pressure drop	see Fig. 12			
R.F. filter box	air			
Required rate of flow at room temperature	q	min.	60	ℓ/min.
Pressure drop	see Fig. 13			
R.F. output system	air			
Required rate of flow at room temperature	q	min.	100	ℓ/min.

With only the filament voltage applied some water and air cooling is required.

To safeguard the magnetron against overheating if the water cooling fails, provision is made for mounting a thermoswitch. This switch should operate at a mounting disc temperature of 70 °C for an open water cooling circuit and 85 °C for a closed system.

The r.f. output system of the magnetron is provided with air inlet and outlet holes for the application of at least 100 ℓ/min of cooling air to the ceramic part inside the outer conductor. For an example of a cooling device around the output system see "Output coupling". All inlet holes must be used for entrance of air to obtain the required uniform cooling. The cooling air must be filtered to be free from dust, water and oil.

ACCESSORIES

Cap nut for output coupling	type 55312
Spring ring	type 55313
Soft copper washer, supplied with tube	type 55328
Cap nut	type TE1051b
Hose nipple	type TE1051c
Recommended isolator	2722 163 02004

Dimensions in mm

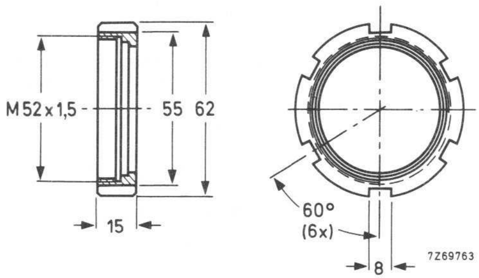


Fig. 2 Cap nut type 55312.

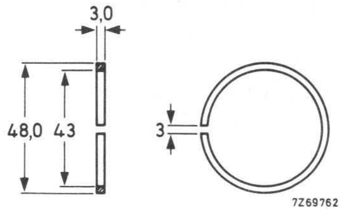


Fig. 3 Spring ring type 55313.

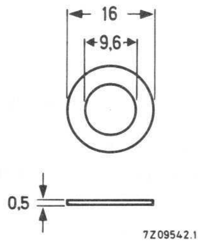


Fig. 4 Washer type 55328.

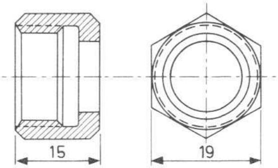


Fig. 5 Cap nut type TE1051b (thread 3/8 in gas).

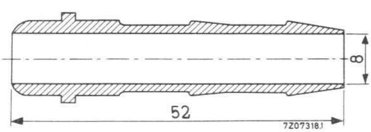


Fig. 6 9 mm hose nipple type TE1051c.

DESIGN AND OPERATING NOTES

General

Whenever it is considered necessary to operate the magnetron at conditions substantially different from those indicated under "Typical operation" the tube manufacturer should be consulted.

The equipment should be designed around the tube specifications given in this data and not around one particular tube since, due to normal production variations, the electrical and mechanical parameters will vary around the nominal values.

Anode supply

The magnetron may be operated from a three-phase full-wave rectified supply unit. This unit should be so designed that no limiting value for the mean and peak anode currents is exceeded, whatever the operating conditions. The use of a current regulating and limiting device is recommended.

Filament supply

The secondary of the filament transformer must be well insulated from the primary since in normal magnetron operation the anode is earthed and the cathode will be at high negative potential with respect to the anode.

The transformer should be so designed that the filament voltage and the peak filament starting current limits are not exceeded.

Load impedance

Optimum output power and life are obtained when the magnetron is loaded with an impedance giving a VSWR of approximately 1,5 in the phase of sink region. This phase condition is reached when the position of the voltage standing wave minimum is at a distance of about 0,42 λ from the reference plane for electrical measurements (see outline drawing) in the direction of the load.

When using the coaxial-to-R26 waveguide transition shown in Fig. 9 this condition is automatically reached, provided antenna type B is used. Antenna type A, together with the above transition, gives a VSWR of about 1 (matched). Detailed construction drawings available on request.

Tube cleanliness

The ceramic parts of the cathode and output structure of the tube must be kept clean during operation. The cooling air should be filtered to prevent deposits forming on the insulation.

STORAGE, HANDLING AND MOUNTING

Storage and handling

The original pack should be used for transporting and storing the tube. Shipment of the tube mounted in the equipment is only permitted if specifically authorized by the manufacturer.

When the tubes have to be unpacked, e.g. at an assembly line for measurement purposes, care should be taken that a minimum distance of 13 cm is maintained between the tubes. As the thoriated tungsten filament is sensitive to shocks and vibration, care should be taken when handling unpacked tubes that undue shocks and vibrations are avoided. High intensity magnetic fields associated with transformers and other magnetic equipment can demagnetize the magnets. Such fields should not be present when the tube is stored or serviced. The best protection of the tube is its original pack.

The user should be aware of the strong magnetic fields around the magnet. When handling and mounting the magnetron, he must use non-magnetic tools and be extremely careful not to have precision instruments nearby.

Mounting

When magnetic materials are present in two or more planes, their minimum distance from the magnet shall be 13 cm in all directions.

All tools (screwdrivers, wrenches, etc.) used close to or in contact with the magnetron must be made of non-magnetic material to avoid unwanted attraction and possible mechanical damage to ceramic parts as well as short-circuit of the magnetic flux.

To prevent mechanical stresses and torques, the output coupling should not be used as the only means of mounting; an additional flexible support of the tube is necessary.

OUTPUT COUPLING

The output system of the magnetron must be coupled via a 16/39 coaxial line (characteristic impedance 53,4 Ω (see Fig. 7) to the load system.

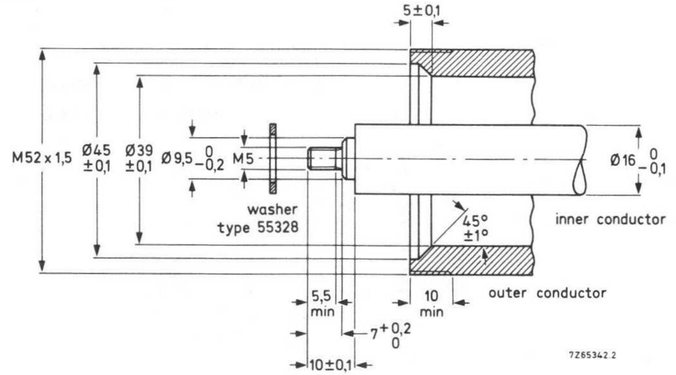


Fig. 7 Output coupling.

The inner conductor should be able to accept the tolerances of the magnetron output system (see outline drawing) and thermal expansion.

The soft copper washer type 55328 shall be used between the inner conductor and the magnetron output system. A firm contact between antenna and inner conductor of tube must be assured.

When screwing the inner conductor into the magnetron output system the maximum permissible torque is 1,5 Nm.

Example of a cooling device for output system (not supplied by the manufacturer)

Material: non-magnetic

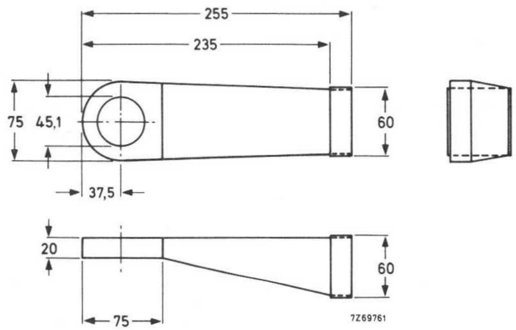


Fig. 8 Cooling device.

Pressure drop at 100 ℓ/min:

about 600 Pa with air outlet via outlet holes;

about 300 Pa if air can also escape towards the load through coaxial line.

An example of the coupling of the tube via a coaxial to an R26 waveguide transition is shown in Fig. 9.

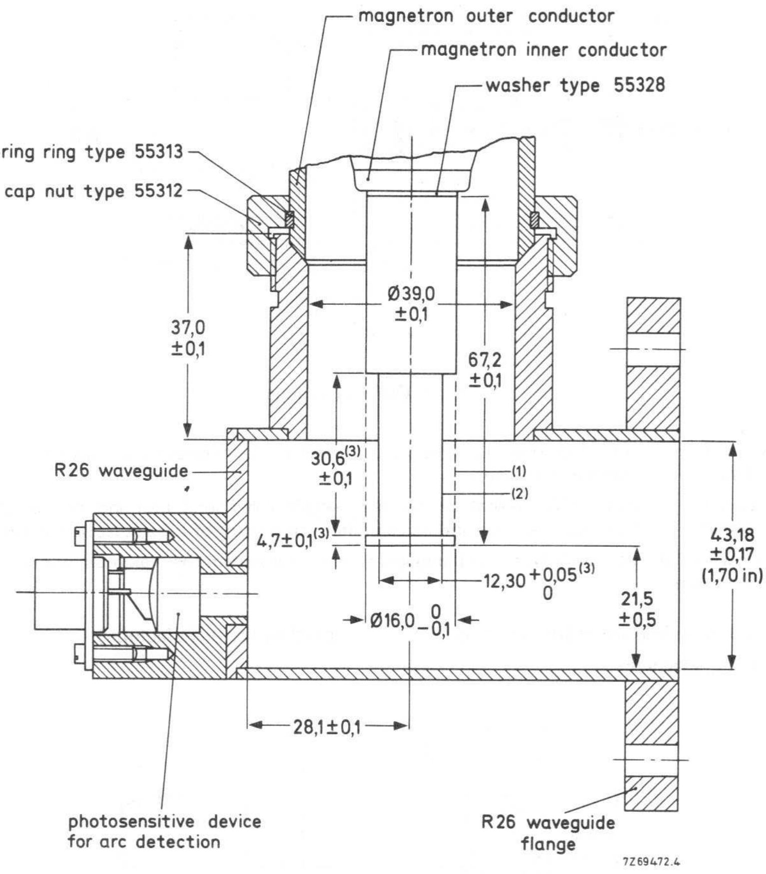


Fig. 9.

(1) Antenna type A (cylindrical) for matched load.

(2) Antenna type B, VSWR ≈ 1,5 in direction of sink for matched waveguide load.

(3) These dimensions for antenna type B only.

MECHANICAL DATA YJ1193

Dimensions in mm

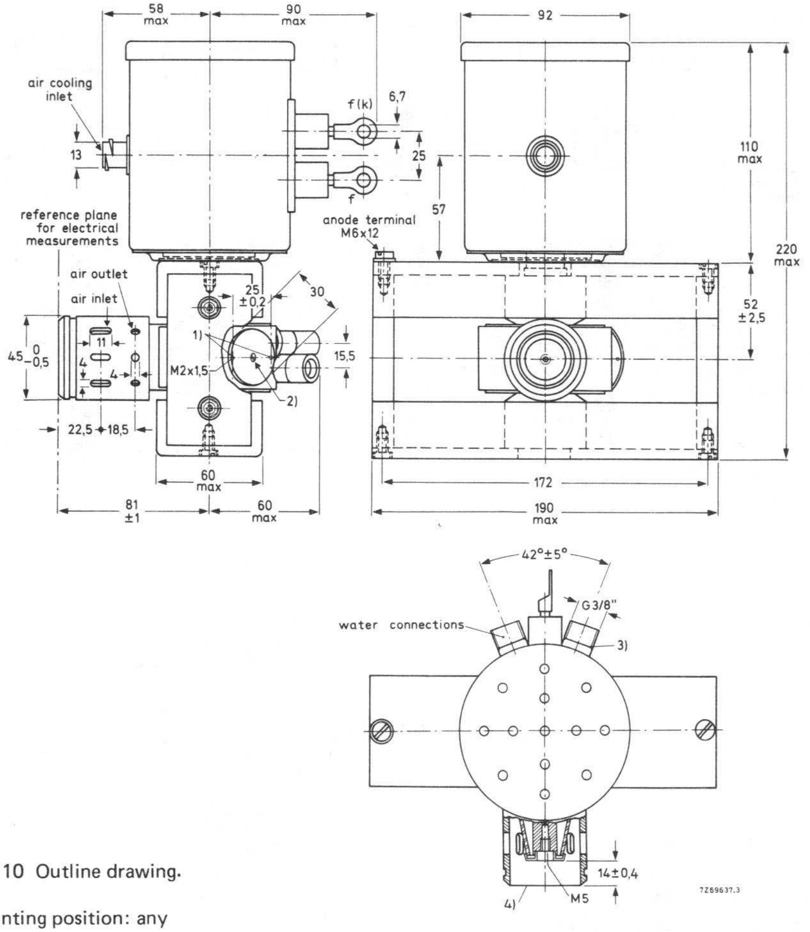


Fig. 10 Outline drawing.

Mounting position: any

Net mass: approx. 4,7 kg

(1) Two M2 screws for mounting a thermoswitch are supplied with the magnetron.

(2) Plate for mounting a thermoswitch; temperature reference point.

(3) To be connected to hose nipple type TE1051c (DIN 44415) for 9 mm hose with cap nut type TE1051b (CR3/8 in DIN 8542 Ms).

(4) Eccentricity of inner conductor with respect to outer conductor max. 0,4 mm.

MECHANICAL DATA YJ1195

Dimensions in mm

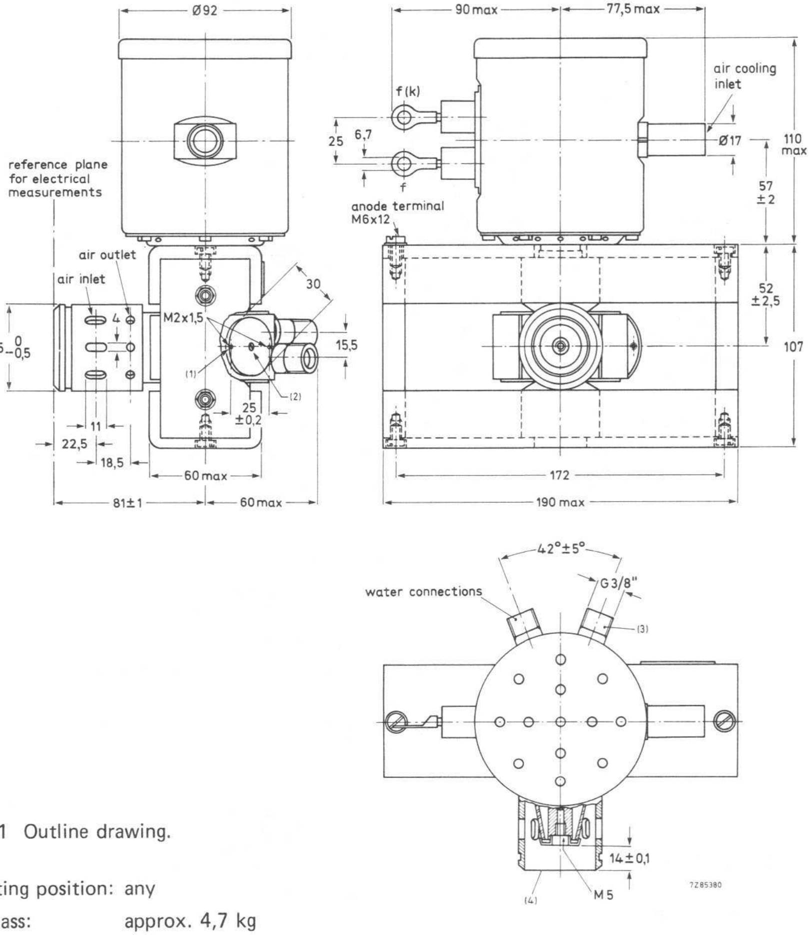


Fig. 11 Outline drawing.

Mounting position: any

Net mass: approx. 4,7 kg

(1) Two M2 screws for mounting a thermoswitch are supplied with the magnetron.

(2) Plate for mounting a thermoswitch; temperature reference point.

(3) To be connected to hose nipple type TE1051c (DIN44415) for 9 mm hose with cap nut type TE1051b (CR3/8 in DIN 8542 Ms).

(4) Eccentricity of inner conductor with respect to outer conductor max. 0,4 mm.

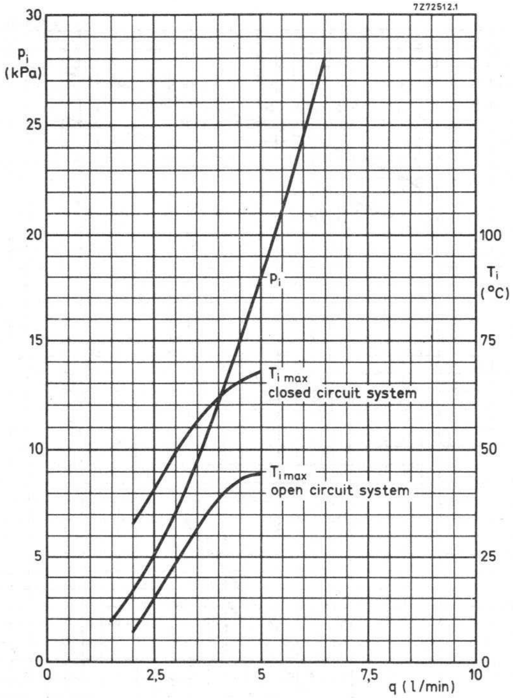


Fig. 12 Minimum required quantity of water q, and pressure drop p_i as a function of water inlet temperature T_i. Water supplied via hose nipple TE1051c.
If additional information is required please contact the manufacturer.

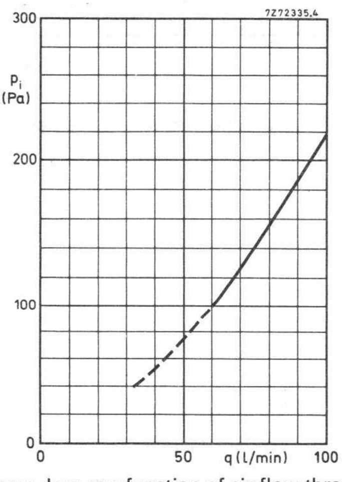


Fig. 13 Pressure drop as a function of air flow through filter box.

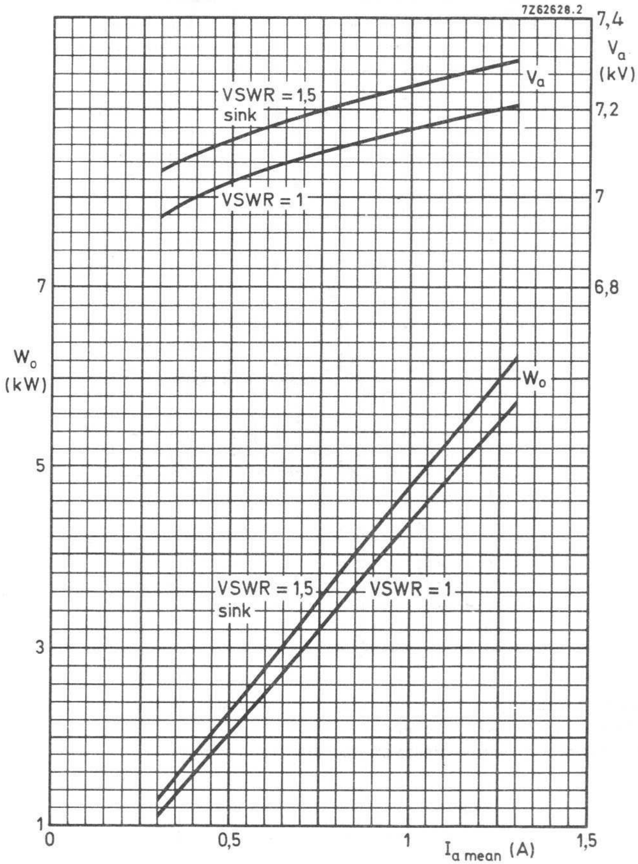


Fig. 14 Output power and anode voltage as a function of anode current.

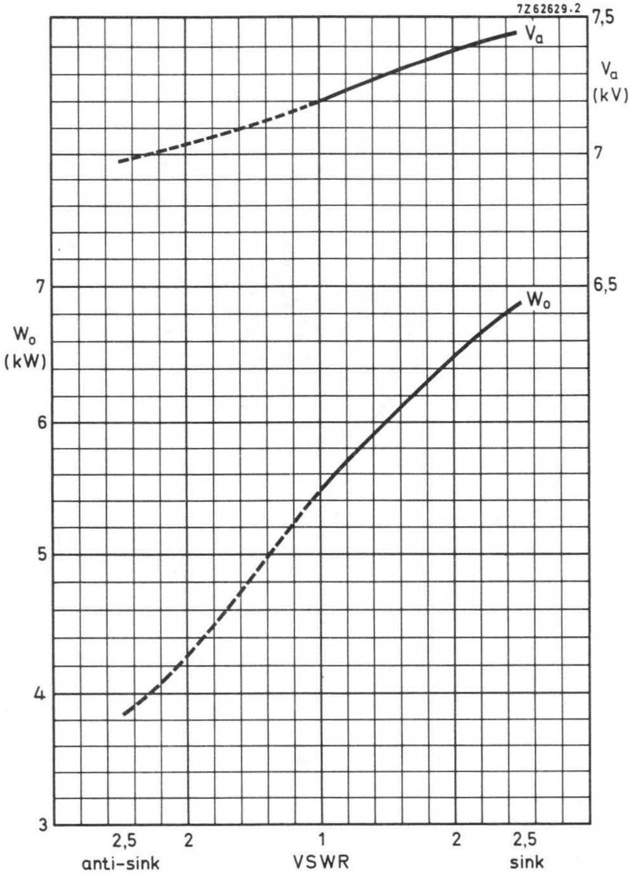


Fig. 15 Output power and anode voltage as a function of load impedance, V_f = 1,0 V; $I_{a\ mean}$ = 1,25 A.

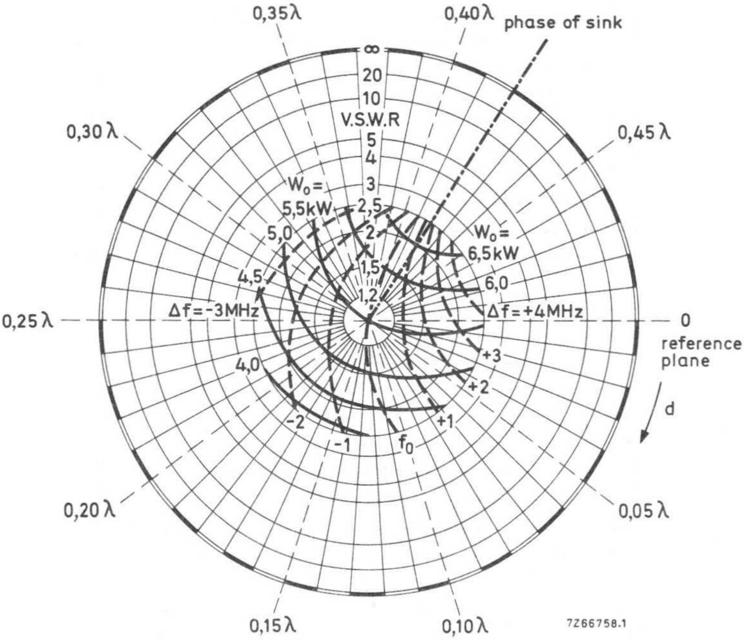


Fig. 16 Load diagram.

Anode supply	three-phase full-wave rectified
Filament voltage	1 V
Anode current, mean	1,25 A
Anode current, peak	1,5 A
Constant cooling	

d = distance of standing wave minimum from reference plane towards load

CONTINUOUS-WAVE MAGNETRONS

Packaged, water-cooled continuous-wave magnetron with integral r.f. filter intended for use with electromagnet in industrial microwave heating applications. The tube features a quick-heating cathode, high efficiency, and has a typical output power up to 6 kW. Types YJ1193E and YJ1195E are only mechanically different.

QUICK REFERENCE DATA

Frequency, fixed within the band	f	2,430 to 2,470 GHz
Output power	W_o	1 to 6 kW
Construction	packaged, metal ceramic	
Cathode	quick heating	
Cooling	water and air	
R.F. filter	integral	

TYPICAL OPERATION

Conditions, for 6 kW output power

Filament voltage, starting	V_f	5,5	V
Waiting time	t_w	10	s ←
Filament voltage, operating	V_f	1,0	V
Anode supply	three phase full-wave rectifier		
Anode current, mean	I_a	1,25	A
Anode current, peak	I_{ap}	1,5	A
Load impedance			
Voltage standing-wave ratio	VSWR	1,5	
Phase in direction of load with respect to reference plane	d	0,42	λ
Cooling	see relevant paragraph		

Performance

Filament current at V_f = 1,0 V	I_f	5	A
Anode voltage, mean	V_a	7,3	kV
Output power	W_o	6	kW
	W_o	> 5,4	kW
Efficiency	η	65	%

For other load impedance and anode current conditions see pages 11 and 12 and "Design and operating notes".

CATHODE: thoriated tungsten

HEATING: direct by a.c. (50 Hz or 60 Hz) or d.c.

With d.c. the filament terminal (f) must have positive polarity.

Filament voltage, starting and stand-by	V_f		5,5 V ± 10%
operating at $I_{a\,mean}$ = 1,25 A	V_f		1,0 V ± 10%
Filament current at V_f = 5,5 V; I_a = 0	I_f	<	44 A 48 A
at V_f = 1,0 V; $I_{a\,mean}$ = 1,25 A	I_f		5 A
Filament starting current, peak	I_{fp}	max.	150 A
Cold filament resistance	R_{fo}		17 mΩ
→ Waiting time (time before application of high voltage)	t_w	min.	10 s

Immediately after applying the anode voltage the filament voltage must be reduced to the operating value.

If it is intended to design the equipment for a variable output power, either continuously adjustable or stepped, the filament voltage must be reduced as a function of the output power (see graph below).

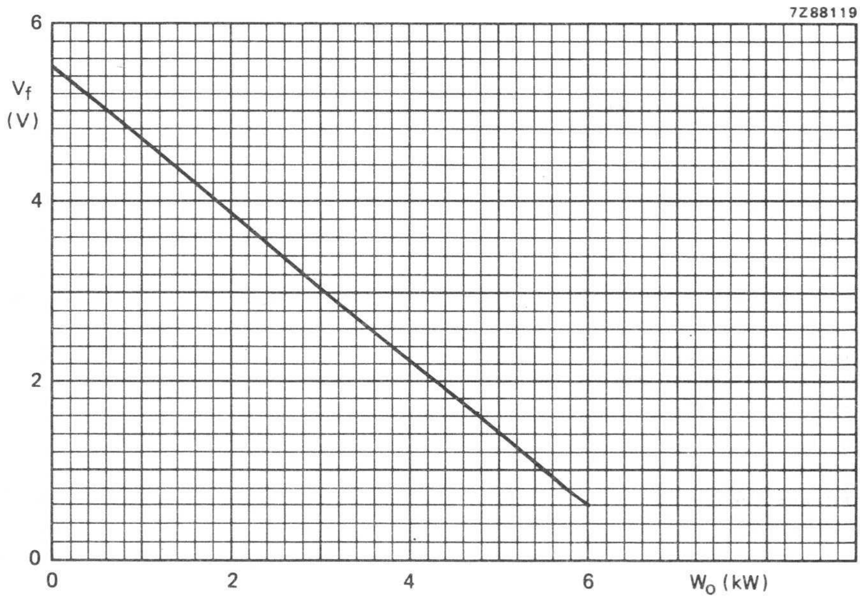


Fig. 1 Filament voltage reduction curve.

TYPICAL CHARACTERISTICS

Measured under matched load conditions (VSWR ⩽ 1,05) and three-phase full-wave rectified supply (See "Design and operating notes".)

Frequency, fixed within the band	f		2,430 to 2,470 GHz
Anode voltage, mean	V_a		7,2 kV
Anode current, mean	I_a		1,25 A
Output power	W_o		5,5 kW

LIMITING VALUES (Absolute maximum rating system)

Anode current, mean	I_a	max.	1,3 A
Anode current, peak	I_{ap}	max.	1,7 A
Anode input power	W_{ia}	max.	9,6 kW
Temperature at reference point,			
closed cooling circuit	T_a	max.	85 °C
open cooling circuit	T_a	max.	70 °C
Cooling water outlet temperature,			
closed cooling circuit	T_o	max.	75 °C
open cooling circuit	T_o	max.	65 °C
Voltage standing-wave ratio	VSWR	max.	2,5

COOLING

Anode block	water		
Minimum required rate of flow and pressure drop	see Fig. 12		
R.F. filter box	air		
Required rate of flow at room temperature	q	min.	60 ℓ/min.
Pressure drop	see Fig. 13		
R.F. output system	air		
Required rate of flow at room temperature	q	min.	100 ℓ/min.

With only the filament voltage applied some water and air cooling is required.

To safeguard the magnetron against overheating if the water cooling fails, provision is made for mounting a thermoswitch. This switch should operate at a mounting disc temperature of 70 °C for an open water cooling circuit and 85 °C for a closed system.

The r.f. output system of the magnetron is provided with air inlet and outlet holes for the application of at least 100 ℓ/min of cooling air to the ceramic part inside the outer conductor. For an example of a cooling device around the output system see "Output coupling". All inlet holes must be used for entrance of air to obtain the required uniform cooling. The cooling air must be filtered to be free from dust, water and oil.

ACCESSORIES

Cap nut for output coupling	type 55312
Spring ring	type 55313
Soft copper washer, supplied with tube	type 55328
Cap nut	type TE1051b
Hose nipple	type TE1051c
Recommended isolator	2722 163 02004

Dimensions in mm

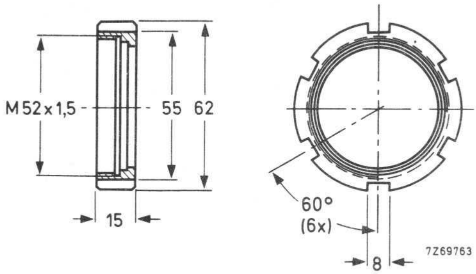


Fig. 2 Cap nut type 55312.

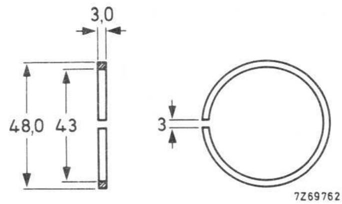


Fig. 3 Spring ring type 55313.

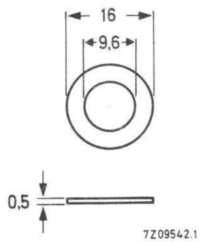


Fig. 4 Washer type 55328.

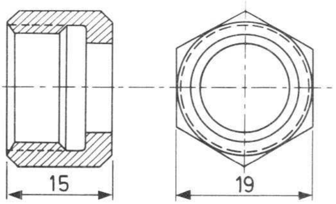


Fig. 5 Cap nut type TE 1051b (thread 3/8 in gas).

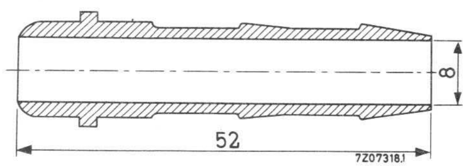


Fig. 6 9 mm hose nipple type TE 1051c.

DESIGN AND OPERATING NOTES

General

The equipment should be designed around the tube specifications given in this data and not around one particular tube since, due to normal production variations, the electrical and mechanical parameters will vary around the nominal values.

Electromagnetic system

Details concerning the design of the electromagnetic system are available on request.

Anode supply

The magnetron may be operated from a three-phase full-wave rectified supply unit. This unit should be so designed that no limiting value for the mean and peak anode currents is exceeded, whatever the operating conditions. The use of a current regulating and limiting device is recommended.

Filament supply

The secondary of the filament transformer must be well insulated from the primary since in normal magnetron operation the anode is earthed and the cathode will be at high negative potential with respect to the anode.

The transformer should be so designed that the filament voltage and the peak filament starting current limits are not exceeded.

Load impedance

Optimum output power and life are obtained when the magnetron is loaded with an impedance giving a VSWR of approximately 1,5 in the phase of sink region. This phase condition is reached when the position of the voltage standing wave minimum is at a distance of about 0,42 λ from the reference plane for electrical measurements (see outline drawing) in the direction of the load.

When using the coaxial-to-R26 waveguide transition shown in Fig. 9 this condition is automatically reached at matched load in the waveguide, provided antenna type B is used. Antenna type A, together with the above transition, gives a VSWR of about 1 (matched). Detailed construction drawings available on request.

Tube cleanness

The ceramic parts of the cathode and output structure of the tube must be kept clean during operation. The cooling air should be filtered to prevent deposits forming on the insulation.

STORAGE, HANDLING AND MOUNTING

Storage and handling

The original pack should be used for transporting and storing the tube. Shipment of the tube mounted in the equipment is only permitted if specifically authorized by the manufacturer.

As the thoriated tungsten filament is sensitive to shocks and vibration, care should be taken when handling unpacked tubes that undue shocks and vibrations are avoided. The best protection of the tube is its original pack.

Mounting

To prevent mechanical stresses and torques, the output coupling should not be used as the only means of mounting; an additional flexible support of the tube is necessary.

OUTPUT COUPLING

The output system of the magnetron must be coupled via a 16/39 coaxial line (characteristic impedance 53,4 Ω (see Fig. 7)) to the load system.

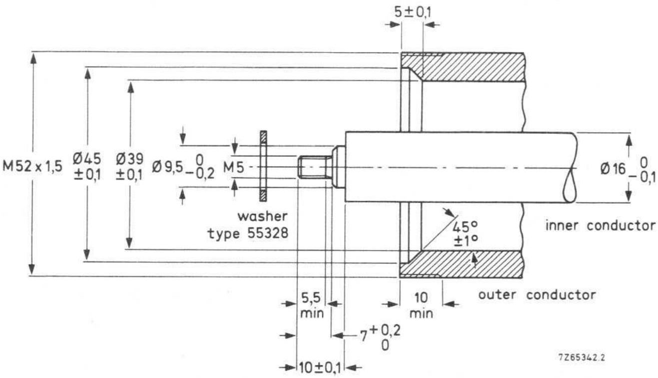


Fig. 7 Output coupling.

The inner conductor should be able to accept the tolerances of the magnetron output system (see outline drawing) and thermal expansion.

The soft copper washer type 55328 shall be used between the inner conductor and the magnetron output system. A firm contact between antenna and inner conductor of tube must be assured.

When screwing the inner conductor into the magnetron output system the maximum permissible torque is 1,5 Nm.

Example of a cooling device for output system (not supplied by the manufacturer)

Material: non-magnetic.

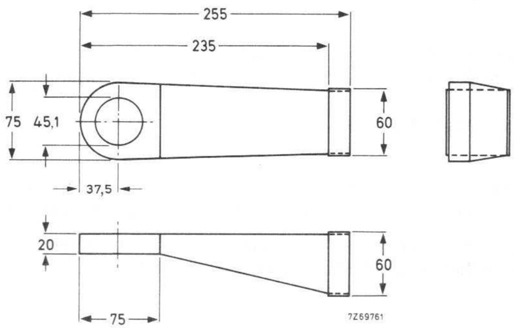


Fig. 8 Cooling device.

Pressure drop at 100 ℓ/min:
- about 600 Pa with air outlet via outlet holes;
- about 300 Pa if air can also escape towards the load through coaxial line.

An example of the coupling of the tube via a coaxial to an R26 waveguide transition is shown in Fig. 9.

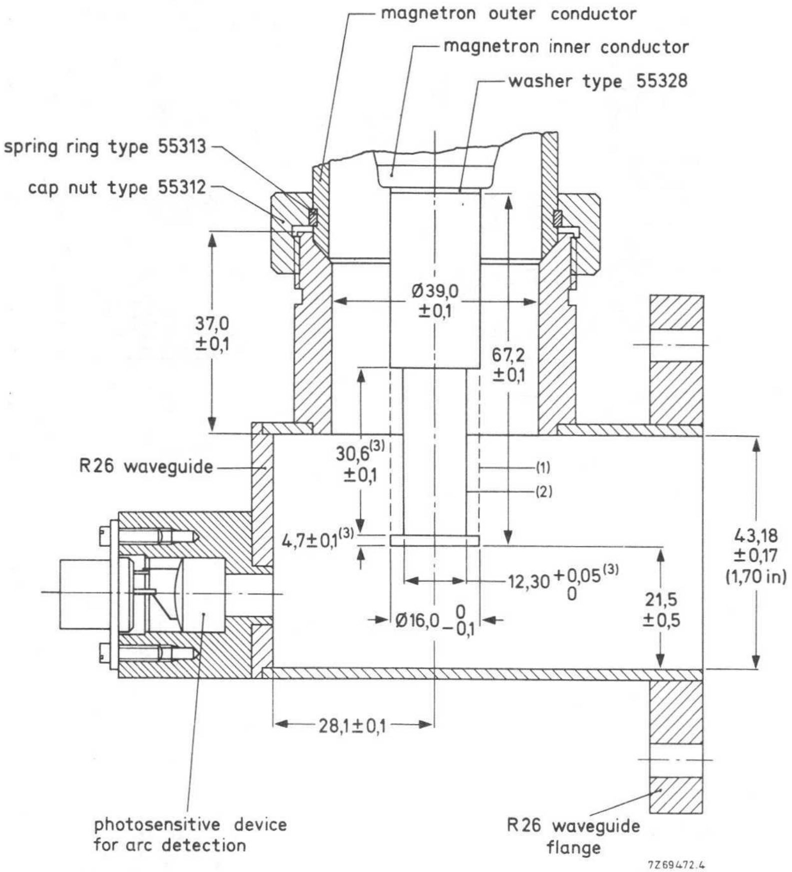


Fig. 9.

(1) Antenna type A (cylindrical) for matched load.

(2) Antenna type B, VSWR ≈ 1,5 in direction of sink for matched waveguide load.

(3) These dimensions for antenna type B only.

MECHANICAL DATA YJ1193E Dimensions in mm

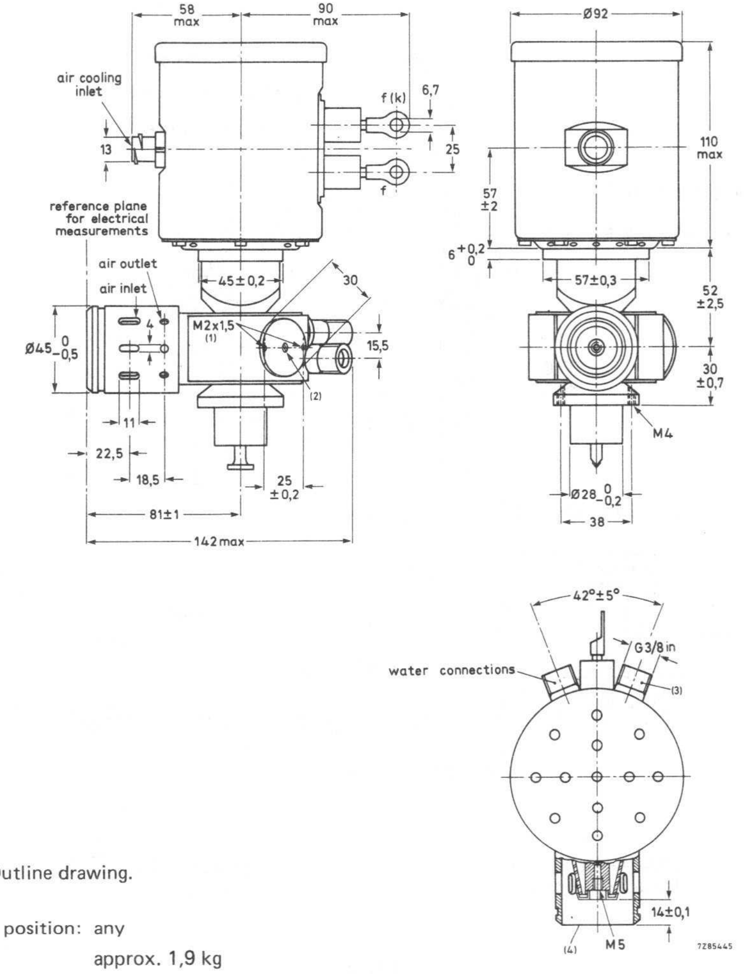


Fig. 10 Outline drawing.

Mounting position: any

Net mass: approx. 1,9 kg

(1) Two M2 screws for mounting a thermoswitch are supplied with the magnetron.

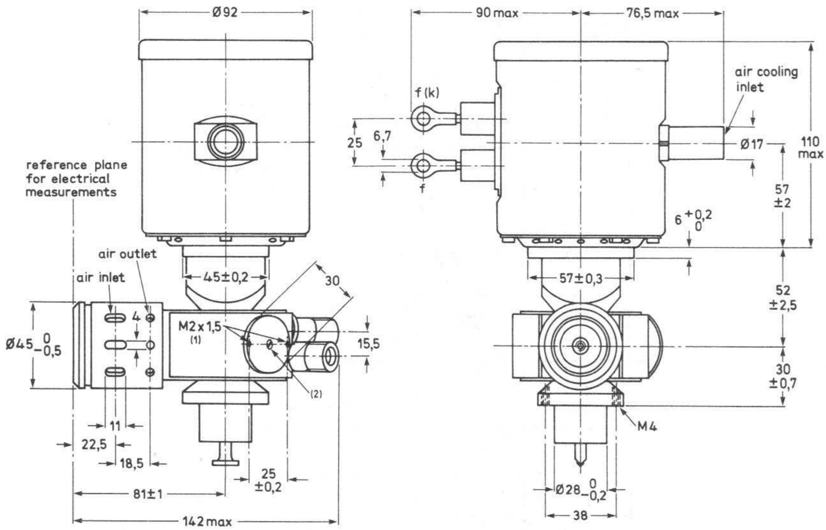
(2) Plate for mounting a thermoswitch; temperature reference point.

(3) To be connected to hose nipple type TE1051c (DIN44415) for 9 mm hose with cap nu type TE 1051b (CR3/8 in DIN8542 Ms).

(4) Eccentricity of inner conductor with respect to outer conductor max. 0,4 mm.

MECHANICAL DATA YJ1195E

Dimensions in mm



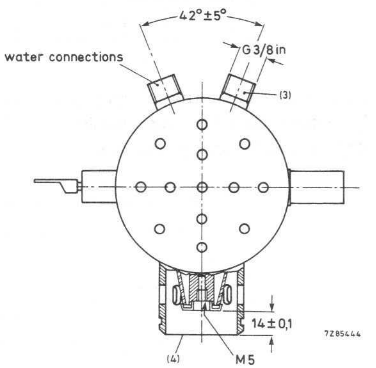


Fig. 11 Outline drawing.

Mounting position: any

Net mass: approx. 1,9 kg

(1) Two M2 screws for mounting a thermoswitch are supplied with the magnetron.

(2) Plate for mounting a thermoswitch; temperature reference point.

(3) To be connected to hose nipple type TE 1051c (DIN 44415) for 9 mm hose with cap nut type TE 1051b (CR3/8 in DIN 8542 Ms).

(4) Eccentricity of inner conductor with respect to outer conductor max. 0,4 mm.

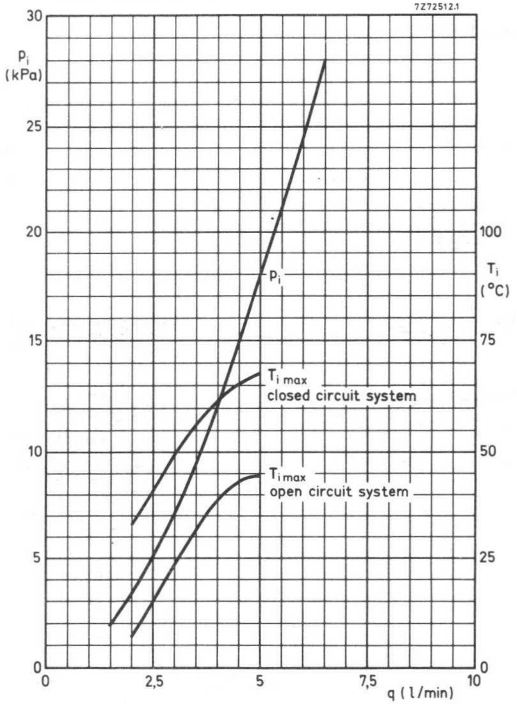


Fig. 12 Minimum required quantity of water q, and pressure drop p_i as a function of water inlet temperature T_i. Water supplied via hose nipple TE 1051c.
If additional information is required please contact the manufacturer.

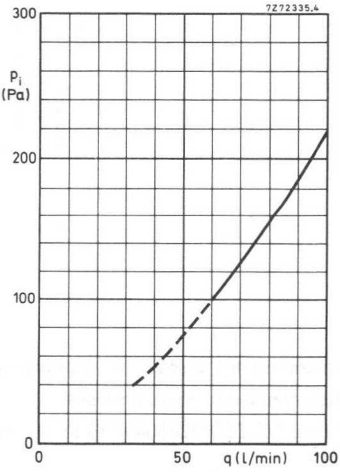


Fig. 13 Pressure drop as a function of air flow through filter box.

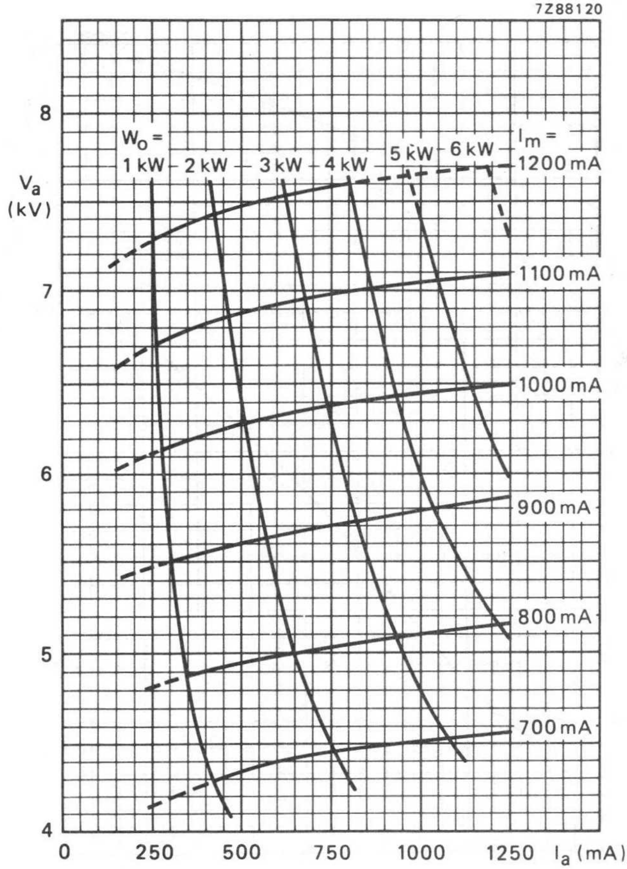


Fig. 14 Performance for VSWR = 1,5 in the phase of sink direction.
Output power and anode voltage as a function of anode current.
Anode voltage is a function of the electric current through the magnetic coils (I_m).
Measured with: Cooling constant; V_f adapted to the output power.

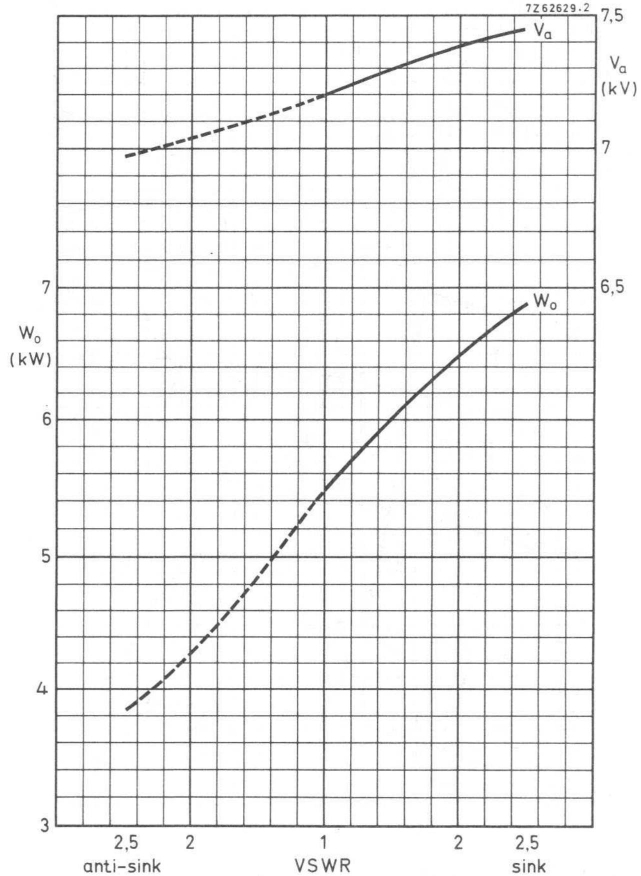


Fig. 15 Output power and anode voltage as a function of load impedance, V_f = 1,0 V; $I_{a\ mean}$ = 1,25 A.

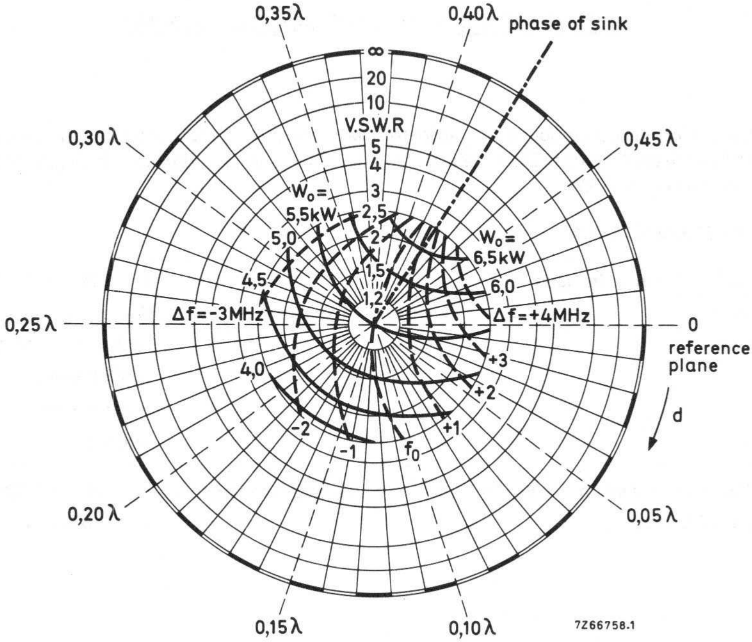


Fig. 16 Load diagram.

Anode supply	three-phase full-wave rectified
Filament voltage	1 V
Anode current, mean	1,25 A
Anode current, peak	1,5 A

Constant cooling

d = distance of standing wave minimum from reference plane towards load.

CONTINUOUS-WAVE MAGNETRON

Packaged, water-cooled continuous-wave magnetron with integral r.f. filter, intended for industrial microwave heating applications. The tube features a quick-heating cathode, high efficiency, and has a typical output power of 6 kW.

QUICK REFERENCE DATA

Frequency, fixed within the band	f	2,350 to 2,400 GHz
Output power	W_o	6 kW
Construction		packaged, metal-ceramic
Cathode		quick-heating
Cooling		water and air
R.F. filter		integral

The **YJ1194** is equivalent to the YJ1193, except for the frequency band, being 2,350 to 2,400 GHz.

Recommended isolator 2722 163 02024

CONTINUOUS-WAVE MAGNETRON

The YJ1280 is an integral magnet c.w. magnetron designed for use in microwave heating applications. With an LC stabilized power supply, it can produce up to 1,5 kW under typical operating conditions. The magnetron is air-cooled and is of a metal-ceramic construction.

QUICK REFERENCE DATA

Frequency, fixed within the band	f	2,425 to 2,475 GHz
Output power	W_o	1,5 kW
Construction		metal-ceramic, packaged

TYPICAL OPERATION

Anode supply		L-C stabilized		
Filament voltage, stand-by		V_f	5,0 V	
Filament voltage, operating		V_f	3,5 V	
Anode current, mean*		I_a	380 mA	
Anode current, peak		I_{ap}	650 mA	
Load imedance	VSWR in direction of sink		2,5	matched
Anode voltage*	V_a	5,7		5,7 kV
Output power	W_o	1,5		1,3 kW
				min. 1,15 kW

For other load impedance and anode current conditions see Figs 3 and 10.

CATHODE: Thoriated tungsten

HEATING: direct by a.c. (50 Hz or 60 Hz) or d.c.**

Filament voltage, starting and stand-by	V_f		5,0 V ± 10%
Filament voltage, operating at I_a mean = 380 mA	V_f		3,5 V ± 10%
Filament current at V_f = 5,0 V and V_a = 0 V	I_f	typ.	28 A
		max.	32 A
Filament peak starting current	I_{fp}	max.	70 A
Cold filament resistance	R_{fo}	approx.	0,020 Ω
Waiting time (time before application of high voltage)	t_w	min.	10 s

* Measured with a moving-coil instrument.
** With d.c. heating the filament connector must have positive polarity.

TYPICAL CHARACTERISTICS

				notes
Frequency, fixed within the band	f	2,425 to 2,475	GHz	1
Anode voltage at I_a mean = 380 mA	V_a	$5{,}8\ ^{+0}_{-0{,}4}$	kV	1,2,3
Output power into matched load	W_o	1,3	kW	

LIMITING VALUES (Absolute maximum rating system)

Anode current, mean	I_a	max.	450	mA	2
	I_a	min.	100	mA	
Anode current, peak at I_a mean = 380 mA	I_{ap}	max.	800	mA	2
Anode voltage, positive and negative	V_a	max.	10	kV	4
Anode input power	W_{ia}	max.	2,7	kW	
Voltage standing-wave ratio (measured with probe 55336)					
continuous	VSWR	max.	4		
during max. 0,02 s and max. 20% of the time	VSWR	max.	10		5
Anode temperature at reference point indicated on outline drawing	T_a	max.	180	°C	
Temperature at any other point on the tube	T	max.	200	°C	

COOLING

Anode block		forced air	
Filament terminal structure		forced air	
Inlet air, typical			
Temperature	T_i	35	°C
Quantity	q	1,2	m^3/min
Pressure drop	p_i	100	Pa

It is recommended that a thermoswitch be mounted at the place indicated in the outline drawing to protect the magnetron against overheating.

On stand-by, with V_f = 5,0 V, some air-cooling is necessary to keep the temperature of the filament terminal, the filament/cathode terminal and the anode block below the maximum limit.

Notes
1. Measured under matched load conditions (VSWR $\leqslant$ 1,05).
2. Measured with a moving-coil instrument.
3. Measured on a filtered anode voltage supply ($I_{ap} \leqslant$ 480 mA).
4. It is recommended that a suitable spark gap be connected between the filament connectors and the anode (earth) to prevent the maximum anode voltage being exceeded.
5. This means: Any period of time up to 0,02 s during which the VSWR is between 4 and 10 must be followed by a period four times as long during which the VSWR is $<$ 4. When operated under these conditions the magnetron should not be permitted to mode.

DESIGN AND OPERATING NOTES

General

Whenever it is considered necessary to operate the magnetron at conditions substantially different from those indicated under "Typical operation' the tube manufacturer should be consulted.

The equipment should be designed around the tube specifications given in this data and not around one particular tube since, due to normal production variations, the design parameters (V_a, R_{fo}, f, W_o etc.) will vary around the nominal values.

Anode supply

It is recommended that the magnetron be operated from an LC stabilized anode supply unit. The unit should be designed so that the limiting values for mean and peak anode current are not exceeded.

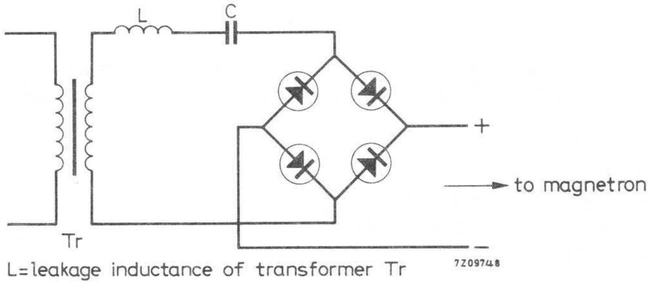


Fig. 1 Basic series resonant circuit of an LC power supply.

Filament supply

The secondary of the filament transformer must be well insulated from the primary since in normal magnetron operation the cathode will be at high negative potential and the anode will be earthed.

The transformer should be designed so that the filament voltage and surge current limits are not exceeded.

Filament/cathode connectors

The magnetron has a high filament current and losses in filament voltage caused by bad connections will result in poor operation. Therefore, it is important to ensure that the filament and filament/cathode connectors make good electrical and thermal contact with their respective terminals.

The connectors, types 55323 and 55324, shown in the drawings have been designed to give the required contact and are recommended for use with this magnetron. A coating of a high temperature resistant silicone grease is recommended to prevent oxidation.

The electrical conductors of the cathode and filament connectors should be of flexible construction in order to eliminate undue stress on the terminals.

Load impedance, measured with measuring probe

The probe 55336 simulates the r.f. output system of the magnetron; it may be coupled to a waveguide, a coaxial line, or directly into a cavity in place of the magnetron; in all cases the type 55341 gasket should be used. The termination of the probe matches a standard male N-type connector.

The use of this measuring probe enables the designer of microwave heating equipment to determine the value of the load impedance (VSWR and phase of reflection), using standard cold measuring techniques, and to arrive at the correct coupling for the magnetron.

Antenna

When an antenna is used, the part of the antenna screwed into the magnetron should be according to Fig. 2.

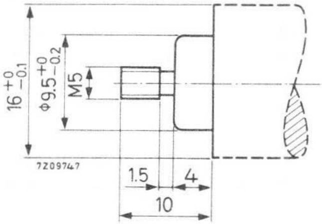


Fig. 2.

A soft copper washer of 0,5 mm thickness type no. 55328 is required between the antenna and the tube to ensure reliable r.f. contact. The maximum torque applied when screwing the antenna into the tube is 150 Ncm.

Stand-by operation

Without anode voltage, the filament voltage during any stand-by period should be kept at $V_f = 5{,}0$ V. Some forced-air cooling will be required to prevent overheating. The full anode voltage may be applied without furhter waiting time.

Shielding

Where required, r.f. radiation from the filament terminals may be reduced by external filtering and/or shielding. Detailed information may be obtained from the manufacturer.

Tube cleanliness

The ceramic parts of the input and output structures of the tube must be kept clean during operation. A protective cover of suitable material should be placed over the tube output if the tube is inserted directly into a cavity. The cooling air should be filtered and ducted to prevent deposits forming on the insulation during operation.

Output coupling

The tube may be coupled by suitable means to a waveguide, a coaxial line, or directly into a cavity.

HANDLING, STORAGE AND MOUNTING

Handling and storage

The original pack should be used for transporting and storing the tube. Shipment of the tube mounted in the equipment is not permitted unless specifically authorized by the tube manufacturer.

When the tubes have to be unpacked, e.g. at an assembly line or for measurement purposes, care should be taken that a minimum distance of 15 cm is maintained between magnets. As the thoriated tungsten filament is sensitive to shocks and vibration, care should be taken when handling and storing unpacked tubes that such shocks and vibration are avoided. High intensity magnetic fields associated with transformers and other magnetic equipment can demagnetize the magnets. Such fields should not be present when the tube is stored, handled or serviced. The best protection of the tube is its original pack.
The user should be aware of the strong magnetic fields around the magnet. When handling and mounting the magnetron, he must use non-magnetic tools and be extremely careful not to have watches and other precision instruments nearby.

Mounting

When magnetic materials are present in two or more planes, the minimum distance from the magnet shall be 13 cm in all directions.

In order to assure a good r.f. contact between the output of the tube and the circuit in which it is connected, the use of the gasket 55341 is essential.

The output coupling of the tube should not be used as the only means of mounting the magnetron. The magnetron should be mounted and secured by the two mounting holes indicated on the outline drawing. When mounting the magnetron, all tools (screwdrivers. wrenches etc.) used close to or in contact with the magnetron must be made of non-magnetic material to avoid unwanted attraction and possible mechanical damage to ceramic parts as well as short-circuiting of the magnetic flux.

The power supply lead to the anode shall be connected to one of the mounting holes (see "a" on the outline drawing).

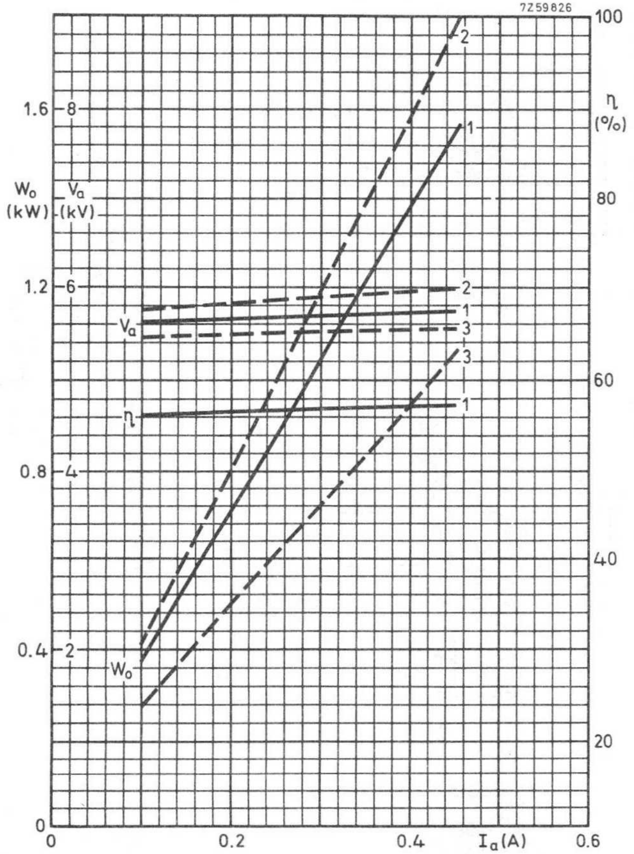


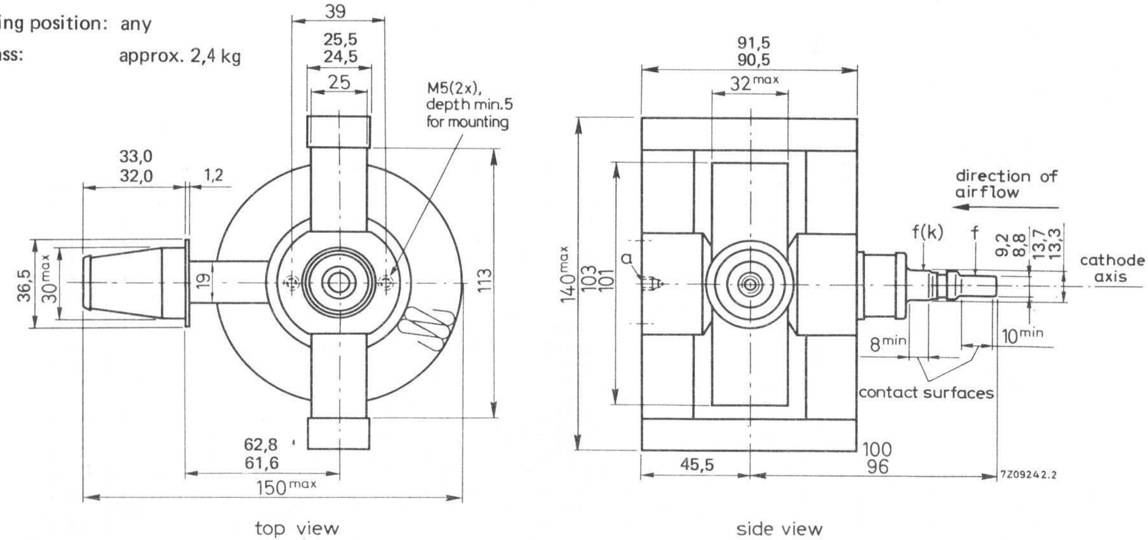
Fig. 3.
1) with VSWR ⩽ 1,05
2) with VSWR = 3 in sink region
3) with VSWR = 3 in anti sink region

MECHANICAL DATA (continued)

Dimensions in mm

Mounting position: any

Net mass: approx. 2,4 kg



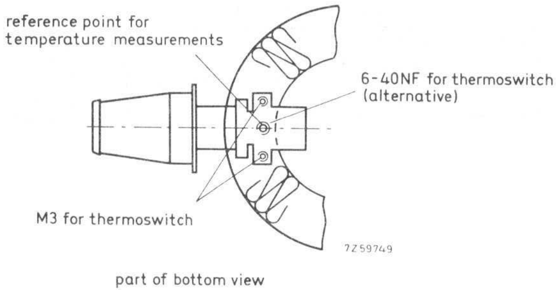


Fig. 4 Outline drawing.

ACCESSORIES

Dimensions in mm

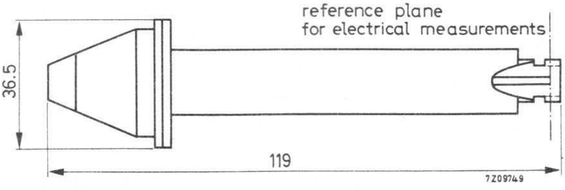


Fig. 5 Measuring probe 55336, for cold measurements only.

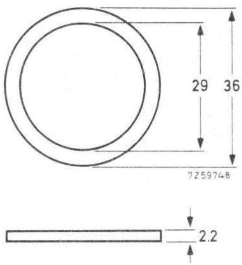


Fig. 6 R.F. gasket 55341, material: monel mesh.

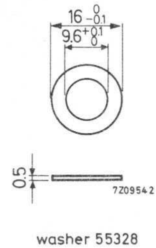


Fig. 7 Washer 55328, material: soft copper.

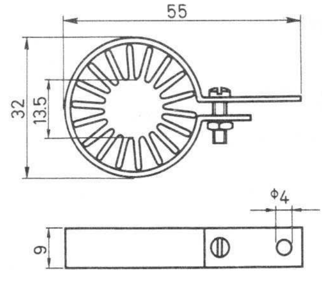


Fig. 8 Filament/cathode connector 55324.

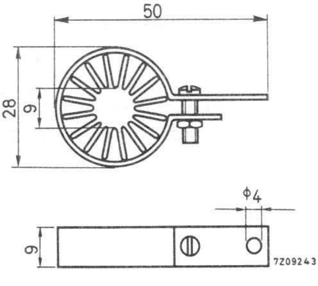


Fig. 9 Filament connector 55323.

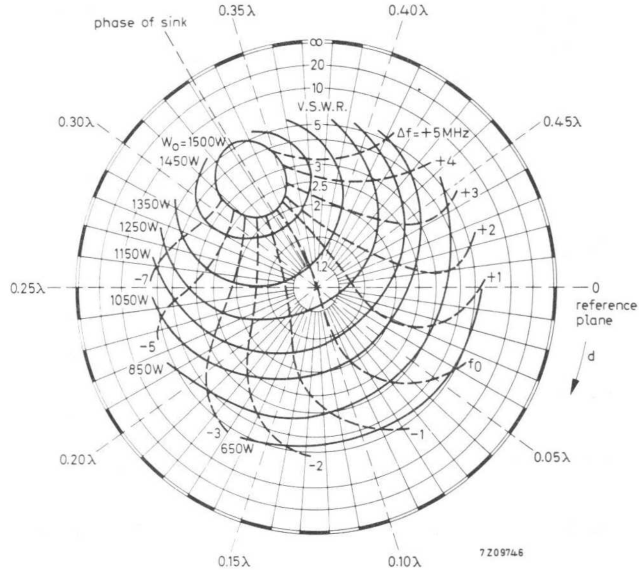


Fig. 10 Load diagram.

Mean anode current		380 mA
Frequency	f_o	2,450 GHz

Constant air cooling

d= distance of voltage standing wave minimum from the reference plane for electrical measurements (measuring probe 55336) towards load

CONTINUOUS-WAVE MAGNETRON

Integral-magnet, forced-air cooled continuous-wave magnetron with integral r.f. filter intended for microwave heating applications. The tube features a quick-heating cathode, high efficiency, and has a typical output power of 2,5 kW.

QUICK REFERENCE DATA

Frequency, fixed within the band	f	2,425 to 2,475	GHz
Output power	W_o	2,5	kW
Construction	packaged, metal-ceramic		
Cathode	quick heating		
R.F. filter	integral		

TYPICAL OPERATION with the tube coupled to an R26 waveguide according to Fig. 3

Conditions

Filament voltage, starting	V_f		5,0	V
Waiting time	t_w		10	s ←
Filament voltage, operating	V_f		3,5	V
Anode supply		L-C stabilized		
Anode current, mean	I_a		680	mA
Anode current, peak	I_{ap}		1100	mA
Load impedance, measured with probe 55345				
Voltage standing-wave ratio	VSWR		2,5	
Phase, in direction of load, with respect to reference plane	d		0,14	λ
Cooling; rate of flow	q	min.	2,5	m^3/min*

Performance

Filament current at V_f = 3,5 V	I_f		27	A
Anode voltage, peak	V_{ap}		5,7	kV
Output power	W_o		2,5	kW
	W_o	min.	2,25	kW
Efficiency	η		69	%

CATHODE: Thoriated tungsten

* Based on a cooling air inlet temperature T_i = max. 50 °C.

HEATING: direct by a.c. (50 Hz or 60 Hz) or d.c.

With d.c. the terminal f(k) must have positive polarity.

Filament voltage, starting and stand-by	V_f		5,0 V ± 10%
operating at $I_{a\ mean}$ = 680 mA	V_f		3,5 V ± 10%
Filament current at V_f = 5,0 V, I_a = 0	I_f	<	41 A 45 A
at V_f = 3,5 V, I_a = 680 mA	I_f		27 A
Filament current, peak starting	I_{fp}	max.	150 A
Cold filament resistance	R_{fo}		13 mΩ
→ Waiting time (time before application of high voltage)	t_w	min.	10 s

TYPICAL CHARACTERISTICS

Measured under matched load conditions (VSWR ⩽ 1,05) and L-C stabilized power supply. (See "Design and operating notes".)

Frequency, fixed within the band	f	2,425 to 2,475 GHz
Anode voltage, peak	V_{ap}	5,5 kV
Anode current, mean	I_a	700 mA
Output power	W_o	2,2 kW

LIMITING VALUES (Absolute maximum rating system)

Anode current, mean	I_a	max.	750 mA
Anode current, peak	I_{ap}	max.	1250 mA
Anode voltage*	V_a	max.	10 kV
Temperature of mounting bracket at central contact point of thermoswitch (see also under "Cooling")	T	max.	140 °C
Voltage standing-wave ratio, measured with probe 55345	VSWR	max.	5
during max. 0,02 s and max. 20% of the time	VSWR	max.	10

Any period of time up to 0,02 s during which the VSWR is between 5 and 10 must be followed by a period four times as long during which the VSWR is ⩽ 5. When operating under these conditions the magnetron should not be permitted to mode.

COOLING

Anode block and filament structure — forced air

For pressure drop as a function of rate of flow see Fig. 8.
The cooling air must be so ducted that it is uniformly distributed.
Direction of air flow: see outline drawing.

With only the filament voltage applied some air cooling is required to keep the temperature below the limiting value.

The magnetron is provided with a normally closed thermoswitch to protect the tube against overheating. The thermoswitch is rated 250 V (a.c.), 10 A. Switching-off temperature 135 ± 5 °C.

* It is recommended that a suitable spark gap be connected between the filament/cathode terminal and the anode (earth) to prevent the max. anode voltage being exceeded.

DESIGN AND OPERATING NOTES

General

Whenever it is considered necessary to operate the magnetron at conditions substantially different from those indicated under "Typical operation" the tube manufacturer should be consulted.

The equipment should be designed around the tube specifications given in this data and not around one particular tube since, due to normal production variations, the design parameters (V_a, R_{fo}, f, W_o etc.) will vary around the nominal values.

ANODE SUPPLY

The magnetron may be operated from an L-C stabilized power supply. Detailed information on power supply design available on request.

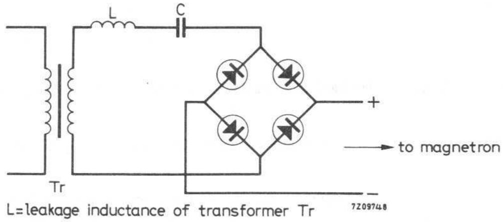


Fig. 1 Basic series resonant circuit of an L-C power supply.

Filament supply

The secondary of the filament transformer must be well insulated from the primary since during normal magnetron operation the anode is earthed and the cathode will be at a high negative potential with respect to the anode.

The transformer should be so designed that the filament voltage and peak filament starting current limits are not exceeded.

Filament and filament/cathode connections

The magnetron has a high filament current and losses in filament voltage caused by bad connections, will result in poor operation. Therefore, it is important to ensure that the leads make good electrical and thermal contact with the tube terminals.

Load impedance, measured with measuring probe

The probe 55345 simulates the r.f. output system of the magnetron; it may be coupled to an R26 waveguide to replace the magnetron; in all cases the type 55344 gasket should be used. The termination of the probe matches a standard N-type connector.

This measuring probe enables the designer of the microwave heating equipment to determine the value of the load impedance (VSWR and phase of reflection), using standard cold measuring techniques, and to arrive at the correct coupling for the magnetron.

Tube cleanness

The ceramic parts of the input and output structure of the tube must be kept clean during installation and operation. The cooling air should be filtered to prevent deposits forming on the insulation.

STORAGE, HANDLING AND MOUNTING

Storage and handling

The original pack should be used for transporting the tube. Shipment of the tube mounted in the equipment is permitted if specifically authorized by the manufacturer.

When the tubes have to be unpacked, e.g. at an assembly line or for measurement purposes, care should be taken that a minimum distance of 13 cm is maintained between tubes. As the thoriated tungsten filament is sensitive to shocks and vibration, care should be taken when handling and storing unpacked tubes that such shocks and vibration are avoided. High intensity magnetic fields associated with transformers and other magnetic equipment can demagnetize the magnets. They should not be present when the tube is stored or serviced. The best protection of the tube is its original pack.

The user should be aware of the strong magnetic fields around the tube. When handling and mounting the magnetron, he must use non-magnetic tools and be extremely careful not to have precision instruments nearby.

Mounting

The magnetron should be mounted with two M4 bolts fitting the nuts on the mounting bracket (see outline drawing).

The output coupling should not be used as the only means of mounting and be kept free from undue stress.

The minimum distance between the magnetron and magnetized materials shall be 13 cm. The minimum distance between the magnetron and other ferromagnetic materials shall be 3 cm.

The gasket 55344 is essential to ensure good r.f. contact between the output of the magnetron and the waveguide to which it is connected.

All tools (screwdrivers, wrenches, etc.) used close to or in contact with the magnetron must be of non-magnetic material to avoid unwanted attraction and possible mechanical damage to ceramic parts as well as short-circuit of the magnetic flux.

MECHANICAL DATA

Mounting position: any

Net mass: approx. 2 kg

ACCESSORIES

Thermoswitch, mounted on tube	type 55347
R.F. gasket, supplied with tube	type 55344
Measuring probe (for measurements only, see Fig. 2)	type 55345

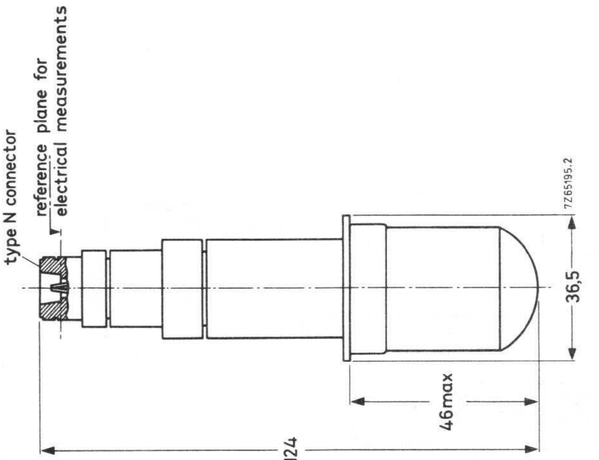


Fig. 2 Measuring probe 55345.

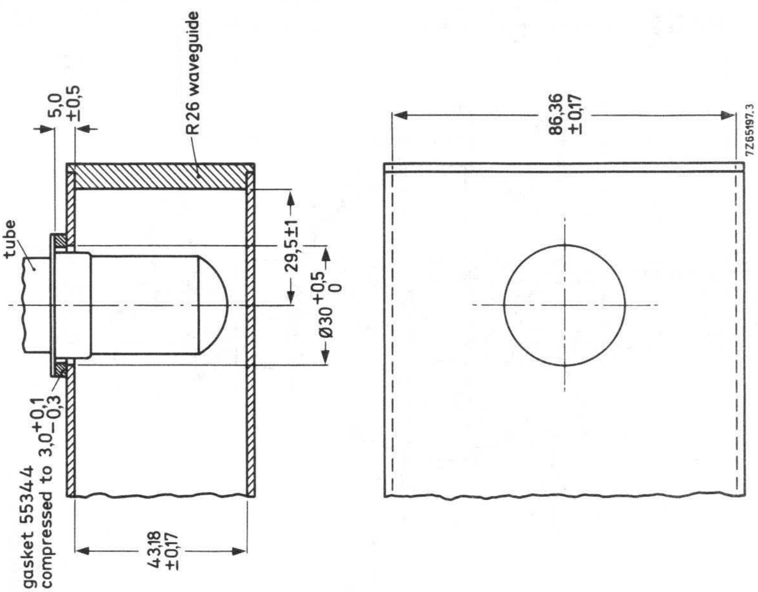


Fig. 3 Launching section.

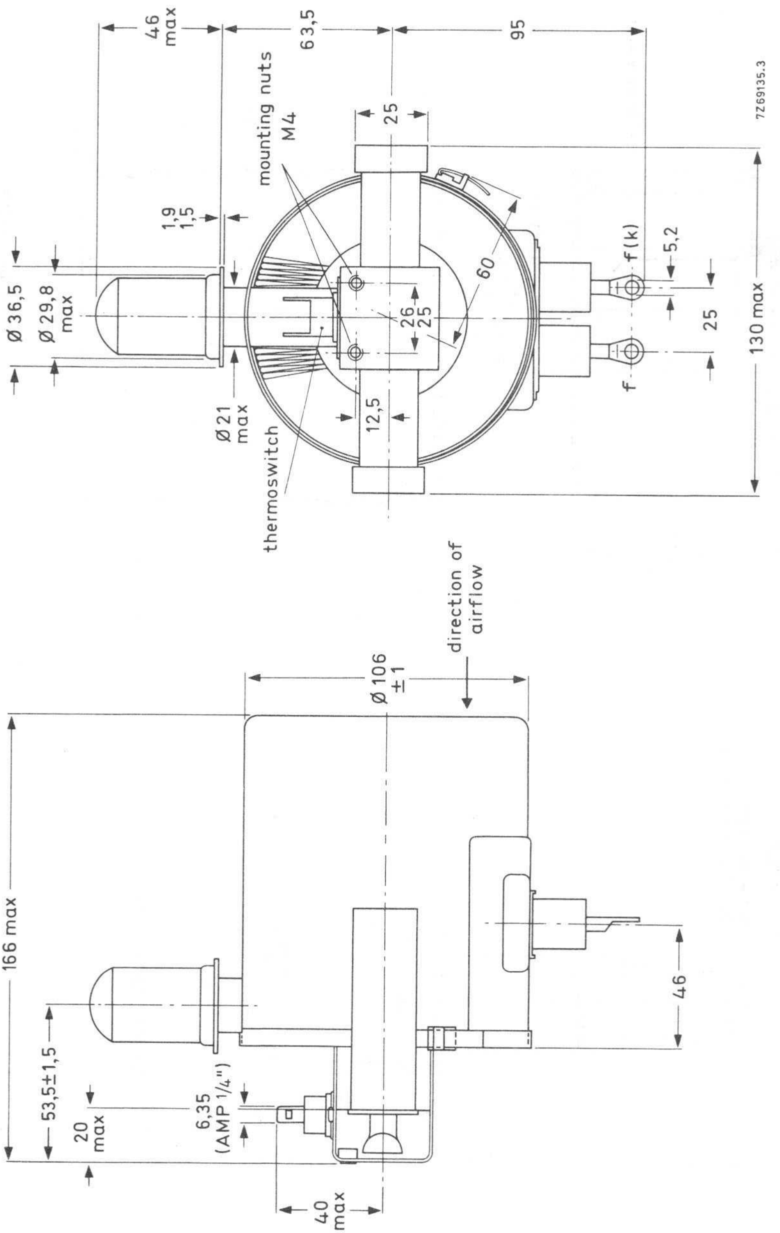


Fig. 4 Outline drawing.

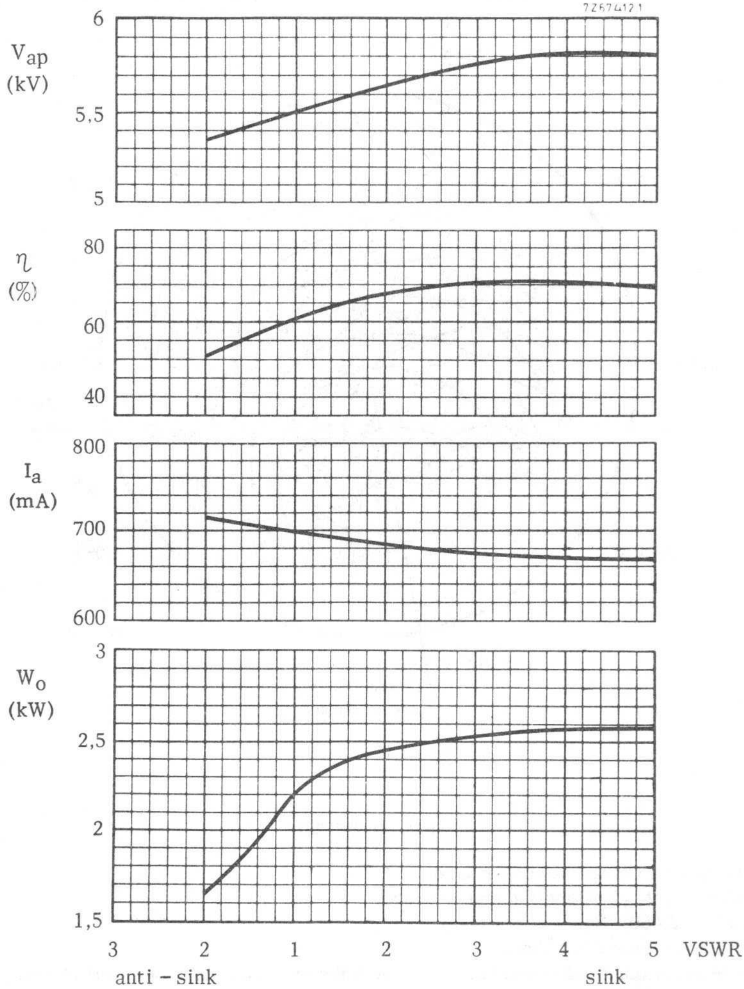

7Z67412.1
V_{ap} (kV)
6
5,5
5
η (%)
80
60
40
I_a (mA)
800
700
600
W_o (kW)
3
2,5
2
1,5
3
2
1
2
3
4
5
VSWR
anti – sink
sink

Fig. 5.

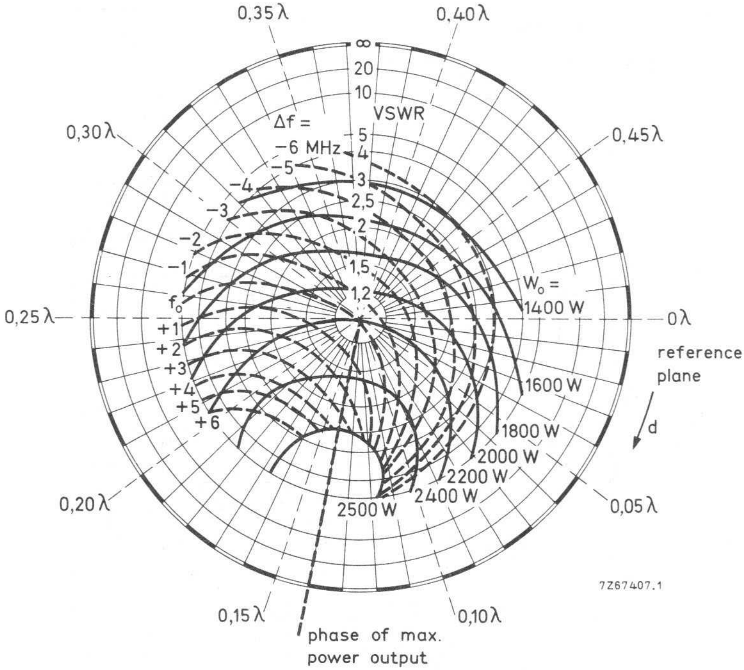


Fig. 6 Load diagram.

Measured with an L-C stabilized power supply.
Mean anode current I_a = 700 mA at matched load.
Frequency f_o = 2,450 GHz.
Constant air cooling q = 2,5 m^3/min.
d = Distance of voltage standing wave minimum from the reference plane for electrical measurements (measuring probe 55345) towards load.

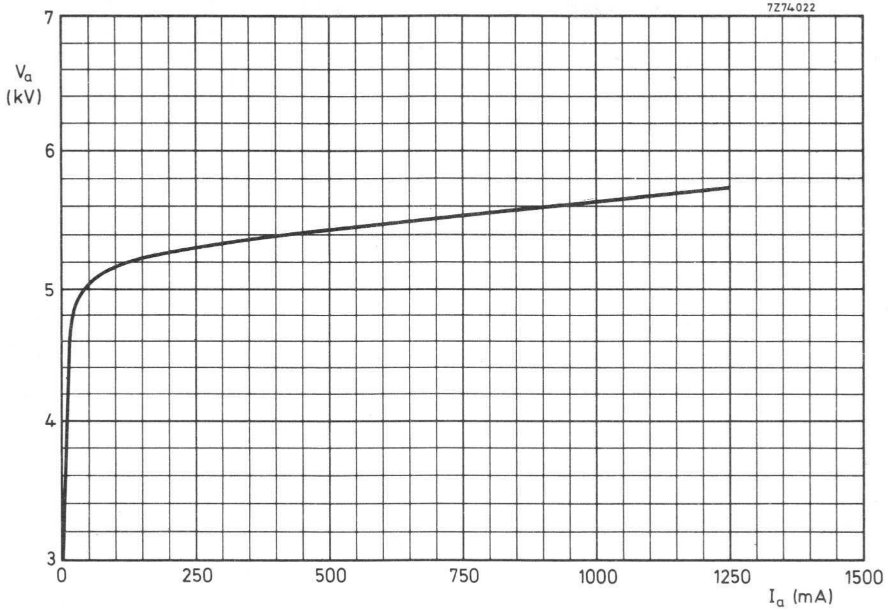


Fig. 7 Dynamic characteristic; anode voltage as a function of anode current at VSWR = 2,5 in direction of sink.

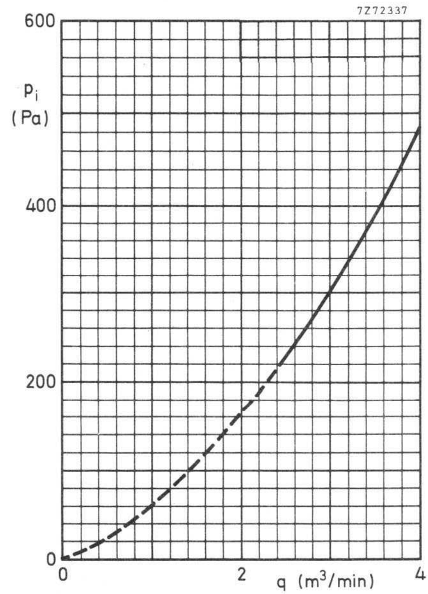


Fig. 8 Pressure drop as a function of rate of flow (air).

CONTINUOUS-WAVE MAGNETRON

Integral-magnet, water cooled continuous-wave magnetron with integral r.f. filter, intended for industrial microwave applications. The tube features a quick-heating cathode, high efficiency, and has a typical output power of 3 kW.

QUICK REFERENCE DATA

Frequency, fixed within the band	f	2,425 to 2,475 GHz
Output power	W_o	3 kW
Construction	packaged, metal-ceramic	
Cathode	quick heating	
R.F. filter	integral	

TYPICAL OPERATION with the tube coupled to an R26 waveguide according to Fig. 2

Conditions

Filament voltage, starting	V_f	5,0 V
Waiting time	t_w	10 s
Filament voltage, operating	V_f	2,5 V
Anode supply	three-phase, full-wave rectified	
Anode current, mean	I_a	800 mA
Anode current, peak	I_{ap}	$<$ 1100 mA
Load impedance measured with probe 55345 Voltage standing-wave ratio	VSWR	2,5
Phase, in direction of load, with respect to reference plane	d	0,14 λ
Cooling of anode block	water, see Fig. 9	
Cooling of filter box	air, q = 60 ℓ/min. see Fig. 8. Inlet temperature T_i = max. 50 °C	

Performance

Filament current at V_f = 2,5 V	I_f	20 A
Anode voltage, peak	V_{ap}	6 kV
Output power	W_o	3,2 kW
	W_o	$>$ 2,9 kW
Efficiency	η	70 %

CATHODE: Thoriated tungsten

HEATING: direct by a.c. (50 Hz or 60 Hz) or d.c.

With d.c. the terminal f(k) must have positive polarity.

Filament voltage, starting and stand-by	V_f		5,0 V ± 10%
operating at $I_{a\ mean}$ = 800 mA	V_f		2,5 V ± 10%
Filament current at V_f = 5,0 V, I_a = 0	I_f		41 A
		<	45 A
at V_f = 2,5 V, I_a = 800 mA	I_f		20 A
Filament current, peak starting	I_{fp}	max.	150 A
Cold filament resistance	R_{fo}		13 mΩ
→ Waiting time (time before application of high voltage)	t_w	min.	10 s

Immediately after applying the anode voltage the filament voltage must be reduced to the operating value. See Fig. 7.

TYPICAL CHARACTERISTICS

Measured under matched load conditions (VSWR ⩽ 1,05) and three-phase full-wave rectified supply. (See "Design and operating notes".)

Frequency, fixed within the band	f	2,425 to 2,475 GHz
Anode voltage, peak	V_{ap}	5,8 kV
Anode current, mean	I_a	800 mA
Output power	W_o	2,8 kW

LIMITING VALUES (Absolute maximum rating system)

Anode current, mean	I_a	max.	850 mA
Anode current, peak	I_{ap}	max.	1100 mA
Anode voltage*	V_a	max.	10 kV
Cooling water outlet temperature,			
open cooling circuit	T_o	max.	65 °C
closed cooling circuit	T_o	max.	75 °C
Temperature of mounting bracket at central contact point of thermoswitch (see also under "Cooling")	T	max.	120 °C
Voltage standing-wave ratio, measured with probe 55345	VSWR	max.	5
during max. 0,02 s and max. 20% of the time	VSWR	max.	10

Any period of time up to 0,02 s during which the VSWR is between 5 and 10 must be followed by a period four times as long during which the VSWR is ⩽ 5. When operating under these conditions the magnetron should not be permitted to mode.

* It is recommended that a suitable spark gap be connected between the filament/cathode terminal and the anode (earth) to prevent the maximum anode voltage being exceeded.

COOLING

Anode block	water

For pressure drop as a function of rate of flow see Fig. 9.

Filter box	air

For pressure drop as a function of rate of flow see Fig. 8.

With only the filament voltage applied the air cooling and some water cooling is required.

The magnetron is provided with a normally closed thermoswitch to protect the tube against overheating. The thermoswitch is rated 250 V (a.c.), 10 A. Switching-off temperature 115 ± 5 °C.

DESIGN AND OPERATING NOTES

General

Whenever it is considered necessary to operate the magnetron at conditions substantially different from those indicated under "Typical operation" the tube manufacturer should be consulted.

The equipment should be designed around the tube specification given in this data and not around one particular tube since, due to normal production variations, the design parameters (V_a, R_{fo}, f, W_o etc.) will vary around the nominal values.

Anode supply

The magnetron may be operated from a non-smoothed three-phase full-wave rectified supply unit. This unit should be so designed that no limiting value for the mean and peak anode current is exceeded, whatever the operating conditions. The use of a current limiting device is recommended.

Filament supply

The secondary of the filament transformer must be well insulated from the primary since during normal magnetron operation the anode is earthed and the cathode will be at high negative potential with respect to the anode.

The transformer should be so designed that the filament voltage and peak filament starting current limits are not exceeded.

Filament and filament/cathode connections

The magnetron has a high filament current and losses in filament voltage caused by bad connections will result in poor operation. Therefore, it is important to ensure that the leads make good electrical and thermal contact with the tube terminals.

Load impedance, measured with measuring probe

The probe 55345 simulates the r.f. output system of the magnetron; it may be coupled to an R26 wave-guide to replace the magnetron; in all cases the type 55344 gasket should be used. The termination of the probe matches a standard N-type connector.

The measuring probe enables the designer of the microwave heating equipment to determine the value of the load impedance (VSWR and phase of reflection), using standard cold measuring techniques, and to arrive at the correct coupling for the magnetron.

Tube cleanness

The ceramic parts of the input and output structure of the tube must be kept clean during installation and operation. The cooling air should be filtered to prevent deposits forming on the insulation.

STORAGE, HANDLING AND MOUNTING

Storage and handling

The original pack should be used for transporting the tube. Shipment of the tube mounted in the equipment is permitted if specifically authorized by the manufacturer.

When the tubes have to be unpacked, e.g. at an assembly line or for measurement purposes, care should be taken that a minimum distance of 13 cm is maintained between tubes. As the thoriated tungsten filament is sensitive to shocks and vibration, care should be taken when handling and storing unpacked tubes that such shocks and vibration are avoided. High intensity magnetic fields associated with transformers and other magnetic equipment can demagnetize the magnets. They should not be present when the tube is stored or serviced. The best protection of the tube is its original pack.

The user should be aware of the strong magnetic fields around the tube. When handling and mounting the magnetron, he must use non-magnetic tools and be extremely careful not to have precision instruments nearby.

Mounting

The magnetron should be mounted with two M4 bolts fitting the nuts on the mounting bracket (see outline drawing).

The output coupling should not be used as the only means of mounting and be kept free from undue stress.

The minimum distance between the magnetron and magnetized materials shall be 13 cm. The minimum distance between the magnetron and other ferromagnetic materials shall be 3 cm.

The gasket 55344 is essential to ensure good r.f. contact between the output of the magnetron and the waveguide to which it is connected.

All tools (screwdrivers, wrenches etc.) used close to or in contact with the magnetron must be of non-magnetic material to avoid unwanted attraction and possible mechanical damage to ceramic parts as well as short circuit of the magnetic flux.

MECHANICAL DATA

Mounting position:	any
Net mass:	approx. 1,8 kg

Accessories

Thermoswitch, mounted on tube	type 55364
R.F. gasket, supplied with tube	type 55344
Measuring probe (for measurements only, see Fig. 1)	type 55345
Recommended isolator	2722 163 02004

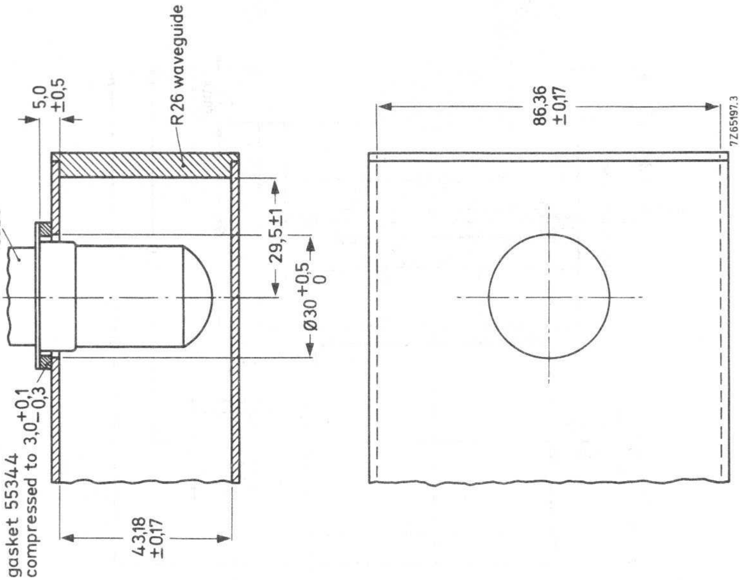


Fig. 2 Launching section.

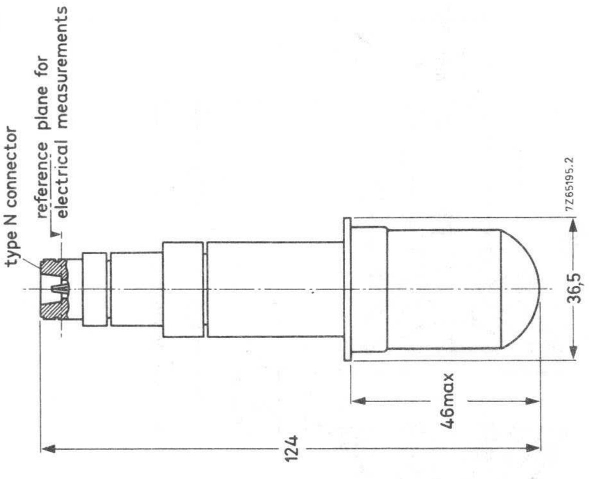


Fig. 1 Measuring probe 55345.

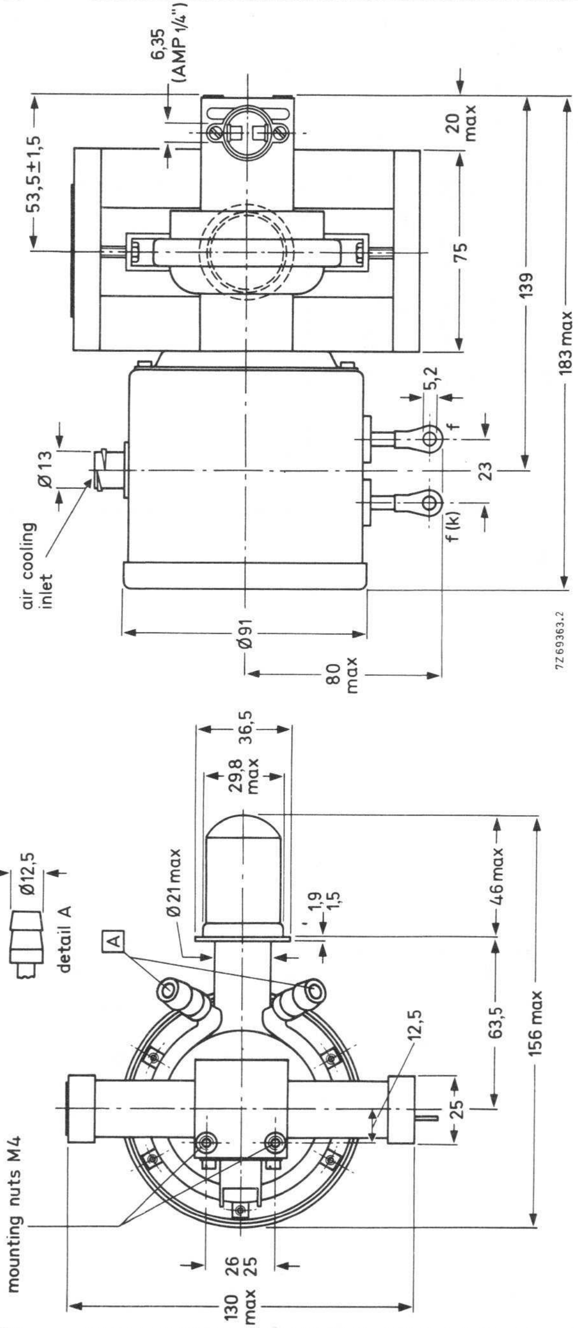
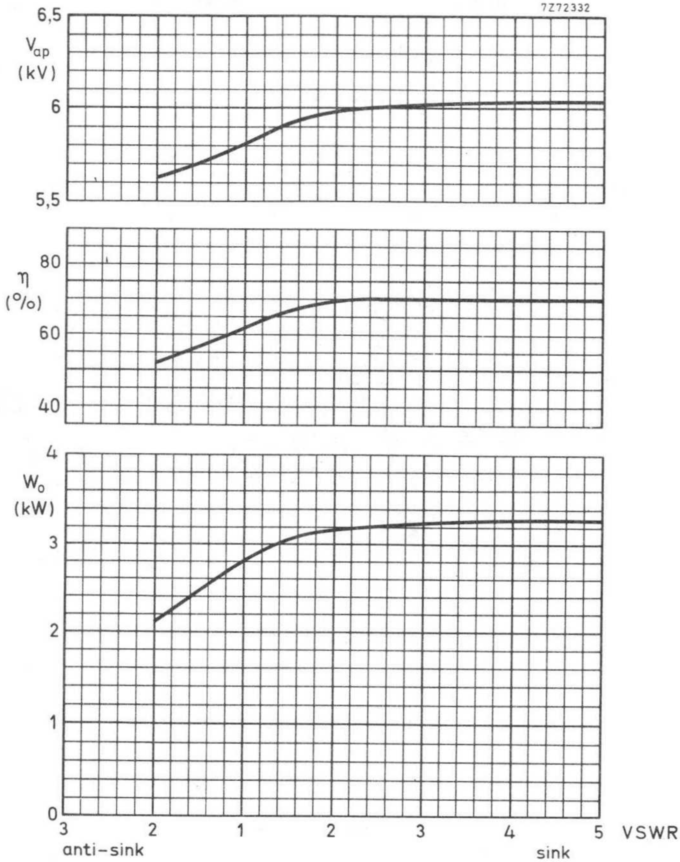


Fig. 3 Outline drawing.



I_a = 800 mA

Fig. 4.

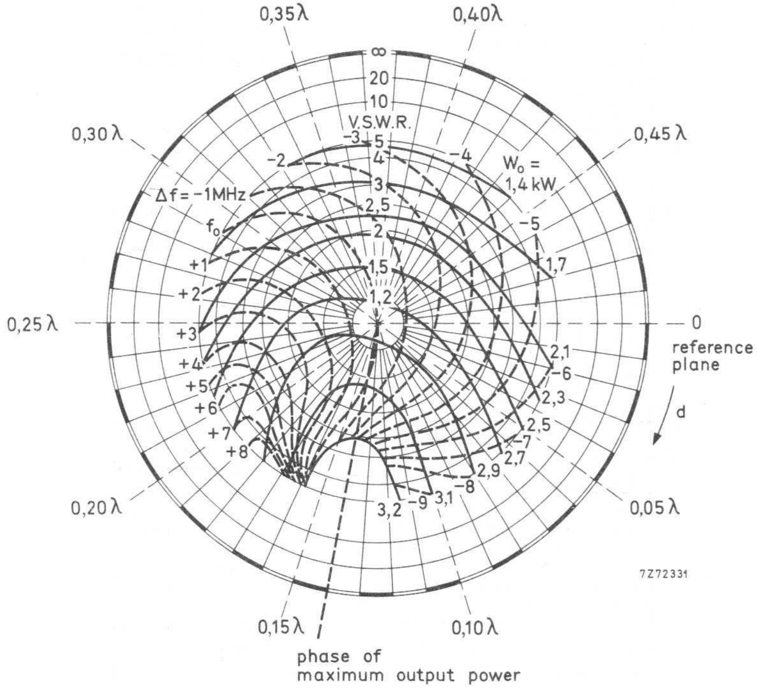


Fig. 5 Load diagram.

Measured with a three-phase full-wave rectified power supply.

Frequency f_o = 2,450 GHz.

Anode current, mean $\quad I_a$ = 800 mA.

Anode current, peak $\quad I_{ap}$ = 1000 mA at matched load.

Constant cooling.

d = Distance of voltage standing wave minimum from the reference plane for electrical measurements (measuring probe 55345) towards load.

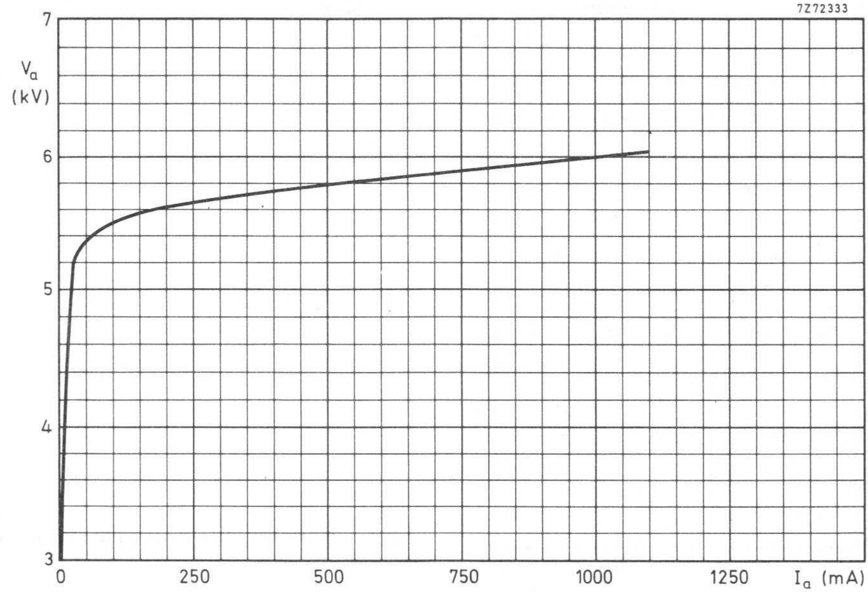


Fig. 6 Dynamic characteristic: anode voltage as a function of anode current at VSWR = 2,5 in direction of sink.

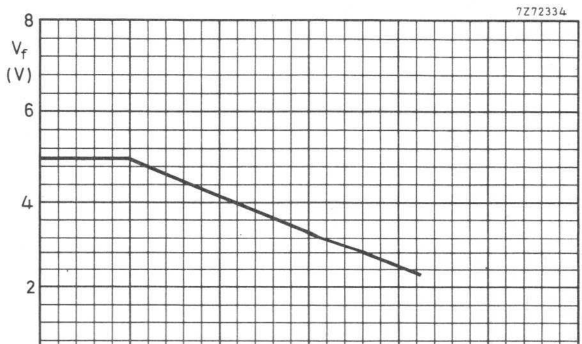


Fig. 7 Filament voltage reduction curve.

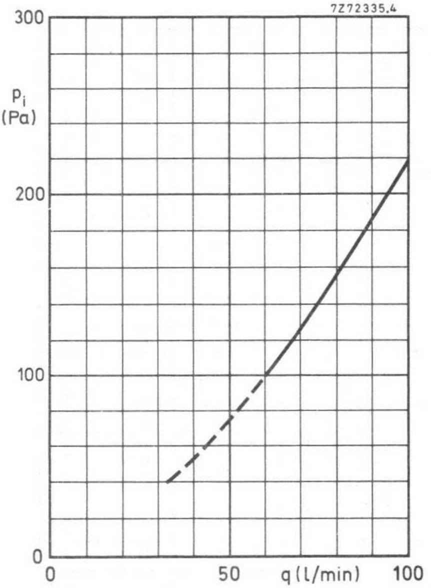


Fig. 8 Pressure drop as a function of rate of air flow.

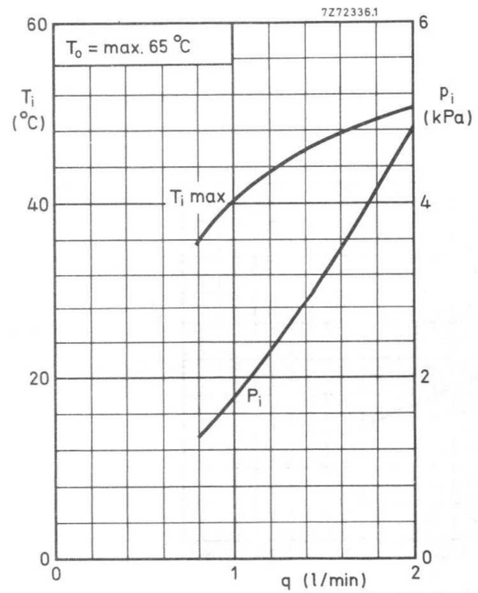


Fig. 9 Pressure drop and maximum inlet temperature as a function of rate of water flow.

CONTINUOUS-WAVE MAGNETRON

Integral-magnet, forced-air cooled continuous-wave magnetron with integral r.f. filter intended for microwave heating applications. The tube features a quick-heating cathode, high efficiency, and has a typical output power of 1,5 kW.

QUICK REFERENCE DATA

Frequency, fixed within the band	f	2,425 to 2,475 GHz
Output power	W_o	1,55 kW
Construction		packaged, metal-ceramic
Cathode		quick heating
R.F. filter		integral

TYPICAL OPERATION with the tube coupled to an R26 waveguide according to Fig. 3

Conditions

Filament voltage, starting	V_f		5,0	V
Waiting time	t_w		10	s ←
Filament voltage, operating	V_f		3,5	V
Anode supply (see "Design and operating notes")		L-C stabilized		
Anode current, mean	I_a		370	mA
Anode current, peak	I_{ap}		600	mA
Load impedance, measured with probe 55345				
Voltage standing-wave ratio	VSWR		2,5	
Phase, in direction of load, with respect to reference plane	d		0,14	λ
Cooling: rate of flow*	q	min.	2	m^3/min

Performance

Filament current at V_f = 3,5 V	I_f		18	A
Anode voltage, peak	V_{ap}		6	kV
Output power	W_o		1,55	kW
	W_o	min.	1,4	kW
Efficiency	η		70	%

CATHODE: Thoriated tungsten

* Based on a cooling air inlet temperature T_i = max. 50 °C.

HEATING: Direct by a.c. (50 Hz or 60 Hz) or d.c.

With d.c. the terminal f(k) must have positive polarity.

Filament voltage, starting and stand-by	V_f		5,0	V ± 10%
operating at $I_{a\,mean}$ = 370 mA	V_f		3,5	V ± 10%
Filament current at V_f = 5,0 V, I_a = 0	I_f		26	A
		<	29	A
at V_f = 3,5 V, I_a = 370 mA	I_f		18	A
Filament current, peak starting	I_{fp}	max.	100	A
Cold filament resistance	R_{fo}		20	mΩ
→ Waiting time (time before application of high voltage)	t_w	min.	10	s

TYPICAL CHARACTERISTICS

Measured under matched load conditions (VSWR ≤ 1,05) and L-C stabilized power supply. (See "Design and operating notes".)

Frequency, fixed within the band	f	2,425 to 2,475	GHz
Anode voltage, peak	V_{ap}	5,9	kV
Anode current, mean	I_a	370	mA
Output power	W_o	1,35	kW

LIMITING VALUES (Absolute maximum rating system)

Anode current, mean	I_a	max.	400	mA
Anode current, peak	I_{ap}	max.	900	mA
Anode voltage*	V_a	max.	10	kV
Temperature of mounting bracket at central contact point of thermoswitch (see also under "Cooling")	T	max.	140	°C
Voltage standing-wave ratio, measured with probe 55345	VSWR	max.	5,5	
during max. 0,02 s and max. 20% of the time	VSWR	max.	10	

Any period of time up to 0,02 s during which the VSWR is between 5,5 and 10 must be followed by a period four times as long during which the VSWR is ≤ 5,5. When operating under these conditions the magnetron should not be permitted to mode.

COOLING

Anode block and filament structure — forced air

For pressure drop as a function of rate of flow, see Fig. 8.
The cooling air must be so ducted that it is uniformly distributed.
Direction of airflow: see outline drawing.

With only the filament voltage applied some air cooling is required to keep the temperature below the limiting value.

The magnetron is provided with a normally closed thermoswitch to protect the tube against overheating. The thermoswitch is rated 250 V (a.c.), 10 A. Switching-off temperature 135 ± 5 °C.

* It is recommended that a suitable spark gap be connected between the filament/cathode terminal and the anode (earth) to prevent the maximum anode voltage being exceeded.

DESIGN AND OPERATING NOTES

General

Whenever it is considered necessary to operate the magnetron at conditions substantially different from those indicated under "Typical operation" the tube manufacturer should be consulted.

The equipment should be designed around the tube specifications given in this data and not around one particular tube since, due to normal production variations, the design parameters (V_a, R_{fo}, f, W_o etc.) will vary around the nominal values.

Anode supply

The magnetron may be operated from an L-C stabilized anode supply unit. Detailed information on power supply design available on request.

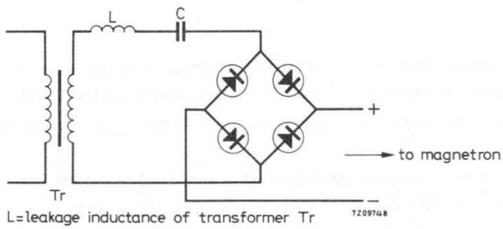


Fig. 1 Basic series resonant circuit of an L-C power supply.

Filament supply

The secondary of the filament transformer must be well insulated from the primary since during normal magnetron operation the anode is earthed and the cathode will be at high negative potential with respect to the anode.

The transformer should be so designed that the filament voltage and filament peak starting current limits are not exceeded.

Filament and filament/cathode connections

The magnetron has a high filament current and losses in filament voltage caused by bad connections, will result in poor operation. Therefore, it is important to ensure that the leads make good electrical contact with the tube terminals.

Load impedance, measured with measuring probe

The probe 55345 simulates the r.f. output system of the magnetron; it may be coupled to an R26 waveguide to replace the magnetron; in all cases the type 55344 gasket should be used. The termination of the probe matches a standard N-type connector.

The measuring probe enables the designer of the microwave heating equipment to determine the value of the load impedance (VSWR and phase of reflection), using standard cold measuring techniques, and to arrive at the correct coupling for the magnetron.

Tube cleanness

The ceramic parts of the input and output structure of the tube must be kept clean during installation and operation. The cooling air should be filtered to prevent deposits forming on the insulation during operation.

STORAGE, HANDLING AND MOUNTING

Storage and handling

The original pack should be used for transporting the tube. Shipment of the tube mounted in the equipment is permitted if specifically authorized by the manufacturer.

When the tubes have to be unpacked, e.g. at an assembly line or for measurement purposes, care should be taken that a minimum distance of 13 cm is maintained between tubes. As the thoriated tungsten filament is sensitive to shocks and vibration, care should be taken when handling and storing unpacked tubes that such shocks and vibration are avoided. High intensity magnetic fields associated with transformers and other magnetic equipment can demagnetize the magnets. They should not be present when the tube is stored or serviced. The best protection of the tube is its original pack.

The user should be aware of the strong magnetic fields around the tube. When handling and mounting the magnetron, he must use non-magnetic tools and be extremely careful not to have precision instruments nearby.

Mounting

The magnetron should be mounted with two M4 bolts fitting the nuts on the mounting bracket (see outline drawing). The magnetron earth connection can be made via these nuts.

The output coupling should not be used as the only means for mounting and be kept free from undue stress.

The minimum distance between the magnetron and magnetized materials shall be 13 cm. The minimum distance between the magnetron and other ferromagnetic materials shall be 3 cm.

The gasket 55344 essential to ensure good r.f. contact between the output of the magnetron and the waveguide to which it is connected.

All tools (screwdrivers, wrenches etc.) used close to or in contact with the magnetron must be of non-magnetic material to avoid unwanted attraction and possible mechanical damage to ceramic parts as well as short circuit of the magnetic flux.

MECHANICAL DATA

Mounting position:	any
Net mass:	approx. 2 kg

Accessories

Thermoswitch, mounted on tube	type 55347
R.F. gasket, supplied with tube	type 55344
Measuring probe (for measurements only, see Fig. 2)	type 55345

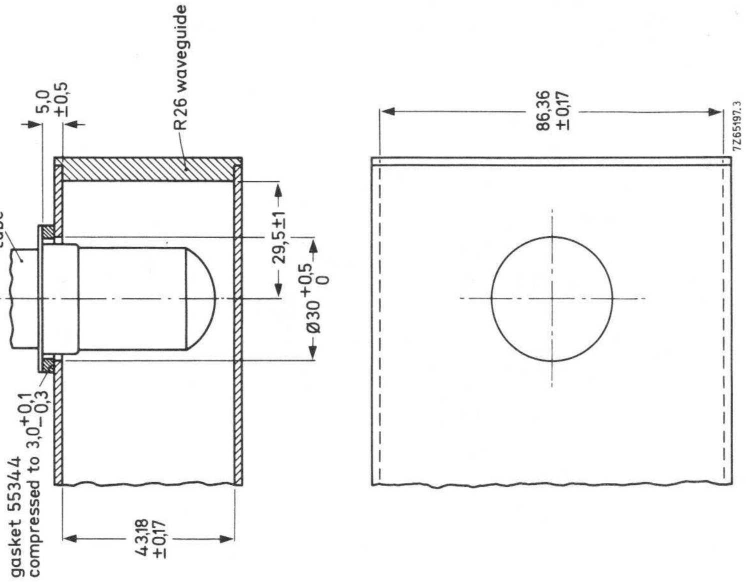


Fig. 3 Launching section.

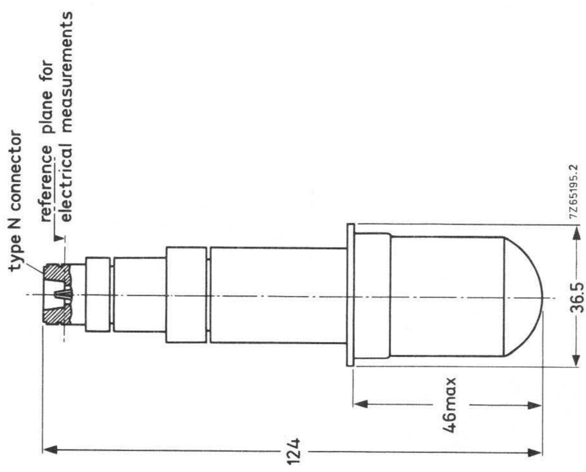


Fig. 2 Measuring probe 55345.

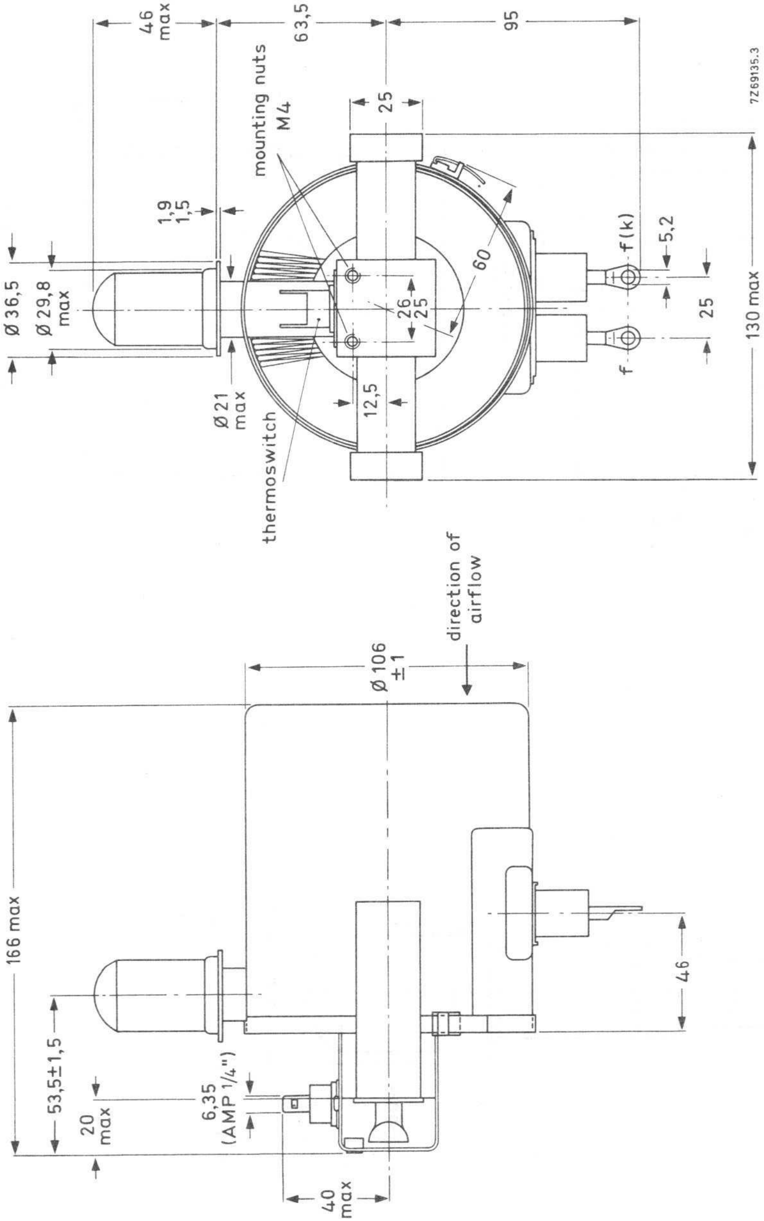


Fig. 4 Outline drawing.

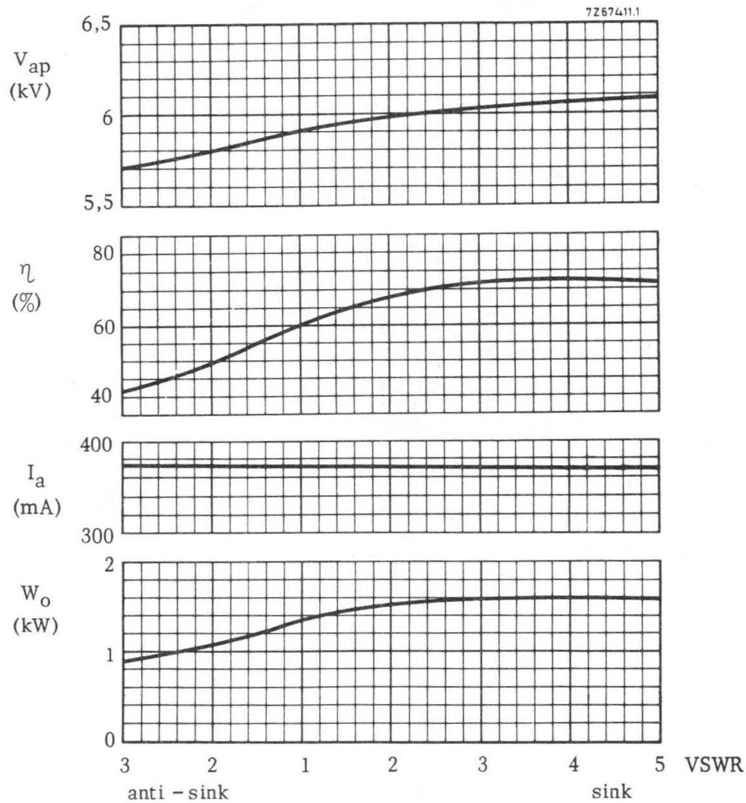

7Z67411.1
V_{ap} (kV)
6,5
6
5,5
η (%)
80
60
40
I_a (mA)
400
300
W_o (kW)
2
1
0
3 2 1 2 3 4 5 VSWR
anti - sink
sink

Fig. 5.

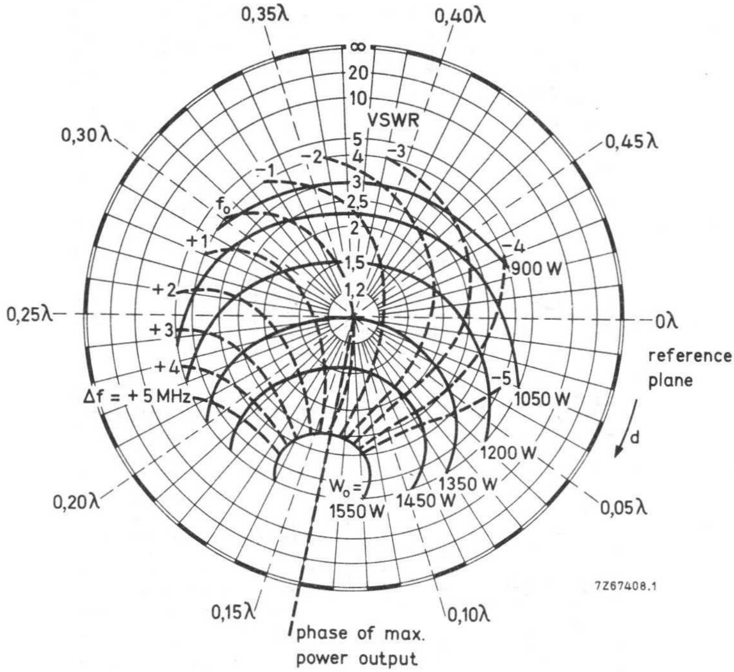


Fig. 6 Load diagram.

Measured with an L-C stabilized power supply.
Mean anode current I_a = 370 mA at matched load.
Frequency f_o = 2,450 GHz.
Constant air cooling q = 2m^3/min.
d = Distance of voltage standing wave minimum from the reference plane for electrical measurements (measuring probe 55345) towards load.

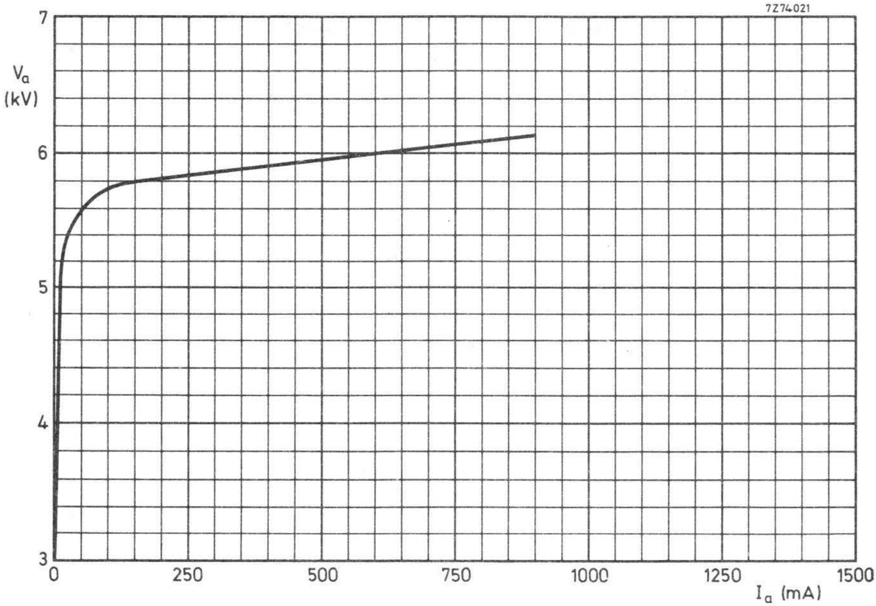


Fig. 7 Dynamic characteristic; anode voltage as a function of anode current at VSWR = 2,5 in direction of sink.

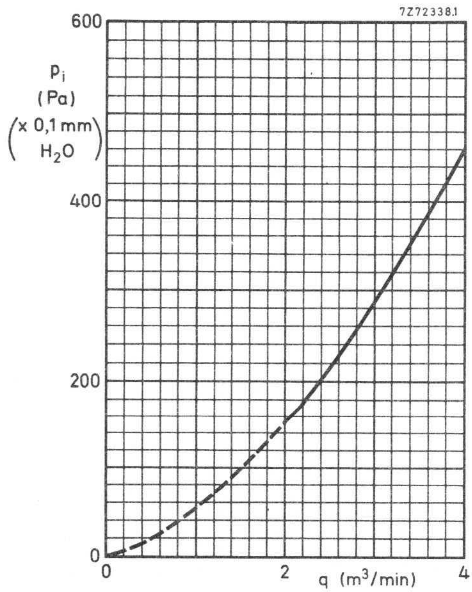


Fig. 8 Pressure drop as a function of rate of flow (air).

CONTINUOUS-WAVE MAGNETRON

Packaged, metal-ceramic, forced-air cooled, continuous-wave magnetron with integral r.f. cathode filter. The tube is primarily intended for use in domestic microwave ovens and features cold-start operation and high efficiency. Under typical operating conditions the output power is 1100 W. This lightweight tube may be mounted in any position.

QUICK REFERENCE DATA

Frequency, matched load	f		2,450 GHz
Output power	W_o		1100 W
Construction	packaged, metal-ceramic		
Cathode	thoriated tungsten, cold-start, quick heating		
R.F. cathode filter	integral		

TYPICAL OPERATION

Conditions

Filament voltage	V_f		3,2 V
Anode supply (see "Design and operating notes")	L-C stabilized half-wave doubler		
Anode current, mean	I_a		380 mA
Anode current, peak	I_{ap}	≈	1250 mA
Cooling; rate of flow	q		1 m^3/min

Performance (at matched load; for other load conditions see Fig. 5)

Filament current	I_f		14,5 A
Anode voltage, peak	V_{ap}		4 kV
Frequency	f		2,450 GHz
Output power	W_o		1100 W
	W_o	>	950 W
Efficiency	η		72 %

CATHODE: Thoriated tungsten, cold start, quick heating

HEATING

Filament voltage	V_f		3,2	V ± 10%
Filament current at V_f = 3,2 V, I_a = 0	I_f		15,5	A
Cold filament resistance	R_{fo}		30	mΩ
→ Pre-heating time (waiting time)	t_w		10	

TYPICAL CHARACTERISTICS

Frequency, fixed within the band	f	2,435 to 2,465	GHz
Phase of sink, measured with probe type 55371	d	0,11	λ

LIMITING VALUES (Absolute maximum rating system)

Filament voltage	V_f	max. min.	3,2 3,2	V + 10% V −10%
Anode current, mean	I_a	max.	420	mA
Anode current, peak			*	
Anode voltage**	V_a	max.	12	kV
Cooling; rate of flow	q	min.	1	m^3/min
Temperature at reference point (see outline drawing)	T	max.	180	°C
Voltage standing-wave ratio, measured with probe 55371	VSWR	max.	4	
during max. 0,02 s and max. 20% of the time	VSWR	max.	10	

Any period of time up to 0,02 s during which the VSWR is between 4 and 10 must be followed by a period four times as long during which the VSWR is ⩽ 4.

COOLING

Anode block	forced air			
Required quantity of air, based on an air inlet temperature of 50 °C max. under typical operating conditions	q	min.	1	m^3/min
Pressure drop as a function of rate of flow	see Fig. 7			
Direction of air flow through radiator	arbitrary			

To protect the magnetron against overheating it is recommended that a thermoswitch be mounted in the position shown on the outline drawing. Thermoswitch switching-off temperature 100 °C.

* Under no circumstances should the magnetron be permitted to mode. Amongst other conditions, the moding stability of a magnetron depends on the r.f. loading conditions such as VSWR, phase of reflection, and coupling section. It also depends on peak anode current, mean anode current, and current waveform. For a magnetron operating from an L-C stabilized half-wave doubler anode supply, the peak to mean anode current ratio is approximately 3 to 3,5.

** For "cold-start" operation it is recommended that, for the anode voltage, a rectifier be used with a reverse breakdown voltage of 10 to 12 kV and having an avalanche energy rating of ⩾ 2 J.

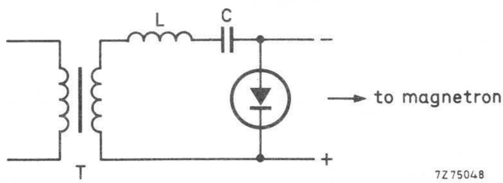
DESIGN AND OPERATING NOTES

General

Whenever operation of the magnetron at conditions substantially different from those indicated under "Typical operation" is considered the tube supplier should be consulted.

Anode supply

The magnetron may be operated from an L-C stabilized half-wave doubler anode supply unit.



L = Leakage inductance of transformer T

Fig. 1 Basic circuit of an L-C stabilized half-wave doubler anode supply unit.

Filament supply

The filament winding of the transformer must be well insulated from the primary winding since the anode is earthed and the cathode is at a high negative potential with respect to the anode and the primary winding.

When "variable power control" is used, please contact the tube supplier.

Load impedance, measured with measuring probe

The measuring probe type 55371 enables the designer of the microwave oven to determine the value of the load impedance (VSWR and phase of reflection), using standard cold measuring techniques, and to arrive at the correct coupling for the magnetron.

For the cold measurements the probe, with gasket type 55372, is coupled to the coupling section instead of the magnetron. The termination of the probe matches a standard N-type connector.

Assistance in the design of the h.f. part of the oven, including the magnetron coupling method, may be given by the tube manufacturer.

Tube cleanness

The ceramic parts of the input and output structure of the tube must be kept clean and dry during installation and operation.

Mounting

The magnetron should be mounted on a non-ferromagnetic coupling section by means of 4 screws through the holes in the air duct or by 4 mounting brackets catalogue number 4322 041 03832 which can be hooked into the slits in the air duct side-walls.

To ensure good r.f. contact between the magnetron and the coupling section the use of gasket type 55372 is essential.

MECHANICAL DATA

Mounting position: any

Net mass: approx. 1 kg

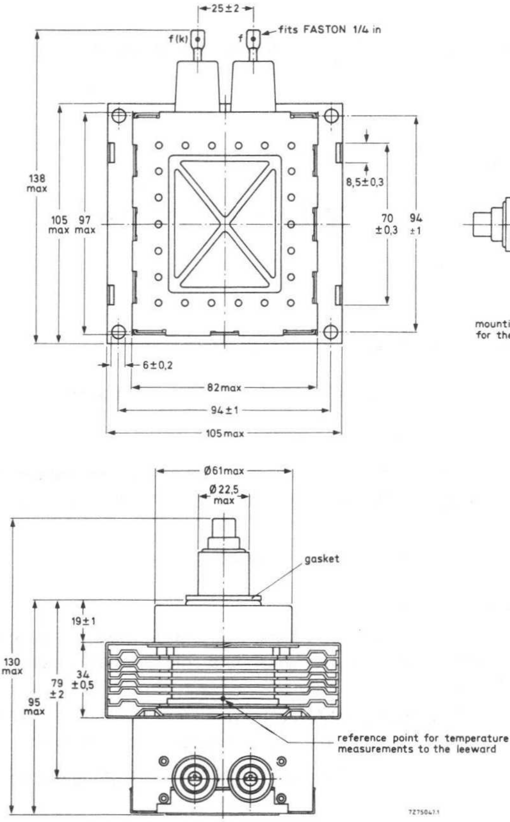


Fig. 2 Outline drawing.

ACCESSORIES

R.F. gasket, supplied with tube	type 55372
Measuring probe for oven design measurements	type 55371

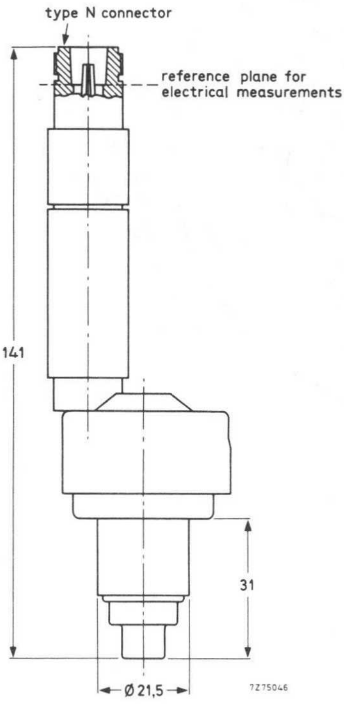


Fig. 3 Measuring probe type 55371.

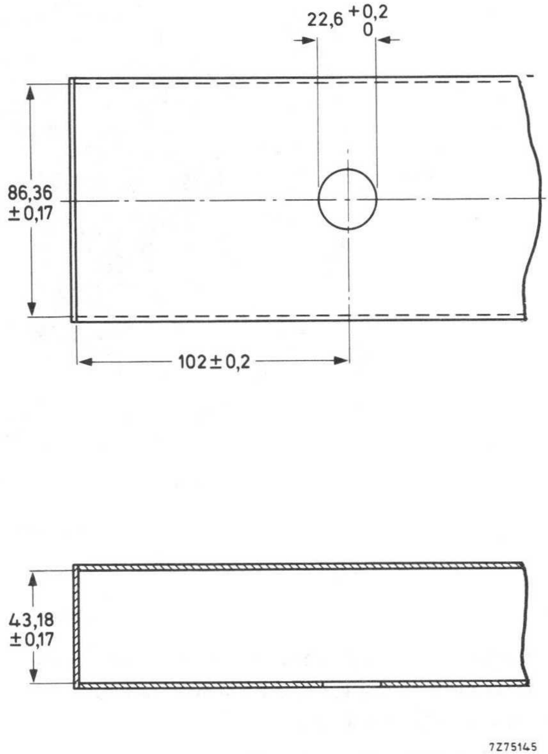


Fig. 4 Coupling section for YJ1500 into a waveguide R26 (used for measurements).

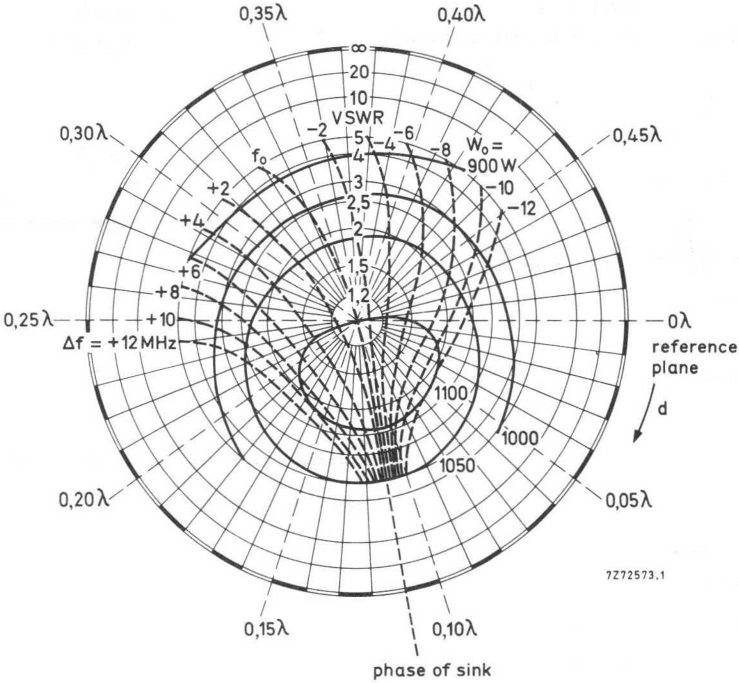


Fig. 5 Load diagram.

Measured with an L-C stabilized half-wave doubler anode supply.

Mean anode current I_a = 380 mA at matched load.

Frequency f_o = 2,450 GHz.

Constant air cooling q = 1 m^3/min.

d = Distance of voltage standing wave minimum from the reference plane for electrical measurements (measuring probe type 55371) towards load.

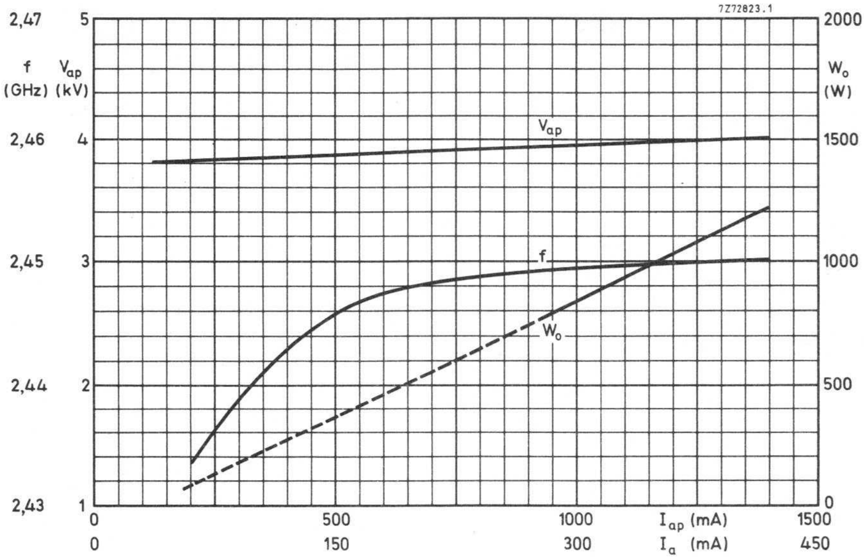


Fig. 6 Peak anode voltage, V_{ap}, as a function of peak anode current, I_{ap}. Frequency, f, as a function of peak anode current, I_{ap}. Output power, W_o, as a function of mean anode current, I_a, measured with an L-C stabilized half-wave doubler supply with $\frac{I_{ap}}{I_a} = \frac{10}{3}$. Load: matched.

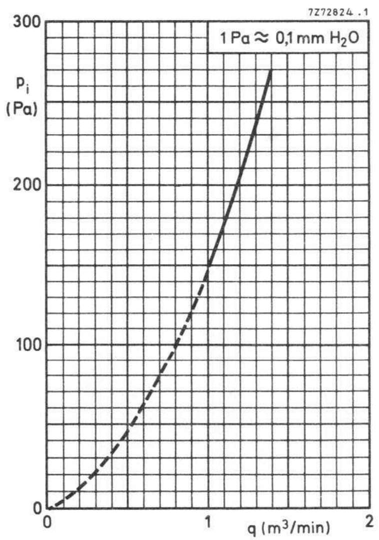


Fig. 7 Pressure drop, p_i, across radiator as a function of air flow, q.

CONTINUOUS-WAVE MAGNETRON

Packaged, metal-ceramic, forced-air cooled, continuous-wave magnetron with integral r.f. cathode filter. The tube is primarily intended for use in diathermy and other low-power heating applications. The tube features cold start operation and high efficiency.

QUICK REFERENCE DATA

Frequency, matched load	f	2,455	GHz
Output power	W_o	265	W
Construction	packaged, metal-ceramic		
Cathode	thoriated tungsten cold start, quick heating		
R.F. cathode filter	integral		
Cooling	forced air		

TYPICAL OPERATION

Tube coupled to waveguide section of Fig. 1.
At matched load in coaxial output line; for other load conditions see Fig. 3.

Anode supply

OPERATION A: Unsmoothed single-phase full-wave rectified voltage

OPERATION B: Pulsed

Conditions		A	B	
Filament voltage, a.c. 50 or 60 Hz	V_f	4	4	V
Anode current				
mean	I_a	150	150	mA
peak	I_{ap}	500	900	mA
Cooling rate of flow	q_{min}	500	500	l/min
Pressure drop	p_i	40	40	Pa
Performance				
Filament current	I_f	17,5	17,5	A
Anode voltage, peak	V_{ap}	2,9	3,0	kV
Frequency	f	2,455	2,455	GHz
Output power, VSWR $< 1,05$	W_o	255	265	W
Efficiency	η	61	61	%

HEATING

Thoriated tungsten, cold start, quick-heating cathode

Filament voltage	V_f	4	V ± 10%
Filament current at V_f = 4 V, I_a = 0	I_f	17,5	A
Cold filament resistance	R_{fo}	30	mΩ
→ Pre-heating time (waiting time)	t_w	10	

For "cold start" operation it is recommended that a rectifier be used with a reverse breakdown voltage of 10 kV and having an avalanche energy of 2 joule.

GENERAL DATA

Electrical

Frequency, fixed within the band	f	2,445 to 2,465	GHz
Phase for maximum output power	d	0,09	λ

Mechanical

Mounting position	any			
Mass		≈	1,0	kg

LIMITING VALUES (Absolute maximum rating system)

Filament voltage	V_f	max.	4,4	V
		min.	3,6	V
Anode current				
mean	I_a	max.	200	mA
peak			950	mA*
Anode voltage	V_a	max.	10	kV
Temperature at reference point (see outline drawing)	T	max.	180	°C
Voltage standing-wave ratio	VSWR	max.	5	
Storage temperature		min.	–30	°C

COOLING

Anode block	forced air			
Required quantity of air, based on an air inlet temperature of 50 °C max. under typical operating conditions	q	min.	300	l/min
Pressure drop as a function of rate of flow	see Fig. 6			
Direction of air flow through radiator	arbitrary			

To protect the magnetron against overheating it is recommended that a thermoswitch be mounted in the position shown on the outline drawing. Temperature at which the thermoswitch will switch off: see Fig. 4.

* Under no circumstances should the magnetron be permitted to mode. Amongst other conditions, the moding stability of a magnetron depends on the R.F. loading conditions such as VSWR, phase of reflection, and coupling section. It also depends on peak anode current, mean anode current, and current waveform.

DESIGN AND OPERATING NOTES

General

Whenever operation of the magnetron at conditions substantially different from those indicated under *Typical operation* is considered the tube supplier should be consulted.

Filament supply

The filament winding of the transformer must be well insulated from the primary winding since the anode is earthed and the cathode is at a high negative potential with respect to the anode and the primary winding.

Tube cleanness

The ceramic part of the output structure of the tube must be kept clean and dry during installation and operation.

Mounting

The magnetron should be mounted on a coupling section by means of the 3 bolts M4 (see outline drawing). To ensure good r.f. contact between the magnetron and the coupling section, the nuts should be fastened evenly.

ACCESSORIES

R.F. gasket, supplied with the tube, type 55372.

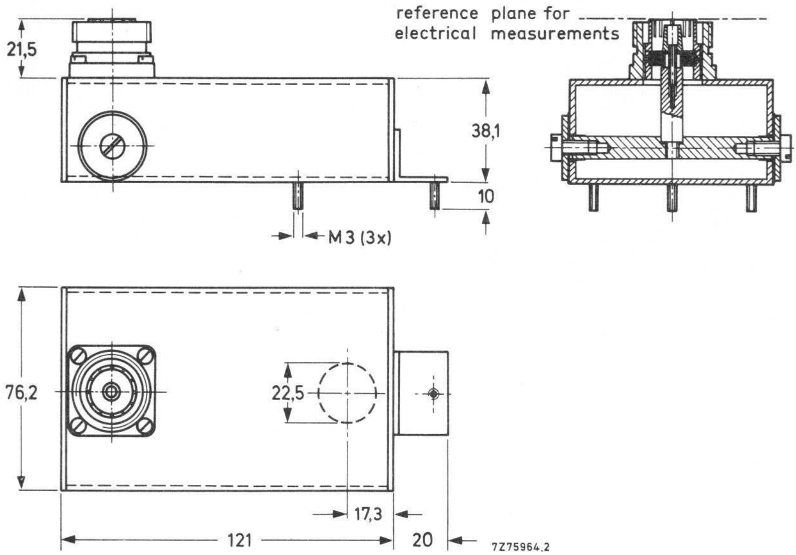


Fig. 1 Coupling section (detailed drawings available on request).

MECHANICAL DATA

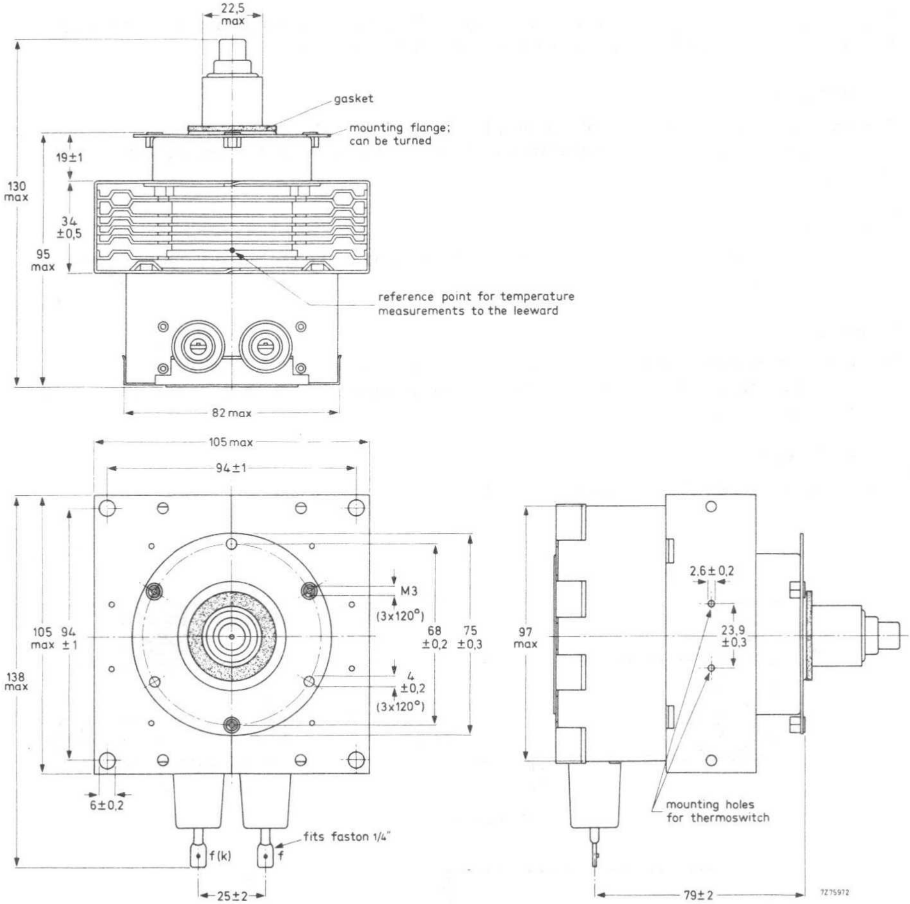


Fig. 2 Outline drawing.

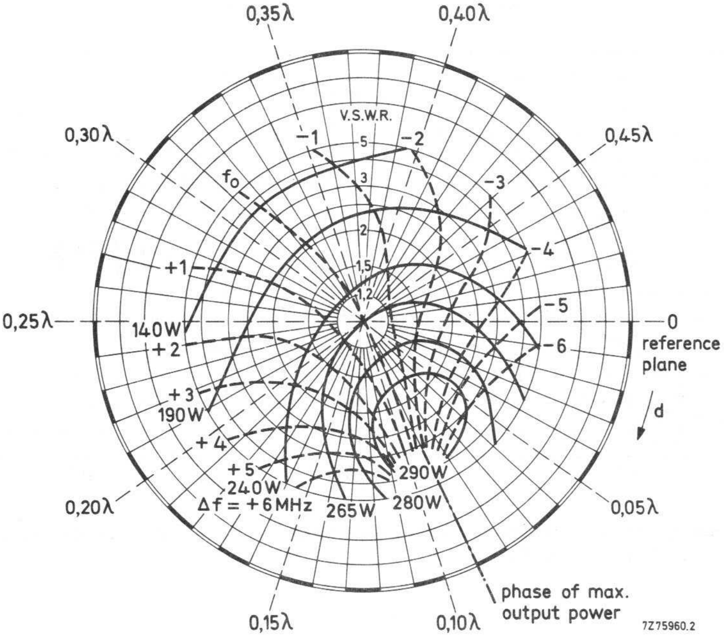


Fig. 3 Load diagram.

Reference plane	output of coupling section (see Fig. 1).
Anode supply	operation B: pulsed
Filament voltage	4 V
Average anode current	150 mA
Peak anode voltage	3 kV
Frequency at matched load	f_0 = 2,455 GHz

d = distance of VSWR - minimum from reference plane towards load

Diagram measured in cold condition.

Cooling characteristics

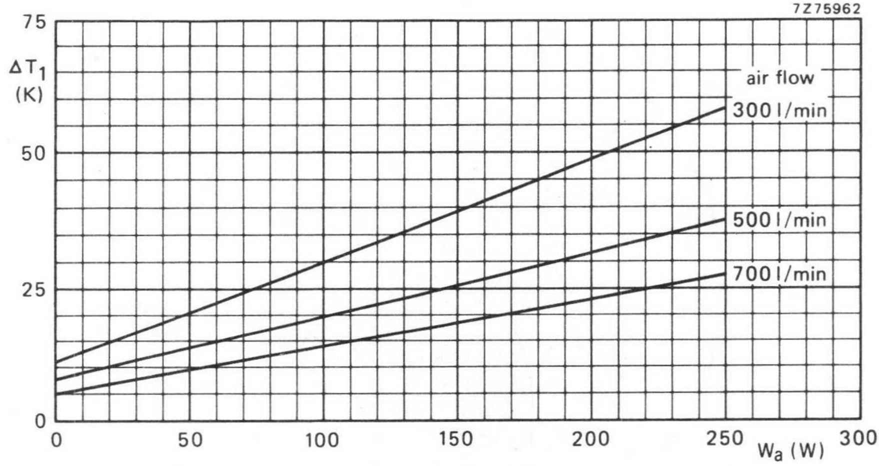


Fig. 4 Increase temperature of thermoswitch mounting position above inlet air temperature, ΔT_1 as a function of anode dissipation, W_a.

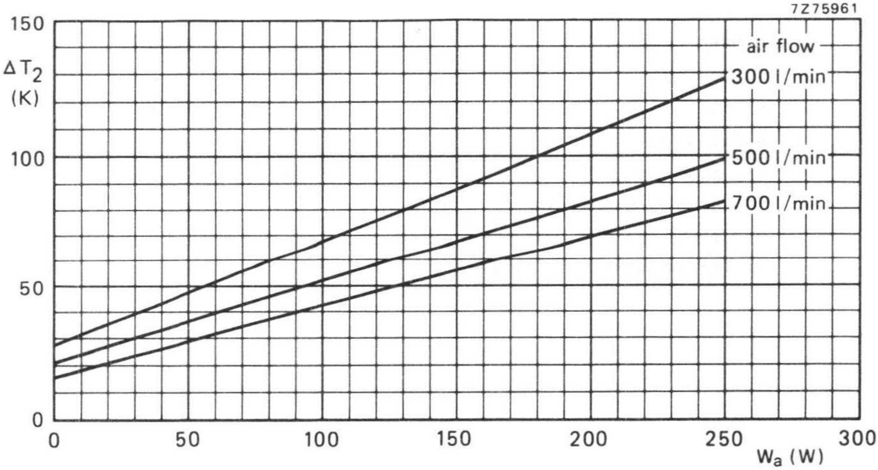


Fig. 5 Increase of anode temperature above inlet air temperature, ΔT_2, as a function of anode dissipation, W_a. Anode dissipation = (peak anode voltage) x (average anode current) – (output power). V_f = 4 V.

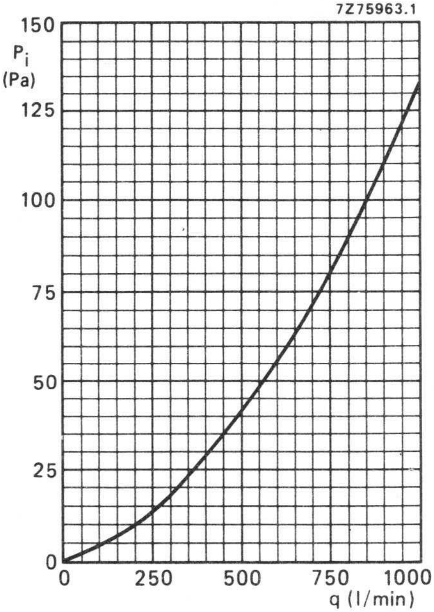


Fig. 6 Pressure drop, p_i, across radiator as a function of air flow, q.

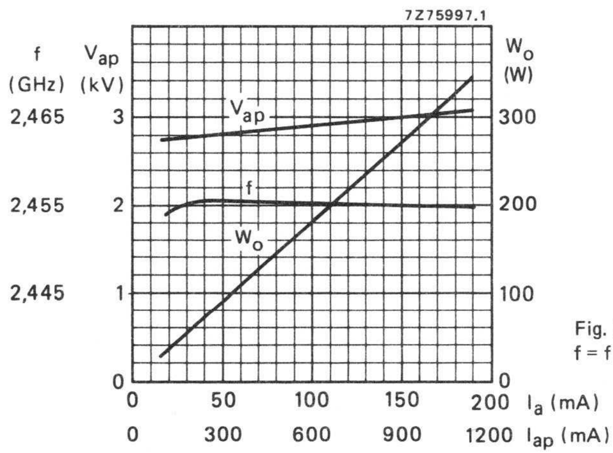


Fig. 7 Performance chart.
$f = f(I_{ap})$; $V_{ap} = f(I_{ap})$; $W_o = f(I_a)$.

CONTINUOUS-WAVE MAGNETRON

Packaged, metal-ceramic, forced-air cooled, continuous-wave magnetron with integral r.f. cathode filter. The tube is primarily intended for use in diathermy and other low-power heating applications. The tube features cold start operation and high efficiency.

QUICK REFERENCE DATA

Frequency, matched load	f	2,46 GHz
Output power	W_o	310 W
Construction	packaged, metal-ceramic	
Cathode	thoriated tungsten cold start, quick heating	
R.F. cathode filter	integral	
Cooling	forced air	

TYPICAL OPERATION

Tube coupled to waveguide section of Fig. 1.
Matched load in coaxial output line; for other load conditions see Fig. 3.

Anode supply

OPERATION A: Unsmoothed single-phase full-wave rectified voltage

OPERATION B: Pulsed

Conditions		A	B	
Filament voltage, a.c. 50 or 60 Hz	V_f	3,4	3,4	V
Anode current				
mean	I_a	150	150	mA
peak	I_{ap}	750	900	mA
Cooling rate of flow	q_{min}	500	500	l/min
Pressure drop	p_i	20	20	Pa
Performance				
Filament current	I_f	15	15	A
Anode voltage, peak	V_{ap}	3,0	3,0	kV
Frequency	f	2,46	2,46	GHz
Output power, VSWR $< 1{,}05$	W_o	300	310	W
Efficiency	η	68	68	%

HEATING

Thoriated tungsten, cold start, quick-heating cathode

Filament voltage	V_f		3,4 V ± 10%
Filament current at V_f = 3,4 V, I_a = 0	I_f		15 A
Cold filament resistance	R_{fo}		32 mΩ
Pre-heating time (waiting time)	t_w		0

GENERAL DATA

Electrical

Frequency, fixed within the band	f		2,450 to 2,470 GHz
Phase for maximum output power	d		0,12 λ

Mechanical

Mounting position	any		
Mass			940 g

LIMITING VALUES (Absolute maximum rating system)

Filament voltage	V_f	max.	3,75 V
		min.	3,05 V
Anode current			
mean	I_a	max.	200 mA
peak			950 mA*
Anode voltage	V_a	max,	10 kV
Temperature at reference point (see outline drawing)	T	max.	180 °C
Voltage standing-wave-ratio	VSWR	max.	5
Storage temperature		min.	–30 °C

COOLING

Anode block	forced air		
Required quantity of air, based on an air inlet temperature of 50 °C max. under typical operating conditions	q	min.	300 l/min
Pressure drop as a function of rate of flow	see Fig. 6		
Direction of air flow through radiator	arbitrary		

To protect the magnetron from overheating we recommend that a thermoswitch be mounted in the position shown on the outline drawing. Temperature at which the thermoswitch will switch off: see Fig. 4.

* Under no circumstances should the magnetron be permitted to mode. Amongst other conditions, the moding stability of a magnetron depends on the R.F. loading conditions such as VSWR, phase of reflection, and coupling section. It also depends on peak anode current, mean anode current, and current waveform.

DESIGN AND OPERATING NOTES

General

Whenever operation of the magnetron at conditions substantially different from those indicated under *Typical operation* is considered the tube supplier should be consulted.

Filament supply

Simultaneous application of filament and anode voltage is permitted ('cold start'). The filament winding of the transformer must be well insulated from the primary winding since the anode is earthed and the cathode is at a high negative potential with respect to the anode and the primary winding.

Tube cleanness

The ceramic part of the output structure of the tube must be kept clean and dry during installation and operation.

Mounting

The magnetron should be mounted on a coupling section by means of the 4 bolts M5 (see outline drawing). To ensure good r.f. contact between the magnetron and the coupling section, the nuts should be fastened evenly.

FILTERS

Coupling filter of Fig. 1 meets CISPR11 recommendations up to 1 GHz. A filter meeting CISPR11 up to 18 GHz is also available.

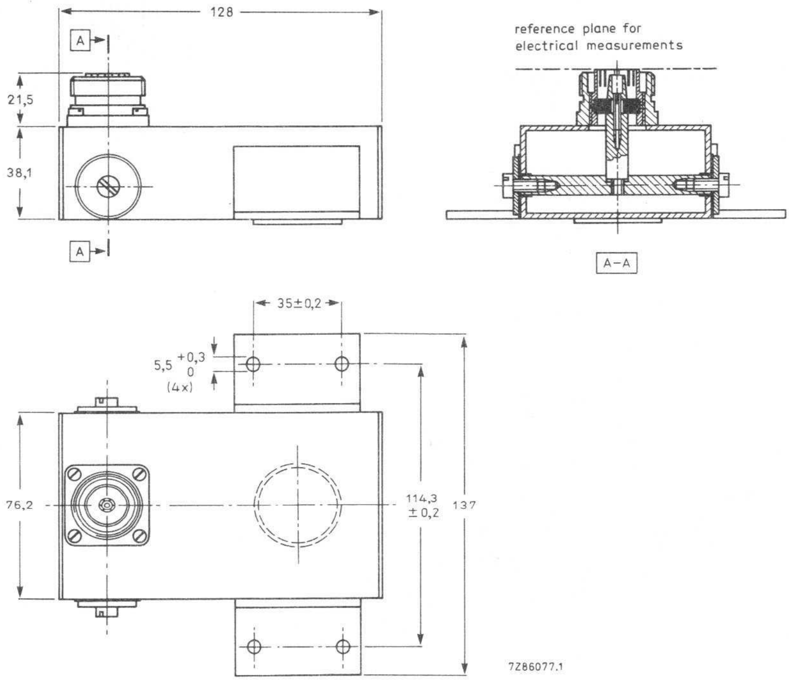


Fig. 1 Coupling filter (detailed drawings available on request).

MECHANICAL DATA

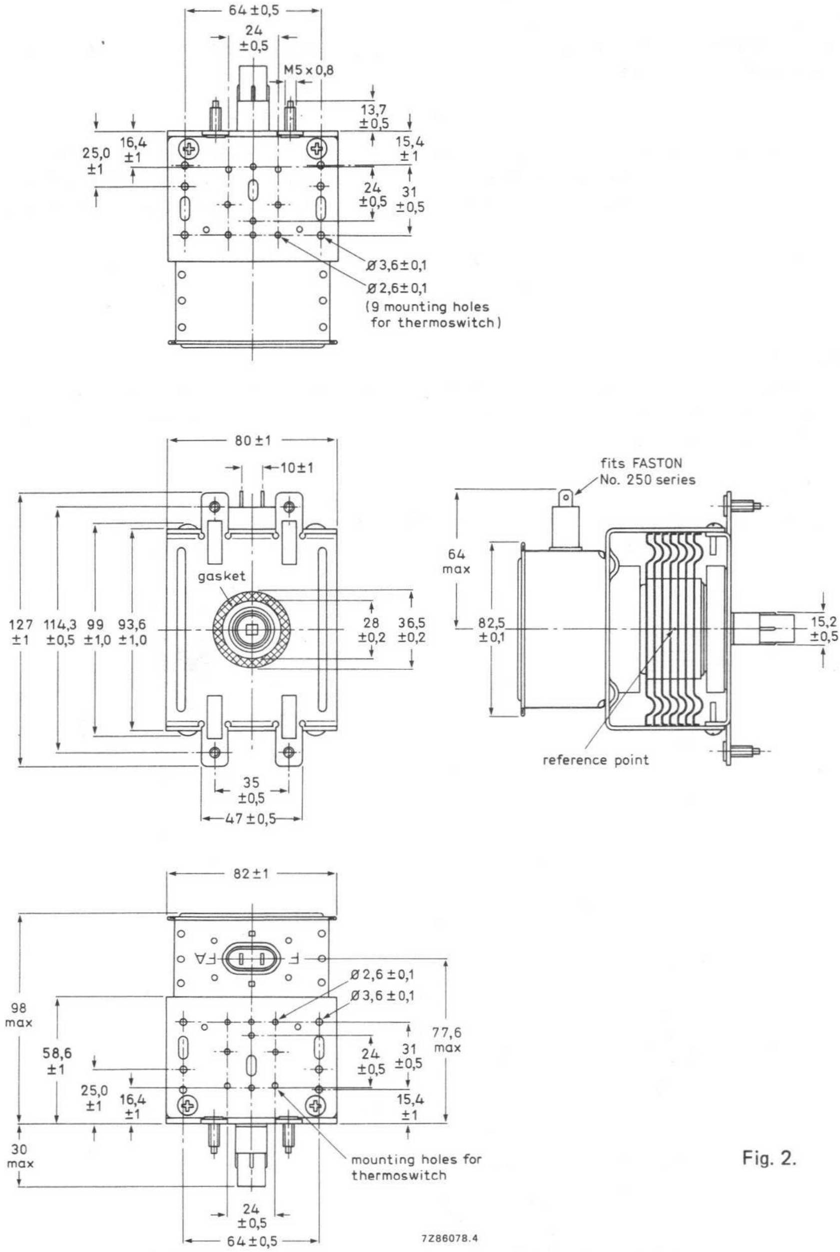


Fig. 2.

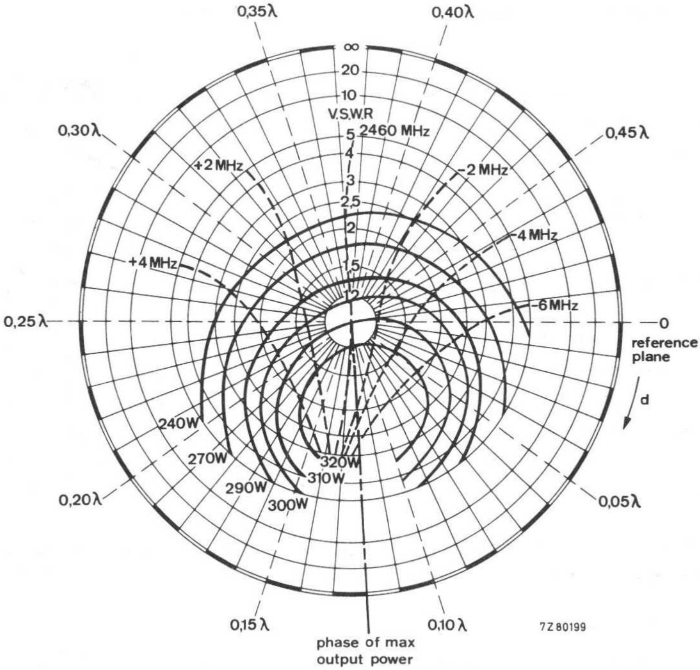


Fig. 3 Load diagram.

Reference plane	output of coupling section (see Fig. 1).
Anode supply	operation B: pulsed
Filament voltage	3,4 V
Average anode current	150 mA
Peak anode voltage	3 kV
Frequency at matched load	f_o = 2,46 GHz

d = distance of VSWR - minimum from reference plane towards load

Diagram measured in cold condition.

Cooling characteristics

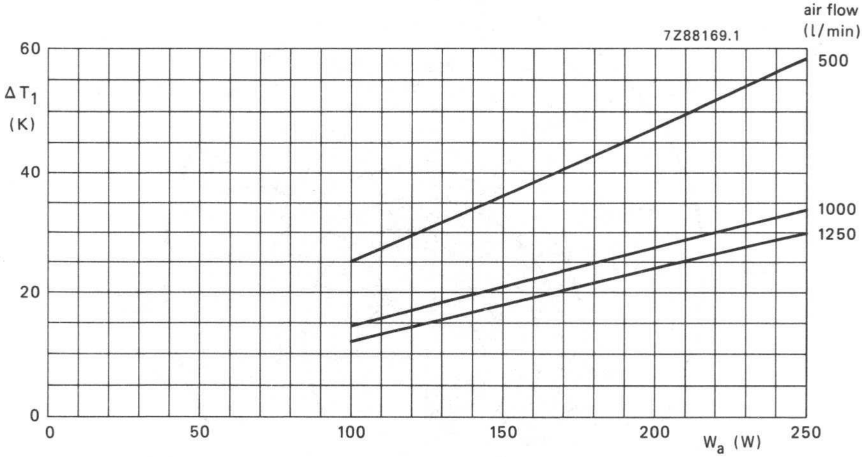


Fig. 4 Increase temperature of thermoswitch mounting position above inlet air temperature, ΔT_1, as a function of anode dissipation, W_a.

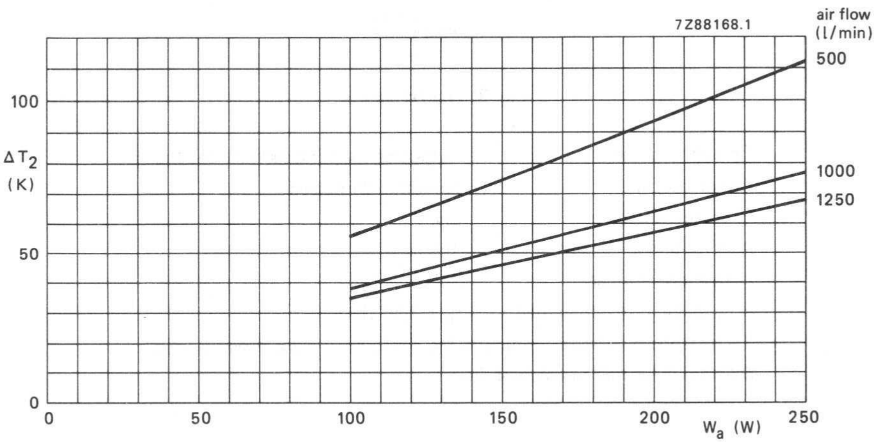


Fig. 5 Increase of anode temperature above inlet air temperature, ΔT_2, as a function of anode dissipation, W_a. Anode dissipation = (peak anode voltage) x (average anode current) – (output power). V_f = 3,4 V.

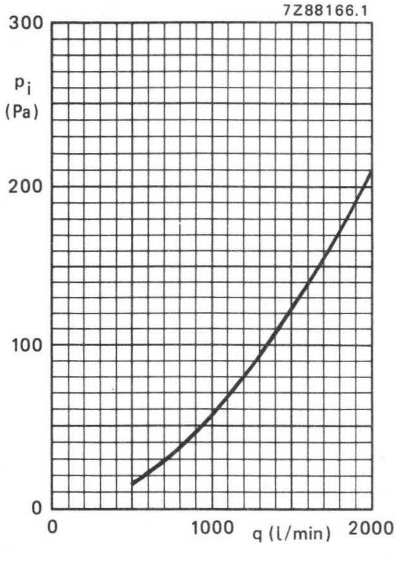


Fig. 6 Pressure drop, p_i, across radiator as a function of air flow, q.

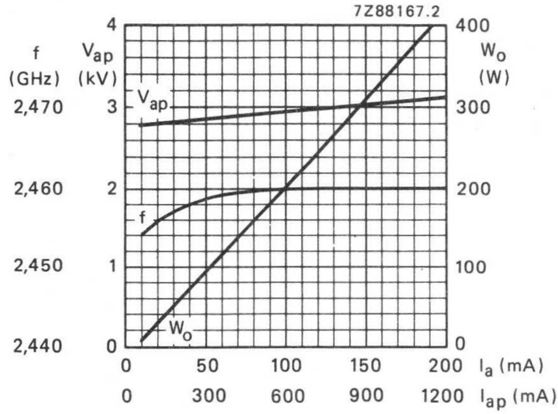


Fig. 7 Performance chart.
$f = f(I_{ap})$; $V_{ap} = f(I_{ap})$; $W_o = f(I_a)$.

CONTINUOUS-WAVE MAGNETRON

Packaged, metal-ceramic, forced-air cooled, continuous-wave magnetron with integral r.f. cathode filter. The tube is primarily intended for use in diathermy and other low-power heating applications. The tube features cold start operation and high efficiency. A built in electromagnet allows output power control.

QUICK REFERENCE DATA

Frequency, matched load	f	2,46 GHz
Output power	W_o	310 W
Output power control	by electromagnet	
Construction	packaged, metal-ceramic	
Cathode	thoriated tungsten cold start, quick heating	
R.F. cathode filter	integral	
Cooling	forced air	

TYPICAL OPERATION

Tube coupled to waveguide section of Fig. 1.
Matched load in coaxial output line; for other load conditions see Fig. 3.

Anode supply

OPERATION A: Unsmoothed single-phase full-wave rectified voltage

OPERATION B: Pulsed

Conditions		A	B	
Filament voltage, a.c. 50 or 60 Hz	V_f	3,4	3,4	V
Anode current				
mean	I_a	150	150	mA
peak	I_{ap}	750	900	mA
Cooling rate of flow	q_{min}	500	500	l/min
Pressure drop	p_i	20	20	Pa
Performance				
Filament current	I_f	15	15	A
Anode voltage, peak	V_{ap}	3,0	3,0	kV
Frequency	f	2,46	2,46	GHz
Output power, VSWR $< 1,05$	W_o	300	310	W
Efficiency	η	68	68	%

HEATING

Thoriated tungsten, cold start, quick-heating cathode			
Filament voltage	V_f		3,4 V ± 10%
Filament current at V_f = 3,4 V, I_a = 0	I_f		15 A
Cold filament resistance	R_{fo}		32 mΩ
Pre-heating time (waiting time)	t_w		0

GENERAL DATA

Electrical

Frequency, fixed within the band	f		2,450 to 2,470 GHz
Phase for maximum output power	d		0,12 λ

Mechanical

Mounting position	any		
Mass		≈	1,1 kg

LIMITING VALUES (Absolute maximum rating system)

Filament voltage	V_f	max.	3,75 V
		min.	3,05 V
Anode current			
mean	I_a	max.	200 mA
peak			950 mA *
Anode voltage	V_a	max.	10 kV
Temperature at reference point (see outline drawing)	T	max.	180 °C
Voltage-standing-wave-ratio	VSWR	max.	5
Storage temperature		min.	−30 °C
Electromagnetic coil dissipation (mean)	W_m	max.	25 W
Electromagnetic coil voltage	V_m	max.	100 V

COOLING

Anode block	forced air		
Required quantity of air, based on an air inlet temperature of 50 °C max. under typical operating conditions	q	min.	300 l/min
Pressure drop as a function of rate of flow	see Fig. 7.		
Direction of air flow through radiator	arbitrary		

To protect the magnetron from overheating, we recommend that a thermoswitch be mounted in the position shown on the outline drawing. Temperature at which the thermoswitch will switch off: see Fig. 5.

* Under no circumstances should the magnetron be permitted to mode. Amongst other conditions, the moding stability of a magnetron depends on the R.F. loading conditions such as VSWR, phase of reflection, and coupling section. It also depends on peak anode current, mean anode current, and current waveform.

DESIGN AND OPERATING NOTES

General

Whenever operation of the magnetron at conditions substantially different from those indicated under *Typical operation* is considered the tube supplier should be consulted.

Filament supply

Simultaneous application of filament and anode voltage is permitted ('cold start'). The filament winding of the transformer must be well insulated from the primary winding since the anode is earthed and the cathode is at a high negative potential with respect to the anode and the primary winding.

Tube cleanness

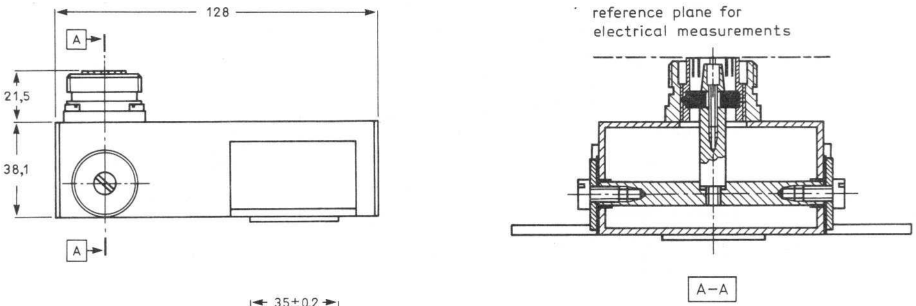
The ceramic part of the output structure of the tube must be kept clean and dry during installation and operation.

Mounting

The magnetron should be mounted on a coupling section by means of the 4 bolts M5 (see outline drawing). To ensure good r.f. contact between the magnetron and the coupling section, the nuts should be fastened evenly.

FILTERS

Coupling filter of Fig. 1 meets CISPR11 recommendation up to 1 GHz. A filter meeting CISPR11 up to 18 GHz is also available.



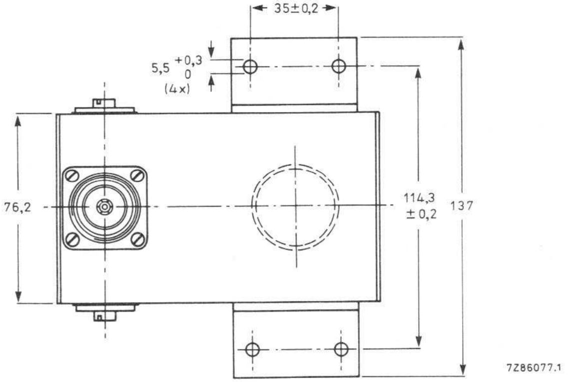


Fig. 1 Coupling filter (detailed drawings available on request).

Electromagnet

Electromagnet coil inductance	L_m	20 mH
Electromagnet coil resistance	R_m	10 Ω

I_m is positive when red connector is positive with respect to blue connector, see Fig. 3.

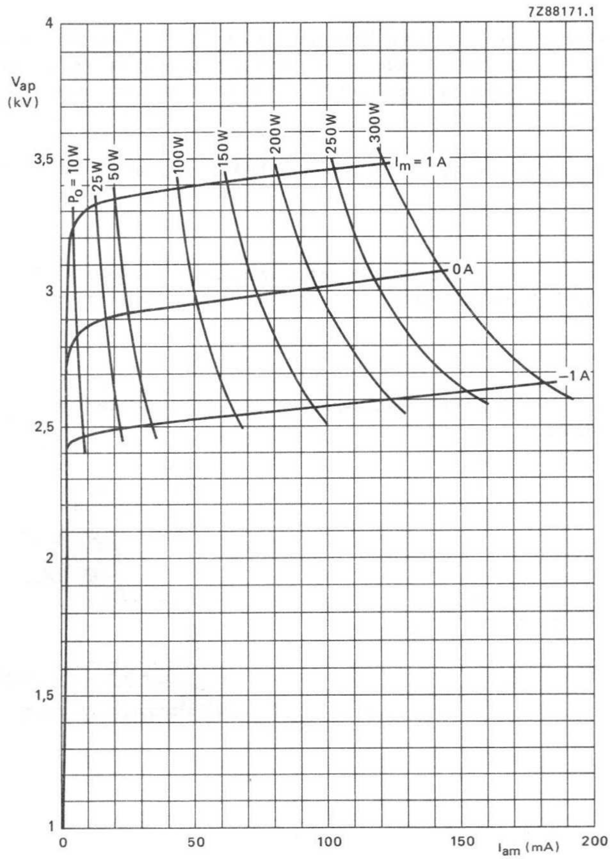


Fig. 2 Performance chart 1.

MECHANICAL DATA

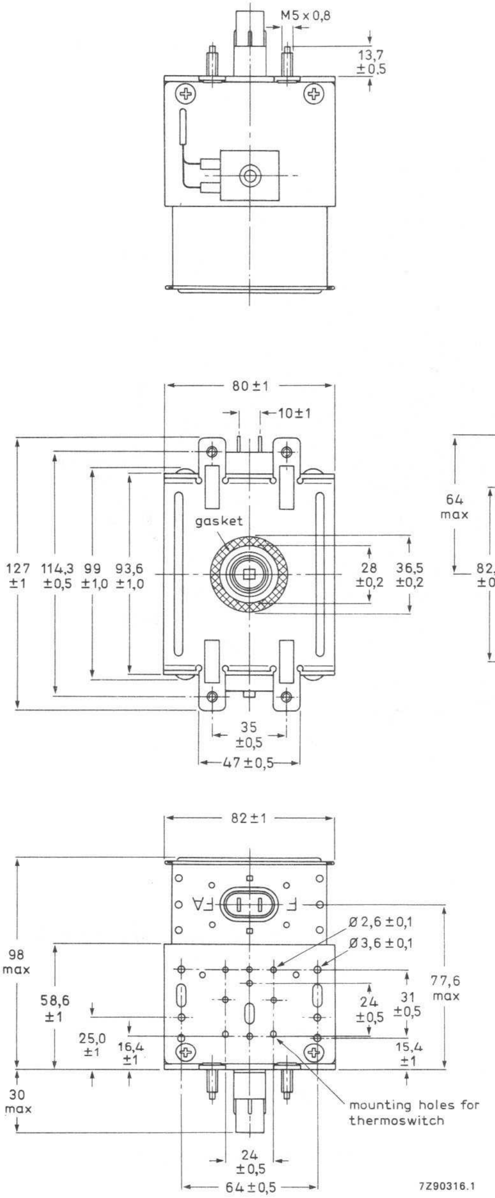


Fig. 3.

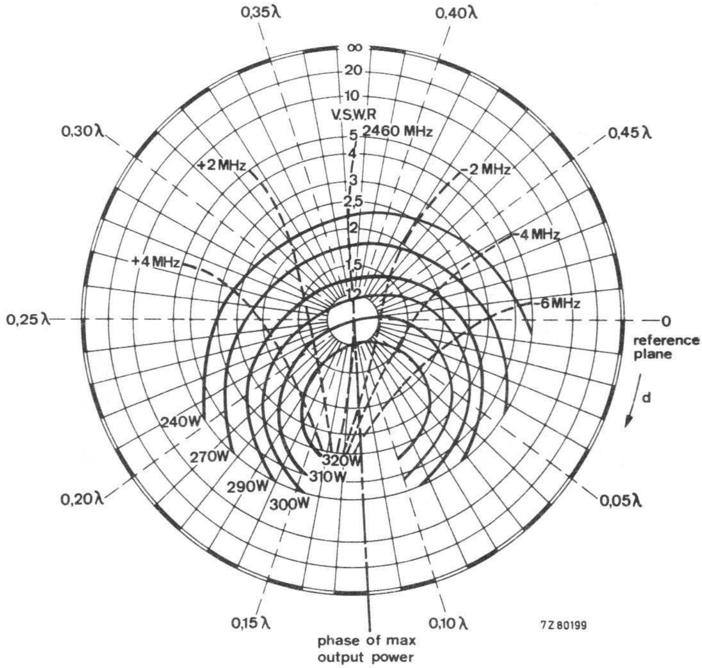


Fig. 4 Load diagram.

Reference plane	output of coupling section (see Fig. 1).
Anode supply	operation B: pulsed
Filament voltage	3,4 V
Average anode current	150 mA
Peak anode voltage	3 kV
Frequency at matched load	2,46 GHz
Electromagnetic coil current	0 A

d = distance of VSWR- minimum from reference plane towards load

Diagram measured in cold condition.

Cooling characteristics

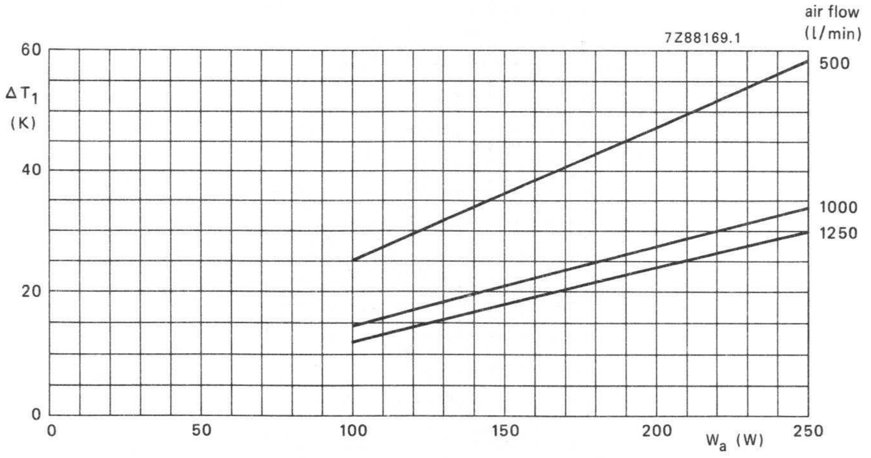


Fig. 5 Increase temperature of thermoswitch mounting position above inlet air temperature, ΔT_1 as a function of anode dissipation, W_a.

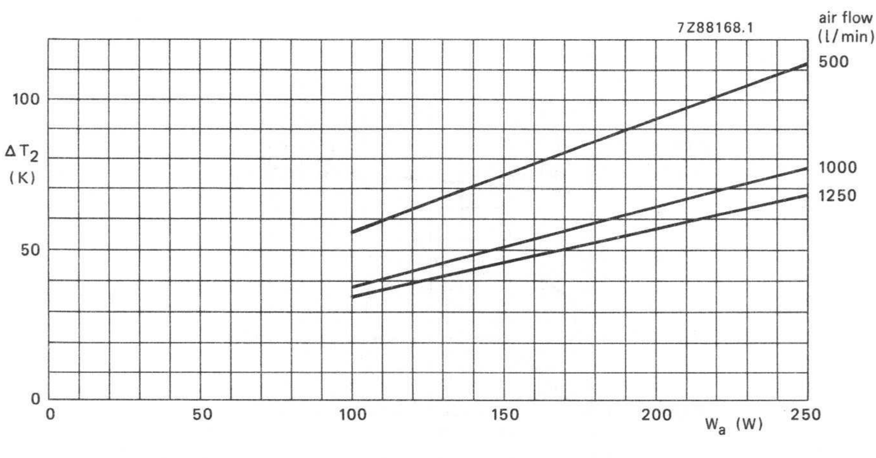


Fig. 6 Increase of anode temperature above inlet air temperature, ΔT_2, as a function of anode dissipation, W_a. Anode dissipation = (peak anode voltage) x (average anode current) — (output power). V_f = 3,4 V.

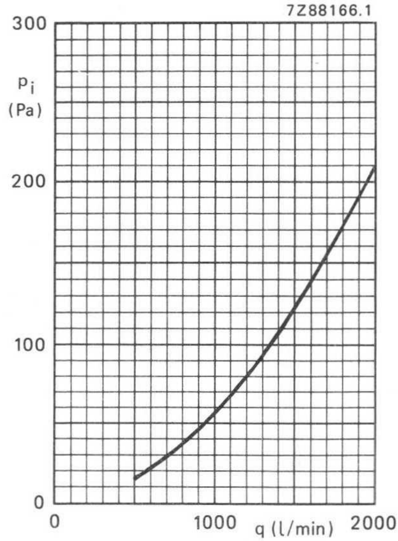


Fig. 7 Pressure drop, p_i, across radiator as a function of air flow, q.

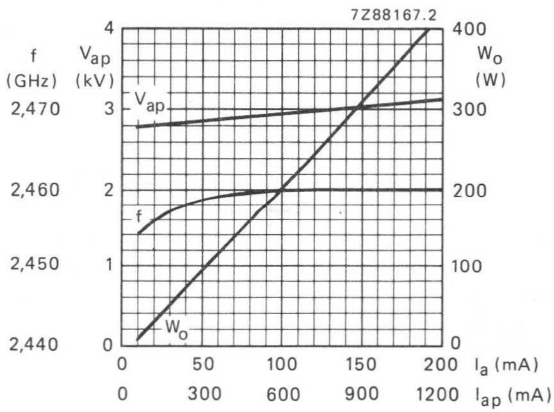


Fig. 8 Performance chart 2.
$f = f(I_{ap})$; $V_{ap} = f(I_{ap}$; $W_o = f(I_a)$.

CONTINUOUS-WAVE MAGNETRON

Packaged, metal-ceramic, forced-air cooled, continuous-wave magnetron with integral r.f. cathode filter. The tube is intended for microwave heating applications and features cold-start operation and high efficiency. Under typical operating conditions the output power is 1260 W. This lightweight tube may be mounted in any position.

QUICK REFERENCE DATA

Frequency, matched load	f	2,46 GHz
Output power	W_o	1260 W
Construction	packaged, metal-ceramic	
Cathode	thoriated tungsten, cold start, quick heating	
R.F. cathode filter	integral	
Cooling	forced-air	

TYPICAL OPERATION

Conditions

Filament voltage	V_f	4,4 V
Anode supply (see *Design and operating notes*)	LC stabilized half-wave doubler	
Average anode current	I_a	400 mA
Cooling, rate of flow	q	1700 l/min
Pressure drop	P_i	190 Pa

Performance (at matched load see Fig. 6; for other load conditions see Fig. 4)

Filament current	I_f	14 A
Anode voltage, peak	V_{ap}	4,5 kV
Frequency	f	2,46 GHz
Output power, VSWR $< 1,1$	W_o	1260 W
Efficiency	η	70 %

HEATING

Thoriaded tungsten, cold start, quick-heating cathode

Filament voltage	V_f		3,8 to 4,8	V
Filament current at $V_f = 4{,}4$ V, $I_a = 0$	I_f		14	A
Cold filament resistance	R_{fo}		40	mΩ
→ Pre-heating time (waiting time)	t_w	min.	10	s

GENERAL DATA

Electrical

Frequency, fixed within the band	f		2,445 to 2,47	GHz

Mechanical

Mounting position	any			
Mass		≈	1,3	kg

LIMITING VALUES (Absolute maximum rating system)

Filament voltage	V_f	max.	4,8	V
		min.	3,8	V
Anode current mean	I_a	max.	450	mA
			1600	mA*
Anode voltage	V_a	max.	10	kV
Anode input power	W_{ia}	max.	2,25	kW
Temperature at reference point (see outline drawing)	T	max.	180	°C**
Storage temperature	T_{stg}	max.	60	°C
		min.	−30	°C
Voltage standing-wave ratio	VSWR	max.	4	
during max. 0,02 S and max. 20%	VSWR	max.	10	*

* Under no circumstances should the magnetron be permitted to mode. Amongst other conditions, the moding stability of a magnetron depends on the r.f. loading conditions such as VSWR, phase of reflection, and coupling section. It also depends on peak anode current, mean anode current, and current waveform.

** For short periods a maximum anode temperature of 240 °C may be allowed.

COOLING

Anode block	forced air		
Required quantity of air, based on an air inlet temperature of 50 °C max. under typical operating conditions	q	min.	1700 l/min
Pressure drop as a function of rate of flow	see Fig. 6		
Direction of air flow through radiator	arbitrary		

To protect the magnetron against overheating it is recommended that a thermoswitch be mounted in the position shown on the outline drawing. Temperature at which the thermoswitch will switch off: see Fig. 5.

ACCESSORIES

Dimensions in mm

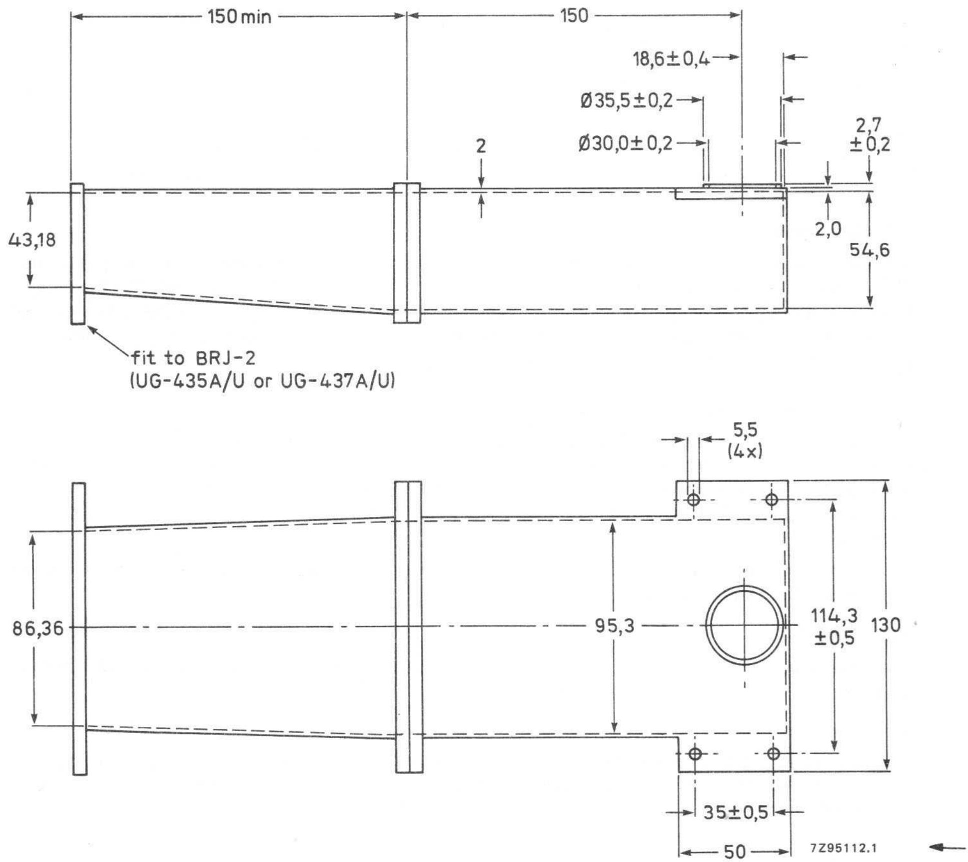


Fig. 1 Coupling section for YJ1540 into a waveguide R22.

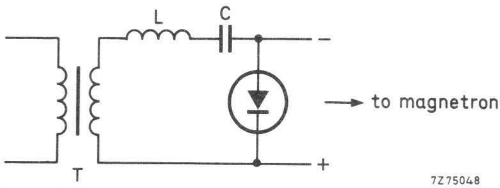
DESIGN AND OPERATING NOTES

General

Whenever operation of the magnetron at conditions substantially different from those indicated under *Typical operation* is considered the tube supplier should be consulted.

Anode supply

The magnetron may be operated from an LC stabilized half-wave doubler anode supply unit.



L = leakage inductance of transformer T.

Fig. 2 Basic circuit of an LC stabilized half-wave doubler anode supply unit.

Filament supply

Simultaneous application of filament and anode voltage is permitted ('cold start', however, pre-heating of the filament for a few seconds is recommended to extend the life of the magnetron. The filament winding of the transformer must be well insulated from the primary winding since the anode is earthed and the cathode is at a high negative potential with respect to the anode and the primary winding.

When 'variable power control' is used, please contact the tube supplier.

Load impedance, measured with measuring probe

The measuring probe type 55396 enables the designer of the microwave oven to determine the value of the load impedance (VSWR and phase of reflection), using standard cold measuring techniques, and to arrive at the correct coupling for the magnetron. For the cold measurements the probe is coupled to the coupling section instead of the magnetron. The termination of the probe matches a standard N-type connector.

Assistance in the design of the h.f. part of the oven, including the magnetron coupling method, may be given by the tube manufacturer.

Tube cleanness

The ceramic part of the output structure of the tube must be kept clean and dry during installation and operation.

Mounting

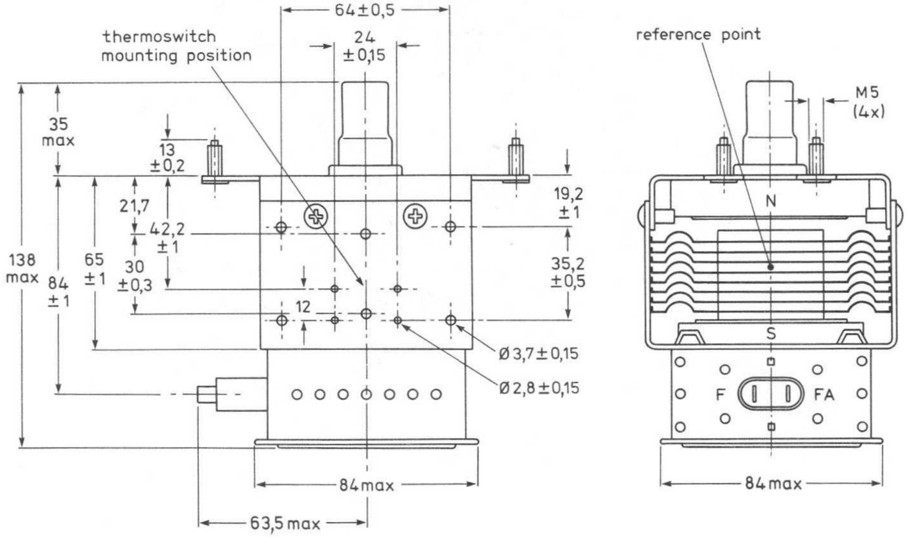
The magnetron should be mounted on a coupling section by means of the 4 bolts M5 (see outline drawing). To ensure good r.f. contact between the magnetron and the coupling section, the nuts should be fastened evenly.

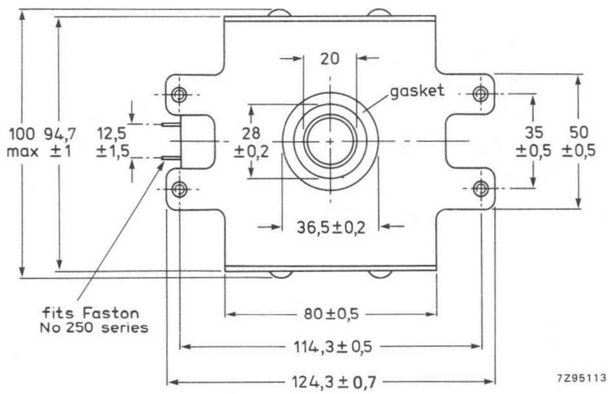
MECHANICAL DATA

Dimensions in mm

Mounting position: any

Net mass: approx. 1,1 kg





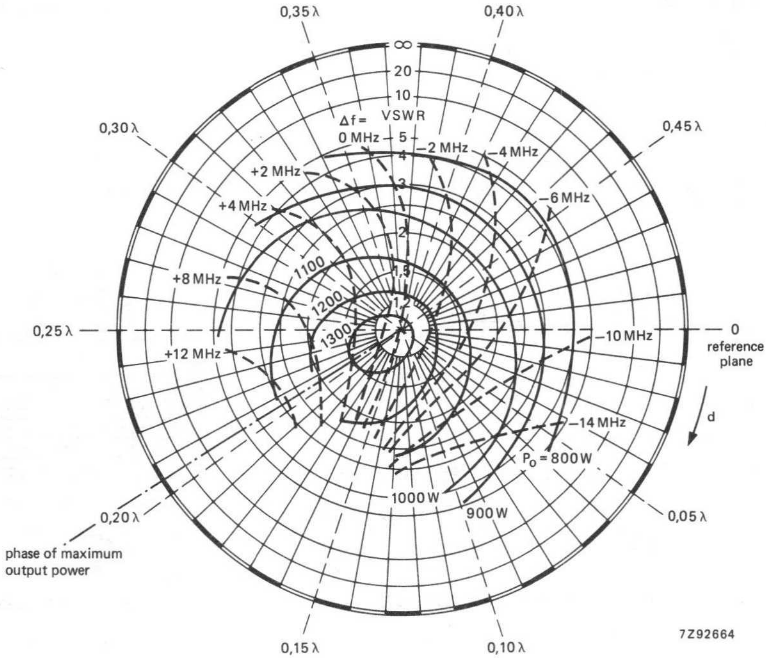


Fig. 4 Load diagram.

Reference plane:	antenna
Anode supply:	unfiltered single-phase full-wave
Filament voltage:	4,4 V
Average anode current:	400 mA
Peak anode voltage:	4,5 kV at matched load
Frequency at matched load:	2,46 GHz

d = distance of VSWR - minimum from reference plane towards load.

Diagram measured under cold condition.

Cooling characteristics

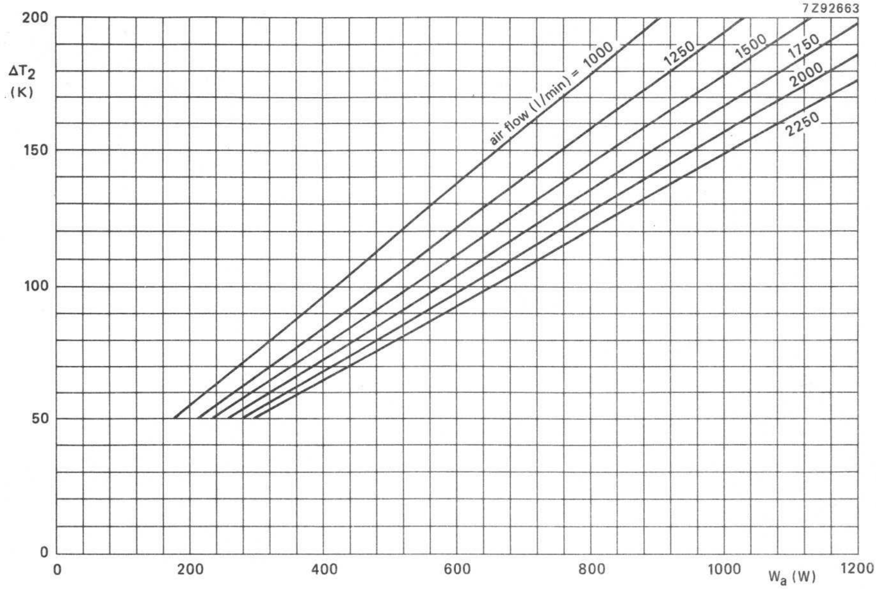


Fig. 5 Increase of anode temperature above inlet air temperature, ΔT_2, as a function of anode dissipation, W_a. Anode dissipation = (peak anode voltage) x (average anode current) – (output power).

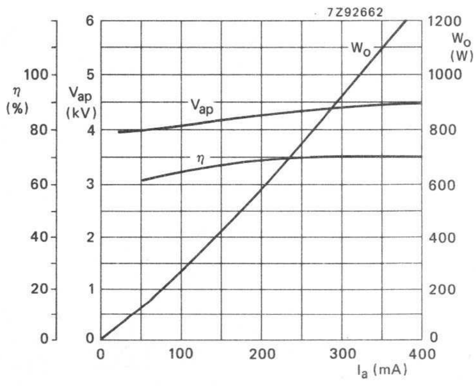


Fig. 6 Performance chart.

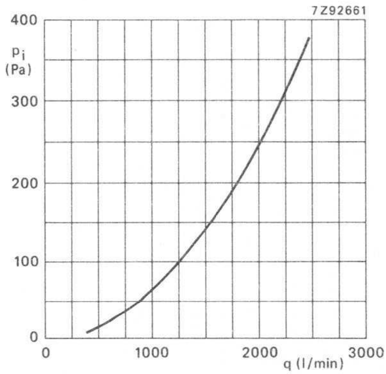


Fig. 7 Pressure drop, p_i, across radiator as a function of air flow, q.

CONTINUOUS-WAVE 5 kW MAGNETRON

Packaged, metal-ceramic, water-cooled continuous-wave magnetron with integral r.f. filter intended for use in industrial microwave heating applications. The tube features a quick-heating cathode, high efficiency, and has a typical output power of 5 kW. A built-in electromagnet allows output power control and stabilization.

QUICK REFERENCE DATA

Frequency, matched load, fixed within the band	f	2,45 to 2,47 GHz
Output power	W_o	5 kW
Output power control and stabilization		by electromagnet
Construction		packaged, metal ceramic
Cathode		quick heating thoriated tungsten
Cooling		water and air
R.F. cathode filter		integral

TYPICAL OPERATION

Tube coupled to waveguide section of Fig. 6. VSWR = 2,5 in phase of maximum W_o (d = 0,03 λ) measured with probe type 55386. Anode supply: three-phase full-wave rectified voltage.

Conditions, for 5 kW output power

Filament voltage, a.c. or d.c., starting	V_f	5,0	V ± 10%
Waiting time	t_w	10	s
Filament voltage, operating	V_f	see Fig. 3	
Anode current, mean	I_a	950	mA
Anode current, peak	I_{ap}	1200	mA
Cooling	see relevant paragraph		

Performance

Filament current at V_f = 5,0 V	I_f	33	A
Electromagnet coil current at T_{amb} = 25 °C	I_m	−1,7	A
Anode voltage, peak	V_{ap}	7,2	kV
Output power	W_o	5	kW
Frequency	f	2,46	GHz
Efficiency	η	72	%

For other load impedance and anode current conditions see Figs 8 and 9 and "Design and operating notes".

CATHODE: thoriated tungsten, quick start

HEATING: direct by a.c. (50 Hz or 60 Hz) or d.c.

Filament voltage, starting and stand-by	V_f		5,0 V ± 10%
Filament current at V_f = 5,0 V; I_a = 0	I_f		33 A
Filament voltage, operating	see Fig. 3		
Cold filament resistance	R_{fo}		23 mΩ
Waiting time (time before application of high voltage)	t_w	min.	10 s

Immediately after applying the anode voltage the filament voltage must be reduced to the operating value, see Fig. 3.

COOLING

Anode block, see Fig. 1	water		
R.F. filter box, see Fig. 2	air		
Required rate of flow at 25 °C	q	min.	100 ℓ/min.
at 50 °C			120 ℓ/min.
Antenna, see Fig. 2	air		
Required rate of flow at 25 °C	q	min.	50 ℓ/min.
at 50 °C			60 ℓ/min.

With only the filament voltage applied some water and air cooling is required.

To safeguard the magnetron against overheating it is recommended to mount a thermoswitch, see outline drawing. This switch should operate at a temperature of 80 ± 5 °C.

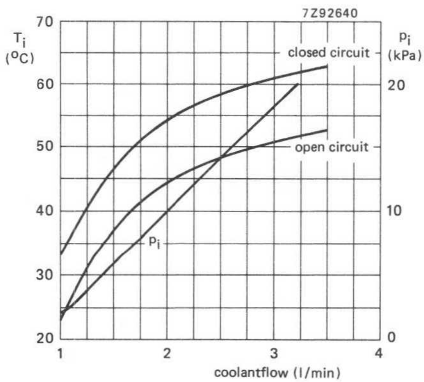


Fig. 1 Pressure drop and maximum inlet temperature as a function of waterflow.

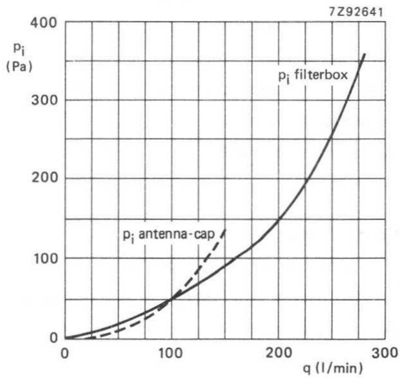


Fig. 2 Pressure drop filterbox and antenna-cap cooling as a function of airflow.

ELECTRICAL DATA

Frequency, matched load, fixed within the band	f		2,450 to 2,470 GHz
Phase for maximum output power	d		0,03 λ
Coil inductance (parallel)	R_e		4,1 Ω
	L_e		20 mH

LIMITING VALUES (Absolute maximum rating system)

Filament voltage, starting	V_f	max.	5,5 V
		min.	4,5 V
Anode current, mean	I_a	min.	100 mA
		max.	1100 mA
Anode current, peak	I_{ap}	max.	1300 mA*
Anode voltage	V_a	max.	10 kV
Temperature at reference point, see outline drawing	T	max.	85 °C
Seal temperature	T_s	max.	220 °C
Cooling water outlet temperature,			
closed cooling circuit	T_o	max.	75 °C
open cooling circuit	T_o	max.	65 °C
Cooling air temperature	T_{air}	max.	50 °C
Voltage standing-wave ratio	VSWR	max.	4,0
Storage temperature	T_{st}	min.	–30 °C
Electromagnet coil current (parallel)	I_m	max.	5 A
Voltage between coil and tube	V_c	max.	48 V

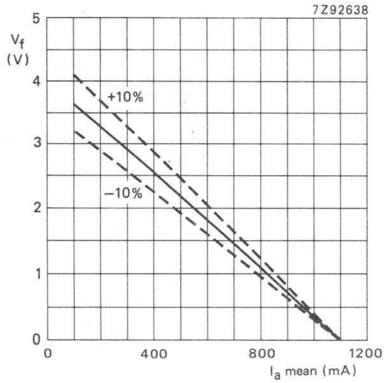


Fig. 3 Filament voltage reduction curve with applied anode voltage. Filament starting voltage without anode voltage is 5,0 V ± 10%.

* Under no circumstances should the magnetron be permitted to mode. Amongst other conditions, the moding stability of a magnetron depends on the r.f. loading conditions such as VSWR, phase of reflection and coupling section. It also depends on peak anode current, mean anode current and current waveform.

MECHANICAL DATA

Dimensions in mm

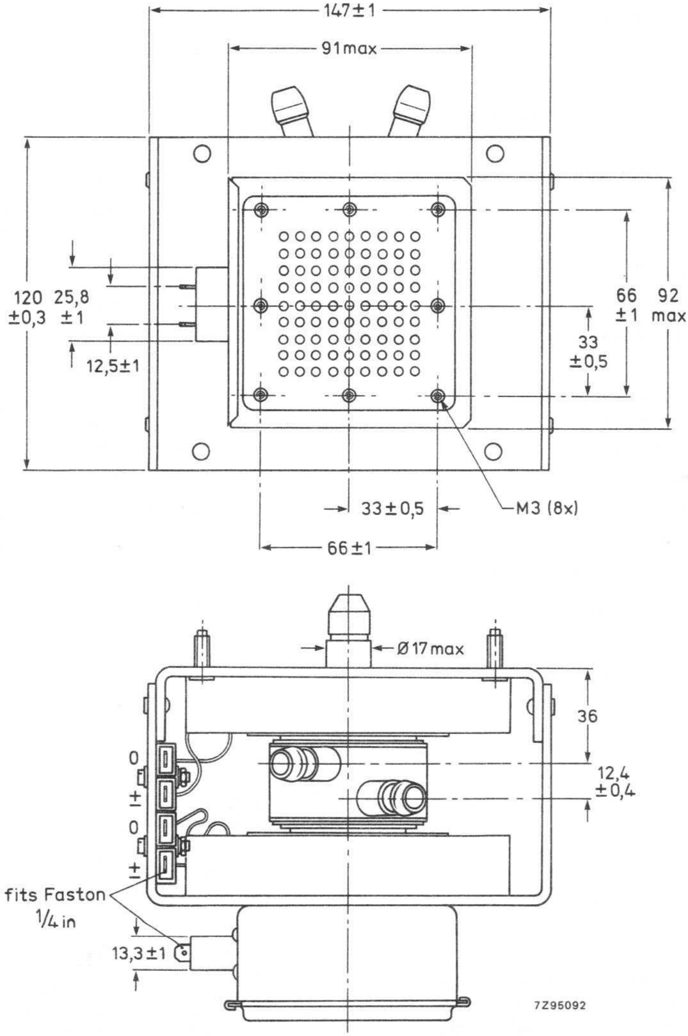


Fig. 4a.

Mounting position: any

Mass: approx. 4,3 kg

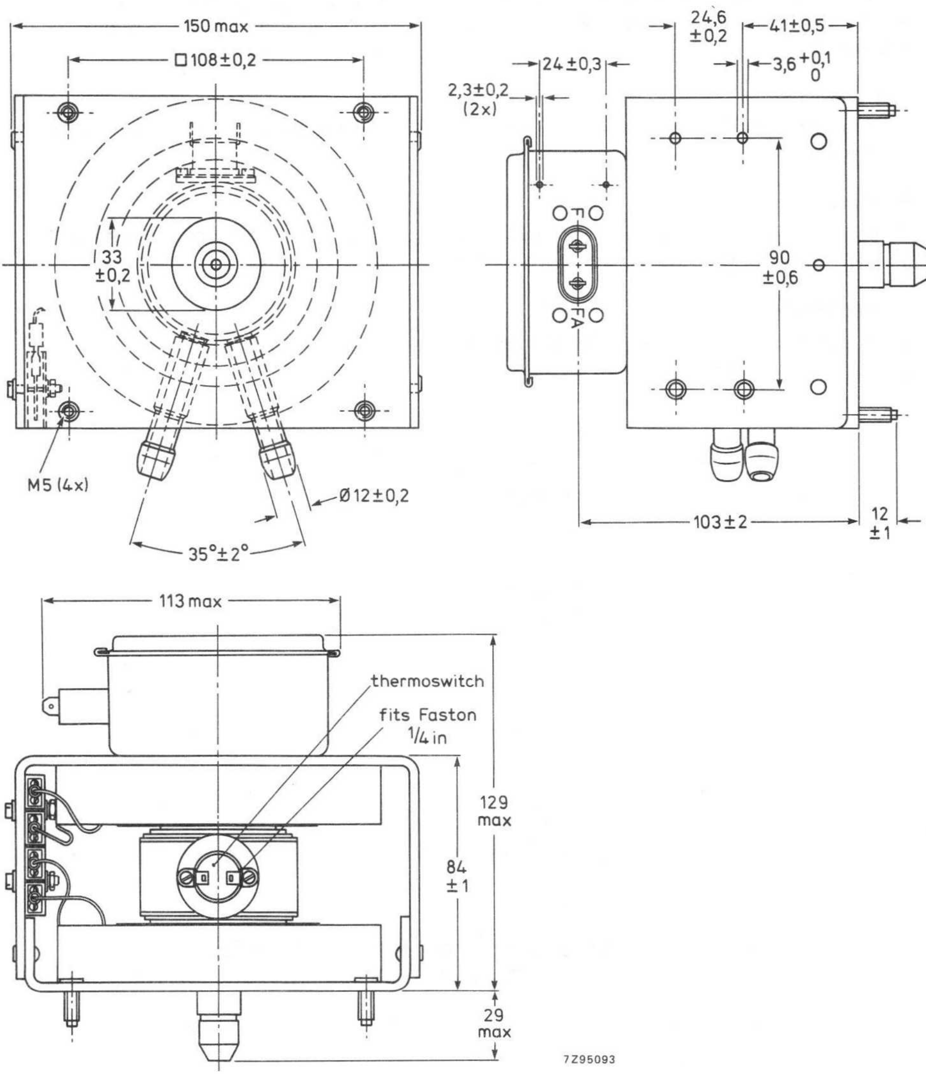

150 max
□108±0,2
33
±0,2
M5 (4x)
Ø12±0,2
35°±2°
24,6
±0,2
41±0,5
24±0,3
3,6 +0,1 0
2,3±0,2
(2x)
F
FA
90
±0,6
103±2
12
±1
113 max
thermoswitch
fits Faston
1/4 in
129
max
84
±1
29
max
7Z95093

Fig. 4b.

DESIGN AND OPERATING NOTES

General

The manufacturer should be consulted when cycled operation or operation without circulator is chosen or when it is considered necessary to operate the magnetron at conditions substantially different from those stated under "Typical operation", or with deviating power supply/control circuitry.

Tube cleanness

The ceramic part of the output structure of the tube must be kept clean and dry during installation and operation.

Mounting

The magnetron should be mounted on a coupling section by means of four M5 bolts (see outline drawing). To ensure good r.f. contact these nuts should be tightened evenly.

ACCESSORIES

An r.f. gasket, catalogue number 8222 033 90851 is supplied with each tube.

A measuring probe 55386, see Fig. 5.

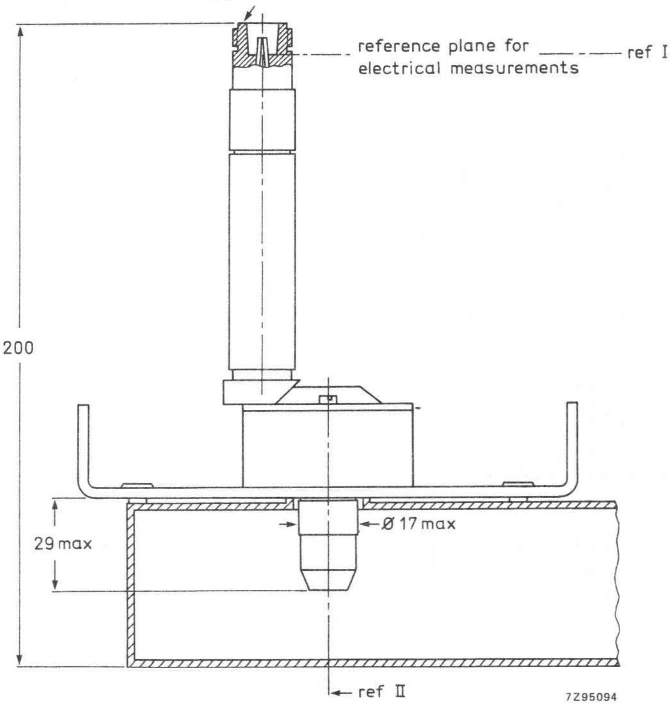


Fig. 5 Measuring probe type 55386 in coupling section R26.

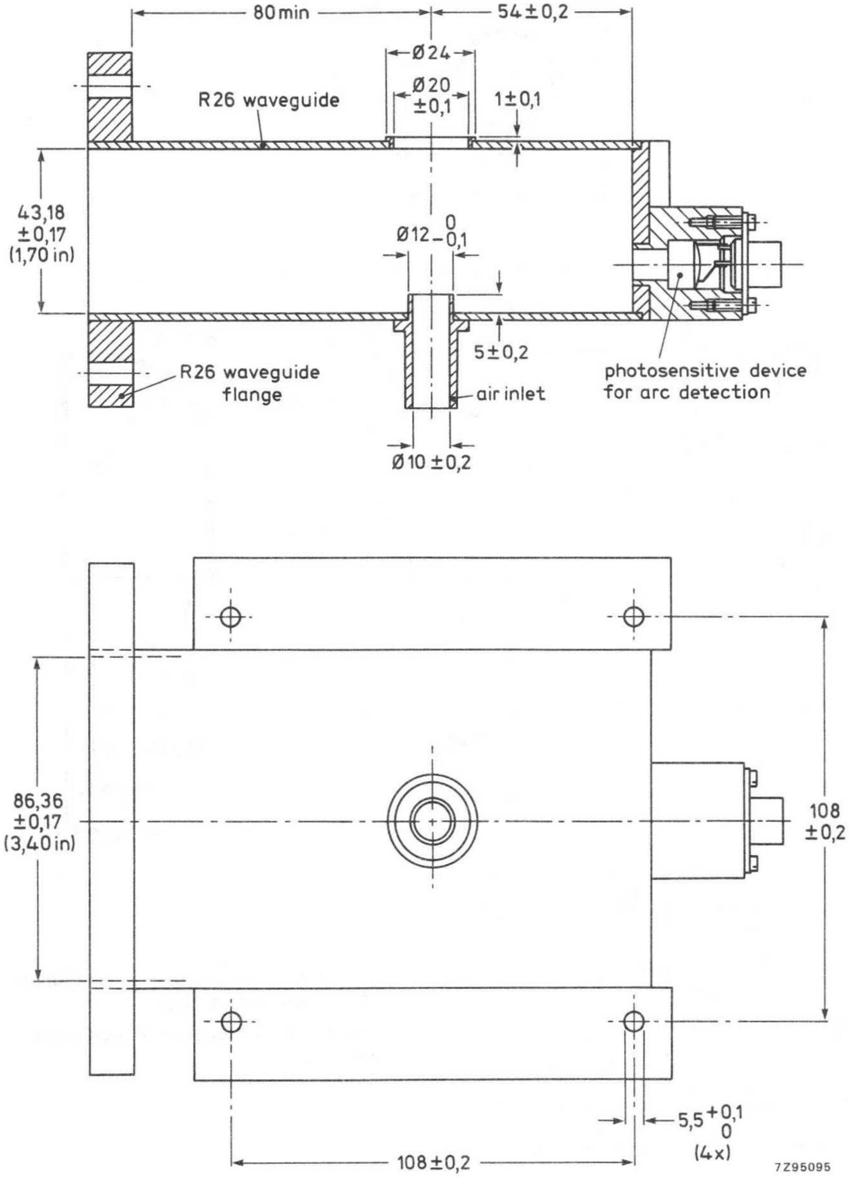


Fig. 6 Waveguide assembly.

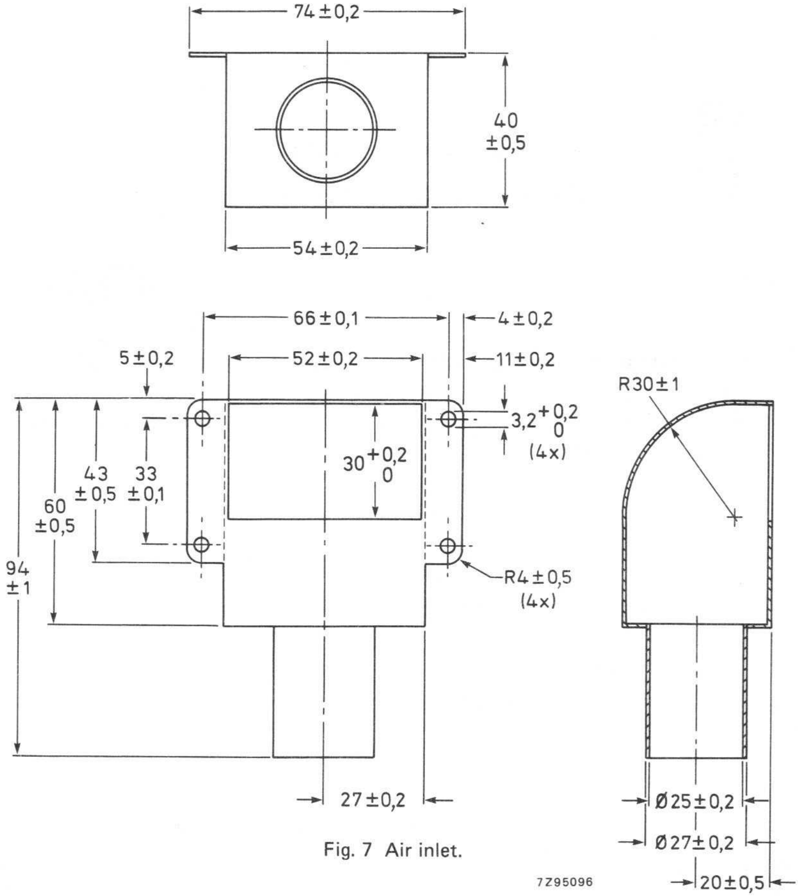


Fig. 7 Air inlet.

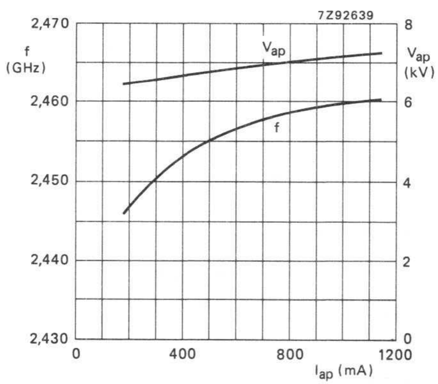


Fig. 8 Peak anode voltage, V_{ap}, as a function of peak anode current, I_{ap}.

Frequency, f, as a function of peak anode current I_{ap}.

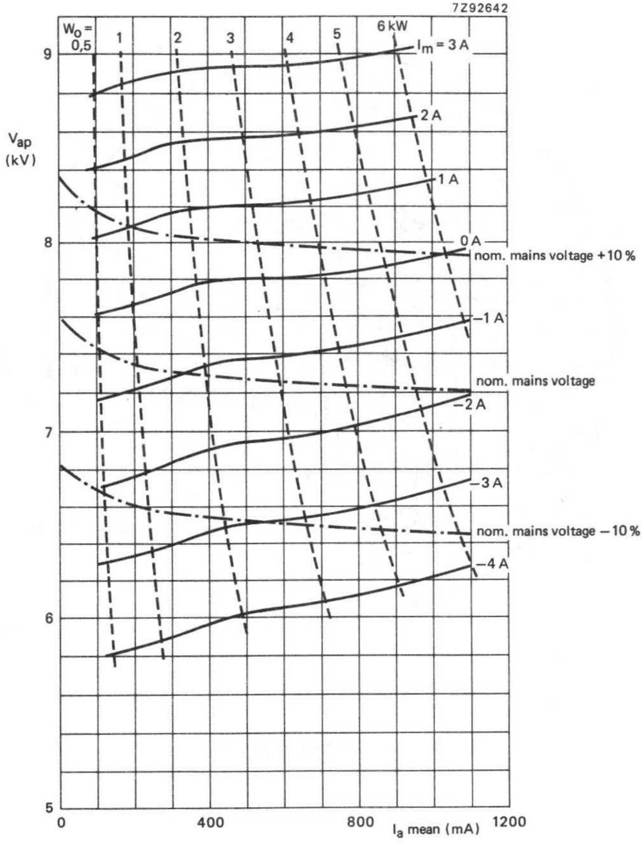


Fig. 9 Performance chart. Conditions: magnet temperature 25 °C; load impedance 2,5 sink.

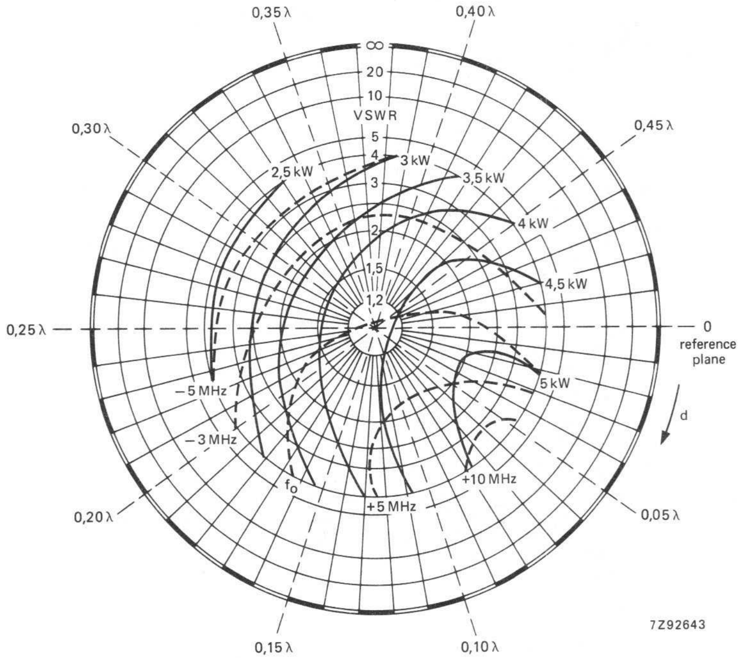


Fig. 10 Load diagram in waveguide.

CONTINUOUS-WAVE MAGNETRON

Integral-magnet, air-cooled or heatsink-cooled continuous-wave magnetron intended for diathermy and other low-power heating applications.

QUICK REFERENCE DATA

Frequency, fixed within the band	f	2,425 to 2,475 GHz
Output power	W_o	200 W
Construction	packaged	
Cathode	nickel matrix type	

CATHODE: nickel matrix type

HEATING: indirect by a.c. 50 Hz to 60 Hz, or d.c.

		Operation A, B, and D	Operation C	
Heater voltage, starting and stand-by	V_f	5,3	4,8	V ± 10%
Hetar current at starting voltage	I_f	3,5	3,3	A
Heater current, peak starting	I_{fp}	max. 8,5		A
Cold heater resistance	R_{fo}	0,2		Ω
Waiting time	t_w	min. 180	min. 240	s

TYPICAL CHARACTERISTICS

Measured under matched load conditions (VSWR < 1,05) and d.c. anode voltage.

Frequency, fixed within the band	f	2,425 to 2,475 GHz
Anode voltage, d.c.	V_a	1,55 to 1,70 kV
Anode current	I_a	200 mA

COOLING

a. Low velocity air flow with a rate of flow of 0,4 to 0,5 m^3/min. Direction of air flow, see outline drawing. The air flow need not be ducted.

or

b. Heatsink. The tube does not require any extra cooling provided it is effectively mounted on a heat-conducting non-magnetic plate. A vertical position of this plate facilitates the heat transfer.

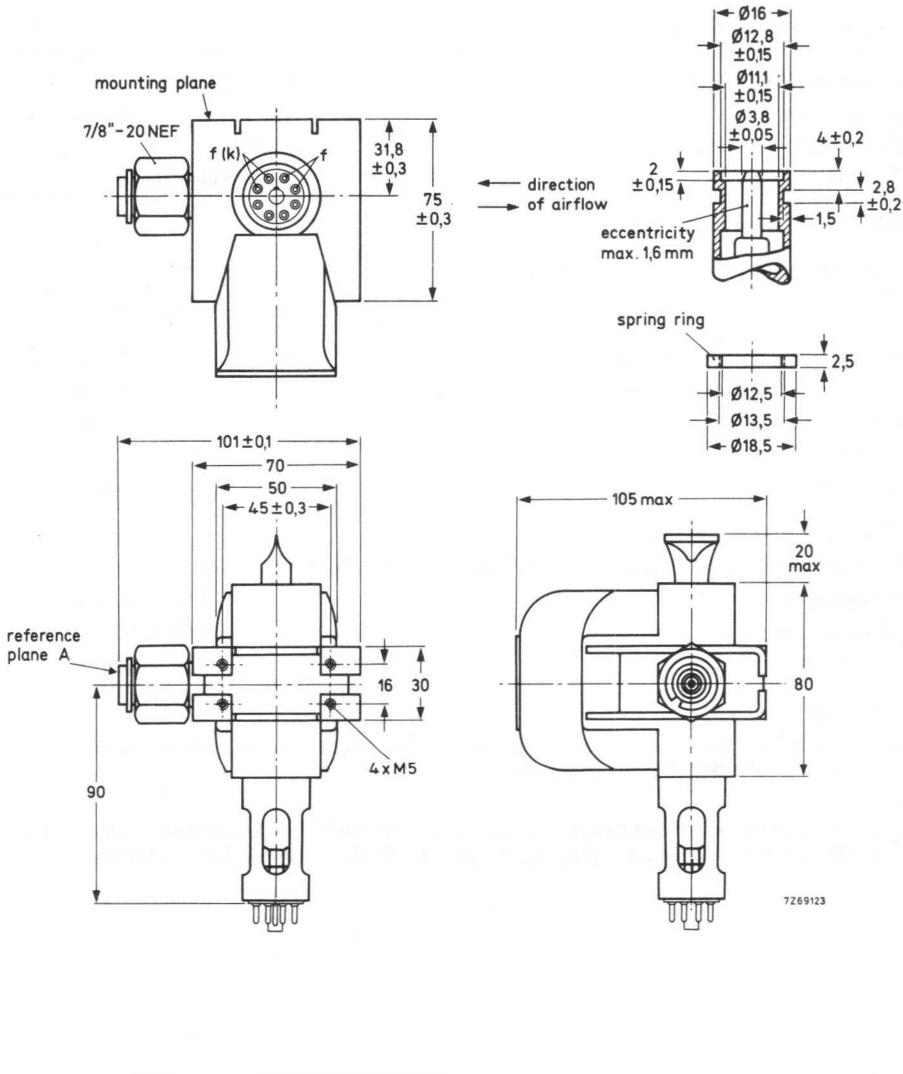
MECHANICAL DATA

Net mass: approx. 2,4 kg

Mounting position: any

Base: octal

The socket for this base should not be rigidly mounted, it should have flexible leads and be allowed to move freely.



INDEX OF TYPE NUMBERS

NOTES

NOTES

NOTES

NOTES

NOTES

Mullard

technical handbook

Book 2

MULLARD DISTRIBUTOR SERVICE

B.A. Electronics Ltd.
Hitchin Road, Arlesey, Beds. SG15 6SU.
Tel: Hitchin (0462) 834777. Telex: 826257

Farnell Electronic Components Ltd.
Canal Road, Leeds LS12 2TU.
Tel: Leeds (0532) 636311. Telex: 55147.

Gothic Crellon Ltd.
380 Bath Road, Slough SL1 6JE.
Tel: Burnham (06286) 4434. Telex: 847571.

Intel Electronics Group Ltd,
Trading Estate, Henlow, Bedfordshire SG16 6DS.
Tel: Hitchin (0462) 812505, (0462) 815555. Telex: 825637.

Jermyn Distribution Ltd.
Vestry Estate, Sevenoaks, Kent TN13 5EU.
Tel: Sevenoaks (0732) 450144. Telex: 95142.

Macro
Burnham Lane, Slough SL1 6LN.
Tel: Burnham (06286) 4422. Telex: 847945.

Online Distribution Ltd.
St. Martins Way, Industrial Estate, Cambridge Road, Bedford MK42 0LF.
Tel: Bedford (0234) 217915. Telex: 827665.

STC Electronic Services
Edinburgh Way, Harlow, Essex CM20 2DF.
Tel: Harlow (0279) 26777. Telex: 81525.

Swift-Sasco Ltd.
Gatwick Road, Crawley, Sussex RH10 2RU.
Tel: Crawley (0293) 28700. Telex: 87131.

Mullard **Mullard Limited**, Mullard House, Torrington Place, London WC1E 7HD. Telephone: (01) 580 6633. Telex: 264341.

Mullard manufacture and market electronic components under their own name and those of associated companies.

Printed in The Netherlands. (1M/285) 9398 128 70011 Publication No. 80505301