Technical Specifications: YJ1600FL

2.45 to 2.47 GHz 6.0kW CW Magnetron

Packaged, metal-ceramic, water cooled continuous wave magnetron with integral RF cathode 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 6 kW. A packaged permanent magnet and an integrated electromagnet system allow accurate output power control and stabilization.

Available accessories:

Isolator	2722-162-10311 (or equivalent)

QUICK REFERENCE DATA

Frequency, matched load, fixed within the band	f	2.45 to 2.47 GHz
Maximum output power with isolator	Wo	6kW
Maximum output power without isolator	Wo	5kW
Output power control and stabilization	by electromagnet	
Construction	packaged, metal ceramic	
Cathode	quick heating, Th-W	
Cooling	water and forced air	
RF cathode filter	integral	

TYPICAL OPERATION

Magnetron coupled to waveguide section of Fig. 5, Load VSWR ≤1.2

Anode supply: Three-phase full-wave rectified voltage. choke 1 to 3 H.

Made In The USA

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Conditions

Conditions, output power± 5 %	Wo	6kW**
Filament voltage, AC or DC, starting	Vf	5V ± 10%
Waiting time	tw	10 s
Filament voltage, operating	Vf	see Fig 3, 0V
Anode current, mean	Ia	1150 mA
Anode current, peak	Iap	1300 mA
Cooling	see relevant paragraph	

Performance

Filament current at Vf = 5V, starting	If	33 A
Electro-magnet current at T ambient= 25 °C	Im	-2A
Anode voltage, peak	Vap	7.2 kV
Output power	Wo	6kW
Frequency	f	2.46 GHz
Efficiency	72%	

Cathode

Thoriated tungsten, quick start.

Heating

Direct by AC (50Hz or 60 Hz) or DC

Filament voltage, starting and stand-by	Vf	5V± 10%
Filament current at Vf = 5V; Ia= 0	If	33 A
Filament voltage, operating	see Fig 3	
Cold filament resistance	Rfo	23 mΩ
Waiting time	tw	minimum 10 s
(Time before application of high voltage)		

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

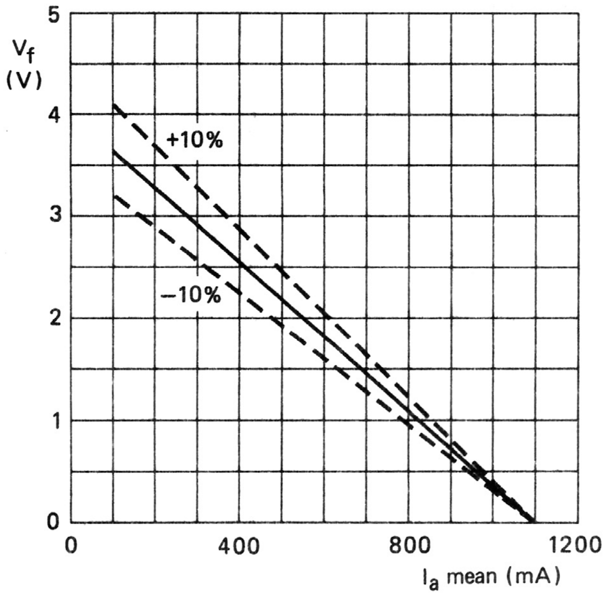

Fig. 3 Filament voltage reduction curve with applied anode voltage. Filament starting voltage without anode voltage is 5.0 V ± 10%

* For launcher sections and for other load impedance and anode current conditions see Fig s 6, 7, 8, and 9 and "Design and operating notes".
** For 6 kW output power, the magnetron must be operated with a VSWR of 2.5 ± 0.5 in the sink phase only.

COOLING

Anode, see Fig. 1	water		
Cathode RF filter box, see Fig. 2	air		
Required rate of flow at 25°C	q	min.	100 l/min
at 50°C			120 l/min
Output 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 will be required.

Interlock protection should be provided to switch off the anode and filament voltages if the cooling water flow is interrupted or will be insufficient to cool the tube properly.
Interlock protection should be provided to switch of the anode and filament voltages if the cooling air flow is interrupted or will be insufficient to cool the output antenna and cathode filter.

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Check all water connections for leaks before applying voltages.

To safeguard the magnetron against overheating it is recommended to use the thermoswitch mounted on the anode, see outline drawing 4b. The switch operates at 80± 5 °C.

The cathode filter air inlet duct should be made according to Fig. 8, or equivalent. Choose the air duct hose connection diameter and the internal hose diameter at least 25 mm to avoid a high back pressure to the blower. (A smaller and less expensive blower may then be used.)
Sufficient filter air flow is essential for good magnetron operation.
The duct should be connected to the filter box in such a way, that the air is blowing through the holes located at the filament connector side of the box.
To allow free air flow the holes in the other half of the cover should be unobstructed.

Never remove the filter box cover as it will void the tube's warranty.
This cover is very important to avoid damage to the tube and to ensure proper magnetron operation.

Sufficient cooling of the magnetron's output structure is important.
Use a tapered air inlet according to the waveguide section figures 5 or 6.

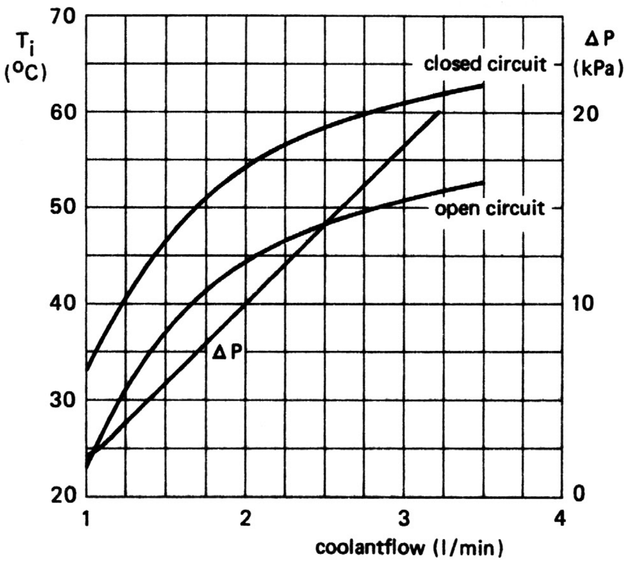

Fig. 1 Pressure drop and maximum inlet temperature as a function of waterflow.

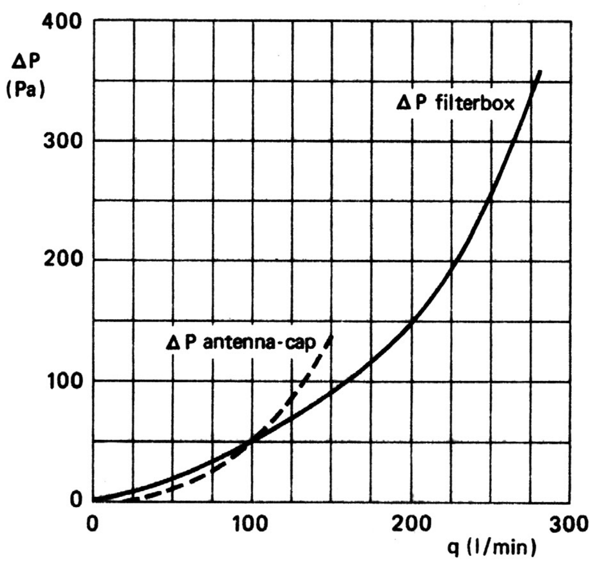

Fig. 2 Pressure drop filterbox and antenna-cap cooling as a function of airflow.

* Under no circumstances should the magnetron be permitted to mode.
Amongs other factors, the moding stability of a magnetron depends on the RF loading conditions (the VSWR and phase of reflection) and the physical dimensions of the launching section.
It depends on peak anode current, mean mode current and current wave form.

** Sink phase only.

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DESIGN AND OPERATING NOTES

General

The manufacturer should be consulted when cycled operation or operation without an isolator will be used or when it is necessary to operate the magnetron at conditions substantially different from those stated under “Typical operation’: or with deviating power supply/control circuitry.

Waveguide coupling section

The magnetron can be mounted to:

1. A launching section according to Fig. 5.
This is the preferred configuration for new installations.
The launcher should be connected to a matched load with VSWR ≤ 1.2.
It presents the optimum RF load to the magnetron to obtain maximum output power and efficiency and to ensure stable operation.
The magnetron may be operated to a maximum output power of 6 kW if an isolator is used. (See Quick Reference Data).
The launcher has the advantage of a higher RF break down voltage in the waveguide than the following alternative.

2. A launching section according to Fig. 6.
Without the use of a circulator this section can be used for other load conditions than matched, up to an output power of 5 kW. (See load diagram Fig.10) The VSWR has to be < 4.0.
At 5 kW the load should have a VSWR of 2.5 ± 0.5 in the sink phase.

Anode supply

The magnetron should be operated with a three-phase, full wave rectified, anode voltage power supply or the magnetron should be operated with a switch mode power supply.
This power supply should be so designed that no limiting value for the mean and peak anode currents will be exceeded, whatever the operating conditions.
The use of a current limiting device, set according to the paragraph: “LIMITING VALUES”, is advisable.

Filament supply

The secondary of the filament transformer must be well insulated from the primary. Normally the anode is grounded and the filament will be at a high negative voltage with respect to the anode. For long magnetron life the transformer should be so designed that the filament voltage limits will not be exceeded.

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Filament connections

Under certain operating conditions the magnetron has a high filament current. Losses in filament voltage caused by bad connections or filament leads that are too small in diameter may result in poor operation and will shorten magnetron life. Therefore, it is important to ensure that the leads make good electrical contact with the tube terminals.

Mounting

The use of an RF gasket, supplied with each magnetron, is essential to ensure good RF contact between the output of the magnetron and the launching section. No loose ends of the gasket wire should stick into the wave guide.
The magnetron should be mounted on a coupling section by means of the four M5 bolts (see outline drawing 4b).
To ensure good RF contact these nuts should be tightened evenly.

Arc detector

To protect the magnetron against failure because of waveguide arcing, an arc detector should be used to switch of the anode power supply in the event of an arc.
The best location of an arc detector is as indicated in Fig 5.

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Tube cleanness

The ceramic output dome and the parts of the cathode terminals must be kept clean and dry during installation and operation.
The cooling air should be filtered to prevent arcing due to deposits.

Electromagnet

The electromagnet has two coils, to be connected in parallel.
The magnetron's magnetic field is the superposition of the permanent field and the electromagnet field. (Maximum+ 15 and minimum - 25% of the permanent field) Without an electromagnet current the magnetron will still operate as a normal magnetron (see Fig. 7) The electromagnet magnet power supply should be capable of delivering a current of 5 A at plus or minus 20 V.
No voltages above 48 Volts are allowed between coil and anode.

Storage

The original packing should be used for transporting the magnetron.
The magnetron should not be shipped when mounted inside the equipment, but if necessary it should be authorized by the manufacturer.
When unpacking the tube, e.g. at an assembly line or for measurement purposes, care should be taken to avoid shocks and vibration.

Mechanical data

Mounting position:	Any
Dimensions:	See outline drawing Fig. 4a & 4b
Net weight:	YJ1600FL approx. 4.3 kg (9.6 lbs.)

Accessories

Supplied with each tube is RF gasket	3322 109 33021
Recommended isolator	2722-162-10311 (or equivalent)

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SAFETY PRECAUTIONS

Strictly adhere to the following precautions when working with magnetrons for industrial applications.

Magnetrons should only be handled by individuals who possess adequate knowledge of electrical and microwave technology and are aware of the hazards.

Richardson Electronics cannot be responsible for the interpretation of the following information, nor can it assume any liability in connection with its use.

1. High Voltage

The magnetron is operated with a grounded anode (body) and a high negative potential at the cathode/filament terminals.

1.1 Never touch or come close to the cathode/filament terminals or their surroundings during operation.
1.2 Never insert metallic wire, tools or other objects into the cathode filter box. Never operate the magnetron with the lid of the filter box removed or open.
1.3 Before removing the magnetron from the installation, always carefully check that the high voltage is turned off and discharge the cathode/filament capacitors. Use a discharging rod, adequately designed for safety.

2. **Radiation leakage**

Care should be taken to avoid microwave radiation leakage from the magnetron or the oven. Leakage from the cathode/filament part of the magnetron is limited by the integrated filter to a level that is harmless for the body.
2.1 Properly install the magnetron in the waveguide coupler.
2.2 Never operate the magnetron with the output gasket removed or damaged. Radiation leakage and arcing will result.
2.3 Never operate the magnetron with the output antenna exposed.
2.4 Never remove or damage the lid of the filter box. Do not deform the box.
2.5 Keep eyes at a sufficient distance from the operating magnetron to avoid exposure to unexpected microwave radiation.
2.6 The use of a microwave leakage measuring device is recommended.

3. **Temperature**

Although the magnetron is water and air cooled during operation, some parts of the magnetron can reach temperatures over 200°C.
3.1 Do not touch the magnetron immediately after turning the power off. Do not immediately switch off the cooling and allow the magnetron to cool before handling.
3.2 Use cotton gloves or equivalent when handling the magnetron.

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Mechanical Data

Dimensions in mm

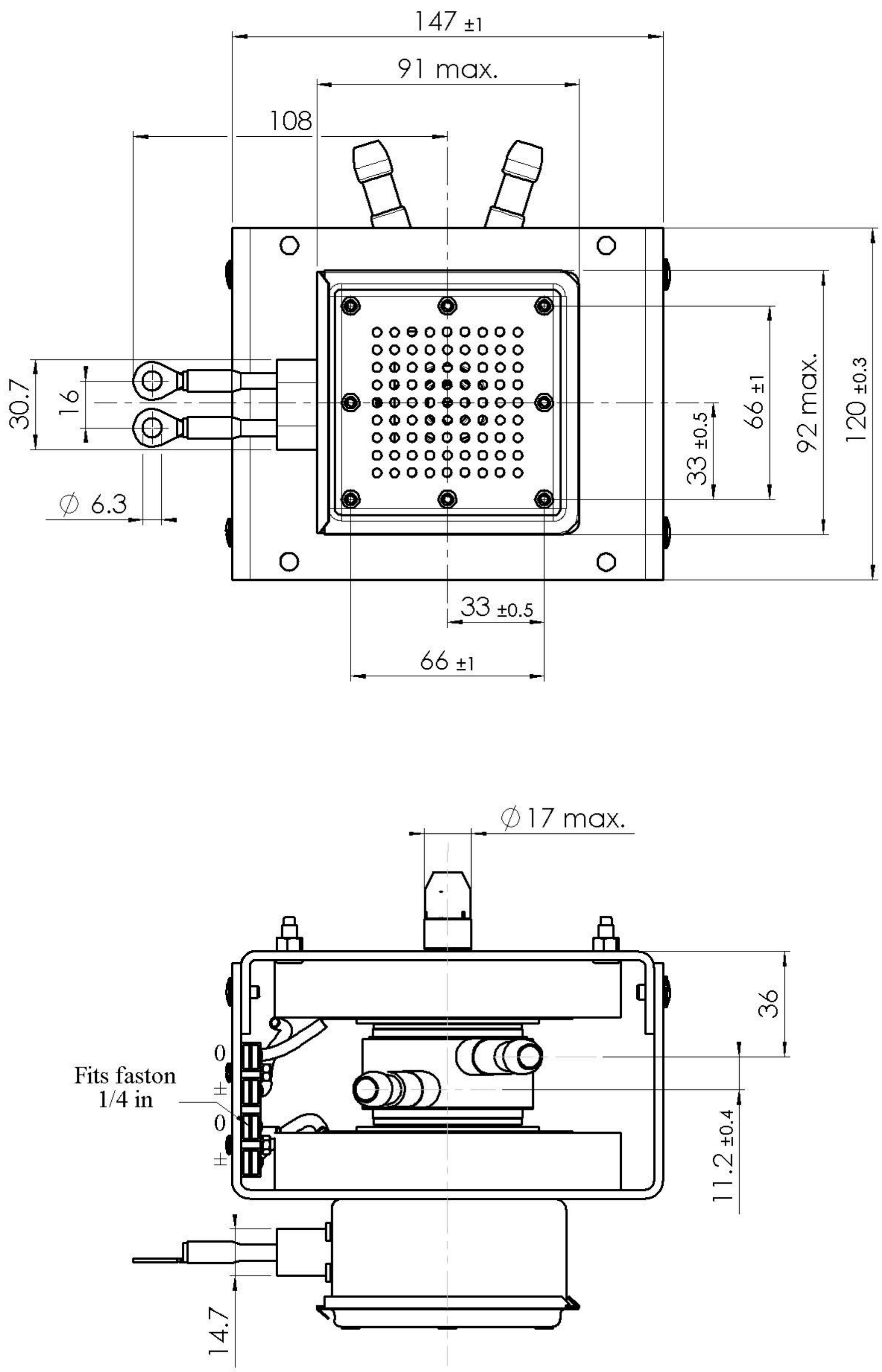

Fig. 4a

Mounting Position: any
Mass: approx. 4.3 kg (9.6 lbs)

Note: Specifications subject to change without notice.

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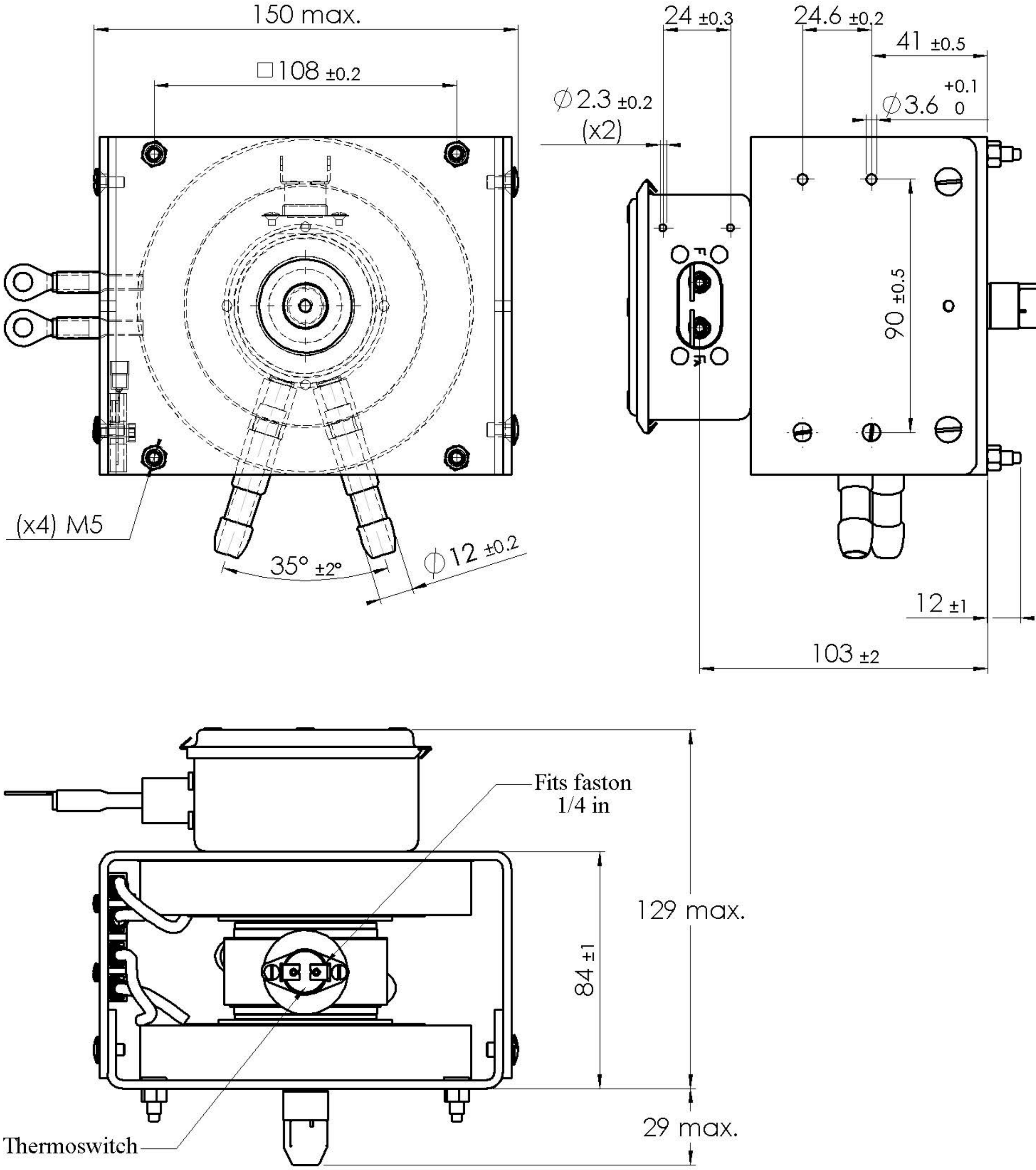

Fig. 4b

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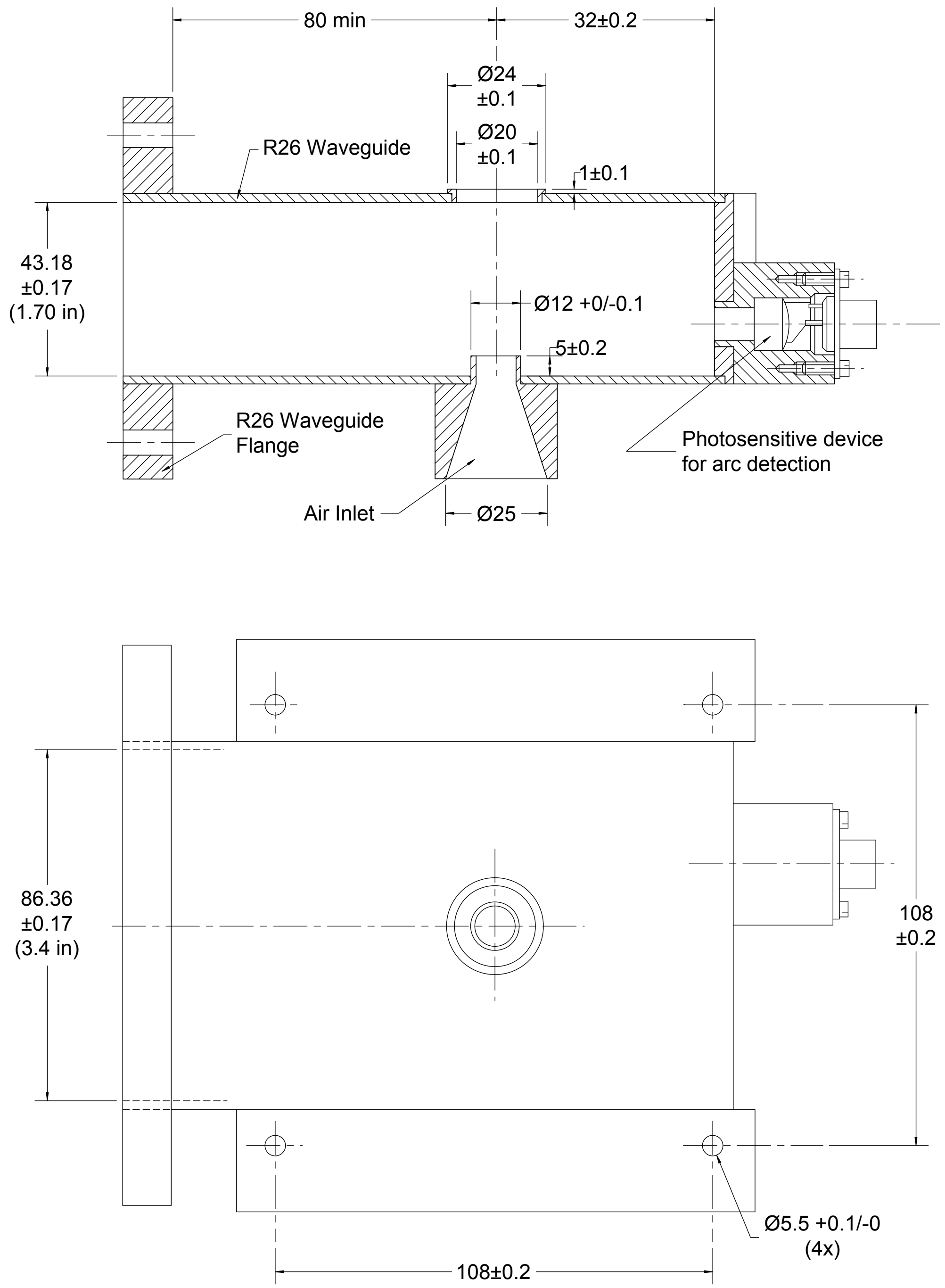

Fig. 5

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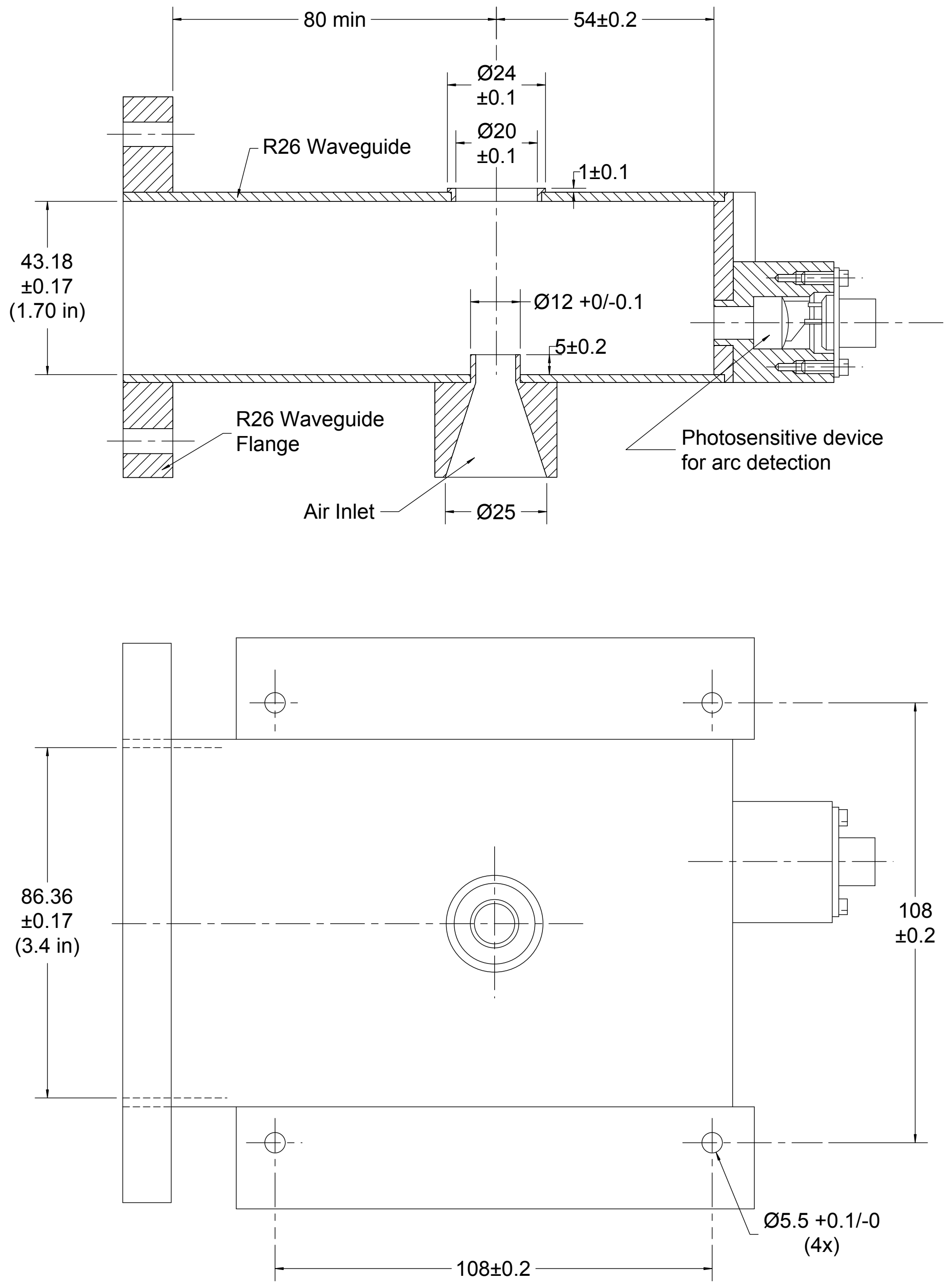

Fig. 6

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Performance Chart

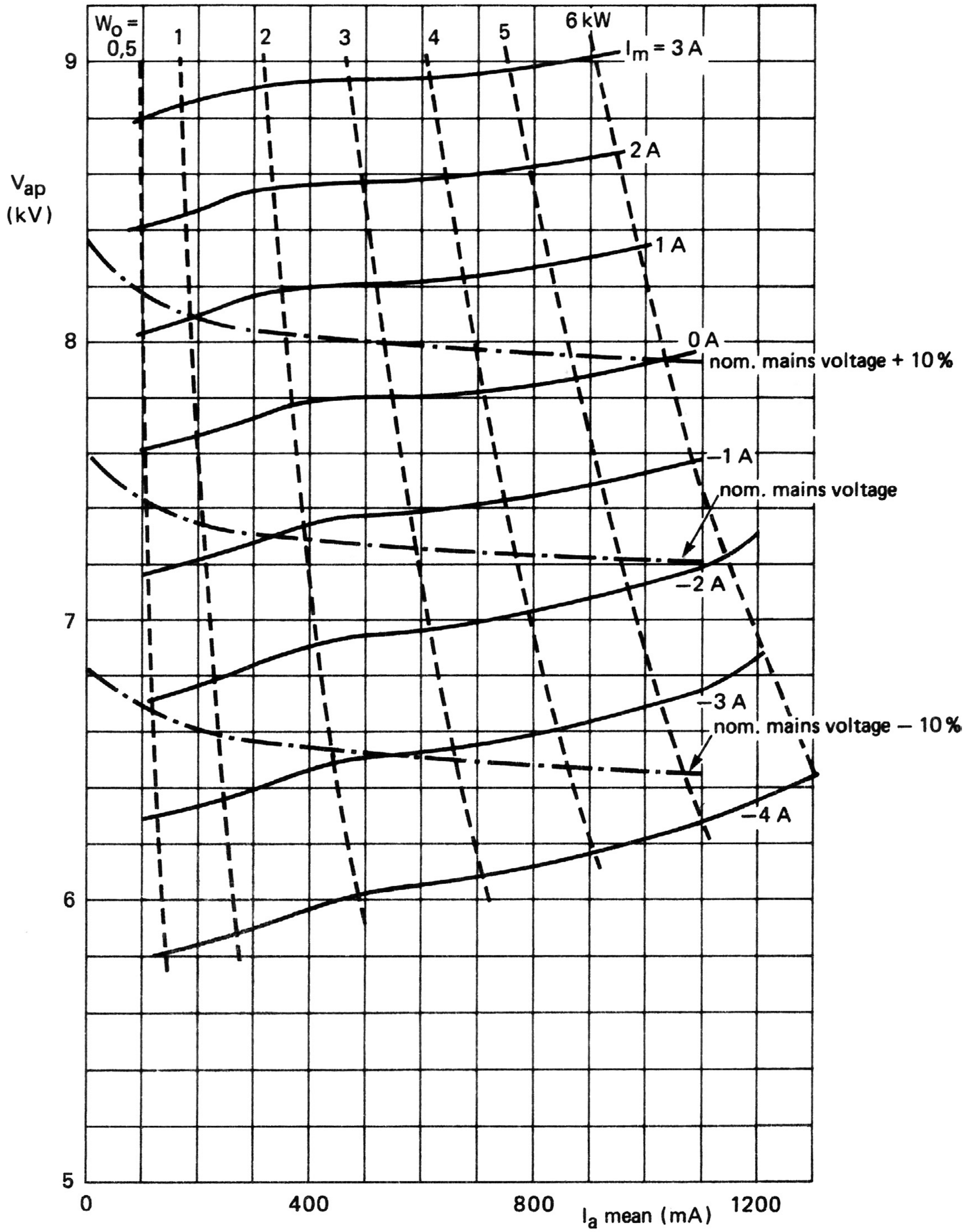

Fig. 7 Performance chart. Conditions: magnet temperature 25°C; load impedance 2.5 sink.

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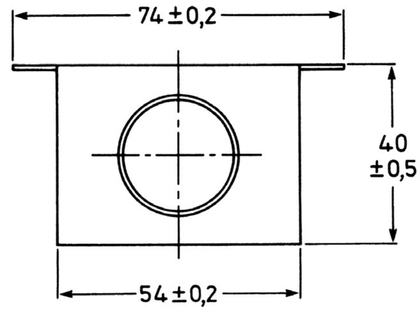
Mechanical Data

Dimensions in mm



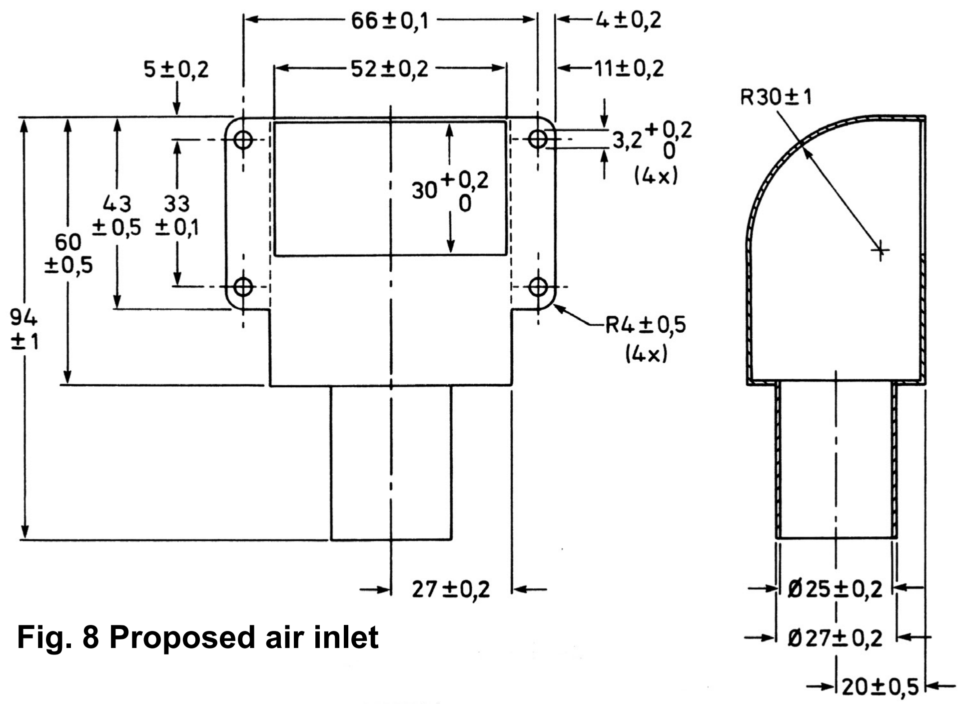


Fig. 8 Proposed air inlet

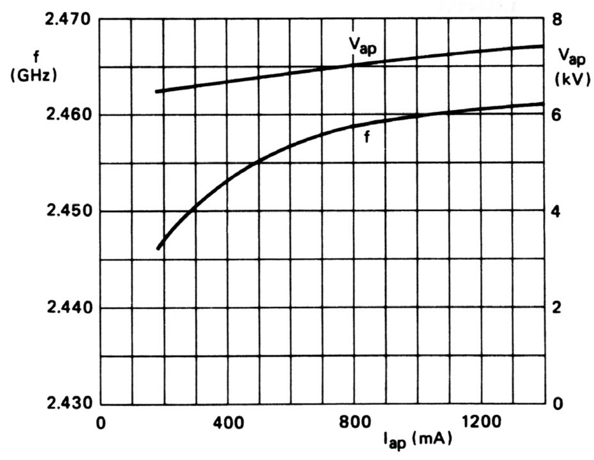


Fig. 9 Peak anode voltage, Vap, as a function of peak anode current, Iap. Frequency, f, as a function of peak anode current, Iap, (typical operation).

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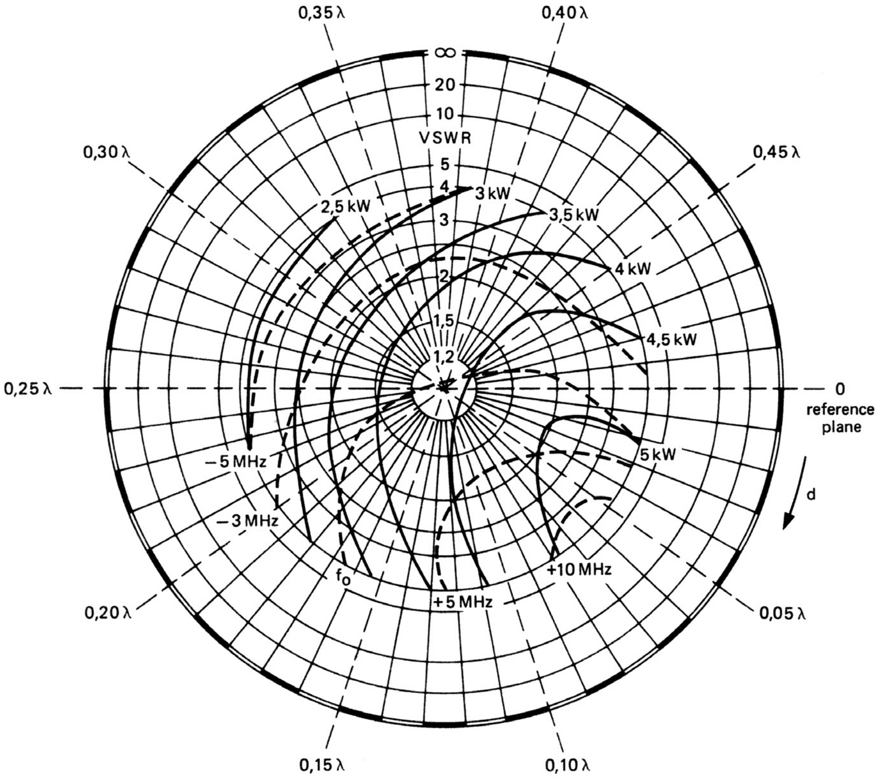
Rieke diagram



Rieke diagram for a YJ1600FL connected to an R26 waveguide fig. 6 Magnet temperature 25°C; Vg = 7.2 kV (peak); Ia = 950 mA; d is the distance from the reference plane towards the load of the voltage standing wave minimum

Fig. 10 Load diagram in waveguide

Anode supply	three phase full-wave rectified
Anode voltage	peak 7.2 kV
Anode current	mean 950mA
Frequency	fo = 2.460 GHz
Magnet temperature	25°C

Rieke diagram for a YJ1600FL connected to an waveguide Fig.6. The reference plane is the transverse plane passing through the antenna axis. The maximum output power of 5 kW is obtained near the sink region with a distance from the reference plane to the voltage minimum of the standing wave about 0.05 /. and a v.s.w.r. of about 2.5. Continuous operation of the magnetron in the antisink region should be avoided because the efficiency is low and the life of the tube will be shortened. To prevent a mismatch, the use of an isolator is recommended. For 6 kW operation, an isolator should always be used.

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Warranty and factors affecting the life of the YJ1600 magnetron

Warranty

The warranty is:

500 hours full credit
5000 hours prorata at 5 kW without isolator
2000 hours prorata at 6 kW with a isolator

The hours of operation determine the amount of credit, but this is not valid beyond 12 months in the equipment or 18 months from invoice date.

The right to access to equipment installation for the purpose of inspection of operating conditions shall be accorded to a representative of the manufacturer or any agent appointed by him, if so desired.

The liabilities under this warranty are limited optionally to replacement or credit in lieu of replacement. The decision of the manufacturer's engineers on the cause of failure and applicable allowance is final.

Factors Affecting Life of Magnetron

It can be expected that the YJ1600FL will have a very long life, if operated according the "typical operating conditions" as indicated in the tube's data. However, the life can be negatively affected by several conditions.

Therefore:

- The tube should not be operated for periods longer than 3 minutes at anode currents of less than 300 mA (1.5 kW output). If operated for an interval {less than 3 minutes) at an anode current of less than 300 mA, the magnetron should be operated for at least an equal time period at an anode current greater than 300 mA.
  If the tube is operated with an average anode current below 300 mA for longer than 3 minutes at a time, the tube may internally arc and be permanently damaged.
  Although every magnetron is aged by the manufacturer, there is a bigger risk of arcing for new magnetrons put in service.

- The life of a YJ1600FL magnetron will be reduced, by operating the magnetron for long periods with average anode currents less than 300 mA.

- The number of cycles between low and high power should be kept below 30000 over the total life span of the tube.

- The number of standby hours (only filament voltage applied to the magnetron) should be counted toward the total number of life hours. (The filament temperature at standby is approximately equal to the filament temperature in operating condition. Therefore, the rate of evaporation of thorium from the cathode will also be approximately equal.)

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