



high power microwave tubes

EMI Varian Ltd

EMI-Varian Ltd. was formed as a result of an agreement between EMI Ltd. of U.K. and Varian Associates of U.S.A. to pool their research, technology and manufacturing resources, with respect to microwave tubes and associated devices.

Both companies have vast experience in microwave and power tubes and associated components and together can offer a wide range of products backed by unrivalled technical know-how.

EMI-Varian Ltd., markets in the U.K. the products of the following Divisions of Varian Associates:

Bomac Division, Beverly, Massachusetts.
Eimac Division, San Carlos, California.
LEL Division, Copiague L.I., New York.
Palo Alto Tube Division, Palo Alto, California.
TWT Division, Palo Alto, California.
S-F-D Laboratories, Inc., Union, New Jersey.
Solid State Microwave Division, Beverly, Massachusetts.
National Electronics Inc., Geneva, Illinois.
Varian of Canada Ltd.

Varian Associates products available through EMI-Varian:

Reflex klystrons
2-Cavity klystron oscillators
Backward wave oscillators
Magnetron oscillators
Crossed-field amplifiers
Klystron amplifiers
Travelling wave tubes
Solid-state products
Microwave components
Microwave mixer-preamplifiers
R.F. amplifiers, converters and components
I.F. amplifiers and components
Strip transmission line components
Pulse modulation receivers

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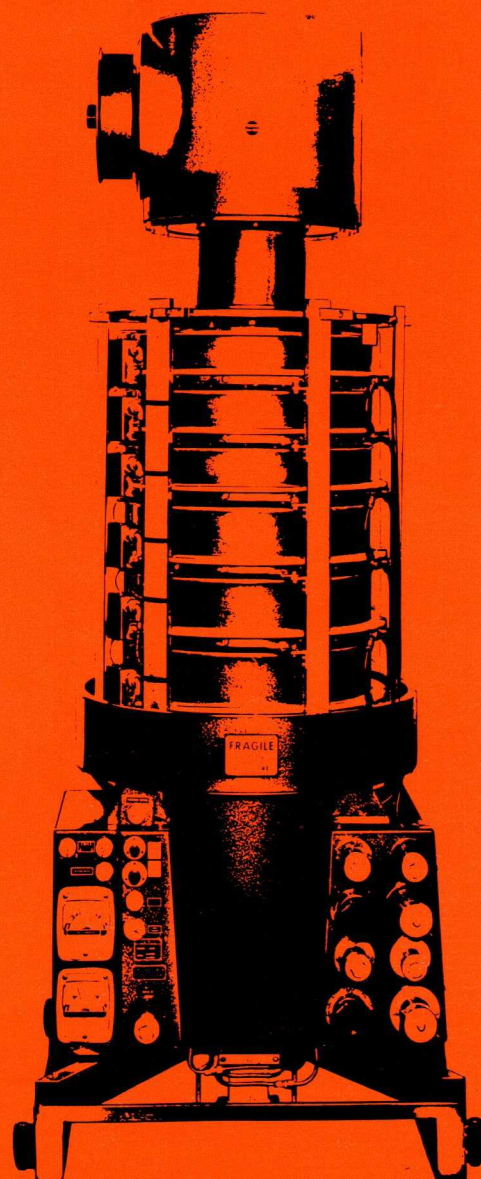
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high power microwave tubes

With its integrated resources for research into microwave power devices and its enlarged production facilities EMI-Varian Ltd. can not only meet the currently increasing demand for this type of equipment but also cope with the rapidly developing requirements in design.

By utilising new design techniques evolved in its research departments the company can manufacture a wide range of high power microwave amplifiers such as klystrons and travelling wave tubes together with their associated devices.

The range of tubes includes particularly lightweight, electrostatically focused, ruggedised klystrons for mobile use as well as electromagnetically focused power amplifiers up to the multi-megawatt level.



PT1001

high power klystron amplifier

The PT 1001 is an 'S' band, water cooled, pulsed, 6 cavity klystron amplifier with electromagnetic focusing. Peak pulse powers of between 4 and 10 MW can be obtained with this tube which was designed for use in high power surveillance and air traffic control radar systems.

The tube perveance is 1.5 micropervs, its frequency range 2.7 to 3.3 GHz with an output flat to within ± 1 dB over a 100 MHz bandwidth.

Quantity production has assured a high reliability, but in any case tube repairs can be undertaken at a fraction of the cost of a new tube.

The klystron is supported in a frame carrying

panels containing connections for water, air and electrical services.

The klystron is fitted with a built-in getter ion pump for use after movement or during periods of storage.

The gun assembly is immersed in an oil tank and lead shielding is provided around collector and output cavity to minimise X-ray radiation. The maximum radiation permitted with the shielding in position is 0.5 roentgen/hour and extra lead cladding of the tube cubicle should be provided by the user to reduce this still further to an acceptable local level.

The weight of the klystron including coils is 1160 Kgs.

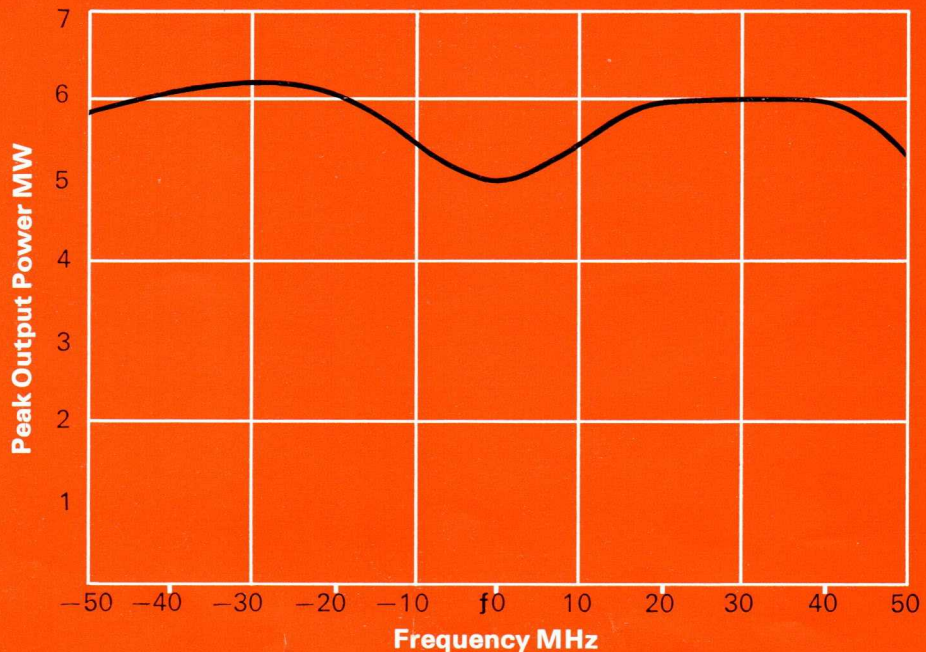


SPECIFICATION

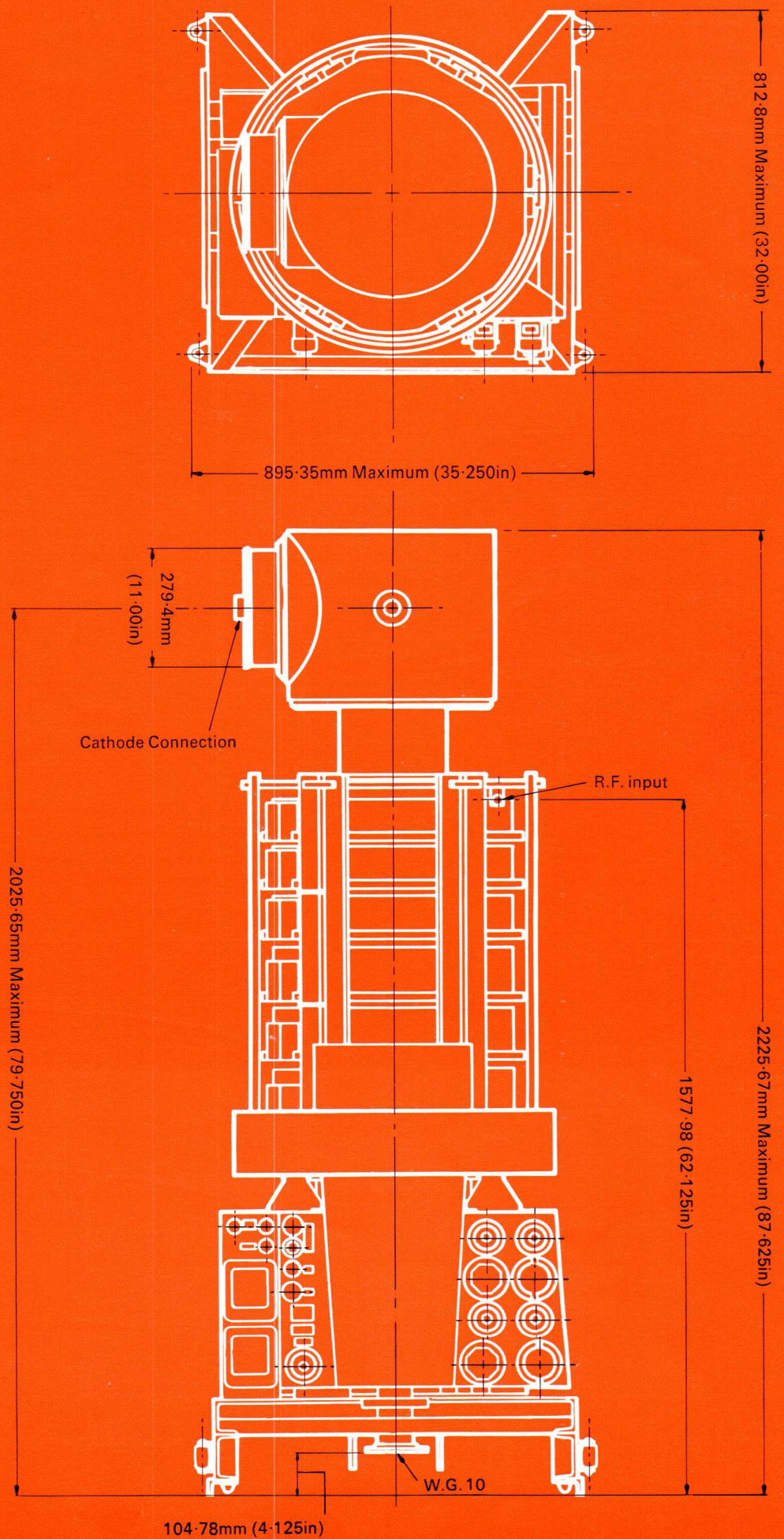
Output peak power	nominal	6 MW
Output mean power	maximum	25 kW
Input peak power	maximum	20 MW
Input mean power	maximum	65 kW
Peak beam voltage	maximum	180 kV
Peak beam current	maximum	110 A
Frequency range		2.7 to 3.3 GHz
Instantaneous bandwidth	± 1 dB	100 MHz
Gain		47 dB
Beam pulse length	maximum	13.5 microsecs.
Conversion efficiency	nominal	30%
*Heater volts	maximum	10 V
Heater current	surge maximum	120 A
*Heater current	run maximum	60 A
Warm up time	minimum	30 minutes
R/F input connection	coaxial	Type N or C
R/F output connection	waveguide	Size 10
Air pressure in output w/g	maximum	51 p.s.i. gauge
	minimum	43 p.s.i. gauge
Air flow	minimum	185 gms/min.
Water pressure	maximum	60 p.s.i.
Water flow	minimum	100 litres/min.
Coil supply requirements		160 V @ 50 A
Ion pump anode volts		2 kV
Ion pump anode current	maximum	175 mA
Ion pump filament volts		12.5 V r.m.s.
Ion pump filament current	surge	25 A r.m.s.
	run	18 A r.m.s.

*Actual heater current for individual valves is determined at the time of manufacture and annotated on the L.H. connecting panel. User supplies should be set to maintain this within $\pm 3\%$.

typical bandwidth curve for operation at 180 kV



outline of klystron amplifier PT 1001



PT1006

permanent magnet focused klystron amplifier

The PT 1006 is a long established, highly reliable 'S' band, water cooled amplifier originally designed as a driver for megawatt amplifiers.

It is currently supplied to several universities and atomic energy research establishments in the UK and overseas. Use of the valve is also being made in the assessment of the efficiency of experimental radars.

This klystron has a large degree of versatility as it can provide pulse power outputs of between 20 and 200 kW peak, with an efficiency of at least 25% in narrow band operation.

A tube life in excess of 6000 hours has been obtained in several applications. Long shelf life is also obtainable provided the klystron is run up for a short period every 3 months.

Although normally a 4 cavity valve, 5 cavity versions could be made available to special order giving an increased gain for broad bandwidth applications.

The input RF is applied via a 50 ohm co-axial connection, the output is a WG 10 waveguide with a circular plain flange.

The weight of the tube is 57 kgs.

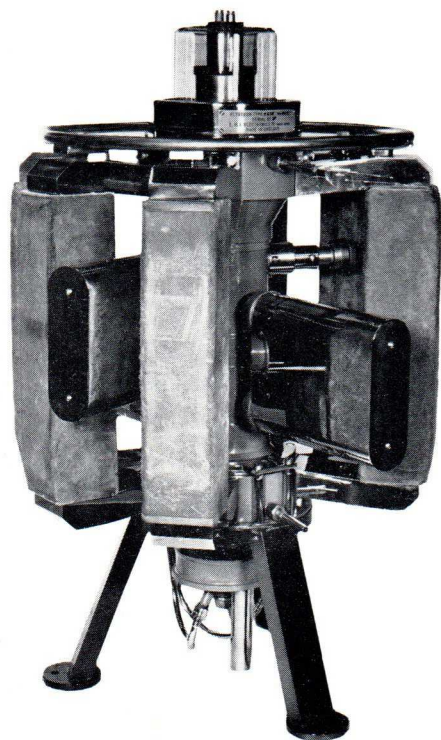
SPECIFICATION

Tunable frequency range		2.70 to 3.05 GHz
Output peak power		20 to 200 kW (Note A)
Output mean power	maximum	270 W
Input peak power		80 to 800 kW
Input mean power	maximum	900 W
Beam voltage	maximum	50 kV
Beam current	maximum	16 A
Perveance		1.4 μ P
Pulse length	maximum	12 μ S
Saturated gain	High efficiency tuned	44 dB minimum (Note B)
Saturated gain	Broadband tuned (1½%)	27 dB minimum
Heater volts	nominal	9 to 11.5 V
Heater current	nominal	5.5 to 9 A
Water cooling:	minimum flow	1.5 litres per minute
	maximum outlet temp.	60°C
	maximum pressure	2 kg/cm ²
	differential across valve	

Note A: 200 kW obtained with high efficiency tuning.

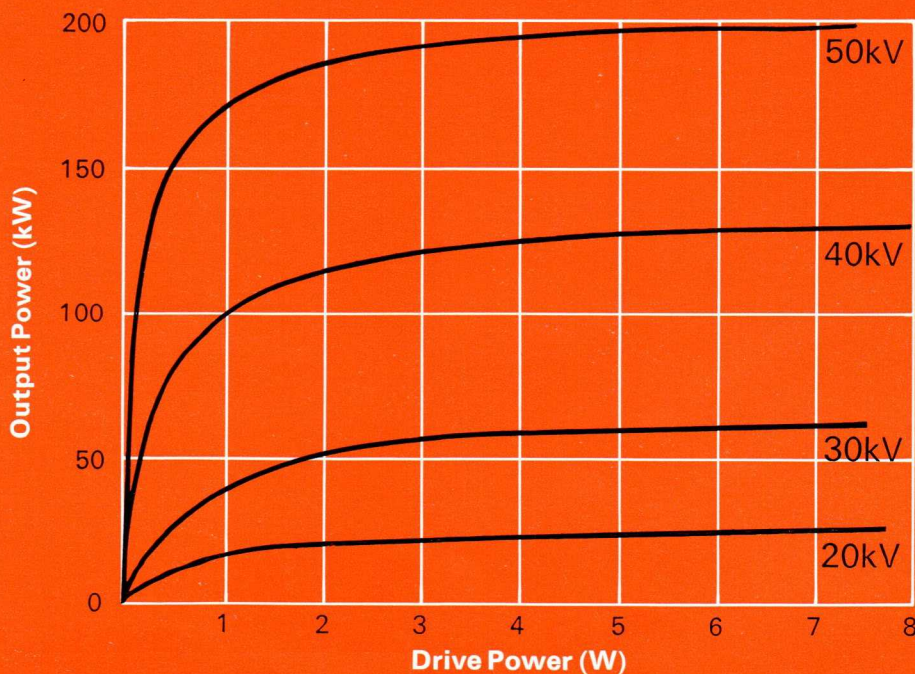
Note B: Synchronously tuned small signal gain is 60 dB.

Note C: The normal warm up time is 15 minutes, but this may be reduced to 10 minutes by applying an increase of 10% to the heater voltage marked on the valve. This overload should not be maintained longer than 10 minutes otherwise the life of the cathode may be considerably shortened.

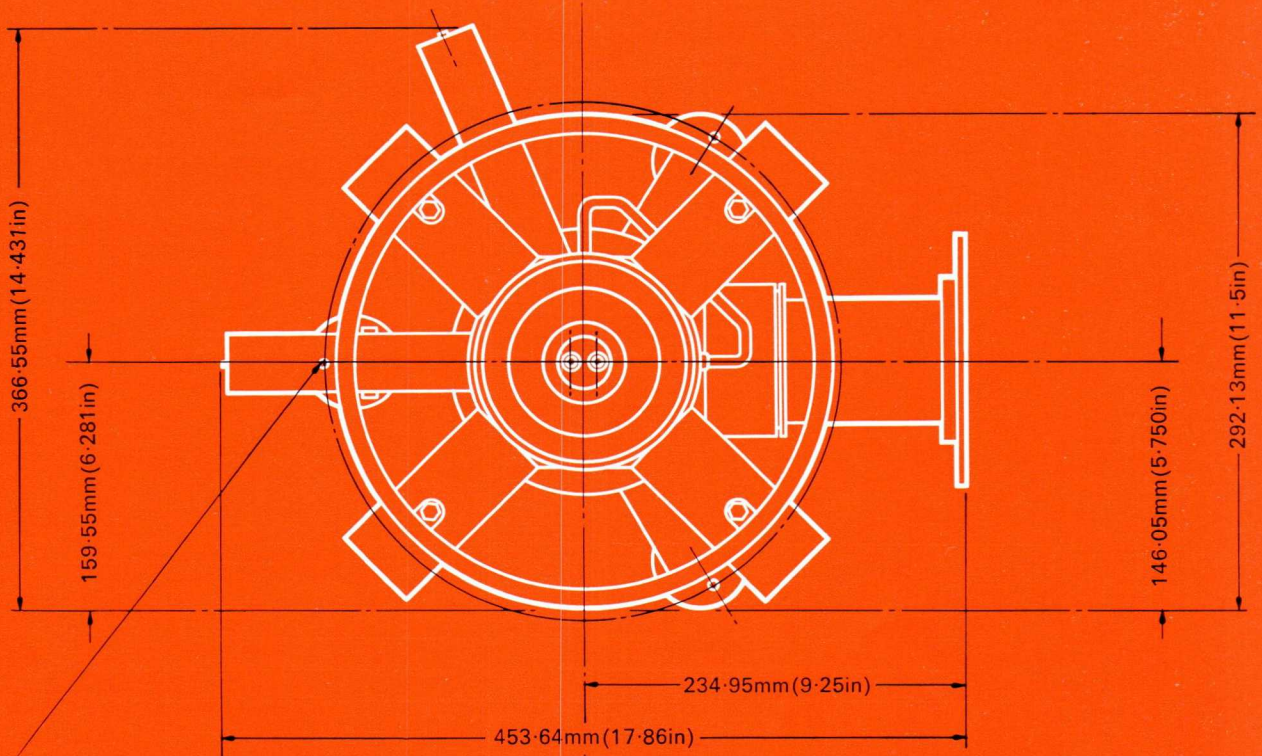


PT 1006 drive vs power output at various beam voltages

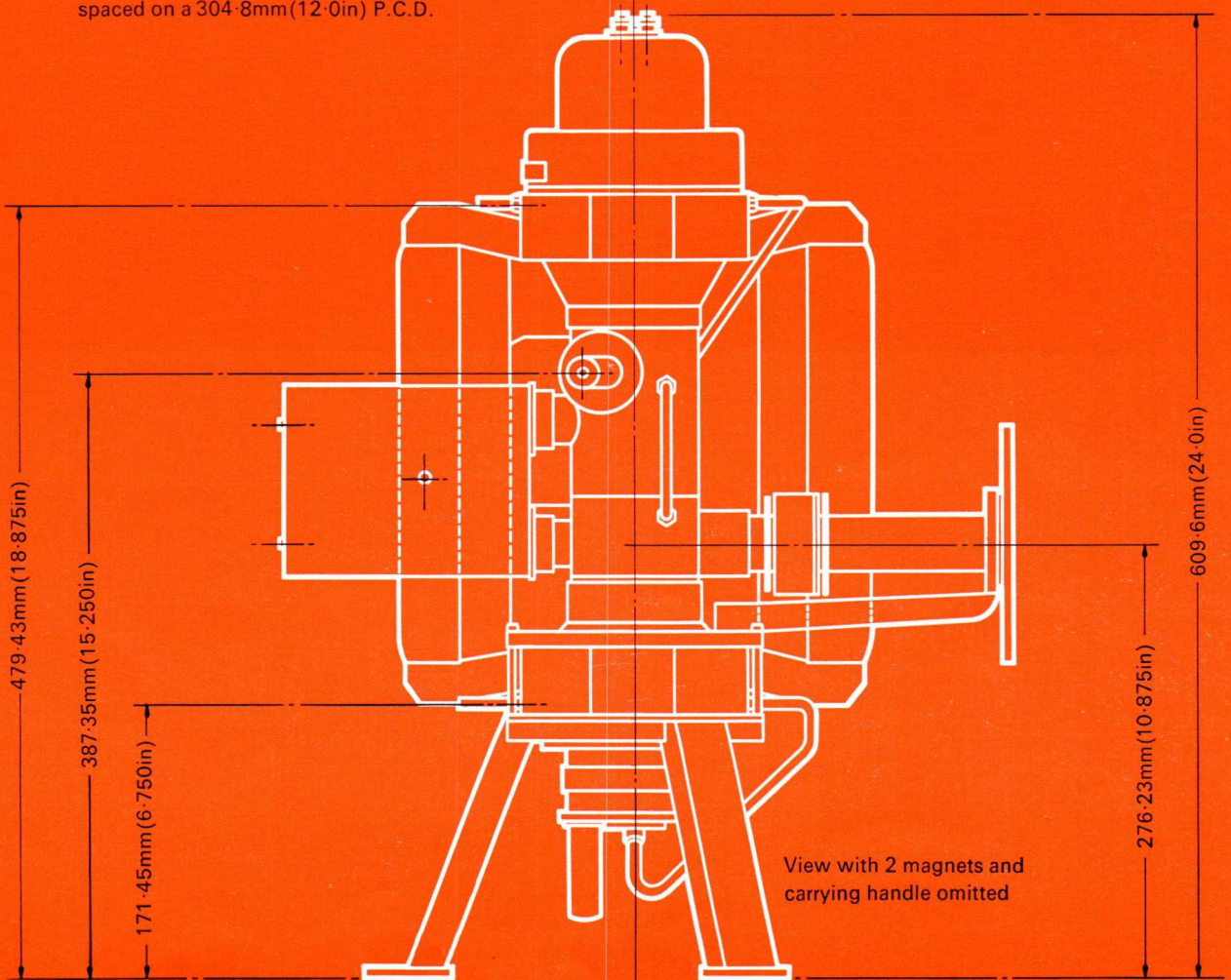
(Tuning optimised at each drive level)



outline of klystron amplifier PT1006



3-6.73mm (0.265in) dia. holes equi spaced on a 304.8mm (12.0in) P.C.D.



PT1010

electro-statically focused klystron

This klystron, basically designed for mobile applications, is a compact, ruggedised, microwave amplifier, operating in 'S' band. 4 or 5 cavity versions are available, anode or cathode modulated, air or water cooled, without the normal weight and size penalty of the electromagnetic or permanent magnet focused equivalent.

The PT 1010 series have pulse power outputs of up to 2.5 kW when anode modulated, and up to 10 kW when cathode modulated.

Additional benefits are the lack of magnetic interference and absence of any coil supply requirements.

The development of EMI ESF Klystrons is based on many years experience. They are now in quantity production. This has resulted in a high reliability.

The basic weight varies slightly depending on the particular requirement, but is of the order of 5 kg. (11 lb.) not including cooling arrangements or provision for mounting. The air cooled version when cased weighs 10 kg. (22 lb.).

Any one tube can be mechanically tuned over 200 MHz within the overall frequency range of 3,000 to 3,500 MHz.

The beam perveance is $0.55 \times 10^{-6} \text{ A/V}^{\frac{3}{2}}$.

In the anode modulated version the cathode is held at a negative d.c. potential with respect to the body of the tube and the modulating anode is biased below the cathode potential for beam cut-off. The modulating anode is then pulsed positive with respect to the cathode (by approximately 7% of the cathode volts) to give the correct focusing conditions and perveance. The modulating anode takes less than 2 mA peak current and requires only 3.2 kV maximum pulse to achieve full output at the maximum beam voltage of 12.5 kV.

The cathode modulated version can be used to increase the peak power available up to a maximum of 10 kW at 20 kV beam voltage. In this case the modulating anode is eliminated and no bias supply is required.

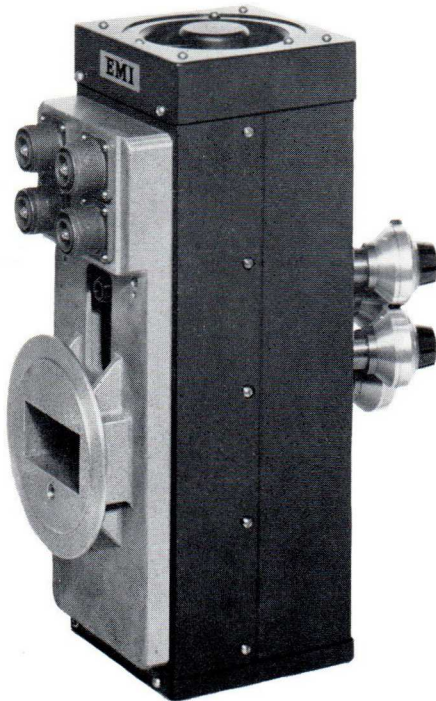
No additional supplies are required in either cathode or anode modulated versions for focusing as the Einzel lenses are operated at cathode potential.

SPECIFICATION

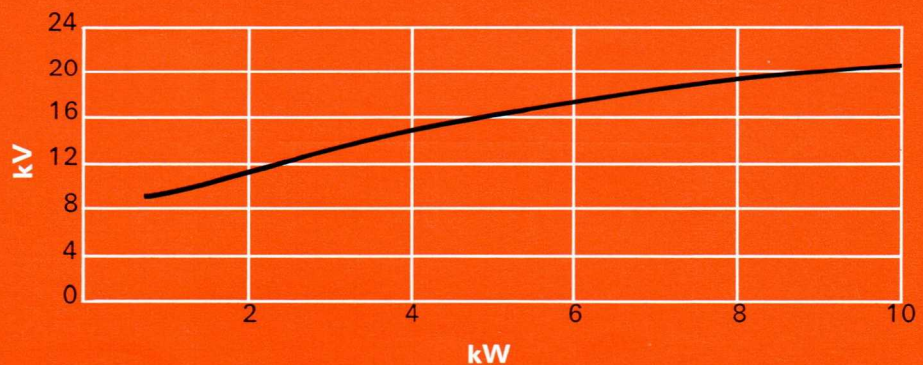
Noise level measurements indicate that the klystron noise contribution is negligible compared to the available drive sources, i.e. better than 70 dB down in a 1 kHz band.

		Anode Modulated	Cathode Modulated
Output peak power	max.	2.5 kW	10 kW
Output mean power	max.	250 W	250 W
Input peak power	max.	10 kW	32 kW
Input mean power	max.	1.2 kW	1.2 kW
Peak beam voltage	max.	-12.5 kV	-20 kV
Peak beam current	max.	0.8 A	1.56 A
Frequency range		Band centre between 3,100 and 3,400 MHz. Tuning range 200 MHz for any one tube.	
Instantaneous bandwidth	-1 dB	5 MHz	
for saturation gain at 3,250 MHz-3 dB		7.5 MHz	
Gain	Small signal	65 dB	
	Saturation	43 dB	
Pulse duration	max.	12 μ s	
Conversion efficiency	min.	20%	
Rate of change of phase with beam voltage (calculated)		0.085 degrees/volt at 12.5 kV	
Heater volts	nominal	5.5 to 8.5 V	
	typical	6.5 V	
Heater current	max.	2.5 A	
	typical	1.9 A	
Input connection		50 ohms coax - N type connector	
Output connection		W.G. 10 - special flange	

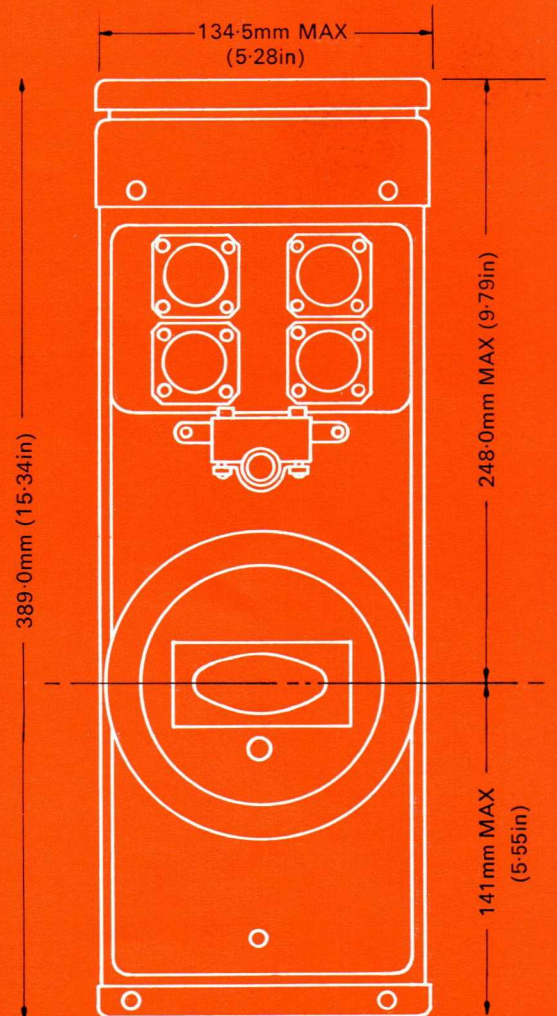
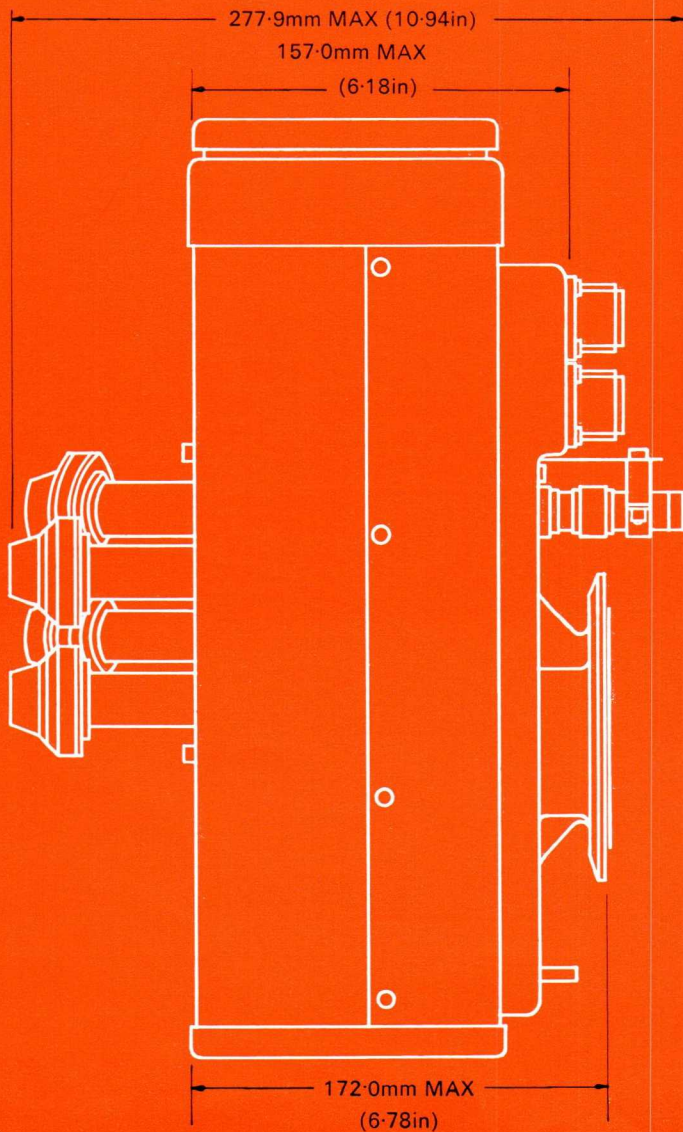
All enquiries with regard to specific applications will receive immediate attention.



power volts curve for typical cathode modulated PT 1010



outline of klystron amplifier PT 1010 air cooled and cased



PT1016

electro-statically focused klystron

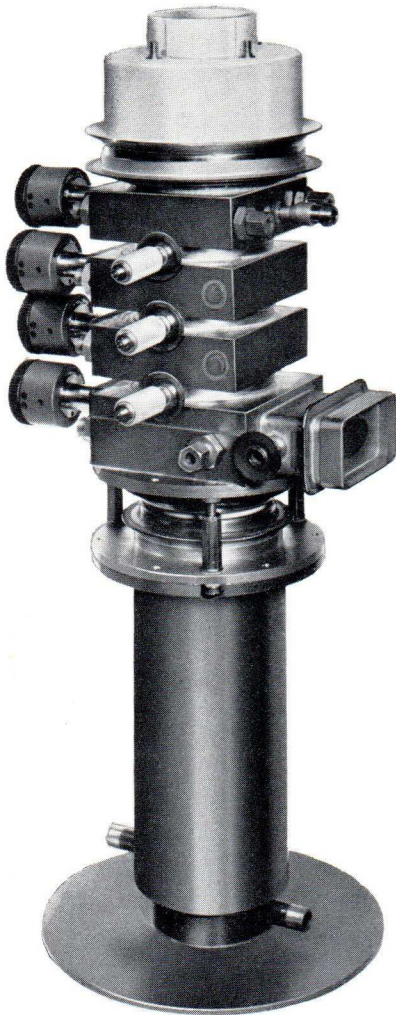
This tube is a 4 cavity S band amplifier originally designed for lightweight airborne applications.

It is liquid cooled and is shown in the photograph without the interface hardware. This hardware can be designed to suit individual requirements and will include terminations for cooling connections.

The tube is tuneable over 200 MHz within the frequency limits of 3100 to 3600 MHz and is electrostatically focused thus requiring no external focusing coils or permanent magnets.

The R/F output is via Size 10 waveguide and the input is a type N connector.

With appropriate power supplies a very low noise output is available.



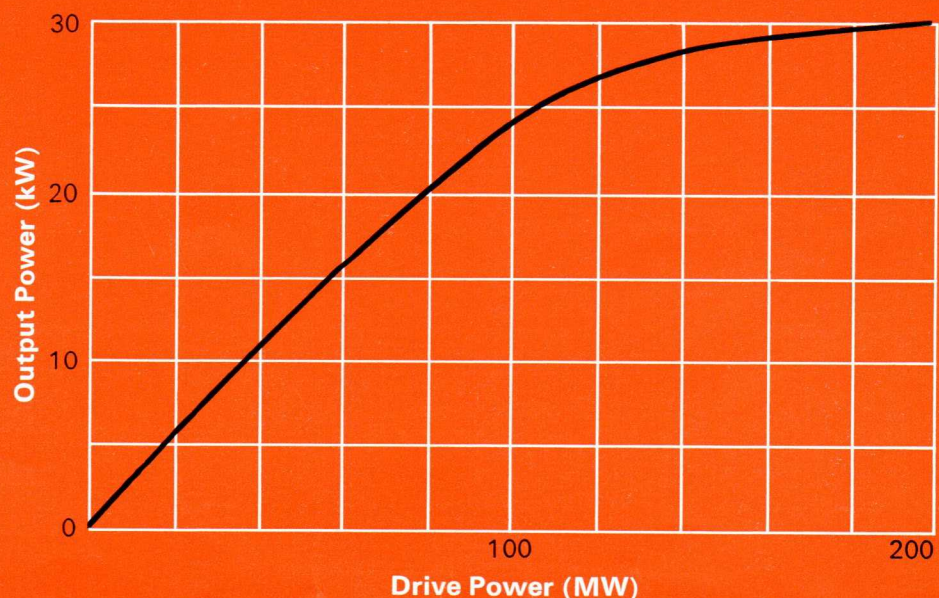
SPECIFICATION

Frequency Range — Tunable over 200 MHz within the frequency limits 3100 to 3600 MHz.

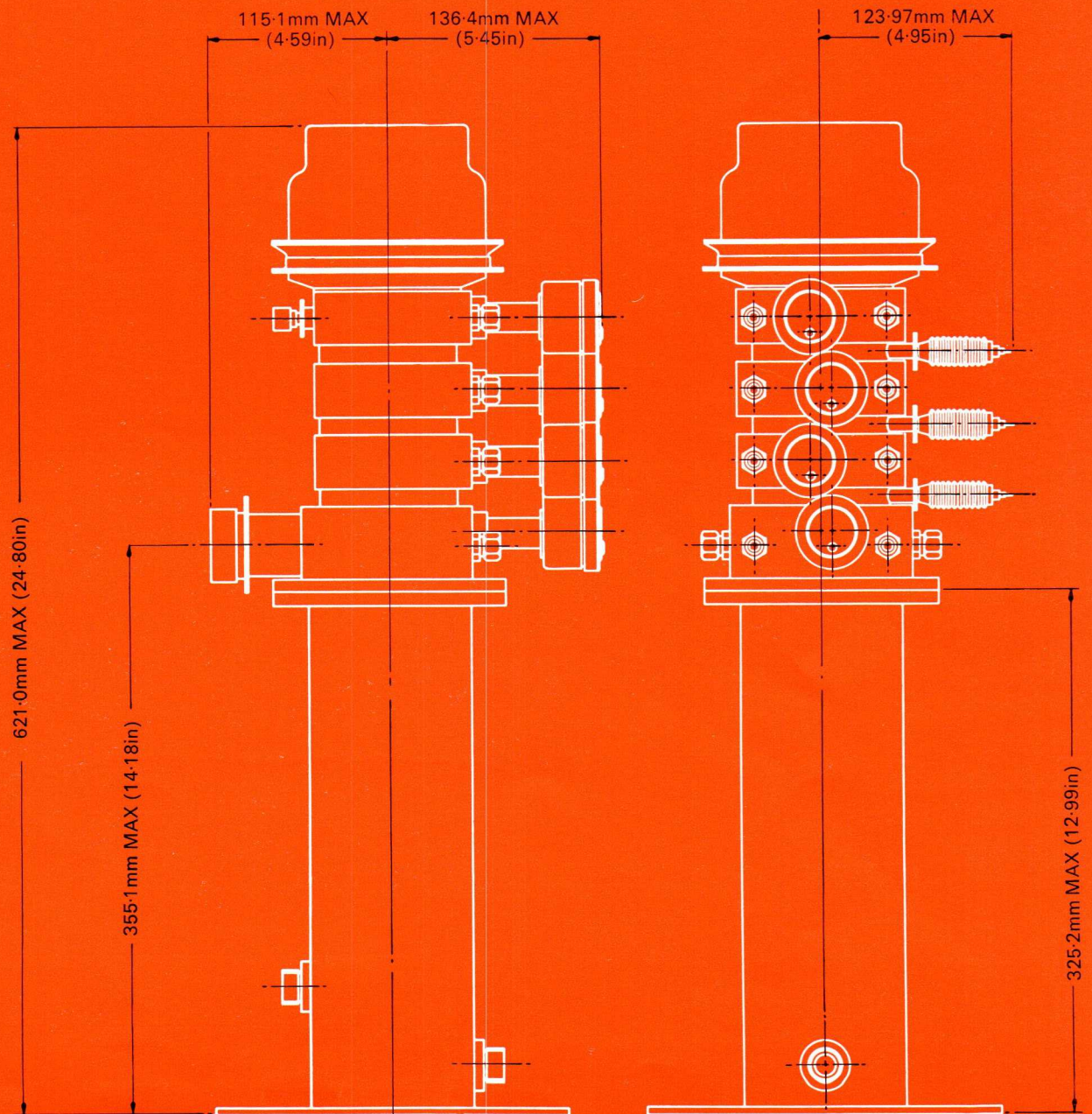
	Anode modulated	Cathode modulated
Peak R/F output power	20 kW	30 kW
Mean R/F output power	10 kW	10 kW
Gain	50 dB	50 dB
Beam voltage	27 kV	31 kV
Beam current	2.1 A	2.75 A
Beam perveance	0.5 μ P	0.5 μ P
P.R.F.	50 kHz	30 kHz
Pulse length	10 μ S	10 μ S
Attenuation (beam off)	100 dB	100 dB
Efficiency	35%	35%
Heater volts	10 to 12 V	10 to 12 V
Heater current	6 to 7 A	6 to 7 A
Target cooling water	4 gallons (18 litres) per minute minimum.	
Body cooling water	1 gallon (4.5 litres) per minute minimum.	
Tuner cooling water	0.5 gallons (2.2 litres) per minute minimum.	

Water outlet temperature not to exceed 60°C

**PT1016
drive vs
power
output
at 33kV**
(Typical)



outline of klystron amplifier PT 1016



PT1020

travelling wave tube

The PT 1020 is a C band, water cooled travelling wave tube with electromagnetic focusing. It was originally designed for use with high power, pulse compression or pulse coded radar systems.

The tube consists of a clover leaf type of coupled cavity slow wave structure. Input and output couplings are by waveguide.

The tube is severed to prevent instability but instead of internal loads at the severed ends of the slow wave structure the terminations are coupled to two more waveguides which are connected to external waveguide water loads.

The system ensures that the tube will withstand large mismatches in the output line and the resultant backward wave in the slow

wave structure will not burn out the load.

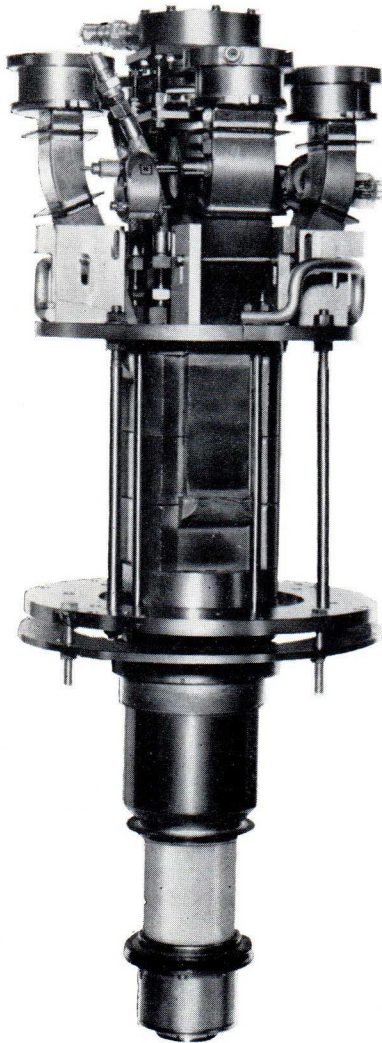
The tube output is flat to better than ± 1 dB at saturation with a constant drive and its perveance is 2 micropervs.

External waveguide systems should be pressurised with dry air between the limits 40 and 60 p.s.i.

The tube is operated with its gun section immersed in an oil tank and lead shielding is provided around the collector and output cavity as a protection against X-ray radiation.

A getter ion pump is fitted to ensure long tube life.

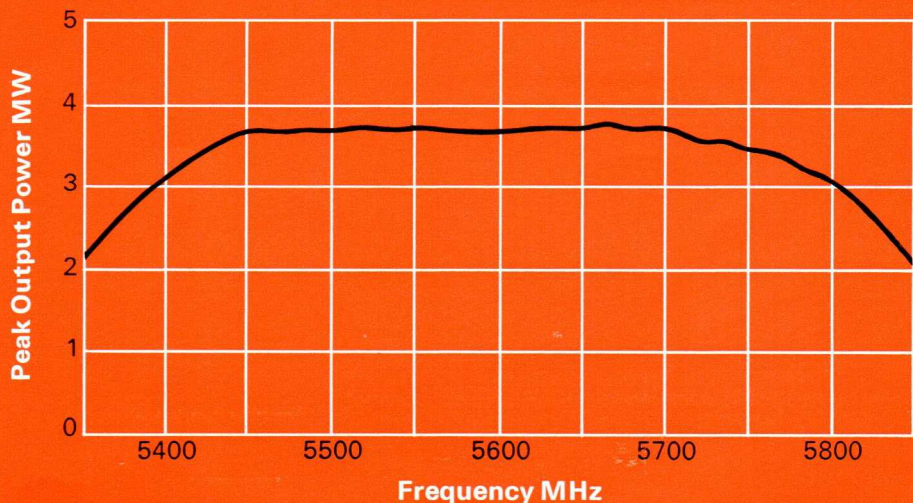
The total weight of the PT 1020 is 204 Kgs. including coils and lead shielding.



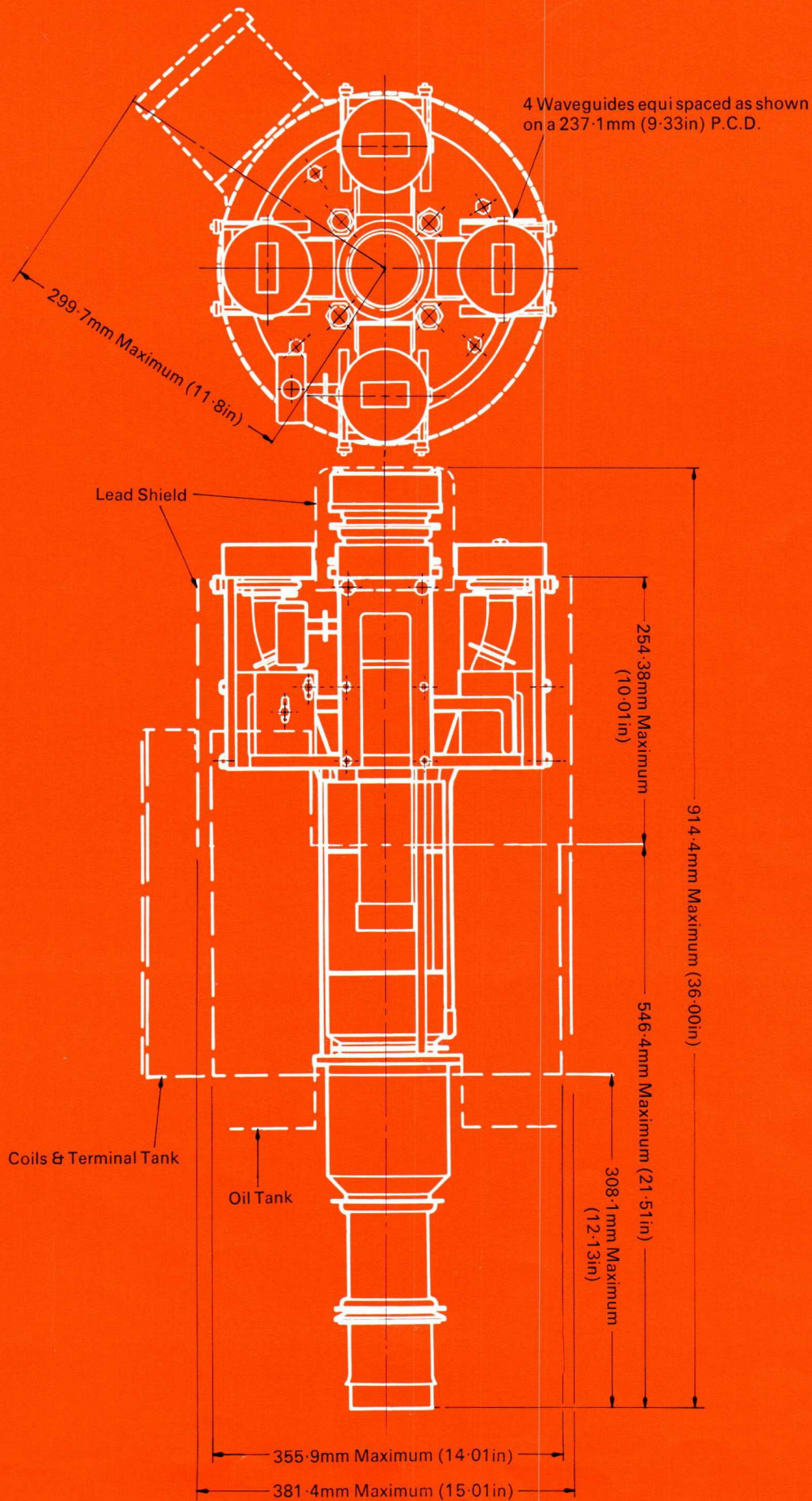
SPECIFICATION

Output peak power	maximum	4 MW
Output mean power	maximum	6.4 kW
Input peak power	maximum	13.5 MW
Input mean power	maximum	27 kW
Peak beam voltage	maximum	135 kV
Peak beam current	maximum	100 A
Frequency range		5.35 to 5.85 GHz
Gain, minimum saturated		33 dB
Pulse duration beam	typical	5 μ s
Pulse duration r.f. drive	typical	4 μ s
Conversion efficiency		30%
Heater volts	nominal	17 V
Heater power	nominal	200 W
Waveguide connections		WG 12 standard choke flanges
Water connections		Hansen non-drip fittings
*Water flow tube		60 litres/min.
max. pressure		100 p.s.i.
*Water flow coils		10 litres/min.
max. pressure		100 p.s.i.
Getter ion pump voltage		3.3 kV
Number of coils		4
Coil voltage	maximum	90 V
Coil current	maximum	15 A per coil
* de-ionised water to be used.		

power
frequency
curve for
travelling
wave tube
PT 1020



outline of travelling wave tube amplifier PT1020



PT1024

electro-statically focused klystron

The PT1024, basically designed for light-weight ship-borne, applications, is a ruggedised amplifier operating in L band. It is a 4 cavity water-cooled tube and its light weight is due to the electrostatic focusing arrangements obviating the need for electromagnetic coils or permanent magnets.

Cathode modulation is used and current models are tunable over 75 MHz within the frequency limits 1200 to 1400 MHz.

Development of this tube is continuing in

order that higher power levels can be obtained and to extend the frequency limits.

The R/F output is via a $3\frac{1}{8}$ " coaxial window of 50 ohm nominal impedance and the R/F input is via a Type N connector.

Custom built mounting arrangements can be designed if the standard designs available are unsuitable. The photograph shows the tube not fitted with a mounting, the outline drawing shows a typical mounting arrangement.

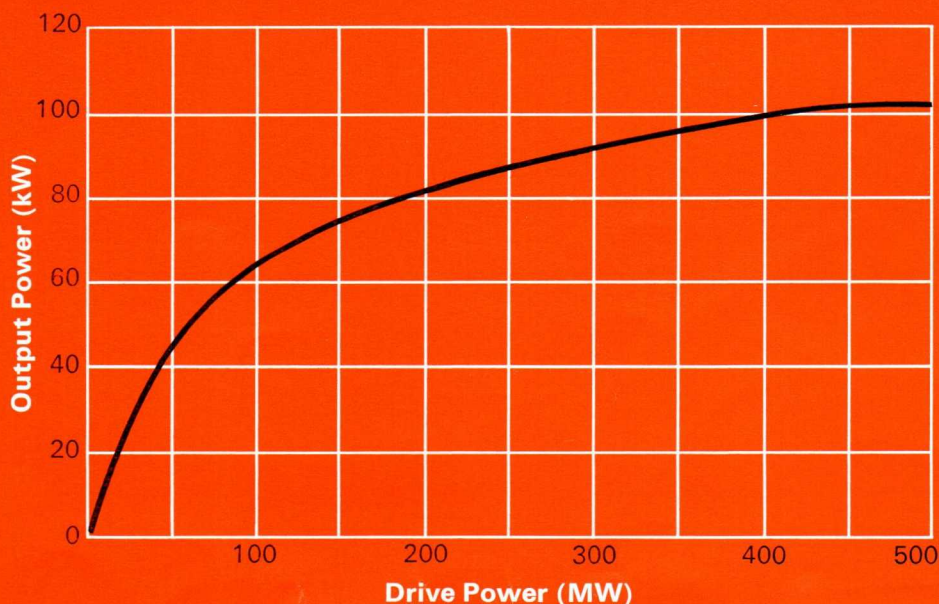


SPECIFICATION

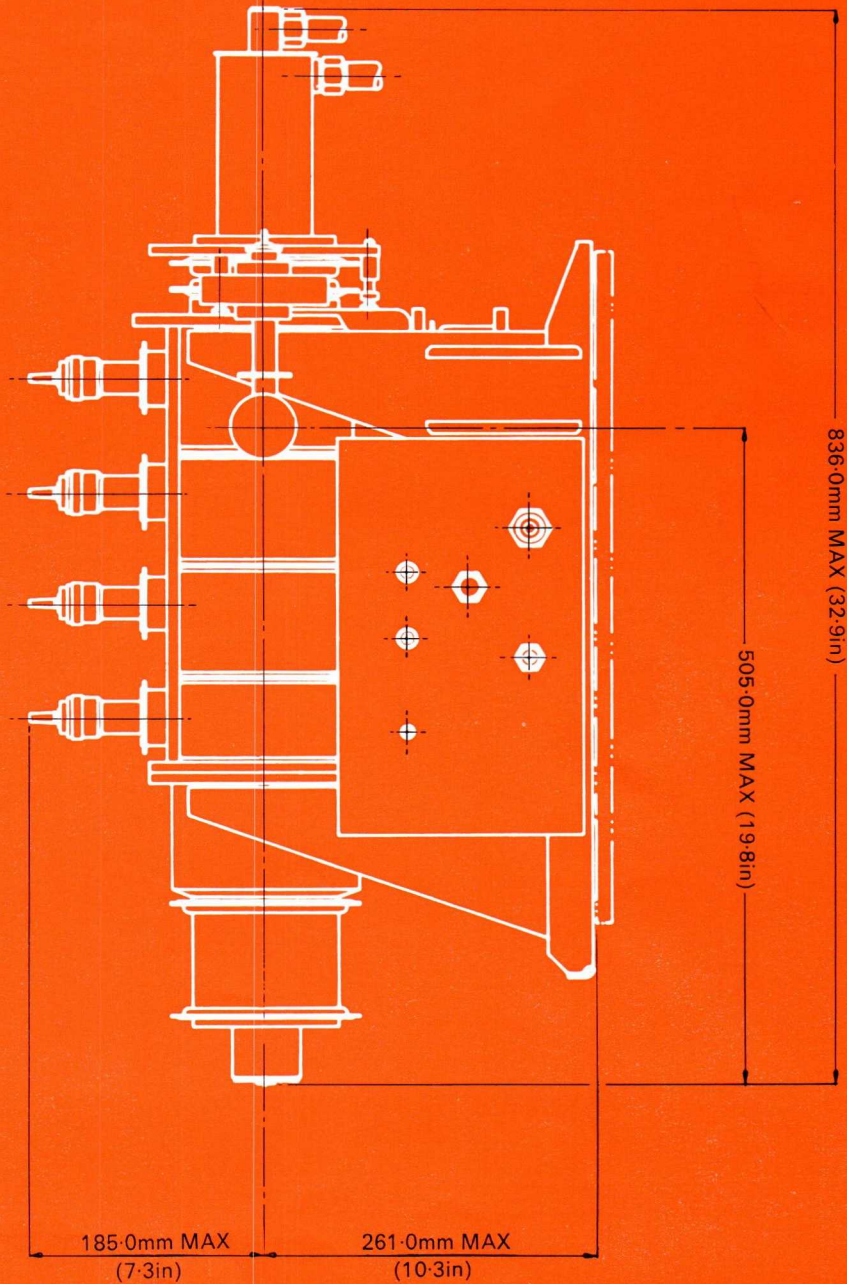
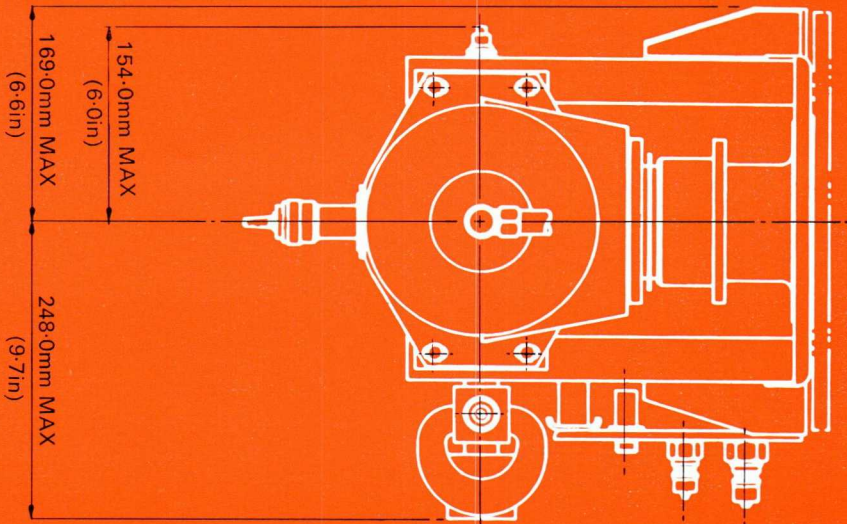
Frequency Range — Tunable over 75 MHz within the frequency limits 1200 to 1400 MHz.

Peak R/F output power		100 kW
Mean R/F output power		6.25 kW
Gain	(maximum)	47 dB
Dynamic bandwidth		5 MHz
Beam voltage	(maximum)	45 kV
Beam current	(maximum)	9 A
Beam perveance		1 μ P
P.R.F.	(maximum)	12.5 kHz
Pulse length	(maximum)	10 μ S
Efficiency	(minimum)	30%
Heater volts	(nominal)	20 V
Heater current	(nominal)	17 A
Target cooling water	(minimum)	30 litres per minute
Body cooling water	(minimum)	10 litres per minute
Weight		60 kg

**PT1024
drive vs
power
output
at 46kV**
(Typical)



outline of klystron amplifier PT 1024



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