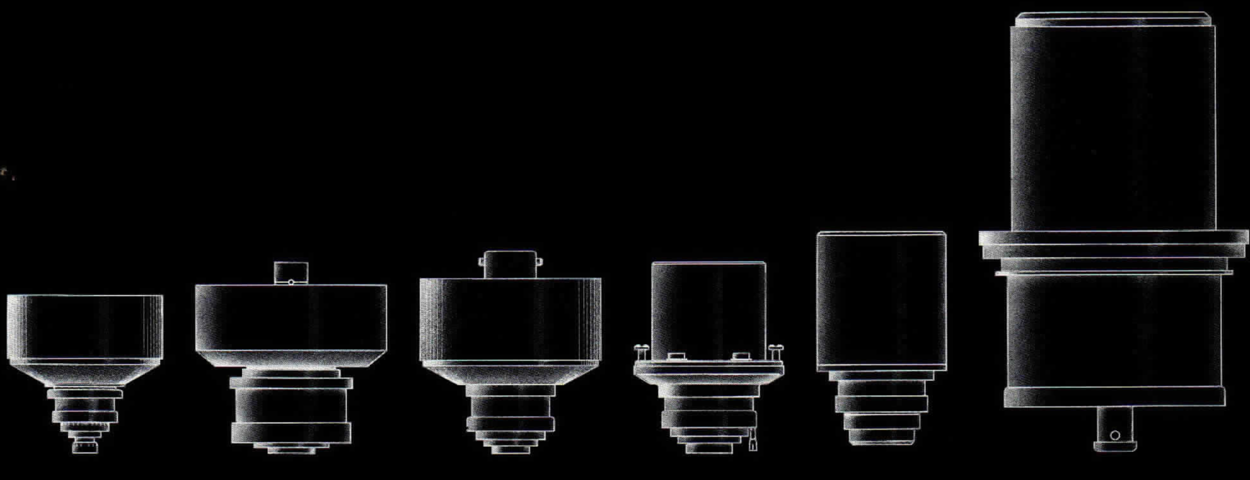
TTE 174

Electron tubes
for TV and radio broadcast



THOMSON TUBES ELECTRONIQUES

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Power-grid tubes for radio & TV broadcasting

Power-grid tubes for radio & TV broadcasting

Greater attention to the cost competetivity of radio or TV stations has made cost-of-ownership of the broadcasting transmitter a vital concern. Of the many competing technologies for the power amplifier, modern high-power tetrodes provide an ideal solution. New developments in tube capabilities have led to higher efficiencies, longer lifetimes, and increased cost effectiveness. Combined with their high reliability and the simplicity of amplifier design, tetrode transmitters also offer a larger bandwidth for future broadcasting techniques.

Thomson Tubes Electroniques has been at the forefront of power-grid tube technology over many years. The company pioneered such developments as Pyrobloc® grids and Hypervapotron™ cooling, and more recently that of the high-power UHF tetrode.

This technical edge is the result of the company's continued R&D investment in grid-tube technology. It also stems from a motivated workforce and its highly qualified engineers and technicians. Their vitality has allowed the electron-tube industry to offer the best solutions for today's and tomorrow's transmitters. The use of advanced analytical and computing tools, as well as our modern production techniques has ensured that our extensive product range has kept pace with evolving needs.

The Power-Grid Tube Division of Thomson Tubes Electroniques is located at Thonon, overlooking Lake Geneva in the French Alps. The company's headquarters in the south-west of Paris are home to the Sales and Marketing Teams. They are part of a worldwide customer support network dedicated to assisting you in correct tube choice, and ensuring you get the most from your Thomson tube.

Thomson is also a leading player in more recent transmission techniques such as satellite news gathering and direct broadcast satellites. The company's space traveling-wave tubes (TWTs) have been chosen for the latest broadcasting satellites including USDBS, Hispasat and Telecom 1 & 2. On the ground, Thomson's TWTs and klystrons provide the performances required for video transmissions via earth stations and mobile uplinks.

Thomson Tubes Electroniques is also engaged in the development of HDTV. The company offers high-definition projection CRTs for large-screen displays, bringing in the era of the electronic cinema.

Furthermore, tetrodes provide the enhanced performances compatible with UHF HDTV transmission. Thomson Tubes Electroniques' long-term commitment to the radio and TV industry has made such technological progress possible. It also guarantees the ongoing availability of our product line.

Whatever your projects in radio or TV, you should be gaining from Thomson Tubes Electroniques, the leading edge in electron tubes.

Index

Thomson power-grid tubes and cavities

Power is indicated as carrier power for radio tubes and peak-of-sync video for TV transmitter

Reference	Power	Band	Type	Cooling	Page
TH 382	11 kW	UHF	Tetrode	air	32
TH 390	2 kW	UHF	Tetrode	air	8
TH 390 A	2 kW	UHF	Tetrode	air	8
TH 392	10 kW	UHF	Tetrode	air	8
TH 393	4.4 kW	UHF	Tetrode	air	33
TH 399	12 kW	Radio	Tetrode	air	34
TH 476	200 kW	Radio	Triode	water	8
TH 477	50 kW	Radio	Triode	water	8
TH 478	250 kW	Radio	Triode	water	8
TH 478 A	250 kW	Radio	Triode	water	8
TH 479	30 kW	Radio	Triode	water	8
TH 483	40 kW	Radio	Triode	water	8
TH 485	100 kW	Radio	Triode	water	8
TH 487	110 kW	Radio	Triode	water	8
TH 491 B	25 kW	UHF	Tetrode	water	8
TH 4T1100	2.3 kW	Radio	Tetrode	air	8
TH 4T4100	5 kW	Radio	Tetrode	air	8
TH 504 C	300 kW	Radio	Triode	water	8
TH 504 V	300 kW	Radio	Triode	water	9
TH 520	70 kW	Radio	Tetrode	water	9
TH 521	70 kW	Radio	Tetrode	water	35
TH 524A	250 kW	Radio	Triode	water	9
TH 527	1 kW	UHF	Tetrode	water	36
TH 532	60 kW	Radio	Tetrode	water	37
TH 537	300 kW	Radio	Tetrode	water	38
TH 538	300 kW	Radio	Tetrode	water	9
TH 538 V	300 kW	Radio	Tetrode	water	9
TH 539	1.25 MW	Radio	Tetrode	water	39
TH 539 A	1.2 MW	Radio	Tetrode	water	9
TH 546	100 kW	FM	Tetrode	water	9
TH 547	2 kW	UHF	Tetrode	water	40
TH 548	520 kW	Radio	Tetrode	water	9
TH 555	200 kW	Radio	Tetrode	water	9
TH 555 A	250 kW	Radio	Tetrode	water	41
TH 558	650 kW	Radio	Tetrode	water	42
TH 561	15 kW	VHF	Tetrode	water	43/44
TH 562	12 kW	Radio	Tetrode	water	45
TH 563	44 kW	UHF	Tetrode	water	46
TH 571 A	41 kW	VHF	Tetrode	water	47

Reference	Power	Band	Type	Cooling	Page
TH 573	350 kW	Radio	Tetrode	water	48
TH 573 V	300 kW	Radio	Tetrode	water	9
TH 576	650 kW	Radio	Tetrode	water	49
TH 580	100 kW	Radio	Tetrode	water	9
TH 581	125 kW	Radio	Tetrode	water	50
TH 581 V	125 kW	Radio	Tetrode	water	9
TH 582	22 kW	UHF	Tetrode	water	51
TH 583	110 kW	Radio	Tetrode	water	9
TH 584	10.5 kW	UHF	Tetrode	water	9
TH 590	10.5 kW	UHF	Tetrode	water	9
TH 593	4.4 kW	UHF	Tetrode	water	52
TH 598	3 kW	Radio	Tetrode	water	53
TH 6090			Thyratron		9
TH 6091			Thyratron		9
TH 6092			Thyratron		9
TH 18006			Cavity		9
TH 18007			Cavity		new
TH 18108			Cavity		20
TH 18230			Cavity		21
TH 18261			Cavity		15
TH 18324			Cavity		13
TH 18326			Cavity		27
TH 18327			Cavity		28
TH 18346			Cavity		24
TH 18362			Cavity		14/17
TH 18363			Cavity		16/25
TH 18462			Cavity		18/19
TH 18482			Cavity		32
TH 18526			Cavity		43
TH 18527			Cavity		47
TH 18550			Cavity		46
TH 18563			Cavity		36/40
TH 18565			Cavity		52
TH 18582			Cavity		51
TH 18665			Cavity		33

Tube selection guide

Band and power output

Band	Reference	Power	Type	Cooling	Page
UHF Television	TH 326	50 W	Triode	air	15
	TH 308	110 W	Triode	air	14
	TH 328	110 W	Triode	air	17
	TH 338	220 W	Triode	air	18
	TH 339	220 W	Planar triode	air	19
	TH 327	550 W	Tetrode	air	16
	TH 527	1 kW	Tetrode	water	36
	TH 347	2 kW	Tetrode	air	25
	TH 547	2 kW	Tetrode	water	40
	TH 393	4.4 kW	Tetrode	air	33
	TH 593	4.4 kW	Tetrode	water	52
	TH 382	11 kW	Tetrode	air	32
	TH 582	22 kW	Tetrode	water	51
	TH 563	44 kW	Tetrode	water	46
VHF Television	TH 225	250 W	Tetrode	air	12
	TH 298	2.2 kW	Tetrode	air	13
	TH 375	10 kW	Tetrode	air	30
	TH 361	15 kW	Tetrode	air	27
	TH 561	15 kW	Tetrode	water	43
	TH 371	21 kW	Tetrode	air	28
	TH 571 A	41 kW	Tetrode	water	47
FM Radio	TH 341	10 kW	Tetrode	air	20
	TH 344	10 kW	Tetrode	air	22
	TH 373	10 kW	Tetrode	air	29
	TH 345	22 kW	Tetrode	air	23
	TH 343	30 kW	Tetrode	air	21
	TH 346	60 kW	Tetrode	air	24
AM Radio - L/M/SW	TH 349	1 kW	Tetrode	air	26
	TH 598	3 kW	Tetrode	water	53
	TH 376	5 kW	Tetrode	air	31
	TH 399	12 kW	Tetrode	air	34
	TH 561	12 kW	Tetrode	water	44
	TH 562	12 kW	Tetrode	water	45
	TH 532	60 kW	Tetrode	water	37
	TH 521	70 kW	Tetrode	water	35
	TH 581	125 kW	Tetrode	water	50
	TH 555 A	250 kW	Tetrode	water	41
	TH 537	300 kW	Tetrode	water	38
	TH 573	350 kW	Tetrode	water	48
	TH 558	650 kW	Tetrode	water	42
	TH 576	650 kW	Tetrode	water	49
	TH 539	1.25 MW	Tetrode	water	39

Power is indicated on the carrier for radio tubes and peak-of-sync video for TV tubes.

Replacement tubes and cavity

The following products continue to be offered as replacements for existing transmitters, thus guaranteeing availability. They are not proposed for new designs, but should you require further information on their performances, do not hesitate to contact Thomson Tubes Electroniques.

Reference	Power	Band	Type	Cooling
TH 287	10 kW	VHF	Triode	air
TH 289	2 kW	Radio	Tetrode	air
TH 289 MA	3 kW	FM	Tetrode	air
TH 290	10 kW	UHF	Tetrode	air
TH 293	2 kW	UHF	Tetrode	air
TH 294	400 W	UHF	Triode	air
TH 306	25 W	UHF	Triode	air
TH 308 B	250 W	UHF	Triode	air
TH 313	5 kW	UHF	Tetrode	air
TH 316	35 W	UHF	Triode	air
TH 331	1 kW	UHF	Tetrode	air
TH 336	25 W	UHF	Triode	air
TH 337	200 W	UHF	Triode	air
TH 340	220 W	UHF	Triode	air
TH 342	500 W	UHF	Triode	air
TH 354	10 kW	VHF	Tetrode	air
TH 360	12 kW	Radio	Tetrode	air
TH 362	12 kW	Radio	Tetrode	air
TH 369	5 kW	FM	Tetrode	air
TH 374	30 kW	FM	Tetrode	air
TH 390	2 kW	UHF	Tetrode	air
TH 390 A	2 kW	UHF	Tetrode	air
TH 392	10 kW	UHF	Tetrode	air
TH 476	200 kW	Radio	Triode	water
TH 477	50 kW	Radio	Triode	water
TH 478	250 kW	Radio	Triode	water
TH 478 A	250 kW	Radio	Triode	water
TH 479	30 kW	Radio	Triode	water
TH 483	40 kW	Radio	Triode	water
TH 485	100 kW	Radio	Triode	water
TH 487	110 kW	Radio	Triode	water
TH 491 B	25 kW	UHF	Tetrode	water
TH 4T1100	2.3 kW	Radio	Tetrode	air
TH 4T4100	5 kW	Radio	Tetrode	air
TH 504 C	300 kW	Radio	Triode	water

Power is indicated as carrier power for radio tubes and peak of sync video for TV transmitter tubes.

Reference	Power	Band	Type	Cooling
TH 504 V	300 kW	Radio	Triode	water
TH 520	70 kW	Radio	Tetrode	water
TH 524 A	250 kW	Radio	Triode	water
TH 538	300 kW	Radio	Tetrode	water
TH 538 V	300 kW	Radio	Tetrode	water
TH 539 A	1.2 MW	Radio	Tetrode	water
TH 546	100 kW	FM	Tetrode	water
TH 548	520 kW	Radio	Tetrode	water
TH 555	200 kW	Radio	Tetrode	water
TH 573 V	300 kW	Radio	Tetrode	water
TH 580	100 kW	Radio	Tetrode	water
TH 581 V	125 kW	Radio	Tetrode	water
TH 583	110 kW	Radio	Tetrode	water
TH 584	10.5 kW	UHF	Tetrode	water
TH 590	10.5 kW	UHF	Tetrode	water
TH 6090			Thyratron	
TH 6091			Thyratron	
TH 6092			Thyratron	
TH 18006			Cavity	

Tube and cavity data sheets

■ Output power

250 W
up to 500 MHz

General characteristics

Cathode ..... oxide
Heating(1) ..... direct, dc or single phase
Interelectrode capacitances, approx.:
- Ground/cathode connection:
  - input ..... 15.7 pF
  - output ..... 4.5 pF
  - feed-through ..... 0.04 pF
- Ground/grid connection:
  - input ..... 13 pF
  - output ..... 4.5 pF
  - feed-through ..... 0.01 pF

Amplification factor, average 5
Transconductance (Ia = 0.2 A, Vg2 = 250 V) ..... 12 mA/V
Operating position ..... any
Weight, approx. ..... 140 g
Dimensions ..... see page 55
Anode, electrode terminal and ceramic cooling (2):
- type ..... forced air
- temperature on the tube, max. ..... 250 °C

Maximum ratings

Anode voltage ..... 2 kV
Control-grid voltage ..... -250 V
Screen-grid voltage ..... 400 V
Peak cathode current ..... 250 mA
Anode dissipation ..... 250 W
Control-grid dissipation ..... 2 W
Screen-grid dissipation ..... 12 W

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation. As an indication for equipment design purposes only, a heater voltage of 6 V produces a heating current of 2.6 A.

(2) Values for cooling given for maximum anode dissipation.

Typical operation carrier conditions

Output power	250	W
Frequency	500	MHz
Anode voltage	2	kV
Screen-grid voltage	250	V
Control-grid bias voltage	- 90	V
Anode current	250	mA
Screen-grid current	10	mA
Control-grid current	10	mA

TH 298 FM/VHF tetrode

■ Output power

up to 2.2 kW
peak-of sync in common amplification
3.75 kW in sound carrier amplification
3 kW in FM radio transmitters

General characteristics

Cathode .... thoriated tungsten
Heating (1) .... direct
Interelectrode capacitances, approx.:
- cathode-control grid .... 40 pF
- control grid-screen grid .... 75 pF
- screen grid-anode .... 11.5 pF

Amplification factor, average 7
Transconductance (Ia = 1.5 A, Vg2 = 600 V) .... 40 mA/V
Operating position .... vertical
Weight, approx. .... 2 kg
Dimensions .... see page 55
Anode cooling (2) .... forced air
- air flow, min. .... 5 m^3/mn
- corresponding pressure drop .... 5 mbar
- outlet air temperature, less than .... 100 °C

Electrode terminal and ceramic seal cooling
- type .... forced air
- temperature on the tube, max .... 250 °C

Maximum ratings

Frequency .... 300 MHz
Anode voltage .... 5 kV
Anode current .... 2.5 A
Anode dissipation .... 5 kW
Control-grid dissipation .... 40 W
Screen-grid dissipation .... 60 W

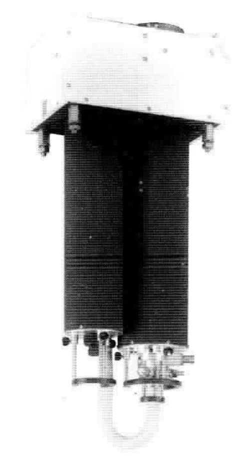
(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation.
As an indication for equipment design purposes only, a heater voltage of 6 V produces a heating current of 50 A.
(2) Values for cooling given for maximum anode dissipation.

Typical operation at 178 MHz TV operation in the matched cavity TH 18324A

	Common amplification	Sound only	FM radio	
Sound carrier output power	-	3.75	-	kW
Peak-of-sync output power	2.2	-	3	kW
- 1 dB bandwidth	8	4	-	MHz
- 3 dB bandwidth	-	-	> 300	kHz
Intermodulation products	- 48	-	-	dB
Gain	14	16.5	23	dB
Anode voltage	4.5	5	5	kV
Screen-grid voltage	500	500	400	V
Anode current, with signal	1.35	1.5	0.8	A
Screen-grid current	10	50	20	mA
Control-grid current	negligible	negligible	35	mA
Anode current at zero signal	0.6	0.6	0.1	A

TH 18324A matched circuit assembly

For UHF-TV transmitters and translators (Band III)



Operating frequency .... 178 to 227 MHz
Dimensions .... 760 x 278 x 178 mm
Weight, approx (without tube) .... 25 kg
RF connections:
- input .... female, type N
- output .... standard EIA rigid coaxial line 7/8"

Cooling .... forced air

■ Output power

up to 110 W
peak-of sync in common amplification

General characteristics

Cathode .... oxide
Heating (1) .... indirect
Interelectrode capacitances, approx.:
  cathode-grid .... 16 pF
  cathode-anode .... 0.13 pF
  grid-anode .... 7.3 pF
Amplification factor, average 80
Transconductance (Ia = 0.25 A) .... 45 mA/V
Operating position .... any
Weight, approx. .... 950 g
Dimensions .... see page 55
Anode cooling (2) .... forced air
  air flow, min. .... 450 l/mn
  corresponding pressure drop .... 0.8 mbar
  outlet air temperature, max. .... 100 °C
Electrode terminal and ceramic seal cooling
  type .... forced air
  temperature on the tube, max. .... 250 °C

Maximum ratings

Frequency .... 1000 MHz
Voltage .... 2.2 kV
Anode current .... 0.6 A
Anode dissipation .... 700 W

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation.
As an indication for equipment design purposes only, a heater voltage of 6.3 V produces a heating current of 6 A.
(2) Values for cooling given for maximum anode dissipation.

Typical operation at 780 MHz in the matched cavity TH 18362

	Common amplification	
Peak-of-sync output power	110	W
- 1 dB bandwidth	10	MHz
Intermodulation products	- 52	dB
Gain	16	dB
Anode voltage	1.8	kV
Grid voltage	20	V
Anode current, with signal	0.3	A
Anode current at zero signal	0.2	A

TH 18362 matched circuit assembly

For UHF-TV transmitters and translators (Bands IV and V)

Operating frequency .... 460 to 860 MHz
Dimensions .... 571.5 x 260 x 162 mm
Weight, approx (without tube) .... 10 kg
RF connections:
  input .... female, type BNC
  output .... female, type N
Cooling .... forced air

■ Output power

up to 50 W
peak-of sync in common amplification

General characteristics

Cathode ....oxide
Heating (1) ....indirect
Interelectrode capacitances, approx.:
  cathode-grid ....22 pF
  cathode-anode ....0.05 pF
  grid-anode ....3.9 pF
Amplification factor, average 250
Transconductance (Ia = 0.15 A) ....80 mA/V
Operating position ....any
Weight, approx. ....170 g
Dimensions ....see page 55
Anode cooling (2) ....forced air
  air flow, min. ....280 l/mn
  corresponding pressure drop ....0.5 mbar
  outlet air temperature, max. ....100 °C
Electrode terminal and ceramic seal cooling
  type ....forced air
  temperature on the tube, max. ....150 °C

Maximum ratings

Frequency ....1000 MHz
Voltage ....2 kV
Anode current ....250 mA
Anode dissipation ....270 W

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation.
As an indication for equipment design purposes only, a heater voltage of 5 V produces a heating current of 2 A.
(2) Values for cooling given for anode dissipation of 200 W.

Typical operation at 780 MHz in the matched cavity TH 18261

	Common amplification	
Peak-of-sync output power	50	W
- 1 dB bandwidth	10	MHz
Intermodulation products	- 53	dB
Gain	20	dB
Anode voltage	1.8	kV
Grid voltage	- 7	V
Anode current, with signal	165	mA
Grid current	negligible	
Anode current at zero signal	140	mA

TH 18261 matched circuit assembly

For UHF-TV transmitters and translators (Bands IV and V)

Operating frequency ....470 to 960 MHz
Dimensions ....460 x 240 x 150 mm
Weight, approx (without tube) ....6 kg
RF connections:
  input ....female, type BNC
  output ....female, type N
Cooling ....forced air

TH 327 UHF tetrode

■ Output power

up to 550 W
peak-of sync in common amplification
up to 1.2 W in sound carrier amplification

General characteristics

Cathode ....thoriated tungsten
Heating (1) ....direct
Interelectrode capacitances, approx.:
- cathode-control grid ....40 pF
- control grid-screen grid ....50 pF
- screen grid-anode ....8.2 pF

Amplification factor, average 7
Transconductance (Ia = 1.5 A, Vg2 = 400 V)..........40 mA/V
Operating position ....vertical
Weight, approx. ....2.3 kg
Dimensions ....see page 55
Anode cooling (2)..........forced air
- air flow, min. ....2 m^3/mn
- corresponding pressure drop ....2 mbar
- outlet air temperature, max. ....100 °C

Electrode terminal and ceramic seal cooling
- type ....forced air
- temperature on the tube, max. ....250 °C

Maximum ratings

Frequency ....1000 MHz
Anode voltage ....5 kV
Anode current .... 2 A
Anode dissipation..........4.5 kW
Control-grid dissipation ....5 W
Screen-grid dissipation ....25 W

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation.
As an indication for equipment design purposes only, a heater voltage of 6 V produces a heating current of 34 A.
(2) Values for cooling given for anode dissipation of 2 kW.

Typical operation at 800 MHz in the matched cavity TH 18363

	Common amplification	Sound only	
Peak-of-sync output power	550	-	W
Sound carrier output power	-	1200	W
- 1 dB bandwidth	10	10	MHz
Intermodulation products	- 54	-	dB
Gain	15.5	15.5	dB
Anode voltage	3.5	4	kV
Screen-grid voltage	400	400	V
Anode current, with signal	0.65	1	A
Screen-grid current	2	5	mA
Control-grid current	negligible	negligible	
Anode current at zero signal	0.5	0.5	A

TH 18363 matched circuit assembly

For UHF-TV transmitters and translators (Bands IV and V)

Operating frequency ....470 to 860 MHz
Dimensions ....644 x 268 x 200 mm
Weight, approx (without tube) ....20 kg
RF connections:
- input ....female, type N
- output ....standard EIA 7/8"

Cooling..........forced air

■ Output power

up to 110 W
peak-of sync in common amplification

General characteristics

Cathode .... oxide
Heating (1) .... indirect
Interelectrode capacitances, approx.:
- cathode-grid .... 19 pF
- cathode-anode .... 0.07 pF
- grid-anode .... 8.2 pF

Amplification factor, average 180
Transconductance (Ia = 0.4 A) .... 85 mA/V
Operating position .... any
Weight, approx. .... 950 g
Dimensions .... see page 55
Anode cooling (2) .... forced air
- air flow, min. .... 470 l/mn
- corresponding pressure drop .... 1 mbar
- outlet air temperature, max. .... 100 °C

Electrode terminal and ceramic seal cooling
- type .... forced air
- temperature on the tube, max. .... 250 °C

Maximum ratings

Frequency .... 1000 MHz
Anode voltage .... 2.2 kV
Anode current .... 0.6 A
Anode dissipation .... 750 W

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation.
As an indication for equipment design purposes only, a heater voltage of 5.5 V produces a heating current of 5.4 A.
(2) Values for cooling given for maximum anode dissipation.

Typical operation at 780 MHz in the matched cavity TH 18362

	Common amplification	
Peak-of-sync output power	110	W
- 1 dB bandwidth	10	MHz
Intermodulation products	- 52	dB
Gain	20	dB
Anode voltage	1.8	kV
Grid voltage	- 6	V
Anode current, with signal	0.43	A
Anode current at zero signal	0.4	A

TH 18362 matched circuit assembly

For UHF-TV transmitters and translators (Bands IV and V)

Operating frequency .... 460 to 860 MHz
Dimensions .... 571.5 x 260 x 162 mm
Weight, approx (without tube) .... 10 kg
RF connections:
- input .... female, type BNC
- output .... female, type N

Cooling .... forced air

TH 338 UHF triode

■ Output power

up to 220 W
peak-of sync in common amplification

General characteristics

Cathode ....oxide
Heating (1) ....indirect
Interelectrode capacitances, approx.:
- cathode-grid ....16 pF
- cathode-anode ....0.13 pF
- grid-anode ....7.3 pF

Amplification factor, average 80
Transconductance (Ia = 0.25 A) ....45 mA/V
Operating position ....any
Weight, approx. ....1.2 kg
Dimensions ....see page 55
Anode cooling (2) ....forced air
- air flow, min. ....1250 l/mn
- corresponding pressure drop ....4.5 mbar
- outlet air temperature, max. ....100 °C

Electrode terminal and ceramic seal cooling
- type ....forced air
- temperature on the tube, max. ....250 °C

Maximum ratings

Frequency ....1000 MHz
Anode voltage ....2.5 kV
Anode current ....0.6 A
Anode dissipation ....1.2 kW

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation.
As an indication for equipment design purposes only, a heater voltage of 6.3 V produces a heating current of 6 A.
(2) Values for cooling given for anode dissipation of 1 kW.

Typical operation at 780 MHz in the matched cavity TH 18462

	Common amplification	
Peak-of-sync output power	220	W
- 1 dB bandwidth	10	MHz
Intermodulation products	- 52	dB
Gain	16	dB
Anode voltage	2.4	kV
Grid voltage	- 22	V
Anode current, with signal	0.45	A
Anode current at zero signal	0.4	A

TH 18462 matched circuit assembly

For UHF-TV transmitters and translators (Bands IV and V)

Operating frequency ....460 to 860 MHz
Dimensions ....571.5 x 260 x 162 mm
Weight, approx (without tube) ....10 kg
RF connections:
- input ....female, type BNC
- output ....female, type N

Cooling ....forced air

TH 339 UHF triode

■ Output power

up to 220 W

peak-of sync in common amplification

General characteristics

Cathode .... oxide
Heating (1) .... indirect
Interelectrode capacitances, approx.:
  cathode-grid .... 19 pF
  cathode-anode .... 0.07 pF
  grid-anode .... 7.3 pF
Amplification factor, average 180
Transconductance (Ia = 0.4 A) .... 85 mA/V
Operating position .... any
Weight, approx. .... 1.2 kg
Dimensions .... see page 55
Anode cooling (2) .... forced air
  air flow, min. .... 1250 l/mn
  corresponding pressure drop, max .... 4.5 mbar
  outlet air temperature, max. .... 100 °C
Electrode terminal and ceramic seal cooling
  type .... forced air
  temperature on the tube, max. .... 250 °C

Maximum ratings

Frequency .... 1000 MHz
Anode voltage .... 2.2 kV
Anode current .... 0.6 A
Anode dissipation .... 1.2 kW

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation.
As an indication for equipment design purposes only, a heater voltage of 5.5 V produces a heating current of 5.5 A.

(2) Values for cooling given for anode dissipation of 1 kW.

Typical operation at 780 MHz in the matched cavity TH 18462

	Common amplification	
Peak-of-sync output power	220	W
- 1 dB bandwidth	10	MHz
Intermodulation products	- 52	dB
Gain	20	dB
Anode voltage	2.0	kV
Grid voltage	- 9	V
Anode current, with signal	0.45	A
Anode current at zero signal	0.35	A

TH 18462 matched circuit assembly

For UHF-TV transmitters and translators (Bands IV and V)

Operating frequency .... 460 to 860 MHz
Dimensions .... 571.5 x 260 x 162 mm
Weight, approx (without tube) .... 10 kg
RF connections:
  input .... female, type BNC
  output .... female, type N
Cooling .... forced air

TH 341 FM tetrode

■ Output power

up to 10 kW
in FM radio transmitters

General characteristics

Cathode ....thoriated tungsten
Heating (1) ....direct, dc or single phase
Interelectrode capacitances, approx.:
  cathode-control grid ....72 pF
  control grid-screen grid ....135 pF
  screen grid-anode ....19 pF
Amplification factor, average 5.5
Transconductance (Ia = 0.15 A, Vg2 = 500 V).......................60 mA/V
Operating position ....vertical
Weight, approx. ....3.5 kg
Dimensions ....see page 55
Anode cooling (2)...forced air
  air flow, min. ....6 m^3/mn
  corresponding pressure drop ....1.5 mbar
  outlet air temperature, max. ....100 °C
Electrode terminal and ceramic seal cooling
  type ....forced air
  temperature on the tube, max. ....250 °C

Maximum ratings

Frequency ....120 MHz
Anode voltage ....8 kV
Anode current .... 6 A
Anode dissipation..................................6 kW
Control-grid dissipation ....50 W
Screen-grid dissipation ....150 W

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation.
As an indication for equipment design purposes only, a heater voltage of 6.5 V produces a heating current of 85 A.
(2) Values for cooling given for maximum anode dissipation.

Typical operation at 108 MHz in the matched cavity TH 18108

	TH 18108G Grounded-grid operation	TH18108K Grounded-cathode operation	
Output power	10	10	kW
- 0.2 dB bandwidth	300	300	kHz
Gain	17	21	dB
Anode voltage	7	6.5	kV
Screen-grid voltage	400	500	V
Anode current, with signal	2	1.95	A
Screen-grid current	60	70	mA
Control-grid current	30	30	mA
Anode current at zero signal	0.25	0.05	A

TH 18108G/TH 18108K matched circuit assemblies

For FM radio transmitters

Operating frequency ....87 to 108 MHz
Dimensions, TH 18108G ....555 x 455 x 241 mm
Dimensions, TH 18108K ....561 x 340 x 241 mm
Weight, approx (without tube), TH 18108G ....38 kg
Weight, approx (without tube), TH 18108K................................25 kg
RF connections:
  input ....female, type N
  output ....EIA standard 1 5/8"
Cooling..forced air

■ Output power

up to 30 kW
in FM radio transmitters

General characteristics

Cathode ....thoriated tungsten
Heating (1) ....direct, dc or single phase
Interelectrode capacitances, approx.:
- cathode-control grid ....110 pF
- control grid-screen grid ....215 pF
- screen grid-anode ....28 pF

Amplification factor, average 7
Transconductance (Ia = 2 A, Vg2 = 500 V) ....100 mA/V
Operating position ....vertical
Weight, approx. ....6 kg
Dimensions ....see page 55
Anode cooling (2) ....forced air
- air flow, min. ....14 m^3/mn
- corresponding pressure drop ....5 mbar
- outlet air temperature, max. ....100 °C

Electrode terminal and ceramic seal cooling
- type ....forced air
- temperature on the tube, max. ....250 °C

Maximum ratings

Frequency ....120 MHz
Anode voltage ....10 kV
Anode current .... 7 A
Anode dissipation ....18 kW
Control-grid dissipation ....100 W
Screen-grid dissipation ....300 W

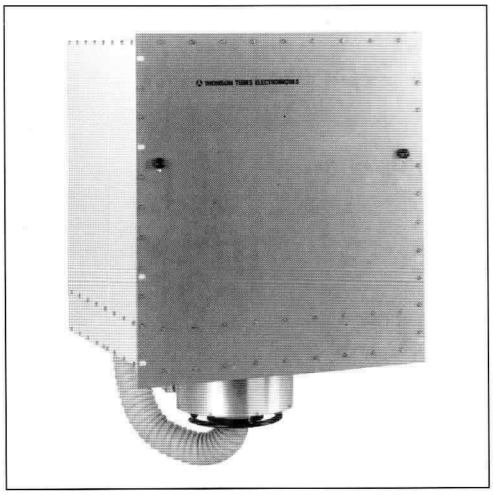
(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation.
As an indication for equipment design purposes only, a heater voltage of 7.6 V produces a heating current of 120 A.
(2) Values for cooling given for anode dissipation of 12 kW.

Typical operation at 108 MHz in the matched cavity TH 18230G

Grounded-grid operation	Example 1	Example 2	
Output power	20	30	kW
- 0.2 dB bandwidth	300	300	kHz
Gain	17	18	dB
Anode voltage	8.5	9.5	kV
Screen-grid voltage	500	600	V
Anode current, with signal	2.9	4.2	A
Screen-grid current	120	220	mA
Control-grid current	30	4	mA
Anode current at zero signal	0.05	0.5	A

TH 18230G matched circuit assembly

For FM radio transmitters



Operating frequency ....87.5 to 108 MHz
Dimensions ....800 x 580 x 483 mm
Weight, approx (without tube) ....63 kg
RF connections:
- input ....female, type N
- output ....EIA standard 3 1/8"

Cooling ....forced air

■ **Output power**

up to 15 kW
in FM radio transmitters

General characteristics

Cathode .... thoriated tungsten
Heating (1) .... direct, dc or ac
Interelectrode capacitances, approx.:
- cathode-control grid .... 95 pF
- control grid-screen .... 76 pF
- screen grid-anode .... 22 pF

Amplification factor, average 8
Transconductance (Ia = 3 A, Vg2 = 800 V) .... 53 mA/V
Operating position .... vertical
Weight, approx. .... 6.7 kg
Dimensions .... see page 55
Anode cooling (2) .... forced air
- air flow, min. .... 12 m^3/mn
- corresponding pressure drop .... 9 mbar
- outlet air temperature, max. .... 100 °C

Electrode terminal and ceramic seal cooling
- type .... forced air
- temperature on the tube, max. .... 220 °C (250 °C on grid connections)

Maximum ratings

Frequency .... 120 MHz
Anode voltage .... 9 kV
Anode current .... 6 A
Anode dissipation .... 12 kW
Control-grid dissipation .... 100 W
Screen-grid dissipation .... 300 W

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation. As an indication for equipment design purposes only, a heater voltage of 9.5 V produces a heating current of 80 A.

(2) Values for cooling given for maximum anode dissipation.

Typical operation at 98 MHz
Class B amplification, Grounded-cathode operation

	Example 1	Example 2	
Output power	15	10	kW
- 0.2 dB bandwidth	300	300	kHz
Gain	23	23	dB
Anode voltage	8.5	7.5	kV
Screen-grid voltage	750	700	V
Control-grid bias voltage	- 90	- 100	V
Anode current, with signal	2.5	1.9	A
Screen-grid current	250	180	mA
Control-grid current	30	20	mA

TH 345

FM tetrode

■ Output power

up to 22 kW
in FM radio transmitters

General characteristics

Cathode ... thoriated tungsten
Heating (1) ... direct, dc or ac
Interelectrode capacitances, approx.:
  cathode-control grid ... 82 pF
  control grid-screen grid ... 128 pF
  screen grid-anode ... 21 pF
Amplification factor, average ... 7
Transconductance (Ia = 3 A, Vg2 = 800 V) ... 80 mA/V
Operating position ... vertical
Weight, approx. ... 7 kg
Dimensions ... see page 55
Anode cooling (2) ... forced air
  air flow, min. ... 22 m^3/mn
  corresponding pressure drop ... 9 mbar
  outlet air temperature, max. ... 100 °C
Electrode terminal and ceramic seal cooling
  type ... forced air
  temperature on the tube, max. ... 220 °C
  (280 °C on heater connections)

Maximum ratings

Frequency ... 120 MHz
Anode voltage ... 12 kV
Anode current ... 6 A
Anode dissipation ... 16 kW
Control-grid dissipation ... 70 W
Screen-grid dissipation ... 270 W

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation. As an indication for equipment design purposes only, a heater voltage of 9 V produces a heating current of 120 A.

(2) Values for cooling given for maximum anode dissipation.

Typical operation at 108 MHz Grounded-grid operation

	Example 1	Example 2	
Output power	11.3	22	kW
- 0.2 dB bandwidth	300	300	kHz
Gain	18	16	dB
Anode voltage	9	9	kV
Screen-grid voltage	600	800	V
Control-grid bias voltage	- 140	- 140	V
Anode current, with signal	1.6	3.4	A
Screen-grid current	100	230	mA
Control-grid current	5	20	mA

TH 346 FM tetrode

■ Output power

up to 60 kW
in FM radio transmitters

General characteristics

Cathode ....thoriated tungsten
Heating (1) ....direct, dc or single phase ac
Interelectrode capacitances, approx.:
- cathode-control grid ....160 pF
- control grid-screen grid ....210 pF
- screen grid-anode ....30 pF

Amplification factor, average 6
Transconductance (Ia = 5 A, Vg2 = 800 V)..........................110 mA/V
Operating position ....vertical
Weight, approx. ....26 kg
Dimensions ....see page 55
Anode cooling (2)...forced air
- air flow, min. ....25 m^3/mn
- outlet air temperature, max. ....100 °C

Electrode terminal and ceramic seal cooling
- type ....forced air
- temperature on the tube, max. ....200 °C

Maximum ratings

Frequency ....120 MHz
Anode voltage ....15 kV
Anode current .... 25 A
Anode dissipation ....30 kW
Control-grid dissipation ....300 W
Screen-grid dissipation ....600 W

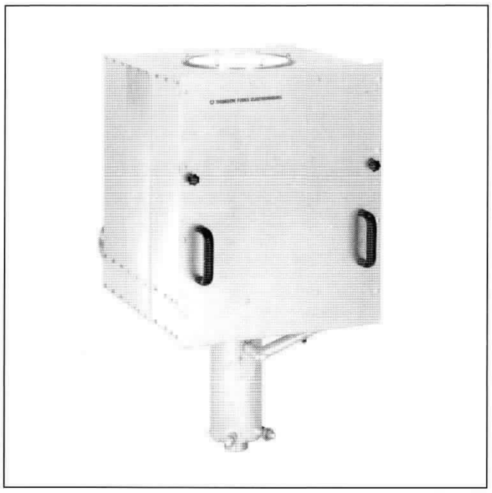
(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation.
As an indication for equipment design purposes only, a heater voltage of 10 V produces a heating current of 210 A.
(2) Values for cooling given for maximum anode dissipation.

Typical operation at 108 MHz in the matched cavity TH 18346

	Grounded-grid operation	
Output power	60	kW
- 0.2 dB bandwidth	300	kHz
Gain	14	dB
Anode voltage	10	kV
Screen-grid voltage	1000	V
Control-grid bias voltage	- 450	V
Anode current, with signal	7.4	A
Screen-grid current	380	mA
Control-grid current	370	mA

TH 18346 matched circuit assembly

For FM radio transmitters



Operating frequency ....86.5 to 108 MHz
Dimensions ....980 x 580 x 483 mm
Weight, approx (without tube) ....65 kg
RF connections:
- input ....female, type 7/8"
- output ....EIA standard 3 1/8"

Cooling...forced air

TH 347 UHF tetrode

■ Output power

up to 1.1 kW
peak-of-sync in common amplification
2.2 kW peak-of-sync in vision carrier amplification

General characteristics

Cathode ....thoriated tungsten
Heating (1) ....direct, dc or single phase ac
Interelectrode capacitances, approx.:
- cathode-control grid ....40 pF
- control grid-screen grid ....50 pF
- screen grid-anode ....8.2 pF

Amplification factor, average 7
Transconductance (Ia = 1.5 A, Vg2 = 400 V).........................40 mA/V
Operating position ....vertical
Weight, approx. ....2.3 kg
Dimensions ....see page 55
Anode cooling (2)...forced air
- air flow, min. ....2.5 m^3/mn
- air inlet pressure, max...3 mbar
- outlet air temperature, max. ....100 °C

Electrode terminal and ceramic seal cooling
- type ....forced air
- temperature on the tube, max. ....250 °C

Maximum ratings

Frequency....................................1000 MHz
Anode voltage ....5 kV
Anode current .... 2 A
Anode dissipation...............................4.5 kW
Control-grid dissipation ....5 W
Screen-grid dissipation ....25 W

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation.
As an indication for equipment design purposes only, a heater voltage of 6 V produces a heating current of 34 A.
(2) Values for cooling given for anode dissipation of 2.5 kW.

Typical operation at 800 MHz in the matched cavity TH 18363

	Common amplification	Vision only	
Peak-of-sync output power	1.1	2.2	kW
- 1 dB bandwidth	10	10	MHz
Intermodulation products	- 54	-	dB
Gain	15.5	15.5	dB
Anode voltage	4	4	kV
Screen-grid voltage	400	400	V
Anode current, with signal	0.8	1.5	A
Screen-grid current	5	8	mA
Control-grid current	negligible	2	mA
Anode current at zero signal	0.5	0.5	A

TH 18363 matched circuit assembly

For UHF-TV transmitters and translators (Bands IV and V)

Operating frequency...470 to 860 MHz
Dimensions ....644 x 268 x 200 mm
Weight, approx (without tube) ....20 kg
RF connections:
- input ....female, type N
- output ....EIA standard 7/8"

Cooling...forced air

■ Output power

1 kW

in SSB, up to 110 MHz

General characteristics

Cathode .... oxide
Heating (1) .... indirect
Interelectrodes capacitances, approx.(ground/cathode conection):
input .... 75 pF
reaction .... 0.06 pF
output .... 14.5 pF
Amplification factor, average 4.5
Transconductance (Ia = 0.3 A, Vg2 = 225 V) .... 25 mA/V
Operating position .... vertical
Weight, approx .... 0.84 kg
Connector .... TH 16054
Dimensions .... see page 55
Anode cooling (2) .... forced air
air flow, min .... 1.5 m^3/mn
air inlet pressure, max .... 2 mbar
outlet air temperature .... 100 °C
Electrode terminal and ceramic cooling:
type .... forced air
temperature on the tube, max .... 250 °C

Maximum ratings

Anode voltage .... 3 kV
Control-grid voltage .... - 150 V
Screen-grid voltage .... 400 V
Cathode current, average .... 0.9 A
Anode dissipation .... 1.5 kW
Control-grid dissipation .... 1 W
Screen-grid dissipation .... 12 W

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation. As an indication for equipment design purposes only, a heater voltage of 6 V produces a heating current of 10.5 A.

(2) Values for cooling given for maximum anode dissipation.

Typical operation carrier conditions

Output power	1	kW
Frequency	30	MHz
Anode voltage	2.75	kV
Screen-grid voltage	225	V
Control-grid bias voltage	- 36	V
Anode current	700	mA
Screen-grid current	20	mA
Control-grid current	1	mA

■ Output power

up to 5.25 kW
peak-of-sync in common amplification
15 kW peak-of-sync in vision carrier amplification

General characteristics

Cathode .... thoriated tungsten
Heating (1) .... direct
Interelectrode capacitances, approx.:
- cathode-control grid .... 83 pF
- control grid-screen grid .... 135 pF
- screen grid-anode .... 17 pF

Amplification factor, average 5.5
Transconductance (Ia = 1.5 A, Vg2 = 500 V) .... 60 mA/V
Operating position .... vertical
Weight, approx. .... 7.5 kg
Dimensions .... see page 55
Anode cooling (2) .... forced air
- air flow, min. .... 13 m^3/mn
- corresponding pressure drop, max. .... 9 mbar
- outlet air temperature, max. .... 100 °C

Electrode terminal and ceramic seal cooling
- type .... forced air
- temperature on the tube, max. .... 250 °C

Maximum ratings

Frequency .... 300 MHz
Anode voltage .... 7 kV
Anode current .... 6 A
Anode dissipation .... 12 kW
Control-grid dissipation .... 50 W
Screen-grid dissipation .... 150 W

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation. As an indication for equipment design purposes only, a heater voltage of 7 V produces a heating current of 140 A.
(2) Values for cooling given for maximum anode dissipation.

Typical operation at 224 MHz in the matched cavity TH 18326A

	Common amplification	Vision only	
Peak-of-sync output power	5.25	15	kW
- 1 dB bandwidth	9	9	MHz
Intermodulation products	- 54	-	dB
Gain	16.5	16	dB
Anode voltage	5.4	5.6	kV
Screen-grid voltage	600	600	V
Anode current, with signal	2.4	3.2	A
Screen-grid current	20	35	mA
Control-grid current	negligible	negligible	
Anode current at zero signal	1.8	1.2	A

TH 18326A matched circuit assembly

For VHF-TV transmitters and translators (Band III)

Operating frequency .... 160 to 230 MHz
Dimensions .... 1361 x 391 x 256 mm
Weight, approx (without tube) .... 70 kg
RF connections:
- input .... female, type N
- output .... EIA standard 1 5/8"

Cooling .... forced air

TH 371

VHF tetrode

■ Output power

up to 21 kW
peak-of sync in common amplification
33 kW peak-of sync in vision carrier amplification

General characteristics

Cathode ....thoriated tungsten
Heating (1) ....direct
Interelectrode capacitances, approx.:
  cathode-control grid ....130 pF
  control grid-screen grid ....210 pF
  screen grid-anode ....25 pF
Amplification factor, average 8
Transconductance (Ia = 1.5 A, Vg2 = 600V).........................140 mA/V
Operating position ....vertical
Weight, approx. ....14 kg
Dimensions ....see page 55
Anode cooling (2)...forced air
  air flow, min. ....22 m^3/mn
  corresponding pressure drop ....12 mbar
  outlet air temperature, max. ....100 °C
Electrode terminal and ceramic seal cooling
  type ....forced air
  temperature on the tube, max. ....250 °C

Maximum ratings

Frequency.......................................300 MHz
Anode voltage..8 kV
Anode current .... 10 A
Anode dissipation................................18 kW
Control-grid dissipation ....150 W
Screen-grid dissipation ....400 W

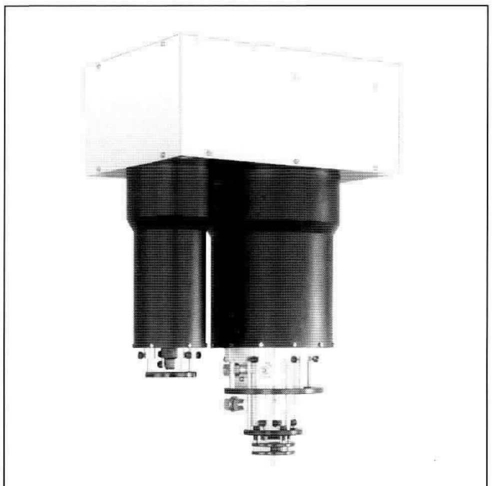
(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation.
As an indication for equipment design purposes only, a heater voltage of 8 V produces a heating current of 180 A.
(2) Values for cooling given for maximum anode dissipation.

Typical operation at 174 MHz in the matched cavity TH 18327A

	Common amplification	Vision only	
Peak-of-sync output power	21	33	kW
- 1 dB bandwidth	9	9	MHz
Intermodulation products	- 54	-	dB
Gain	16.5	16.5	dB
Anode voltage	6	5.9	kV
Screen-grid voltage	600	600	V
Anode current, with signal	5.4	6.3	A
Screen-grid current	85	90	mA
Control-grid current	15	25	mA
Anode current at zero signal	2	2	A

TH 18327A matched circuit assembly

For VHF-TV transmitters and translators (Band III)



Operating frequency..170 to 230 MHz
Dimensions ....977 x 450 x 344 mm
Weight, approx (without tube) ....80 kg
RF connections:
  input ....female, type N
  output ....standard EIA 3 1/8"
Cooling...forced air

TH 373

FM tetrode

■ Output power

up to 12 kW

in FM radio transmitters

General characteristics

Cathode .... thoriated tungsten
Heating (1) .... direct, dc or ac
Interelectrode capacitances, approx.:
cathode-control grid .... 78 pF
control grid-screen grid .... 115 pF
screen grid-anode .... 22 pF
Amplification factor, average 8
Transconductance (Ia = 2.5 A, Vg2 = 800 V) .... 55 mA/V
Operating position .... vertical
Weight, approx. .... 6.7 kg
Dimensions .... see page 55
Anode cooling (2) .... forced air
air flow, min. .... 12 m^3/mn
corresponding pressure drop .... 9 mbar
outlet air temperature, max. .... 100 °C
Electrode terminal and ceramic seal cooling
type .... forced air
temperature on the tube, max. .... 220 °C

Maximum ratings

Frequency .... 120 MHz
Anode voltage .... 9 kV
Anode current .... 6 A
Anode dissipation .... 12 kW
Control-grid dissipation .... 100 W
Screen-grid dissipation .... 300 W

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation. As an indication for equipment design purposes only, a heater voltage of 9.5 V produces a heating current of 80 A.

(2) Values for cooling given for maximum anode dissipation.

Typical operation at 110 MHz for FM radio transmitters Grounded-cathode operation

	Example 1	Example 2	
Output power	15	10	kW
- 0.2 dB bandwidth	300	300	kHz
Gain	23	25	dB
Anode voltage	7.5	7.5	kV
Screen-grid voltage	800	1000	V
Control-grid bias voltage	- 110	- 120	V
Anode current, with signal	2.3	2.35	A
Screen-grid current	200	150	mA
Control-grid current	50	0	mA

TH 375

VHF tetrode

■ Output power

up to 5.5 kW

peak-of-sync in common amplification

15 kW

peak-of-sync in vision carrier amplification

General characteristics

Cathode .... thoriated tungsten
Heating (1) .... direct, dc or ac
Interelectrode capacitances, approx.:
- cathode-control grid .... 76 pF
- control grid-screen grid .... 122 pF
- screen grid-anode .... 22 pF

Amplification factor, average 8.4
Transconductance (Ia = 3 A, Vg2 = 800 V) .... 70 mA/V
Operating position .... vertical
Weight, approx. .... 6.7 kg
Dimensions .... see page 55
Anode cooling (2) .... forced air
- air flow, min. .... 12 m^3/mn
- corresponding pressure drop .... 9 mbar
- outlet air temperature, max. .... 100 °C

Electrode terminal and ceramic seal cooling
- type .... forced air
- temperature on the tube, max. .... 250 °C

Maximum ratings

Frequency .... 250 MHz
Anode voltage .... 5.5 kV
Anode current .... 8 A
Anode dissipation .... 12 kW
Control-grid dissipation .... 100 W
Screen-grid dissipation .... 250 W

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation. As an indication for equipment design purposes only, a heater voltage of 10 V produces a heating current of 86 A.

(2) Values for cooling given for maximum anode dissipation.

Typical operation at 220 MHz for VHF-TV transmitters and translators (Band III)

	Common amplification	Vision only	
Peak-of-sync output power	5.5	16	kW
- 1 dB bandwidth	9	7	MHz
Intermodulation products	- 54	-	dB
Gain	15.5	14	dB
Anode voltage	4.7	5.2	kV
Screen-grid voltage	800	900	V
Control-grid bias voltage	- 70	- 90	V
Anode current, with signal	2.4	3.8	A
Screen-grid current	120	60	mA
Control-grid current	20	50	mA

■ Output power

5 kW

in SSB, up to 110 MHz

General characteristics

Cathode .... thoriated tungsten
Heating (1) .... direct, dc or single phase
Interelectrodes capacitances, approx. (grounded cathode):
- input .... 115 pF
- reaction .... 0.4 pF
- output .... 12 pF

Amplification factor, average 7
Transconductance (Ia = 1.5 A, Vg2 = 600 V) .... 40 mA/V
Operating position .... vertical
Weight, approx .... 2 kg
Dimensions .... see page 55
Connector .... TH 16121
Anode cooling (2) .... forced air
- air flow, min .... 5 m³/mn
- corresponding pressure drop .... 9 mbar
- outlet air temperature .... 100 °C

Electrode terminal and ceramic cooling:
- type .... forced air
- temperature on the tube, max .... 250 °C

Maximum ratings

Anode voltage .... 6.5 kV
Control-grid voltage .... - 200 V
Screen-grid voltage .... 900 V
Peak cathode current .... 10 A
Anode dissipation .... 5 kW
Control-grid dissipation .... 40 W
Screen-grid dissipation .... 60 W

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation. As an indication for equipment design purposes only, a heater voltage of 6 V produces a heating current of 50 A.

(2) Values for cooling given for maximum anode dissipation.

Typical operation carrier conditions

Output power	5	kW
Frequency	30	MHz
Anode voltage	6	kV
Screen-grid voltage	800	V
Control-grid bias voltage	- 110	V
Anode current	1.5	A
Screen-grid current	40	mA
Control-grid current	0	A
Anode current at zero signal	0.7	A

■ Output power

up to 5.25 kW
peak-of-sync in common amplification
11 kW
peak-of-sync in vision carrier amplification

General characteristics

Cathode .... thoriated tungsten
Heating (1) .... direct
Interelectrodes capacitances, approx.:
- cathode-control grid .... 72 pF
- control grid-screen grid .... 93 pF
- screen grid-anode .... 13.2 pF

Amplification factor, average 8
Transconductance (Ia = 1.5 A, Vg2 = 300 V) .... 80 mA/V
Operating position .... vertical
Weight, approx .... 7 kg
Dimensions .... see page 55
Anode cooling (2) .... forced air
- air flow, min .... 13 m^3/mn
- corresponding pressure drop .... 8 mbar
- outlet air temperature, max. .... 100 °C

Electrode terminal and ceramic seal cooling
- type .... forced air
- temperature on the tube, max .... 300 °C

Maximum ratings

Frequency .... 1000 MHz
Anode voltage .... 6.5 kV
Anode current .... 4.5 A
Anode dissipation .... 12.5 kW
Control-grid dissipation .... 50 W
Screen-grid dissipation .... 120 W

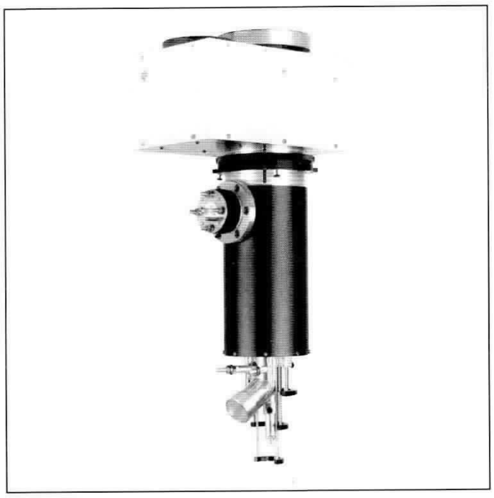
(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation.
As an indication for equipment design purposes only, a heater voltage of 4.2 V produces a heating current of 125 A.
(2) Values for cooling given for maximum anode dissipation.

Typical operation at 800 MHz in the matched cavity TH 18482

	Common amplification	Vision only	
Peak-of-sync output power	5.25	11	kW
- 1 dB bandwidth	12	12	MHz
Intermodulation products	- 52	-	dB
Gain	15.5	15.4	dB
Anode voltage	5.5	5.5	kV
Screen-grid voltage	600	600	V
Anode current, with signal	2.7	3.25	A
Screen-grid current	30	30	mA
Control-grid current	10	5	mA
Anode current at zero signal	1.2	1.2	A

TH 18482 matched circuit assembly

For UHF-TV transmitters and translators (Bands IV and V)



Operating frequency .... 470 to 860 MHz
Dimensions .... 1143 x 391 x 256 mm
Weight, approx (without tube) .... 70 kg
RF connections:
- input .... female, type N
- output .... standard EIA 1 5/8" or 3 1/8"

Cooling .... forced air

■ Output power

up to 2.2 kW
peak-of-sync in common amplification
4.4 kW peak-of-sync in vision carrier amplification
2.5 kW in sound carrier amplification

General characteristics

Cathode .... thoriated tungsten
Heating (1) .... direct
Interelectrodes capacitances, approx.:
- cathode-control grid .... 45 pF
- control grid-screen grid .... 72 pF
- screen grid-anode .... 9 pF

Amplification factor, average 8
Transconductance (Ia = 1.5 A, Vg2 = 400 V) .... 80 mA/V
Operating position .... vertical
Weight, approx .... 3.6 kg
Dimensions .... see page 55
Anode cooling (2) .... forced air
- air flow, min .... 8 m^3/mn
- corresponding pressure drop .... 9 mbar
- outlet air temperature, max. .... 100 °C

Electrode terminal and ceramic seal cooling
- type .... forced air
- temperature on the tube, max .... 300 °C

Maximum ratings

Frequency .... 1000 MHz
Anode voltage .... 6 kV
Anode current .... 3 A
Anode dissipation .... 7.5 kW
Control-grid dissipation .... 25 W
Screen-grid dissipation .... 75 W

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation.
As an indication for equipment design purposes only, a heater voltage of 6 V produces a heating current of 65 A.
(2) Values for cooling given for maximum anode dissipation.

Typical operation at 800 MHz in the matched cavity TH 18665

	Common amplification	Sound only	Vision only	
Peak-of-sync output power	2.2	-	4.4	kW
Sound carrier output power	-	2.5	-	kW
-1 dB bandwidth	11.5	11.5	11.5	MHz
Intermodulation products	- 52	-	-	dB
Gain	16	16	16	dB
Anode voltage	5.5	4	5	kV
Screen-grid voltage	600	500	700	V
Anode current, with signal	1.6	2	1.9	A
Screen-grid current	10	30	15	mA
Control-grid current	negligible	5	1	mA
Anode current at zero signal	0.9	0.85	0.9	A

TH 18665 matched circuit assembly

For UHF-TV transmitters and translators (Bands IV and V)

Operating frequency .... 470 to 860 MHz
Dimensions .... 788 x 335 x 220 mm
Weight, approx (without tube) .... 45 kg
RF connections:
- input .... male, type N
- output .... standard EIA 1 5/8"

Cooling .... forced air

■ Output power

12 kW

in SSB, up to 120 MHz

General characteristics

Cathode .... thoriated tungsten
Heating (1) .... direct, dc or single phase
Interelectrodes capacitances, approx. (grounded cathode):
input .... 218 pF
reaction .... 0.8 pF
output .... 17 pF
Amplification factor, average 5.5
Transconductance (Ia = 2 A) .... 60 mA/V
Operating position .... vertical
Weight, approx .... 7.5 kg
Dimensions .... see page 55
Connector .... TH 16116
Anode cooling (2) .... forced air
air flow, min .... 13 m^3/mn
corresponding pressure drop .... 8 mbar
outlet air temperature .... 100 °C
Electrode terminal and ceramic cooling:
type .... forced air
temperature on the tube, max .... 250 °C

Maximum ratings

Anode voltage .... 8 kV
Control-grid voltage .... - 200 V
Screen-grid voltage .... 800 V
Peak cathode current .... 40 A
Anode dissipation .... 12 kW
Control-grid dissipation .... 100 W
Screen-grid dissipation .... 250 W
Anode current at zero signal .... 1.2 A

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation. As an indication for equipment design purposes only, a heater voltage of 7 V produces a heating current of 140 A.

(2) Values for cooling given for maximum anode dissipation.

Typical operation carrier conditions

Output power	10	kW
Frequency	30	MHz
Anode voltage	7.2	kV
Screen-grid voltage	600	V
Control-grid bias voltage	- 100	V
Anode current	2.4	A
Screen-grid current	30	mA
Control-grid current	0	mA
Anode current at zero signal	1.2	A

AM tetrode

■ Output power

50 kW
in SW and MW, up to 30 MHz

General characteristics

Cathode .... thoriated tungsten
Heating (1) .... direct
Interelectrodes capacitances, approx.:
- cathode-control grid .... 140 pF
- control grid-screen grid .... 265 pF
- control grid-anode .... 1.4 pF
- screen grid-anode .... 35 pF

Amplification factor, average 4.8
Transconductance (Ia = 4 A, Vg2 = 800 V) .... 80 mA/V
Operating position .... vertical
Weight, approx .... 13 kg
Dimensions .... see page 55
Connector .... TH 16101
Anode cooling (2) .... Vapotron
Electrode terminal cooling .... forced air
- air flow, min. .... 650 l/mn
- air inlet pressure, max .... 12 mbar

Temperature on the tube, max .... 150 °C

Maximum ratings

Anode voltage .... 13 kV
Control-grid voltage .... - 500 V
Screen-grid voltage .... 1 kV
Peak cathode current .... 60 A
Anode dissipation .... 60 kW
Control-grid dissipation .... 300 W
Screen-grid dissipation .... 600 W

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation. As an indication for equipment design purposes only, a heater voltage of 10 V produces a heating current of 200 A.

(2) Values for cooling given for maximum anode dissipation.

Typical operation
Class C - Carrier conditions

Output power	55	kW
Frequency	30	MHz
Anode voltage	11	kV
Screen-grid voltage	700	V
Control-grid bias voltage	- 300	V
Anode current	7.5	A
Screen-grid current	150	mA
Control-grid current	400	mA

■ Output power

up to 550 W peak-of-sync in common amplification
1 kW peak-of-sync in vision carrier amplification
1.2 kW in sound carrier amplification

General characteristics

Cathode .... thoriated tungsten
Heating (1) .... direct
Interelectrodes capacitances, approx.:
- cathode-control grid .... 40 pF
- control grid-screen grid .... 50 pF
- screen grid-anode .... 8.2 pF

Amplification factor, average 7
Transconductance (Ia = 1.5 A, Vg2 = 400 V) .... 40 mA/V
Operating position .... vertical, anode up
Weight, approx .... 2.1 kg
Dimensions .... see page 55
Anode cooling (2) .... Hypervapotron
- water flow, min .... 3 l/mn
- water inlet pressure, max .... 5 bar
- outlet water temperature, less than .... 80 °C

Electrode terminal and ceramic seal cooling
- type .... forced air
- temperature on the tube, max .... 250 °C

Maximum ratings

Frequency .... 1000 MHz
Anode voltage .... 5 kV
Anode current .... 2 A
Anode dissipation .... 5 kW
Control-grid dissipation .... 5 W
Screen-grid dissipation .... 25 W

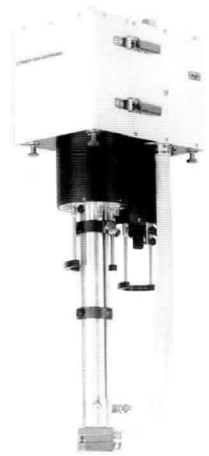
(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation.
As an indication for equipment design purposes only, a heater voltage of 5.8 V produces a heating current of 34 A.
(2) Values for cooling given for maximum anode dissipation.

Typical operation at 850 MHz in the matched cavity TH 18563

	Sound only amplification	
Carrier output power	1.2	kW
- 1 dB bandwidth	10	MHz
Gain	15.5	dB
Anode voltage	4	kV
Screen-grid voltage	400	V
Anode current, with signal	1	A
Screen-grid current	5	mA
Control-grid current	negligible	
Anode current at zero signal	0.5	A

TH 18563 matched circuit assembly

For UHF-TV transmitters and translators (Bands IV and V)



Operating frequency .... 470 to 860 MHz
Dimensions .... 670 x 268 x 174 mm
Weight, approx (without tube) .... 17 kg
RF connections:
- input .... female, type N
- output .... standard EIA 7/8"

Cooling .... Hypervapotron and forced air

■ Output power

60 kW

in SW and MW, up to 30 MHz

General characteristics

Cathode ..... thoriated tungsten
Heating (1) ..... direct, dc or single phase
Interelectrodes capacitances, approx.:
- cathode-control grid ..... 140 pF
- control grid-screen grid ..... 265 pF
- control grid-anode ..... 1.4 pF
- screen grid-anode ..... 35 pF

Amplification factor, average 4.8
Transconductance (Ia = 4 A) ..... 80 mA/V
Operating position ..... vertical, anode up
Weight, approx ..... 17 kg
Dimensions ..... see page 55
Connector ..... TH 16118
Anode cooling (2) ..... Hypervapotron
water flow, min ..... 25 l/mn
- water inlet pressure, max ..... 5 bar
- outlet water temperature, less than ..... 80 °C

Electrode terminal and ceramic cooling:
- type ..... forced air
- temperature on the tube, max ..... 200 °C

Maximum ratings

Anode voltage ..... 12 kV
Control-grid voltage ..... - 500 V
Screen-grid voltage ..... 900 V
Peak cathode current ..... 70 A
Anode dissipation ..... 60 kW
Control-grid dissipation ..... 300 W
Screen-grid dissipation ..... 600 W

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation. As an indication for equipment design purposes only, a heater voltage of 10 V produces a heating current of 200 A.

(2) Values for cooling given for maximum anode dissipation.

Typical operation carrier conditions

Output power	55	kW
Frequency	30	MHz
Anode voltage	11	kV
Screen-grid voltage	700	V
Control-grid bias voltage	- 300	V
Anode current	7.5	A
Screen-grid current	150	mA
Control-grid current	350	A

TH 537

AM tetrode

■ Output power

350 kW
in LW and MW,

300 kW
in SW, up to 50 MHz

General characteristics

Cathode ....thoriated tungsten
Heating (1) ....direct, dc or single phase
Interelectrodes capacitances, approx.:
- cathode-control grid ....310 pF
- control grid-screen grid ....510 pF
- control grid-anode ....4.5 pF
- screen grid-anode ....74 pF

Amplification factor, average 4.3
Transconductance (Ia = 25 A, Vg2 = 1000 V) ....400 mA/V
Operating position ....vertical, anode up
Weight, approx ....56 kg
Dimensions ....see page 55
Connector ....TH 16108A
Anode cooling (2) ....Hypervapotron
- water flow, min ....150 l/mn
- water inlet pressure, max ....5 bar
- outlet water temperature, less than ....80 °C

Electrode terminal and ceramic cooling:
- type ....forced air
- temperature on the tube, max ....200 °C

Maximum ratings

Anode voltage ....15 kV
Control-grid voltage ....- 800 V
Screen-grid voltage ....1200 V
Peak cathode current ....400 A
Anode dissipation ....300 kW
Control-grid dissipation ....2 kW
Screen-grid dissipation ....5 kW

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation. As an indication for equipment design purposes only, a heater voltage of 18 V produces a heating current of 430 A.

(2) Values for cooling given for maximum anode dissipation.

Typical operation carrier conditions

Output power	300	kW
Frequency	30	MHz
Anode voltage	14	kV
Screen-grid voltage	1000	V
Control-grid bias voltage	- 550	V
Anode current	25	A
Screen-grid current	1.5	A
Control-grid current	1	A

■ Output power

1.25 MW
in LW and MW

General characteristics

Cathode ....thoriated tungsten
Heating (1) ....direct, dc or single phase
Interelectrodes capacitances, approx.:
- cathode-control grid ....830 pF
- control grid-screen grid ....1600 pF
- control grid-anode ....15.5 pF
- screen grid-anode ....220 pF

Amplification factor, average 5
Transconductance (Ia = 35 A, Vg2 = 1000 V) ....600 mA/V
Operating position ....vertical, anode up
Weight, approx ....155 kg
Dimensions ....see page 55
Connector ....TH 16114
Anode cooling (2) ....Hypervapotron
- water flow, min ....400 l/mn
- water inlet pressure, max ....5 bar
- outlet water temperature, less than ....80 °C

Electrode terminal and ceramic cooling:
- type ....forced air
- temperature on the tube, max ....200 °C

Maximum ratings

Anode voltage ....15 kV
Control-grid voltage ....- 800 V
Screen-grid voltage ....1250 V
Peak cathode current ....1300 A
Anode dissipation ....1 MW
Control-grid dissipation ....6 kW
Screen-grid dissipation ....16 kW

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation. As an indication for equipment design purposes only, a heater voltage of 30 V produces a heating current of 900 A.

(2) Values for cooling given for maximum anode dissipation.

Typical operation carrier conditions

Output power	1000	kW
Frequency	2	MHz
Anode voltage	13.0	kV
Screen-grid voltage	1100	V
Control-grid bias voltage	- 550	V
Anode current	85	A
Screen-grid current	8	A
Control-grid current	7	A

■ Output power

up to 1.1 kW

peak-of-sync in common amplification

General characteristics

Cathode .... thoriated tungsten
Heating (1) .... direct
Interelectrodes capacitances, approx.:
  cathode-control grid .... 40 pF
  control grid-screen grid .... 50 pF
  screen grid-anode .... 8.2 pF
Amplification factor, average 7
Transconductance (Ia = 1.5 A, Vg2 = 500 V) .... 40 mA/V
Operating position .... vertical, anode up
Weight, approx .... 2.1 kg
Dimensions .... see page 55
Anode cooling (2) .... Hypervapotron
  water flow, min .... 3 l/mn
  water inlet pressure, max .... 5 bar
  outlet water temperature, less than .... 80 °C
Electrode terminal and ceramic seal cooling
  type .... forced air
  temperature on the tube, max .... 250 °C

Maximum ratings

Frequency .... 1000 MHz
Anode voltage .... 5 kV
Anode current .... 2 A
Anode dissipation .... 5 kW
Control-grid dissipation .... 5 W
Screen-grid dissipation .... 25 W

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation.
As an indication for equipment design purposes only, a heater voltage of 6 V produces a heating current of 34 A.

(2) Values for cooling given for maximum anode dissipation.

Typical operation at 850 MHz in the matched cavity TH 18563

	Common amplification	Vision only	
Peak-of-sync output power	1.1	2.2	kW
- 1 dB bandwidth	10	10	MHz
Intermodulation products	- 54		dB
Gain	15.5	15.5	dB
Anode voltage	4	4	kV
Screen-grid voltage	400	400	V
Anode current, with signal	0.8	1.5	A
Screen-grid current	5	8	mA
Control-grid current	negligible	2	mA
Anode current at zero signal	0.5	0.5	A

TH 18563 matched circuit assembly

For UHF-TV transmitters and translators (Bands IV and V)

Operating frequency .... 470 to 860 MHz
Dimensions .... 670 x 268 x 174 mm
Weight, approx (without tube) .... 17 kg
RF connections:
  input .... female, type N
  output .... standard EIA 7/8"
Cooling .... Hypervapotron and forced air

■ Output power

250 kW
in LW and MW,

200 kW
in SW, up to 50 MHz

General characteristics

Cathode .... thoriated tungsten
Heating (1) .... direct, dc or single phase
Interelectrodes capacitances, approx.:
- cathode-control grid .... 350 pF
- control grid-screen grid .... 440 pF
- control grid-anode .... 4 pF
- screen grid-anode .... 62 pF

Amplification factor, average 4.8
Transconductance (Ia = 15 A, Vg2 = 1000 V) .... 220 mA/V
Operating position .... vertical, anode up
Weight, approx .... 38 kg
Dimensions .... see page 55
Connector .... TH 16110
Anode cooling (2) .... Hypervapotron
- water flow, min .... 110 l/mn
- water inlet pressure, max .... 5 bar
- outlet water temperature, less than .... 80 °C

Electrode terminal and ceramic cooling:
- type .... forced air
- temperature on the tube, max .... 200 °C

Maximum ratings

Anode voltage .... 15 kV
Control-grid voltage .... - 800 V
Screen-grid voltage .... 1.2 kV
Peak cathode current .... 300 A
Anode dissipation .... 250 kW
Control-grid dissipation .... 1.5 kW
Screen-grid dissipation .... 4 kW

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation. As an indication for equipment design purposes only, a heater voltage of 15 V produces a heating current of 320 A.

(2) Values for cooling given for maximum anode dissipation.

Typical operation carrier conditions

Output power	200	kW
Frequency	30	MHz
Anode voltage	14	kV
Screen-grid voltage	1000	V
Control-grid bias voltage	- 550	V
Anode current	17	A
Screen-grid current	0.9	A
Control-grid current	0.9	A

■ Output power

650 kW
in LW and MW,

550 kW
in SW, up to 50 MHz

General characteristics

Cathode ....thoriated tungsten
Heating (1) ....direct, dc or single phase
Interelectrodes capacitances, approx.:
  cathode-control grid ....445 pF
  control grid-screen grid ....750 pF
  control grid-anode ....6.3 pF
  screen grid-anode ....100 pF
Amplification factor, average 4.4
Transconductance (Ia = 35 A, Vg2 = 1000 V) ....500 mA/V
Operating position ....vertical, anode up
Weight, approx ....74 kg
Dimensions ....see page 55
Connector ....TH 16124
Anode cooling (2) ....Hypervapotron
  water flow, min ....200 l/mn
  water inlet pressure, max ....5 bar
  outlet water temperature, less than ....80 °C
Electrode terminal and ceramic cooling:
  type ....forced air
  temperature on the tube, max ....200 °C

Maximum ratings

Anode voltage ....15 kV
Control-grid voltage ....- 800 V
Screen-grid voltage ....1.25 kV
Peak cathode current ....600 A
Anode dissipation ....500 kW
Control-grid dissipation ....3 kW
Screen-grid dissipation ....8 kW

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation. As an indication for equipment design purposes only, a heater voltage of 23 V produces a heating current of 500 A.

(2) Values for cooling given for maximum anode dissipation.

Typical operation carrier conditions

Output power	550	kW
Frequency	30	MHz
Anode voltage	14	kV
Screen-grid voltage	1000	V
Control-grid bias voltage	- 550	V
Anode current	47	A
Screen-grid current	4.2	A
Control-grid current	4	A

TH 561 VHF tetrode

■ Output power

up to 10.5 kW
peak-of-sync in common amplification
15 kW
peak-of-sync in vision carrier amplification

General characteristics

Cathode .... thoriated tungsten
Heating (1) .... direct
Interelectrodes capacitances, approx.:
- cathode-control grid .... 83 pF
- control grid-screen grid .... 135 pF
- screen grid-anode .... 17 pF

Amplification factor, average 5.5
Transconductance (Ia = 2 A, Vg2 = 500 V) .... 60 mA/V
Operating position .... vertical, anode up
Weight, approx .... 4.4 kg
Dimensions .... see page 55
Anode cooling (2) .... Hypervapotron
- water flow, min .... 12 l/mn
- water inlet pressure, max .... 5 bar
- outlet water temperature, less than .... 80 °C

Electrode terminal and ceramic seal cooling
- type .... forced air
- temperature on the tube, max .... 250 °C

Maximum ratings

Frequency .... 300 MHz
Anode voltage .... 7 kV
Anode current .... 6 A
Anode dissipation .... 20 kW
Control-grid dissipation .... 50 W
Screen-grid dissipation .... 150 W

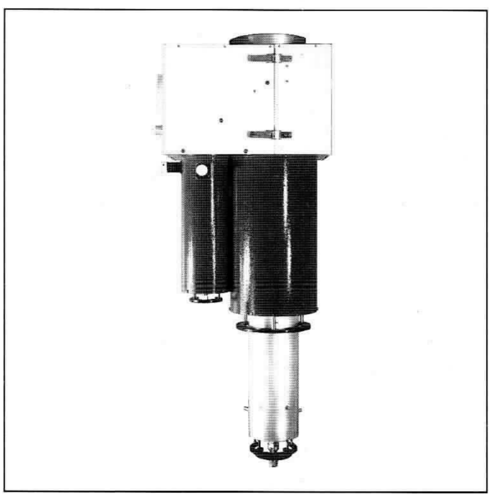
(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation.
As an indication for equipment design purposes only, a heater voltage of 7 V produces a heating current of 140 A.
(2) Values for cooling given for maximum anode dissipation.

Typical operation at 174 MHz in the matched cavity TH 18526

	Common amplification	Vision only	
Peak-of-sync output power	10.5	15	kW
- 1 dB bandwidth	9	9	MHz
Intermodulation products	- 50	-	dB
Gain	16	16	dB
Anode voltage	5.5	5.5	kV
Screen-grid voltage	600	600	V
Anode current, with signal	3.1	3.2	A
Screen-grid current	30	35	mA
Control-grid current	3	negligible	mA
Anode current at zero signal	1.2	1.2	A

TH 18526A matched circuit assembly

For VHF-TV transmitters and translators (Band III)



Operating frequency .... 170 to 230 MHz
Dimensions .... 1430 x 420 x 266 mm
Weight, approx (without tube) .... 70 kg
RF connections:
- input .... female, type N
- output .... standard EIA 3 1/8"

Cooling .... Hypervapotron and forced air

■ Output power

12 kW

in SW, up to 300 MHz

General characteristics

Cathode .... thoriated tungsten
Heating (1) .... direct, dc or single phase
Interelectrodes capacitances, approx.:
- cathode-control grid .... 83 pF
- control grid-screen grid .... 135 pF
- control grid-anode .... 0.8 pF
- screen grid-anode .... 17 pF

Amplification factor, average 5.5
Transconductance (Ia = 1.5 A, Vg2 = 500 V) .... 60 mA/V
Operating position .... vertical
Weight, approx .... 4.4 kg
Dimensions .... see page 55
Connector .... TH 16132
Anode cooling (2) .... Hypervapotron
- water flow, min .... 8 l/mn
- water inlet pressure, max .... 5 bar
- outlet water temperature, less than .... 80 °C

Electrode terminal and ceramic cooling:
- type .... forced air
- temperature on the tube, max .... 250 °C

Maximum ratings

Anode dc voltage .... 8 kV
Control-grid voltage .... - 200 V
Screen-grid voltage .... 800 V
Peak cathode current .... 30 A
Anode dissipation .... 20 kW
Control-grid dissipation .... 100 W
Screen-grid dissipation .... 250 W

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation. As an indication for equipment design purposes only, a heater voltage of 7 V produces a heating current of 140 A.

(2) Values for cooling given for maximum anode dissipation.

Typical operation carrier conditions

Output power	12	kW
Frequency	30	MHz
Anode voltage	7.5	kV
Screen-grid voltage	600	V
Control-grid bias voltage	- 145	V
Anode current	2.3	A
Screen-grid current	100	mA
Control-grid current	10	mA

■ Output power

12 kW
up to 120 MHz

General characteristics

Cathode ....thoriated tungsten
Heating (1) ....direct, dc or single phase
Interelectrodes capacitances, approx.:
- cathode-control grid ....72 pF
- control grid-screen grid ....92 pF
- control grid-anode ....0.8 pF
- screen grid-anode ....16 pF

Amplification factor, average 5.5
Transconductance (Ia = 2 A, Vg2 = 500 V) ....60 mA/V
Operating position ....vertical, anode up
Weight, approx ....4.4 kg
Dimensions ....see page 55
Anode cooling (2) ....Hypervapotron
- water flow, min ....8 l/mn
- water inlet pressure, max ....5 bar
- outlet water temperature, less than ....80 °C

Electrode terminal and ceramic cooling:
- type ....forced air
- temperature on the tube, max ....250 °C

Maximum ratings

Anode voltage ....8 kV
Control-grid voltage ....- 200 V
Screen-grid voltage ....800 V
Peak cathode current ....40 A
Anode dissipation ....20 kW
Control-grid dissipation ....100 W
Screen-grid dissipation ....250 W

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation. As an indication for equipment design purposes only, a heater voltage of 7 V produces a heating current of 140 A.

(2) Values for cooling given for maximum anode dissipation.

Typical operation carrier conditions

Output power	12	kW
Frequency	30	MHz
Anode voltage	7.5	kV
Screen-grid voltage	500	V
Control-grid bias voltage	- 110	V
Anode current	2.3	A
Screen-grid current	100	mA
Control-grid current	10	mA

■ Output power

up to 31.5 kW
peak-of-sync in common amplification
44 kW
peak-of-sync in vision carrier amplification

General characteristics

Cathode ....thoriated tungsten
Heating (1) ....direct
Interelectrodes capacitances, approx.:
    cathode-control grid ....92 pF
    control grid-screen grid ....148 pF
    screen grid-anode ....18 pF
Amplification factor, average 5.5
Transconductance (Ia = 4 A, Vg2 = 600 V)..........................100 mA/V
Operating position ....vertical, anode up
Weight, approx ....6.5 kg
Dimensions ....see page 55
Anode cooling (2) ....Hypervapotron
    water flow, min ....50 l/mn
    water inlet pressure, max..5 bar
    outlet water temperature, less than ....80 °C
Screen grid terminal cooling ....water
    water flow, min ....2 l/mn
Electrode terminal and ceramic seal cooling
    type ....forced air
    temperature on the tube, max ....300 °C

Maximum ratings

Frequency.....................................1000 MHz
Anode voltage ....9 kV
Anode current ....9 A
Anode dissipation...............................42 kW
Control-grid dissipation ....80 W
Screen-grid dissipation ....200 W

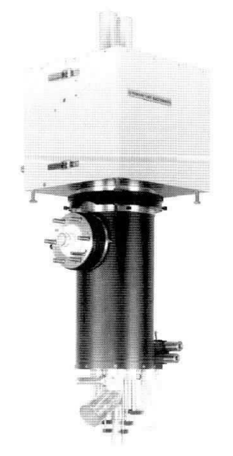
(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation.
As an indication for equipment design purposes only, a heater voltage of 5.2 V produces a heating current of 210 A.
(2) Values for cooling given for maximum anode dissipation.

Typical operation at 700 MHz in the matched cavity TH 18550

	Common amplification	Vision only	
Peak-of-sync output power	31.5	44	kW
- 1 dB bandwidth	12	12	MHz
Intermodulation products	- 48	-	dB
Gain	14.5	14.7	dB
Anode voltage	8.5	9	kV
Screen-grid voltage	800	800	V
Control-grid bias voltage	- 113	- 114	V
Anode current, with signal	6.45	6.75	A
Screen-grid current	130	70	mA
Control-grid current	150	90	mA

TH 18550 matched circuit assembly

For UHF-TV transmitters and translators (Bands IV and V)



Operating frequency..460 to 860 MHz
Dimensions ....1183 x 349 x 353 mm
Weight, approx (without tube) ....70 kg
RF connections:
    input...female, type LC or 7/16
    output..standard EIA 3 1/8"
Cooling ....Hypervapotron and forced air

TH 571A — VHF tetrode

■ Output power

up to 21 kW
peak-of-sync in common amplification
41 kW
peak-of-sync in vision carrier amplification

General characteristics

Cathode .... thoriated tungsten
Heating (1) .... direct, dc or single phase
Interelectrodes capacitances, approx.:
  cathode-control grid .... 130 pF
  control grid-screen grid .... 210 pF
  screen grid-anode .... 25 pF
Amplification factor, average 8
Transconductance (Ia = 5 A, Vg2 = 600 V) .... 140 mA/V
Operating position .... vertical, anode up
Weight, approx .... 7.5 kg
Dimensions .... see page 55
 Anode cooling (2) .... Hypervapotron
  water flow, min .... 18 l/mn
  water inlet pressure, max .... 5 bar
  outlet water temperature, less than .... 80 °C
Electrode terminal and ceramic seal cooling
  type .... forced air
  temperature on the tube, max .... 250 °C

Maximum ratings

Frequency .... 300 MHz
Anode voltage .... 8 kV
Anode current .... 10 A
Anode dissipation .... 50 kW
Control-grid dissipation .... 150 W
Screen-grid dissipation .... 400 W

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation.
As an indication for equipment design purposes only, a heater voltage of 8 V produces a heating current of 185 A.

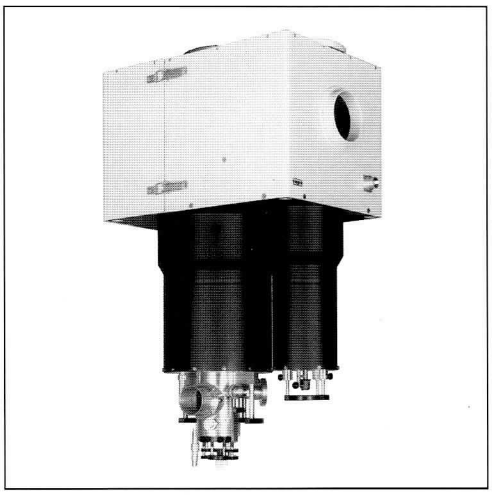
(2) Values for cooling given for maximum anode dissipation.

Typical operation at 174 MHz in the matched cavity TH 18527A

	Common amplification	Vision only	
Peak-of-sync output power	21	41	kW
- 1 dB bandwidth	9	8.5	MHz
Intermodulation products	- 54	-	dB
Gain	16.5	17	dB
Anode voltage	6	7.3	kV
Screen-grid voltage	600	600	V
Anode current, with signal	5.4	5.9	A
Screen-grid current	85	120	mA
Control-grid current	15	10	mA
Anode current at zero signal	2	2	A

TH 18527A matched circuit assembly

For VHF-TV transmitters and translators (Band III)



Operating frequency .... 170 to 230 MHz
Dimensions .... 1053 x 479 x 330 mm
Weight, approx (without tube) .... 90 kg
RF connections:
  input .... female, type N
  output .... standard EIA 3 1/8"
Cooling .... Hypervapotron and forced air

TH 573 AM tetrode

■ Output power

350 kW
in LW and MW,

300 kW
in SW, up to 50 MHz

General characteristics

Cathode ....thoriated tungsten
Heating (1) ....direct, dc or single phase
Interelectrodes capacitances, approx.:
- cathode-control grid ....355 pF
- control grid-screen grid ....610 pF
- control grid-anode ....4.7 pF
- screen grid-anode ....85 pF

Amplification factor, average 4.3
Transconductance (Ia = 25 A, Vg2 = 1000 V) ....400 mA/V
Operating position ....vertical, anode up
Weight, approx ....60 kg
Dimensions ....see page 55
Connector ....TH 16124
Anode cooling (2) ....Hypervapotron
- water flow, min ....150 l/mn
- water inlet pressure, max ....5 bar
- outlet water temperature, less than ....80 °C

Electrode terminal and ceramic cooling:
- type ....forced air
- temperature on the tube, max ....200 °C

Maximum ratings

Anode voltage ....15 kV
Control-grid voltage ....- 800 V
Screen-grid voltage ....1.2 kV
Peak cathode current............................400 A
Anode dissipation...............................300 kW
Control-grid dissipation ....2 kW
Screen-grid dissipation ....5 kW

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation. As an indication for equipment design purposes only, a heater voltage of 15 V produces a heating current of 500 A.

(2) Values for cooling given for maximum anode dissipation.

Typical operation carrier conditions

Output power	300	kW
Frequency	30	MHz
Anode voltage	14	kV
Screen-grid voltage	1000	V
Control-grid bias voltage	- 550	V
Anode current	25	A
Screen-grid current	1.5	A
Control-grid current	1	A

■ Output power

550 kW
in SW, up to 50 MHz

General characteristics

Cathode .... thoriated tungsten
Heating (1) .... direct, dc or single phase
Interelectrodes capacitances, approx.:
- cathode-control grid .... 687 pF
- control grid-screen grid .... 814 pF
- control grid-anode .... 10 pF
- screen grid-anode .... 142 pF

Amplification factor, average 5
Transconductance (Ia = 35 A, Vg2 = 1000 V) .... 600 mA/V
Operating position .... vertical, anode up
Weight, approx .... 110 kg
Dimensions .... see page 55
Connector .... TH 16138
Anode cooling (2) .... Hypervapotron
- water flow, min .... 300 l/mn
- water inlet pressure, max .... 5 bar
- outlet water temperature, less than .... 80 °C

Electrode terminal and ceramic cooling:
- type .... forced air
- temperature on the tube, max .... 200 °C

Maximum ratings

Anode voltage .... 15 kV
Control-grid voltage .... - 1000 V
Screen-grid voltage .... 2 kV
Peak cathode current .... 650 A
Anode dissipation .... 800 kW
Control-grid dissipation .... 4 kW
Screen-grid dissipation .... 12 kW

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation. As an indication for equipment design purposes only, a heater voltage of 19 V produces a heating current of 1000 A.

(2) Values for cooling given for maximum anode dissipation.

Typical operation carrier conditions

Output power	550	kW
Frequency	30	MHz
Anode voltage	15	kV
Screen-grid voltage	1200	V
Control-grid bias voltage	- 800	V
Anode current	39	A
Screen-grid current	7	A
Control-grid current	2	A

■ Output power

125 kW

in MW and SW, up to 50 MHz

General characteristics

Cathode ..... thoriated tungsten
Heating (1) ..... direct, dc or single phase
Interelectrodes capacitances, approx.:
- cathode-control grid ..... 180 pF
- control grid-screen grid ..... 310 pF
- control grid-anode ..... 2.3 pF
- screen grid-anode ..... 47 pF

Amplification factor, average 5
Transconductance (Ia = 25 A, Vg2 = 1000 V) ..... 140 mA/V
Operating position ..... vertical, anode up
Weight, approx ..... 35 kg
Dimensions ..... see page 55
Connector ..... TH 16111
Anode cooling (2) ..... Hypervapotron
- water flow, min ..... 70 l/mn
- water inlet pressure, max ..... 5 bar
- outlet water temperature, less than ..... 80 °C

Electrode terminal and ceramic cooling:
- type ..... forced air
- temperature on the tube, max ..... 200 °C

Maximum ratings

Anode voltage ..... 15 kV
Control-grid voltage ..... - 800 V
Screen-grid voltage ..... 1.2 kV
Peak cathode current ..... 160 A
Anode dissipation ..... 150 kW
Control-grid dissipation ..... 0.8 kW
Screen-grid dissipation ..... 2 kW

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation. As an indication for equipment design purposes only, a heater voltage of 10 V produces a heating current of 280 A.

(2) Values for cooling given for maximum anode dissipation.

Typical operation carrier conditions

Output power	125	kW
Frequency	30	MHz
Anode voltage	14	kV
Screen-grid voltage	1000	V
Control-grid bias voltage	- 550	V
Anode current	10.5	A
Screen-grid current	0.8	A
Control-grid current	0.9	A

TH 582 — UHF tetrode

■ Output power

up to 22 kW
peak-of-sync in common amplification
10.5 kW
peak-of-sync in common amplification

General characteristics

Cathode .... thoriated tungsten
Heating (1) .... direct, dc or single phase
Interelectrodes capacitances, approx.:
- cathode-control grid .... 72 pF
- control grid-screen grid .... 93 pF
- screen grid-anode .... 13.2 pF

Amplification factor, average 8
Transconductance (Ia = 2 A, Vg2 = 300 V) .... 80 mA/V
Operating position .... vertical, anode up
Weight, approx .... 4.1 kg
Dimensions .... see page 55
Anode cooling (2) .... Hypervapotron
- water flow, min .... 15 l/mn
- water inlet pressure, max .... 5 bar
- outlet water temperature .... 80 °C

Screen grid terminal cooling .... water
- water flow, min .... 1.5 l/mn

Electrode terminal and ceramic seal cooling
- type .... forced air
- temperature on the tube, max .... 300 °C

Maximum ratings

Frequency .... 1000 MHz
Anode voltage .... 7.5 kV
Anode current .... 5.5 A
Anode dissipation .... 25 kW
Control-grid dissipation .... 50 W
Screen-grid dissipation .... 120 W

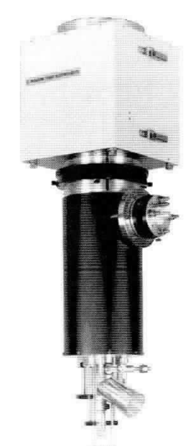
(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation. As an indication for equipment design purposes only, a heater voltage of 4.2 V produces a heating current of 146 A.
(2) Values for cooling given for maximum anode dissipation.

Typical operation at 700 MHz in the matched cavity TH 18582

	Common amplification	Vision only	
Peak-of-sync output power	10.5	22	kW
- 1 dB bandwidth	12.5	12.5	MHz
Intermodulation products	- 48	-	dB
Gain	15	15.1	dB
Anode voltage	5.5	7.3	kV
Screen-grid voltage	600	800	V
Anode current, with signal	3.45	4.3	A
Screen-grid current	50	60	mA
Control-grid current	20	20	mA
Anode current at zero signal	1.5	1.6	A

TH 18582 matched circuit assembly

For UHF-TV transmitters and translators (Bands IV and V)



Operating frequency .... 478 to 860 MHz
Dimensions .... 1092 x 322 x 285 mm
Weight, approx (without tube) .... 70 kg
RF connections:
- input .... female, type N, LC or 7/16"
- output .... standard EIA 3 1/8" rigid coaxial line

Cooling .... Hypervapotron and forced air

TH 593 UHF tetrode

■ Output power

up to 2.2 kW
peak-of-sync in common amplification
4.4 kW peak-of-sync in vision carrier amplification
2.5 kW in sound carrier amplification

General characteristics

Cathode ....thoriated tungsten
Heating (1) ....direct
Interelectrodes capacitances, approx.:
  cathode-control grid ....45 pF
  control grid-screen grid ....72 pF
  screen grid-anode ....9 pF
Amplification factor, average 8
Transconductance (Ia = 2 A, Vg2 = 300 V) ....60 mA/V
Operating position ....vertical, anode up
Weight, approx ....2.9 kg
Dimensions ....see page 55
Anode cooling (2) ....Hypervapotron
  water flow, min ....6 l/mn
  water inlet pressure, max ....5 bar
  outlet water temperature, less than ....80 °C
Electrode terminal and ceramic seal cooling
  type ....forced air
  temperature on the tube, max ....300 °C

Maximum ratings

Frequency ....1000 MHz
Anode voltage ....6 kV
Anode current ....3 A
Anode dissipation ....10 kW
Control-grid dissipation ....25 W
Screen-grid dissipation ....75 W

(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation.
As an indication for equipment design purposes only, a heater voltage of 6 V produces a heating current of 65 A.

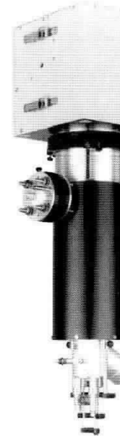
(2) Values for cooling given for maximum anode dissipation.

Typical operation at 800 MHz in the matched cavity TH 18565

	Common amplification	Sound only	Vision only	
Peak-of-sync output power	2.2	-	4.4	kW
Sound carrier output power	-	2.5	-	kW
-1 dB bandwidth	11.5	11.5	11.5	MHz
Intermodulation products	- 52	-	-	dB
Gain	16	16	16	dB
Anode voltage	5.5	5	5	kV
Screen-grid voltage	600	500	700	V
Anode current, with signal	1.6	2	2	A
Screen-grid current	10	30	15	mA
Control-grid current	negl.	5	1	mA
Anode current at zero signal	0.9	0.85	0.9	A

TH 18565 matched circuit assembly

For UHF-TV transmitters and translators (Bands IV and V)



Operating frequency ....470 to 860 MHz
Dimensions ....826 x 250 x 260 mm
Weight, approx (without tube) ....34 kg
RF connections:
  input ....female, type N
  output ....standard EIA 1 5/8"
Cooling ....Hypervapotron and forced air

■ Output power

3 kW

up to 120 MHz

General characteristics

Cathode .... thoriated tungsten
Heating (1) .... direct, dc or single phase
Interelectrodes capacitances, approx.:
- cathode-control grid .... 40 pF
- control grid-screen grid .... 75 pF
- control grid-anode .... 0.4 pF
- screen grid-anode .... 11.5 pF

Amplification factor, average 7
Transconductance (Ia = 1.5 A, Vg2 = 600 V) .... 40 mA/V
Operating position .... vertical
Weight, approx .... 3 kg
Dimensions .... see page 55
Anode cooling (2) .... Hypervapotron
- water flow, min .... 2 l/mn
- water inlet pressure, max .... 5 bar
- outlet water temperature .... 100 °C

Electrode terminal and ceramic cooling:
- type .... forced air
- temperature on the tube, max .... 250 °C

Maximum ratings

Anode dc voltage .... 5 kV
Control-grid voltage .... - 200 V
Screen-grid voltage .... 800 V
Peak cathode current .... 10 A
Anode dissipation .... 5 kW
Control-grid dissipation .... 40 W
Screen-grid dissipation .... 100 W

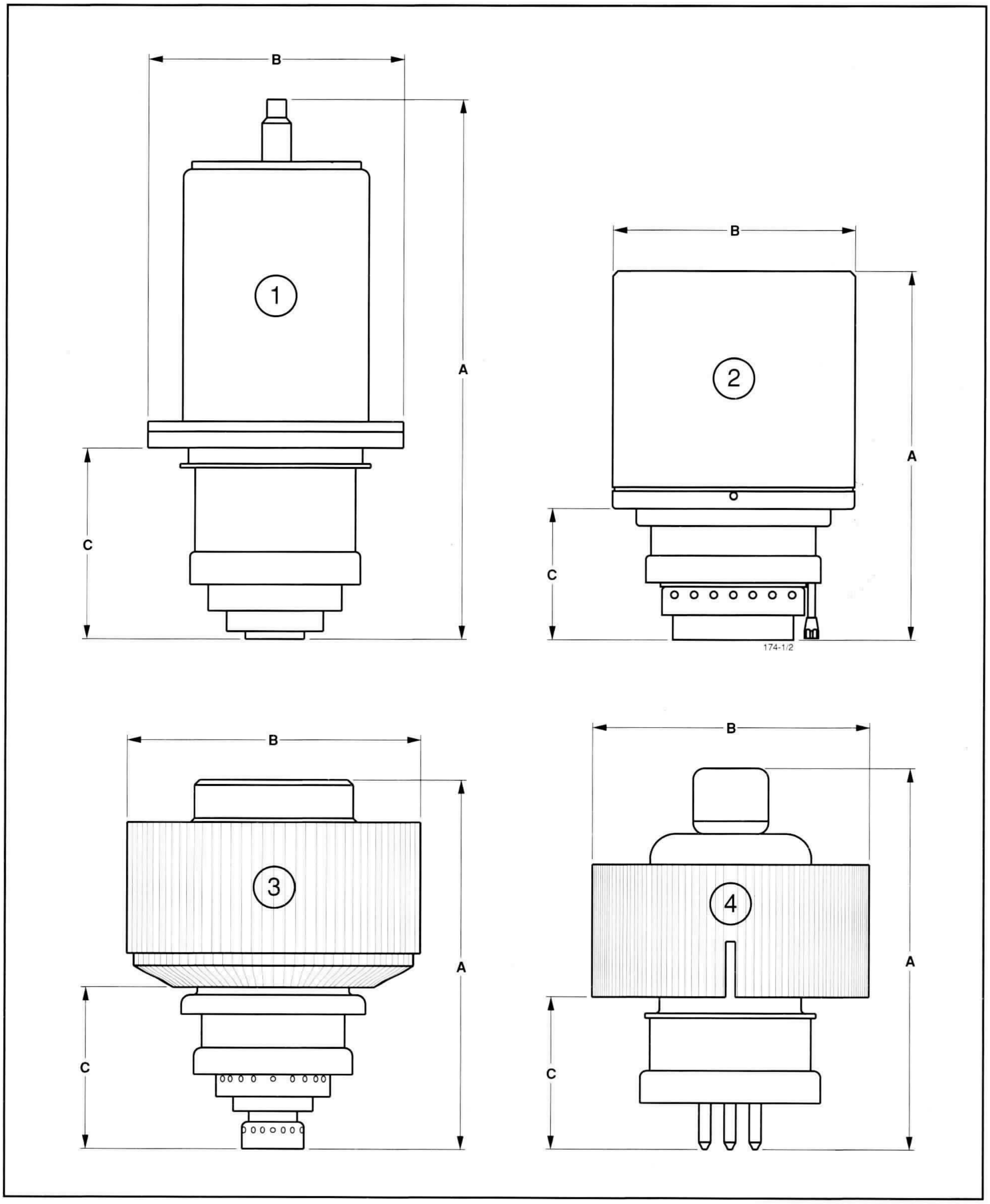
(1) Thomson Tubes Electroniques defines the operating voltage according to each particular situation. As an indication for equipment design purposes only, a heater voltage of 6 V produces a heating current of 50 A.

(2) Values for cooling given for maximum anode dissipation.

Typical operation carrier conditions

Output power	3	kW
Frequency	30	MHz
Anode voltage	4.5	kV
Screen-grid voltage	750	V
Control-grid bias voltage	- 120	V
Anode current	1	A
Screen-grid current	10	mA
Control-grid current	negligible	

Tube dimensions



Reference	Drawing	Dimensions (mm)		
		A	B	C
TH 225	4	62.5	41.7	31
TH 298	3	140	104	59
TH 308	3	79	70	58
TH 326	3	63	54	32
TH 327	3	135	110	79
TH 328	3	81	70	60
TH 338	3	81	80	60
TH 339	3	81	80	60
TH 341	3	150	130	67
TH 343	3	180	162	75
TH 344	3	170	172	80
TH 345	3	198	200	85
TH 346	3	290	186	125
TH 347	3	135	110	79
TH 349	4	117	85	45
TH 361	3	170	170	90
TH 371	3	209	202	93
TH 373	3	175	172	72
TH 375	3	170	172	90
TH 376	3	140	104	59
TH 382	3	158	170	83
TH 393	3	145	135	85
TH 399	3	170	170	90
TH 521	1	340	200	145
TH 527	2	156	94	60
TH 532	1	390	190	172
TH 537	1	560	310	360
TH 539	1	885	410	284
TH 547	2	156	94	60
TH 555A	1	575	270	198
TH 558	1	653	320	245
TH 561	2	195	128	65
TH 562	2	195	128	65
TH 563	2	190	126	69
TH 571A	2	222	148	70
TH 573	1	583	320	273
TH 576	1	695	346	215
TH 581	1	490	270	198
TH 582	2	166	128	60
TH 593	2	156	108	61
TH 598	2	156	108	61

Quality performances of tetrode technologies

Triodes and tetrodes played a fundamental role in the birth and progress of electronics from the early days of this century. Today, semiconductor devices have taken over much of this role in everyday equipment, and have enabled such revolutions in our lives as high-speed computing. Power-grid tubes have nevertheless continued to evolve at a considerable rate, and the major progress that has been made in high-power tetrodes is of great benefit for television and radio broadcasting.

The invention of the transistor in 1948 rapidly led to the virtual disappearance of low-power electron tubes in such uses as audio amplifiers and radio receivers. In broadcasting, however, despite the advent of "all solid-state" equipment, power-grid tubes continue to be widely used, and continue to be included in new equipment designs. The explanation for this fact can be found in the performances that today's tetrodes provide :

- extremely high per-unit power capability (whereas a large number of transistors must be operated in parallel at the expense of much greater equipment complexity) ;
- extremely low temperature sensitivity ;
- high gain per unit ;
- very high linearity and phase stability ;
- excellent isolation between stages : the anode has almost no effect on the grid while in a transistor the emitter always acts to some degree on the base ;
- good resistance to electric shock.

Tetrodes have large bandwidths, high linearity and low overall energy consumption, but have in the past been limited by the power output a single tube can provide. This has in part been overcome by more efficient anode cooling methods and the associated increase in power-grid tube dissipation capabilities. The resulting smaller and more compact tetrodes have contributed to much simpler and handier radio and TV transmitter designs when using these components.

High-power tetrode technology

High-power tetrodes have been made possible by a combination of new materials and new techniques. Thomson has been at the forefront of this search, and we set out here the main advances that led to high-power capabilities.

Thoriated tungsten cathodes

Cathodes are heated to emit the electrons needed for tube operation. In medium and high-power tubes, the heating current flows through the cathode itself, and this is known as direct heating.

Thoriated-tungsten is used for the cathode since it provides sufficient electron-emission density at a temperature of only 1900 to 2000 °K. It is produced using thin tungsten wire, only a few tenths of a millimeter in diameter, containing a small percentage of thorium oxide. The wire is wound onto a cylindrical mandrel to form two layers that cross each other askew, and then welded at each crossing point. This forms a cylindrical "cage" (Figure 1). Finally, the cage is welded to plates at each end forming the heating-current connection.

The cathode is activated by raising its temperature to 2300 °K for several minutes in a carbon-hydride atmosphere. Thorium is generated by this process and diffuses towards the surface of the wire where it forms a monoatomic layer.

This process leads to cathodes capable of generating high current densities at decreased temperatures (up to 2.5 A/cm^2). Carburized thoriated-tungsten cathodes also withstand the effects of residual gases and ion bombardment in the tube more readily. In this respect, they are greatly superior to oxide cathodes, and are the preferred type for high-power tubes with high operating voltages.

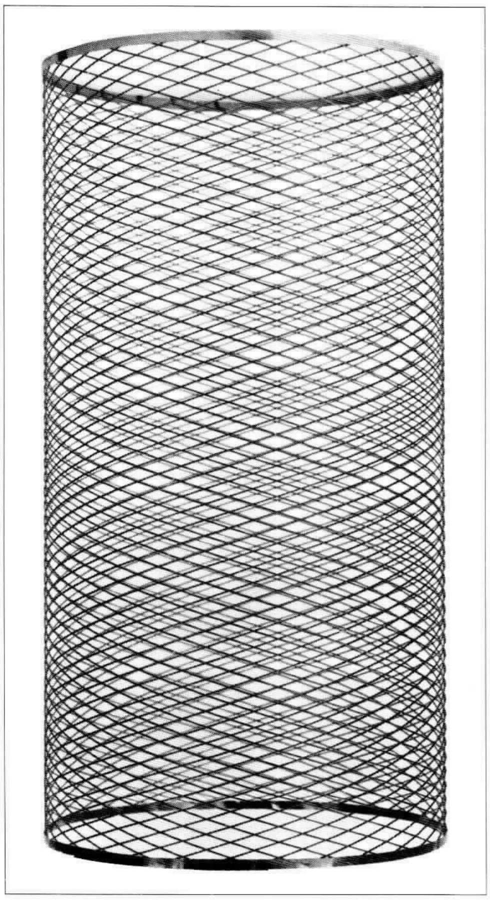


Figure 1
A tetrode cathode

Grids

Grid design considerations

The shape of the control grid and its distance from the cathode and, to a lesser extent, from the anode define the operating characteristics of a triode. The necessary reduction of the grid current to a minimum requires the grid to be highly transparent.

So as to minimize the grid current in a tetrode, the two grids must be precisely aligned, so that the electrons passing through the first (the control grid) are likely to pass through the second (the screen grid). Finally, normal tube operation requires the screen grid voltage to remain significantly lower than the anode voltage and this requires decreased spacing between screen and control grids in tube construction.

The classical solution

In a classical power-grid tube, the behavior of the grids is determined by three main parameters :

1) Thermal emission : The problem of thermal emission arises from emissive material from the cathode being deposited on the grid. This is compounded by the naturally high emissivity of the normal grid materials : molybdenum, tantalum, and tungsten. As a result of these two phenomena, the grid becomes a parasitic cathode, emitting electrons when heated by electron bombardment or by the real cathode.

2) Secondary emission : The secondary emission effect is directly related to the type of grid material used, its surface state, and the velocity of the impinging electrons. It is worsened by deposits of cathode material.

To reduce the disturbing effects of thermal and secondary emission, the emissivity of the grid surface is usually decreased by applying a coating of zirconium or carbon. These coatings are difficult to apply, and have the added inconvenience of making the grid more brittle and less able to support accidental thermal overloads, further accentuated with age.

3) Mechanical rigidity : Ordinary grids are made using spot-welding techniques, and pose major difficulties for high-power tube operation. The welds may crystallize leading to even greater fragility, their high thermal impedance can cause grid deformations, and their uneven structure causes variations in the interelectrode distance.

The useful properties of Pyrobloc® grids

Conventional grid materials cannot meet the combined requirements of compactness and high power. Thomson Tubes Electroniques' research efforts found the answer in pyrolytic graphite. This led to an entirely new type of grid, patented by Thomson Tubes Electroniques as the Pyrobloc grid.

Pyrolytic graphite is a form of crystallized carbon produced by decomposing a hydrocarbon gas at very high temperature under controlled environmental conditions. A layer of pyrolytic graphite is deposited on a special blank, the layer's thickness being proportional to the deposition time. The structure and mechanical properties of the deposited graphite depend upon the imposed conditions.

Four groups of properties make pyrolytic graphite a clearly superior grid material :

Thermal properties

Figure 2 shows the thermal conductivity of various materials as a function of the temperature. The thermal conductivity of pyrolytic graphite parallel to the deposition plane [ab] is close to that of copper or tungsten. In the perpendicular direction [c], however, its thermal conductivity is even lower than that of stabilized zirconia.

This phenomenon allows the power dissipated as heat on a Pyrobloc grid to be easily and efficiently transferred to its support. This transfer is facilitated by the one-piece construction of these grids.

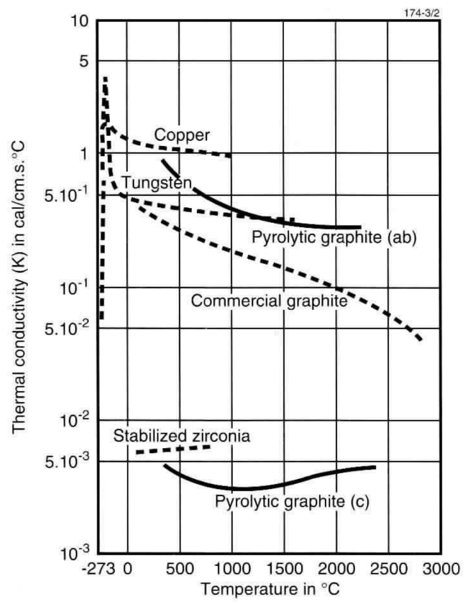


Figure 2
Thermal conductivity of various materials

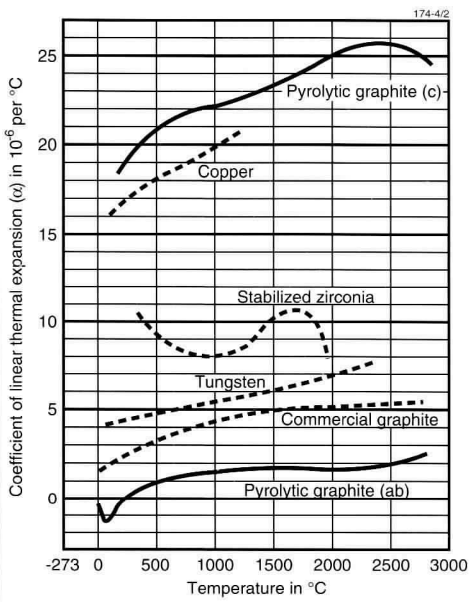


Figure 3
Thermal expansion coefficient of various materials

Looking now at thermal expansion, Figure 3 shows that it is very low in the [ab] direction for pyrolytic graphite. It follows that the variation in diameter of a Pyrobloc grid is negligible at normal operating temperatures. This allows the screen and control grids to be spaced extremely closely.

In addition, the excellent resistance to thermal shock and superior high-temperature stability of pyrolytic graphite enables Pyrobloc grids to withstand short-term overloads with no damage. Conventional metal grids would very likely be destroyed under the same conditions.

Finally, one of the most important thermal properties of pyrolytic graphite is that it is a near black-body material with a very high heat-radiation capacity.

Reduced grid emission

The secondary-emission effects of graphite are much less pronounced than those of conventional grid materials. The much lower operating temperature of Pyrobloc grids results in a significant reduction in the thermal emission from the coating of cathode material inevitably deposited on the grids.

Mechanical properties

The mechanical strength of pyrolytic graphite compares more than favorably to those of other grid materials. To mention only the most important characteristics :

- flexural strength,
  [ab] direction . . . 1 700 kg/cm^2
- ultimate tensile strength,
  [ab] direction . . . 1 100 kg/cm^2
- compressive strength,
  [ab] direction . . . 1 500 kg/cm^2
- compressive strength,
  [c] direction . . . 5 000 kg/cm^2

Unlike other grid materials, pyrolytic graphite strength increases with temperature. Due to its excellent stability at high temperatures (e.g. at 1850 °C, vapor pressure is close to 10^{-7} torr), a

Pyrobloc grid can be operated at the same temperature as a thoriated-tungsten cathode.

Electrical properties

Electrical anisotropy is an inherent characteristic of pyrolytic materials. This explains the large difference in electrical resistivity of pyrolytic graphite in the [ab] and [c] directions (Figure 4). Furthermore, the electrical resistivity in the [ab] direction remains virtually constant and at a minimum for the normal operating temperatures of power-grid tubes. It follows that Pyrobloc grids conduct almost as well as coated-metal grids.

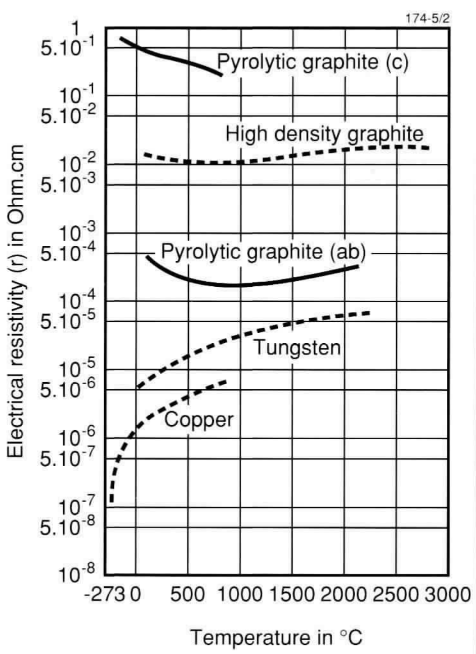


Figure 4
Comparison of electrical resistivity

Manufacturing Pyrobloc grids

The industrialization of pyrolytic-graphite grids involved a certain number of challenges. Commercially available graphite, for instance, was found to be unsuitable due to the impurities it contains. This was resolved by developing the high-temperature pyrolytic-graphite deposition process previously described. The resulting one-piece grid "castings" present several advantages. All of the grid elements (cap, mesh, and supporting base) form a continuous structure, no welding or mechanical assembly being necessary.

An original processing method was then developed to manufacture any type of grid mesh from these "castings" (Figure 5). Individual strand cross sections as small as 0.01 mm^2 can be made with extremely high precision. All the Pyrobloc-grid manufacturing and processing techniques developed and patented by Thomson Tubes Electroniques were decisive in the production of high-power tetrodes.

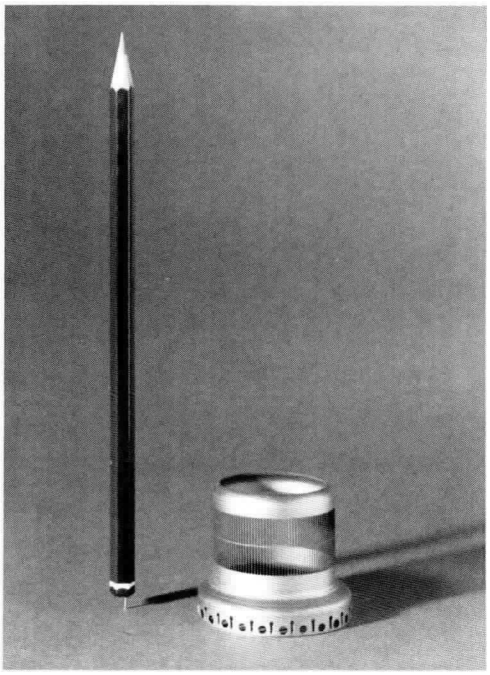


Figure 5
Pyrobloc grid of a tetrode

Anodes

In general, power-grid tube anodes are massive copper electrodes whose structure is essentially determined by the power that they must dissipate in the form of heat. In coaxial tubes, they surround all of the other electrodes.

One constraint often imposed on the anode cooling system is the fact that the cathode is operated at ground potential. This requires insulation between the anode and ground, and this insulation must be able to withstand the maximum value of the anode voltage.

For the most commonly encountered power levels, natural radiation, conduction or convection is not sufficient to cool the anode. These tubes are therefore cooled by forced air, circulating water, or by vapor-related methods.

Forced-air cooling

The dissipation per unit area may be increased by about 20 times over that in naturally cooled tubes by blowing air onto the tube outer surfaces at a high velocity - 30 m/sec, for instance. In external-anode types, a finned heat radiator is welded to the anode (Figure 6). In the tube shown, this radiator is enclosed in a cylinder that forces the cooling air flow between the fins, requiring only a slight overpressure.

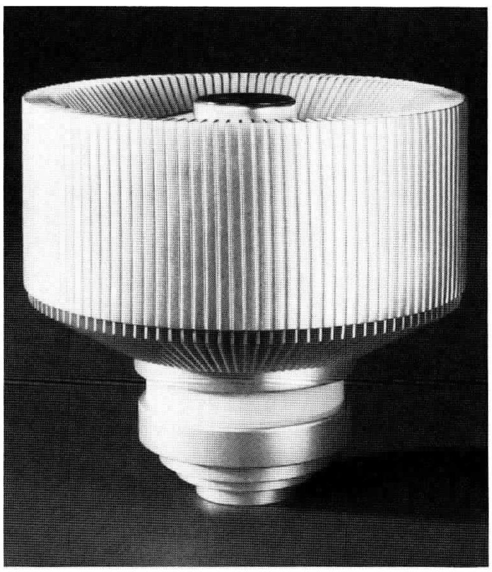


Figure 6
A typical air-cooled Thomson tetrode for TV transmitters (TH 382 for 10 kW-UHF)

Hypervapotron™ cooling

Hypervapotron cooling provides a large margin for heat removal from the anode, even for very high power tubes. It is the outgrowth of the discovery of the Vapotron® effect at Thomson Tubes Electroniques in the early 1950's.

This cooling process relies on the combination of two phenomena. Complex boiling phenomena within narrow slots on the anode surface form a vapor which is then expelled. This water vapor is then instantly condensed in a fast-moving flow of relatively cool water, directed at right angles to these slots within the tube water jacket.

Figure 7 illustrates the Hypervapotron cooling technique. The gap between two facing surfaces is reduced to a narrow slot, and aggregate (film and bubble forming) boiling takes place. Furthermore, a natural pulsating regime is established. First, the vapor produced by the complex boiling builds up in the slot. Then it is expelled at high velocity and quickly condensed in the flow of water across the slots. Finally, a simultaneous suction action draws water back in to replenish the slot.

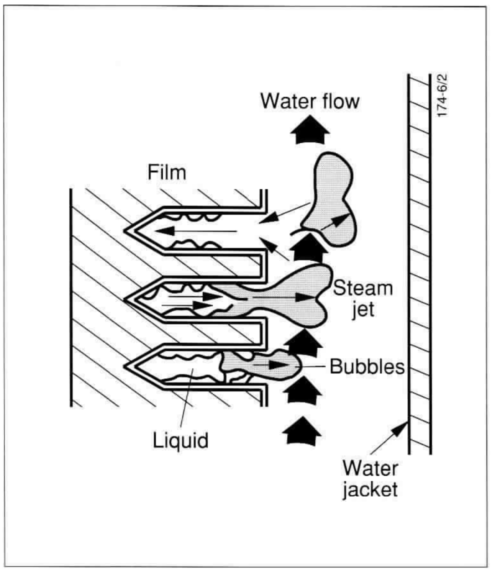


Figure 7
Hypervapotron anode cross section, showing operation

The immediate condensation of the vapor reduces the disturbing effects due to large amounts of water vapor being generated, and eliminates any need for an external condensor. The water outlet temperature may reach any value as long as it remains under 80 °C at atmospheric pressure. The hot outlet water may be routed through a heat exchanger, for example, to provide a secondary hot-water circuit for building heating or other uses at no additional cost.

Hypervapotron-cooled tubes are rated at 1 kW/cm^2, the theoretical limit being 2 kW/cm^2 anode dissipation.

Figure 8
A Hypervapotron-cooled tetrode for TV applications (TH 582 20 kW UHF)

Ceramic insulators

A power-grid tube ceramic insulator (Figure 9) must satisfy the following properties :

- electrical insulation between the different electrode terminals,
- perfect vacuum-tightness,
- good mechanical stability at high operating temperatures.

Ceramics containing a high percentage of alumina satisfy these properties, and allow the development of more powerful tubes, or of tubes operating at a higher voltage.

Their main physical characteristics are :

- dielectric rigidity : 20 kV/mm
- electric conductivity at 20 °C : $< 10^{-12}\Omega^{-1}m^{-1}$
- loss factor at 1 MHz : approx. 10^{-4}
- good thermal conductivity ($30\ Wm^{-1}{}^{\circ}C^{-1}$) leading to a good resistance to thermal shock
- good mechanical stability at high temperatures (melting point is at 1600 °C which is well above normal operating temperature).

Due to their overall physical characteristics, on the one hand, and modern production methods, on the other, ceramic insulators can be manufactured to very tight physical tolerances, enabling extremely high centering precision during tube manufacturing. Ceramic-to-metal seals can withstand elevated operating temperatures without affecting the life of the tube.

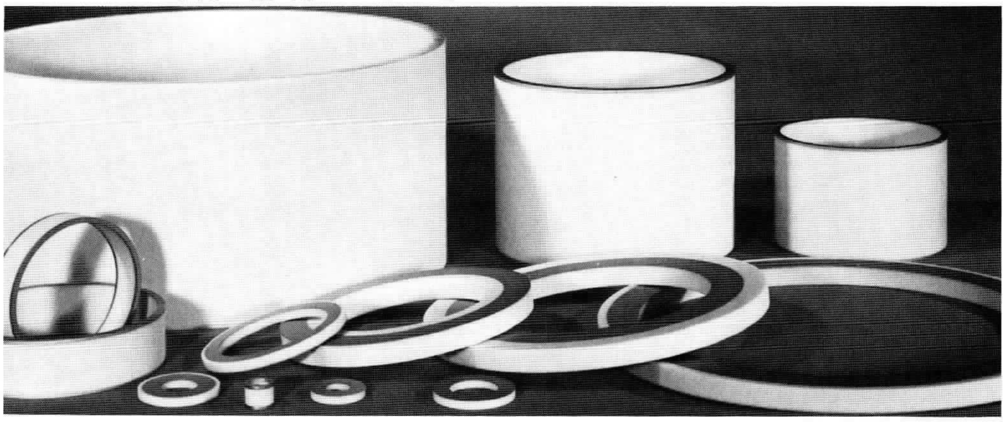


Figure 9
Ceramic insulators used on various types of power grid tubes

Power-grid tube performances in transmitters

Radio transmitters

The technologies developed by Thomson Tubes Electroniques have provided a range of tetrodes with performances well adapted to radio-transmitter operation :

- transmitter efficiencies greater than 70 percent in the short wave,
- high operating stability,
- excellent linearity,
- reduced cost of ownership resulting from enhanced lifetimes of Thomson tubes,
- simple transmitter operation and maintenance.

Furthermore, tetrode quality is followed from design through to manufacture, ensuring tube reproducibility and reliability.

Thomson tetrodes exist for all types of transmitter, and are used in the audio and radio frequency stages. They operate with large safety margins, whatever the modulation method :

- conventional amplitude modulation with a modulation transformer,
- doherty modulation,
- pulse duration modulation.

Transmitter efficiency is very high when using tetrodes with pyrolytic-graphite grids :

- the minimum residual anode voltage, and thus the anode power dissipation, may be adjusted to a low value without risk of grid overheating,
- the interelectrode distances are very precise, and from this the tube transconductance is high. The cathode easily provides the peak current required under these conditions.

The most recent tube developed by Thomson for 500-kW SW transmitters (the TH 576 with an anode efficiency of more than 90 percent) makes transmitter efficiencies of greater than 75 percent possible over the entire 3 to 26 MHz short-wave band.

TV transmitters

The demand for cost effective solutions to TV broadcasting transmitters has initiated a wealth of new electron-tube technologies. Thomson Tubes Electroniques continues to invest in tetrode technology to attain the higher power capabilities needed in today's transmitters.

Several factors influence which type of amplifier tube and which specific tube model will be best for the power or driver stage in a given transmitter or translator. These include the planned operating frequency, the type of operation envisaged (combined vision and sound carriers or separate-carrier amplification), the output power and gain necessary, the most appropriate cooling method, etc. When faced with this choice, the original-equipment manufacturer (OEM) or end user will find a consultation with our commercial and technical assistance staff extremely useful.

Amplification mode

Television signals are amplified in one of two ways :

1) Combined carrier amplification : the sound and vision carriers are amplified together through the power stage.

2) Separate carrier amplification : the sound and vision carriers are amplified separately and combined before the antenna.

Gain

The product of gain (G) and bandwidth (B) is a constant for an ideal power-grid tube operating in a coaxial-cavity circuit.

$$B.G = \frac{g_m}{\alpha\,\beta\,C}$$

where

g_m is the anode-to-grid transconductance ;
α is the coefficient characterizing the coaxial-cavity circuit ;
β is the coefficient characterizing the class of operation of the tube ;
C is the output capacitance.

The coefficient essentially depends on the operating mode of the coaxial-cavity circuit. In the $\lambda/4$ mode, it can easily be held at values below 1.5, whereas in the $3\lambda/4$ mode its minimum value is near 4. The coefficient β is 4π in class B and 2π in class A operation. For maximum tube gain, the coaxial-cavity circuit must be operated in the $\lambda/4$ mode as close to class A as possible, without unduly sacrificing tube efficiency.

Of equal importance is the condition that the output capacitance be as low as possible. A low capacitance also favors the advantageous $\lambda/4$ mode of operation in the upper part of the UHF-TV range.

Figure 10
Some typical TV tetrodes manufactured by Thomson Tubes Electroniques

Thomson Tubes Electroniques' RF-circuit assemblies

connectors

The tube interface with its RF circuit is of great importance for transmitter efficiency and optimal performances. The tube/RF-circuit connectors must provide electrical continuity and mechanical support, as well as allowing the electrode terminals and ceramics to be cooled by forced air.

To meet these requirements, even at high-frequency operation, Thomson has designed a range of RF-circuit connectors for its radio-transmitter tubes (Figure 11). The tube/connector assembly incorporates the following features for trouble-free operation :

- the connector electrode fingers are made of a silver-plated beryllium copper alloy. Their elasticity assures good contact pressure and the conduction of high currents.
- the connector directs the flow of cooling air onto the terminals and through the holes in these, so cooling the ceramic-metal seals efficiently.
- the connector is equipped with cathode-to-ground and screen-grid-to-ground insulators made of Kapton* sheets metallized on both sides, providing high

* Kapton is a registered trademark of Dupont de Nemours (USA).

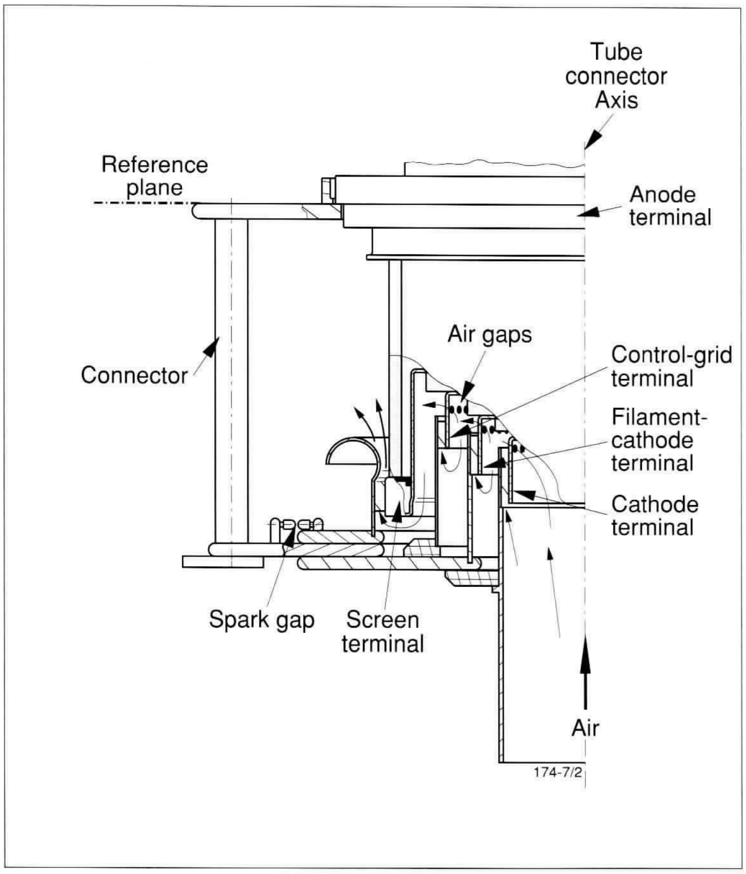


Figure 11
Cross-section of the connector of a tetrode

capacitance values and high-voltage insulation. These capacitances are not sufficient at low frequencies and must be supplemented with suitable capacitors.

- control-grid-to-ground and screen-grid-to-ground spark-gaps, regulated in the factory, help protect the tube by limiting accidental electrode over-voltage.

Maximum tube lifetimes are ensured by respecting the air flow and pressure values given in the tube data sheets. The temperature of the terminals, the ceramic-metal seals and the ceramics must not exceed the maximum temperature specified for the tube being used.

Electron tubes are designed to be mounted vertically on their electrical connectors. The tube must be correctly positioned in its connector to ensure correct cooling with the air flow in the terminals being correctly directed.

Tubes should be installed and removed with care to avoid flattening or breaking the connector fingers. Connector finger damage increases electrical contact resistance, leading to local overheating and possible damage to the electrode terminals. Incorrect electrode cooling also causes overheating of the fingers and reduces their elasticity. The connector fingers should be periodically checked and adequately maintained.

TV-transmitter circuits

Thomson Tubes Electroniques is a major manufacturer of tetrodes for VHF (Band III) and UHF (Bands IV and V) television transmitters. At these frequencies, the performance of a complete amplifier is integrally dependent on the RF-circuit assembly and the tube. It makes no sense to speak of the performance of a tube alone or a circuit alone, but the performance of the tube-plus-circuit pair. This led the company to develop and manufacture matched RF circuits for its TV tetrodes.

New tetrodes at Thomson are developed simultaneously with their associated RF-circuit assemblies (line or coaxial-cavity types). This pair must be designed as a unit if the full performance capabilities of the amplifier tube are to be attained. A good tube-circuit "partnership" is also important for maximum operating reliability.

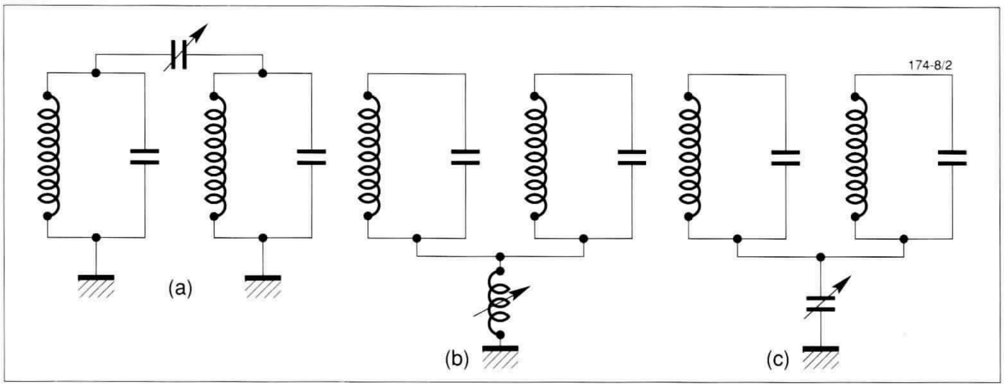
Coupled circuits

Transmission of TV sound and/or vision signals requires a bandwidth (Δf) which depends on the channel frequency f.Δf is between 1.5 and 20 percent of f.

The power-amplifier resonant circuits must be designed so such values may be reached. The input has a single resonant circuit loaded by the tube, which has an input impedance of about ten ohms. The output has a number of coupled circuits. This number depends on the $\Delta f/f$ ratio and the load impedance of the tube (a few hundred ohms).

The advantages of the $\lambda/4$ resonant circuit are fully exploited through two techniques patented by Thomson. These are common inductive or "magnetic coupling" (Figure 12b) and "common capacitive coupling" (Figure 12c). They are used on all our UHF cavities between 2 kW and 50 kW, with proven performance over many years operation. The advantage of both techniques is that the primary circuit of the cavity can be tuned on $\lambda/4$, and so the top channels of UHF-Band V may be reached. Common-capacitive coupling has a further advantage of not being located near the high RF-voltage values inside the cavity circuit, so eliminating breakdown risks. Another spin-off of this technique is that it can be set at a fixed value for the whole UHF range.

Figure 12
Three different solutions for coupling the output circuits in an RF-circuit assembly : (a) "top" coupling, (b) magnetic coupling (c) common-capacitive coupling.



Mechanical simplicity and standardization

Our prime objectives are to design RF circuits that are as mechanically simple as possible with a high degree of parts standardization for different circuits of the same type (line or coaxial cavity). This enables better cost control, more rigourous testing, and simplified circuit production. The OEM or end user also benefits from these goals.

Since most Thomson TV-transmitter tubes exist in both air-cooled and Hypervapotron versions, the corresponding RF-circuit assemblies also exist in two versions. They are, however, virtually identical due to the high degree of standardization.

Thomson Tubes Electroniques also believes in designing polyvalent RF-circuit assemblies whenever possible, able to operate with several different tubes. This sometimes requires slight adjustment in circuit design, but they offer the OEM or end user benefits due to manufacturing efficiency. This provides economies in production, and ensures increased reliability.

Futhermore, our customers may specify refinements for a particular requirement. Our RF-Circuit Department is able to modify existing models, or create entirely new circuits for special applications.

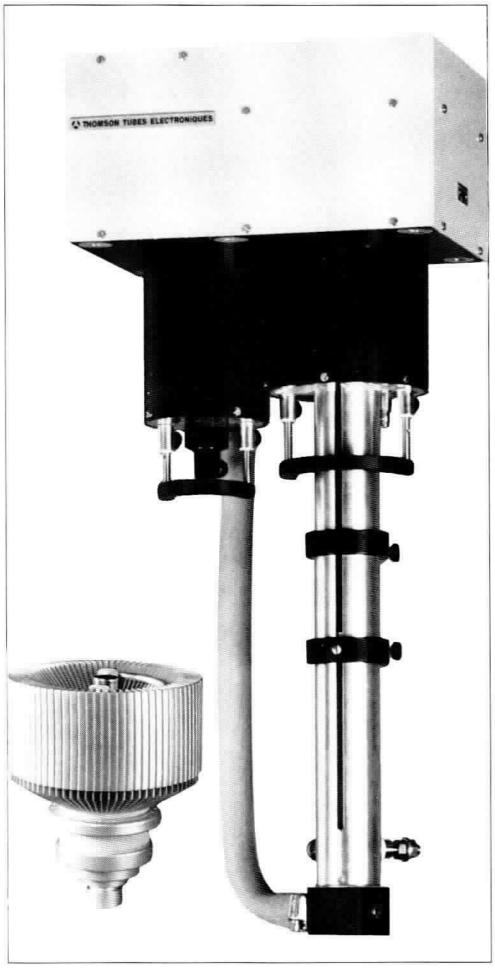


Figure 13
A Thomson Tubes Electroniques UHF-TV air-cooled tetrode TH 347 with its matched coaxial-cavity circuit TH 18363

Materials and technology

To ensure top-quality products, Thomson Tubes Electroniques only uses first-rate and proven materials in their manufacture. Our RF-circuit assemblies are essentially composed of silver-plated brass and beryllium-copper for the electrical contacts. The insulators are made of Teflon* or other polytetrafluorethylenes (PTFEs), and the dielectrics of the distributed capacitors are made of Kapton*.

** Teflon and Kapton are registered trademarks of Dupont de Nemours (USA).*

Although some commercially available socket contacts are employed in our RF-circuit assemblies, we have also developed and patented our own improved contacts (Figure 14). Composed of wire wound on a notched ribbon of copper alloy, these contacts allow much freer circulation of the cooling air for themselves, the tube electrodes and the rest of the circuit assembly. Because they are not soldered in place, they do not loose any elasticity, and contact replacement (when finally necessary) is much simpler.

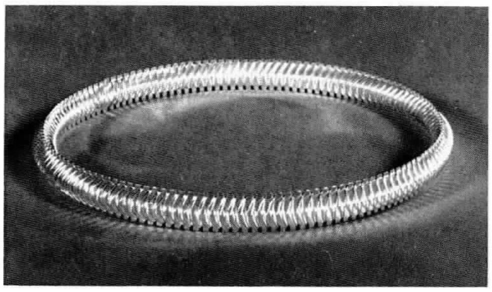


Figure 14
Thomson Tubes Electroniques own socket contacts offer several important advantages

Development and production

Thomson Tubes Electroniques has invested extensively in RF-circuit assembly development and production to take full advantage of the continuing development of new and improved TV-transmitting tetrodes.

An ultramodern, fully-equipped laboratory is at the exclusive disposal of the experienced staff of the RF-Circuit-Assembly Department for the design, development and testing of new and improved RF circuit assemblies. These facilities include all necessary equipment for the production of the best possible circuit designs and the checking out of complete amplifiers to full TV-system requirements. Our customers are welcome to visit these facilities.

As far as this production is concerned, Thomson Tubes Electroniques offers its OEM customers two options. They can buy our circuit assemblies directly from our Thonon-les-Bains (France) plant, or they can produce them under license in their own facilities, using complete manufacturing specifications supplied by the company.

Operating information and recommendations

All Thomson Tubes Electroniques' power-grid tubes are carefully designed and engineered to provide high-quality, long-life service in radio and TV transmitters and translators. When they are installed in coaxial-cavity or line circuits made or approved by Thomson Tubes Electroniques, the user can be further assured that the tube will be operating with correctly designed circuitry.

Whatever the origin of the RF circuitry, the user must however observe a few important precautions and follow certain recommended operating procedures to obtain the top-notch performance that these tubes were designed to deliver. As well as the information in this section, specific details are given in the individual tube data sheets.

If you have questions not answered by the information provided here, or require any personalized assistance with your particular installation, please contact our experienced applications engineers, via our headquarters or via your local Thomson Tubes Electroniques representative.

Transportation, handling and storage

Receipt of the tube

Upon receipt of a tube, before removing it from its container, check for any damage which may have occurred during transportation :

- check that the container is in good condition,
- test filament continuity and absence of short-circuits between the electrodes using an ohmmeter.

In case of damage

- Refer to the instructions on the back of the delivery statement in the "Documents" envelope on the packing case.
- Make the necessary claims to the last shipper within the times required by the insurance.

Storage and handling

The tube must be stored in a dry, dust-free place in a vertical position either in its plastic wrapping or its container.

Handle the tube with care avoiding any shocks.

Never handle the tube by the g2-anode ceramic.

Entering a tube into service

Tube installation

Before installing a new tube, carefully inspect the tube to be replaced and the cavity. Should you detect any anomalies, they must be remedied.

Take particular care of the following :

On the tube to be replaced :
Carefully inspect the fins, ceramics and different collars.

- Any signs of heating indicate insufficient cooling : check the cooling-air filter.
- If there are any traces of sparking (black marks on the collars, streaks on the ceramics), check the state of the cavity and particularly the contacts.

On the cavity :
a) Electrode contacts :

- Check the springiness and condition of the contacts.
- Replace defective contacts.

b) Bypass capacitors (anode and grids) :

- Dust their ends without removing them.
- Replace capacitors showing signs of sparking or heating.

c) air cooling of the tube and cavity assembly :

- Check that the assembly is correctly ventilated, in particular that no foreign body obstructs even partially the cooling-air ducts. Clean the air filter or replace it if required.

First use of a new tube

a) Install the tube as described in the equipment operating instructions. Make sure the tube is correctly seated in the cavity.

b) In the case of a Hypervapotron-cooled tube, make sure the cooling water flow direction is correct. Start the water flowing to fill up the circuits.

c) Apply the heater blackheating voltage (see "Cathodes" below) for at least 10 minutes before applying the other voltages as indicated below.

Voltage application and settings

In TV transmitters
In general, the tube being under permanent blackheating voltage, apply successively :

1 - Ventilation and water cooling systems,

2 - Heater voltage according to the indications supplied by Thomson Tubes Electroniques,

3 - Control-grid bias voltage (Vg1),

4 - Anode voltage,

5 - Screen-grid voltage,

6 - Set Vg1 to obtain the defined zero-signal anode current,

7 - Check at low power, using a sweep-signal generator, the cavity settings on a 50-ohm load. Retuning is generally limited to the primary anode circuit and drive circuit (cathode-control grid setting and matching) in conformity with the recommendations indicated in the equipment instructions.

8 - Once the cavity is set, check its dynamic operation and note all voltage, current and power values for a defined modulation signal.

In radio transmitters
Apply the voltages according to the sequence in the equipment instructions. Increase the HV and power gradually. Apply the modulation gradually.

Cavity tuning after removal/installation

After removal of the cavity, preposition the tuning at those noted before removal.

a) Cavity alone

- Connect the cavity output to the 50-ohm load (VSWR < 1.1).
- Tune the cavity to the low level.
- Check that the output bandwidth (midband frequency, width at –1 dB) and the input matching comply with the transmitter instructions.

- Lock the tuning controls in the positions obtained after tuning.

b) Cavity loaded with HF filter (rejector filter, harmonic suppressor, diplexer)

- The cavity having been tuned, connect it without altering the setting to the filter loaded by the dummy antenna.
- Check the band at low level at the output of the HF filter. Should anomalies appear, check the setting of the filter and the matching of the dummy antenna. Under no circumstances must the cavity tuning be reset to compensate for off-specification band.

c) Operation of the cavity and filter assembly with the driver stages

- Check that the use of the driver stages does not affect the frequency response of the power stage.
- Under no circumstances must the cavity tuning be reset to compensate for an anomaly in the transmitter amplitude-frequency response. **The causes of this anomaly must be found.**

Transmitter design considerations

The following indications are intended for OEMs designing a transmitter using a Thomson power-grid tube. The influence of the transmitter site on cooling requirements is also covered. Power-grid tubes are however much less sensitive to environmental extremes than other technologies.

Thomson Tubes Electroniques' engineers, through the customer support network, are able to provide further assistance so the full potential of Thomson power-grid tubes may be assured. The transmitter thus developed will benefit from the excellent reliability and lifetimes of these tubes, as well as the top-notch performances.

Cathodes

The cathode's mechanical stability and its temperature have always been important factors in enhancing the reliability and lifetime of a power-grid tube. Considering the short distance between the cathode and the control grid, this factor is fundamental in modern power-grid tubes. Three main parameters must be considered.

Heater voltage

The lifetime of a tube is primarily related to the temperature of its cathode. This temperature depends not only on the heating power - the heating voltage applied to the cathode - but also on the combination of the power dissipated on the grids, the cathode current, and the RF losses. For these reasons, the operating heater voltage cannot be given as a general characteristic, but must be defined according to specific operating conditions. This is why the users are urged to forward these conditions to Thomson Tubes Electroniques, who will in turn advise the optimal heating parameters.

Nevertheless, approximate values for the heater voltage and heating current are indicated in Thomson Tubes Electroniques' power-grid tube data sheets.

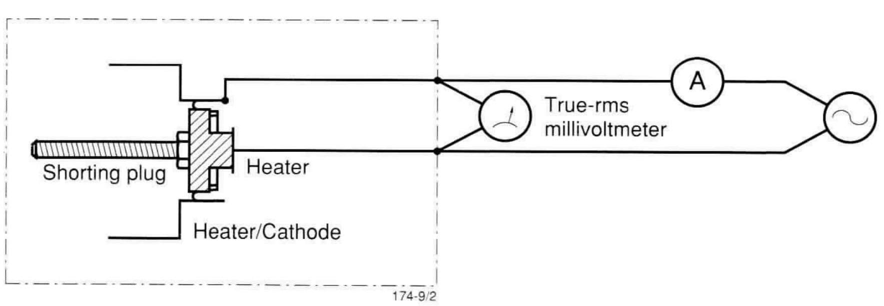


Figure 15
Correct setup for measuring the heating circuit resistance

These are to assist in the appropriate heater transformer design, and assume no other cathode heating factors interfere.

Regulation

In addition to the correct value for the heater voltage, it is also necessary to regulate it in order to obtain a longer cathode lifetime. The tolerance is ± 2 percent. For instance, too high a voltage causes rapid evaporation of the cathode emissive material, whereas if it is too low the signal quality deteriorates.

Application and shutdown of heater voltage

Thoriated-tungsten cathodes

When the heater voltage is applied, the surge current due in part to the low resistance of the cold cathode must be limited.

In addition, the following thermal factors must be allowed for. When the heater voltage is applied to a cage-type cathode, the tungsten wires expand immediately due to their low thermal inertia, whereas the cathode support - made of more bulky parts - heats and expands more slowly. This differential expansion can cause permanent damage to the cathode wire, together with a modification of the tube characteristics, or even electric arcs or intermittent short-circuits between the cathode and the control grid, and tripping of the power supply circuit breakers. A few basic precautions must therefore be taken when applying the heater voltage, so as to avoid these problems.

The surge current at heater voltage turn-on can be limited :

- by a leakage transformer. The general characteristics given on the tube data sheet specify the maximum surge current at heater voltage turn-on, and this value is used to design the transformer.
- by a progressive or step-by-step application of the heater voltage. This solution has the advantage of giving the cathode assembly (cathode and its support) the time required to make up for expansion differences. The correct definition of the steps and their duration is important. This solution has one drawback - it requires a delay while the cathode heats to the correct temperature. This delay before the tube may be operated is not acceptable in certain applications, e.g. emergency broadcasting.

We recommend another procedure based on a permanent reduced heating of the cathode, known as *black heating*. In this case, the full heater voltage may be applied directly or progressively.

This procedure is mandatory when conditions require the heater voltage to be shut down more than once a day.

The black-heating procedure consists of maintaining a reduced heater voltage when the tube is not being operated, in order to keep the cathode at about half its working temperature. This voltage is defined for each type of tube, and its value is about a quarter of the operating value.

Under these circumstances :

- the power consumed is about one-tenth of the operating heating power, and it is not necessary to maintain tube cooling. Nevertheless, the cooling air or water must be able to circulate freely.
- because the cathode temperature is reduced, tube life is not reduced by black-heating time. Thomson Tubes Electroniques' guaranteed tube lifetime includes only the time that the voltage is at its nominal value.

Furthermore, a leakage transformer is not required when cathode black heating is used. The cathode surge current is limited by the resistance of the heated cathode (higher than when it is cold).

This solution offers numerous advantages :

- instant transmitter/translator turn-on,
- stability at starting, the tube already being warmed up,

- protection against freezing (water-cooled tubes),
- prevention of condensation on the tube or in the associated circuit,
- increased operating life.

In the case of extreme necessity, following a power-line outage during a program, for instance, the full cathode-heating voltage may be applied directly, provided the peak surge current in the cold cathode does not exceed the limit given in the data sheet.

Oxide cathodes

The heater voltage should be applied at least 3 minutes before the other voltages are applied. This time is necessary for the cathode to heat up.

Grids

Despite the excellent characteristics of Pyrobloc grids (low thermal and secondary emissions, increased dissipation capability, high mechanical resistance), the impedances of the grid power supplies must be kept low.

In all cases, an overcurrent protective device must be provided. It must be able to cut off the current in less than 100 milliseconds, and set to 1.5 times the normal operating current.

Anodes

Further information on tube protective devices to be designed into the transmitter may be found in the individual tube data sheet.

In addition to the general safety measures linked to high-voltage operation, the anode power supply must be interlocked to the tube protective devices including :

- anode-cooling safety interlocks,
- heater and biasing voltage interlocks,
- anode, control grid, and screen-grid overcurrent systems,
- other safety devices concerning the transmitter circuit and personnel-safety factors.

The tube must also be protected against overdissipation encountered with possible mismatching.

Cooling

Normal operation requires cooling of :

- the tube anode,
- the ceramic insulators,
- the electrode terminals.

In all types of operation, cooling must be effective before the heater voltage is applied, and maintained for at least 3 minutes after its shutdown.

The electrode terminals of the tube and its ceramics are cooled by filtered forced air. The air flow must be directed with care in order to cool the seals and the electrode terminals efficiently. The temperature of the ceramic-metal seals and the ceramics must never exceed the maximum temperature given in the tube data sheet.

An inlet air-flow and pressure safety device, interconnected to the tube protective devices, must be provided.

Depending on the power to be dissipated, the anode may be cooled either by the Hypervapotron method using circulating cooling water, or by forced air. The choice of anode cooling method depends upon the output power levels to be encountered. In general, at component power levels exceeding the following, cooling by means of forced air is no longer feasible :

- FM : . . . . 40 kW
- VHF (Band III), separate-carrier amplification : . . . . 30 kW
- VHF (Band III), combined-carrier amplification : . . . . 20 kW

- UHF (Bands IV and V), separate-carrier amplification : . . . . 10 kW
- UHF (Bands IV and V), combined-carrier amplification : . . . . 5 kW

Water cooling is then necessary.

Thomson Tubes Electroniques will assist you in tube selection.

Hypervapotron cooling

Each tube's individual data sheet specifies the required water pressure and flow rate, and these must be strictly adhered to. The cooling water must be distilled, but not completely degassed, and have a resistivity greater than 50 kΩ-cm.

Hypervapotron tubes are delivered with their integral water jackets. The water inlets and outlets are clearly marked "IN" and "OUT", and with blue for the inlet and red for the outlet. The incoming cooling water must always be connected to the inlet and the outgoing hot water must always be evacuated by the outlet.

The water flow rate, pressure and temperature must fulfill one of the following conditions :

- If the permanent back-pressure at the tube outlet is at least 0.7 bar, the maximum permissible water outlet temperature is 100 °C for a maximum difference between the water inlet and outlet of 60 °C.
- If the back-pressure at the tube outlet is zero, the water outlet temperature must not exceed 80 °C for a maximum difference between the water inlet and outlet of 40 °C.

The following safety devices are needed to achieve full tube dissipation capabilities :

- inlet pressure,
- flow,
- water resistivity,
- water inlet and outlet temperatures.

Cooling circuit maintenance : The instructions given in the equipment operating manual must be observed. The following points are of particular importance :

Antielectrolytic connectors

The antielectrolytic connectors include a threaded pin which is subject to erosion on the tube side and metal deposition on the ground side. It must be periodically inspected, at least once a year. This frequency depends on the water circuit : water quality, flow rate and temperature.

To inspect the antielectrolytic connectors, unscrew the pin on each connector. On the tube side, check the pin length and replace the pin if it is less than 60 mm long. Look for the reason if erosion is excessive. On the ground side, clean each pin.

Insulating hoses and obturating connectors

Check the external appearance of the flexible insulating tubing and the inside of the obturating connectors at least once a year. Replace damaged parts.

Cooling water

For stable operation, we recommend that you :

- regenerate the water using resin to maintain the water resistivity at a correct value (>200 kΩ-cm)
- filter the cooling water to eliminate all solid particles which could clog the cooling-water flow and cause local overloading of the anode.

Forced-air cooling

The anode is cooled by forced air by means of a finned radiator to optimize heat exchange with the air flow.

The cooling air must be correctly filtered to avoid any clogging which could reduce the air flow and cause local overheating of the tube.

An air-flow monitor must be installed in the outlet cooling-air duct, and an air-pressure monitor at the inlet. Both devices must act on the tube protective devices whenever the tube is not properly cooled.

The cooling-air temperature at the outlet must never exceed the maximum rating of 100 °C. A temperature-monitoring device must therefore be installed by the user or the transmitter manufacturer to provide prompt warning of an excessive outlet-air temperature, whose cause may be poor transmitter tuning or defective operation. This device must trigger the tube protective relays, so switching off the tube when the outlet-air temperature is higher than acceptable.

Air cooling and transmitter site

The forced air cooling needed for the anode and the other electrodes is specified in the tube data sheet for standard ambient conditions :

- altitude : sea level
- temperature : 25 °C

When the transmitter site is higher than sea level and/or the ambient temperature differs from 25 °C, the forced-air cooling requirements for the tube may have to be adjusted. These must allow for air density changes with altitude and ambient temperature, so a suitable fan may be selected.

Air flow is corrected by multiplying its value under standard conditions by the coefficient γ_a :

$$\gamma_a = \frac{P_o}{P} \times \frac{273 + T_{in}}{273 + 25}$$

where

P_o : atmospheric pressure at sea level

P : atmospheric pressure at the transmitter site

T_{in} : inlet-air temperature (in °C)

The coefficient γ_a modifies the air-flow volume in order to keep the air mass per unit time constant.

In those situations where the outlet air temperature, T_{out} exceeds 100 °C, a second adjustment has to be introduced. This is done by multiplying the air-flow volume by γ_b :

$$\gamma_b = \frac{T_{out} - 25}{100 - T_{in}}$$

Pressure drop is adjusted in the same way as for the air-flow volume, i.e. by multiplying it by γ_a. An outlet air temperature of more than 100 °C is compensated for by multiplying the pressure drop by the coefficient $\gamma_a \times \gamma_b$.

Selection of a suitable cooling fan

The air-flow versus pressure-drop characteristics supplied by fan manufacturers are generally only given for standard conditions, i.e. sea level and an ambient temperature of about 20 °C. However, the cooling fan must be able to deliver the air flow required for adequate cooling at the transmitter altitude and ambient temperature. Whereas the air flow remains unchanged since the fan speed is constant, the pressure drop has to be corrected using the coefficients γ_a and γ_b.

The transmitter-site values are transposed into standard values as follows :

- **air-flow** :

$$Q = \gamma \times Q_n$$

where

Q_n : air flow specified in the tube data sheet (standard ambient conditions)

Q : air flow to be supplied by the selected fan

γ : γ_a or $\gamma_a \times \gamma_b$, depending on the conditions of the transmitter site

- **pressure drop** :

$$P = P_n \times \gamma^2$$

where

P_n : pressure drop specified in the tube data sheet

P : static pressure produced by the fan to be selected

γ : γ_a or $\gamma_a \times \gamma_b$, depending on the conditions of the transmitter site

Table 1 - Values of γ_a as a function of the local altitude and air input temperature

air temperature at the input (°C)	Local altitude above sea level (m)								
	0	**500**	**1000**	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**
0	0.92	0.98	1.04	1.10	1.17	1.25	1.33	1.43	1.52
10	0.95	1.01	1.07	1.14	1.21	1.29	1.38	1.47	1.57
20	0.98	1.04	1.11	1.18	1.24	1.33	1.42	1.52	1.62
25	1.00	1.06	1.13	1.20	1.27	1.36	1.45	1.55	1.65
30	1.02	1.08	1.15	1.18	1.30	1.39	1.48	1.58	1.68
40	1.05	1.11	1.19	1.26	1.33	1.43	1.52	1.63	1.73
50	1.08	1.14	1.22	1.30	1.37	1.47	1.57	1.67	1.78

Basic principles of power-grid tubes

The basic diode

The operation of grid tubes is based on the movement of electrons from one electrode, the source known as the cathode, toward another, the collector known as the anode. A basic diode only has a cathode and an anode. Other tubes include one or more grids between these two electrodes which serve to modulate the number of electrons with time.

If a positive voltage is applied between the cathode and anode of a diode, the following characteristic curve for voltage versus current is obtained.

$$Ia = f(Va)$$

The part of the curve where the electron current increases rapidly as a function of the voltage is called the space-charge zone. In fact, the presence of electrons near the cathode modifies the electric field produced by the anode. The current varies according to the Langmuir law :

$$Ia = P\,(Va)^{3/2}$$

where P is called the **perveance**.

As the voltage is increased further, the cathode reaches its saturation point, which is a function of the temperature and the nature of the emissive body. The saturation value of the current per unit area is expressed by the Richardson-Dushman formula :

$$J = A.T^2.\exp(-Ws/kT)$$

where
Ws is a parameter related to the extraction of electrons from the cathode,
T is the temperature of the cathode
k is the Boltzmann constant
A is the Richardson constant.

Usually the current does not reach a plateau because of the non-negligible effect of the electric field (the Schottky effect).

Tubes operate in the space charge zone. The increase in the characteristic curve is determined by tube geometric parameters. The ratio :

$$P = Ia/(Va)^{3/2}$$

depends only on the tube geometry.

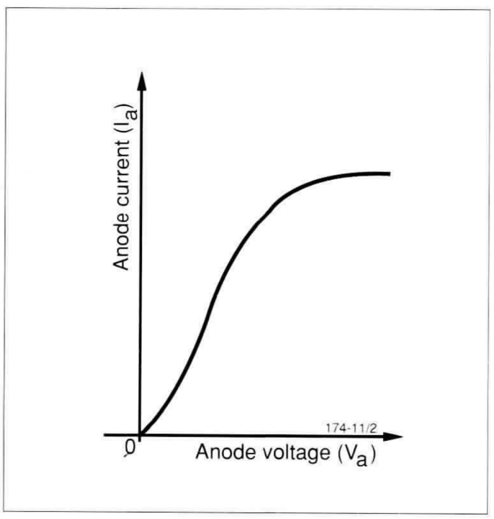


Figure 16
Characteristics of a diode

Triodes

The triode is an electron tube made up of a cathode, a grid and an anode. The grid, placed between the cathode and the anode, controls the flow of electrons between these two electrodes. The grid acts by its electric field and should intercept as few electrons as possible.

Basic mechanisms

When the grid voltage is sufficiently negative, the potential near the cathode is negative everywhere and no electrons can escape, therefore Ia and Ig are equal to zero. When the grid becomes less negative, cathode emission starts and the anode current Ia increases (Figure 17). Finally, when the grid becomes positive, the cathode current continues to increase, but an increasing portion flows to the grid (Ig).

Figure 17 shows that small variations of the grid voltage create large changes in the anode current. It is possible to design amplifiers and oscillators using this effect, by placing the appropriate circuit in series with the grid and anode connections. The fact that small changes in the grid voltage can cause large excursions of the anode current has led to this basic grid being called the control grid.

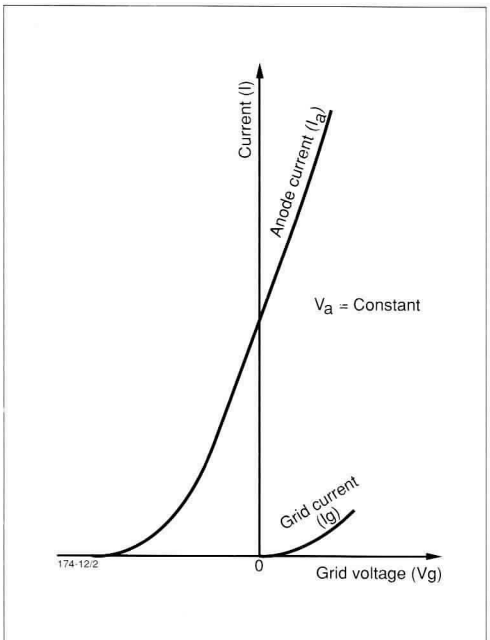


Figure 17
Grid influence on the anode current in a triode

Characteristic curves

The currents Ia and Ig depend on the voltages Va and Vg. This relationship is usually represented by assigning a series of fixed values to one of the three parameters Ia, Va or Vg and then tracing the set of curves that relate the other two parameters. Of the three possible sets of curves, the most commonly used is the set known as the constant-current characteristics (Figure 18).

The appearance of grid current modifies the form of the set of curves ; the lower the anode voltage and the higher the grid voltage, the greater this modification is (see the left side of the set of curves in Figure 18).

Parameters characterizing triode operation

Three fundamental quantities characterize the triode :

1) μ, the amplification factor, a dimensionless number, which is equal to the slope of the constant Ia curves (Figure 18) ;

2) s, the transconductance (mA/V) is the slope of the constant Va curves ;

3) Ri, the internal resistance (Ω), is the inverse slope of the constant Vg curves.

Because μ depends very little upon the operating point (except when there is a strong grid current), it best characterizes the triode. On the other hand, both the transconductance and Ri can only be given for a specified operating point.

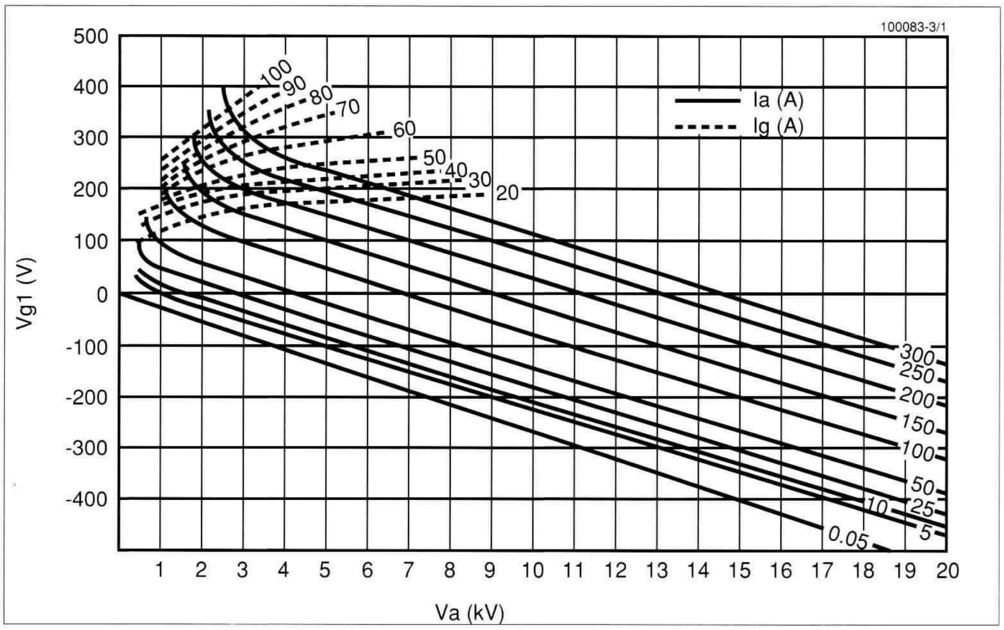


Figure 18
Constant-current characteristics of a triode

Tetrodes

The grid-to-anode interelectrode capacitance limits the performance of the triode. A second grid may be inserted between the control grid and the anode to avoid this inconvenience. Operated at a fixed voltage this electrode constitutes an electrostatic screen that reduces the control grid-to-anode interelectrode capacitance, hence its name : screen grid.

Basic mechanisms

The control grid serves the same purpose in a tetrode as in a triode. The screen grid, which is held at a positive voltage, gives rise to an electron current, most of which reaches the anode. As a result, variations in the anode voltage only slightly influence the anode current, and so the functions of electron generation and collection are practically independent.

It is very important to regulate the voltage of the screen grid carefully. Any surface struck by electrons emits other - secondary - electrons according to its nature and the characteristics of the striking beam. The material which makes up the grid must have a very small secondary emission coefficient to avoid variations in the screen grid current and possible subsequent problems in the startup or operation of the tube.

Characteristic curves

The most frequently used curves are the constant current curves which are drawn for fixed values of the screen grid voltage, i.e. :

Vg1 = f(Va) Ia and Vg2 constant

The fundamental parameters which characterize the operation of the tetrode are (see Figure 19) :

1) the amplification factor μg1g2, which is equal to the slope of the constant current curves :

$$\mu\, g1g2 = \frac{\Delta Vg2}{\Delta Vg1}$$

with Ia and Va constant.

2) The transconductance s, which is the ratio of anode current variations to control-grid voltage variations for a given operating point ;

$$s = \frac{\Delta Ia}{\Delta Vg1}$$

with Va and Vg2 constant.

3) The internal resistance Ri, which is the inverse of the slope of the constant Vg2 curves :

$$Ri = \frac{\Delta Va}{\Delta Ia}$$

with Vg1 and Vg2 constant.

mg1g2 is the main characteristic of a tetrode. Only an estimate of the transconductance can be given because its value depends on the constant Vg2 curves.

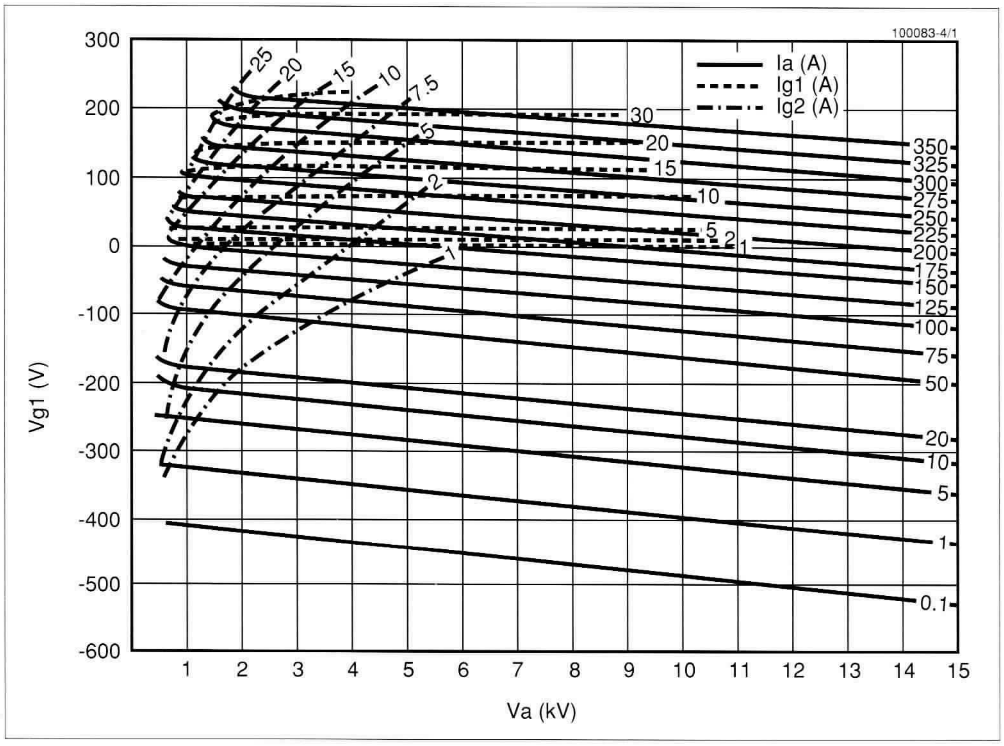


Figure 19
Constant current characteristics of a tetrode

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