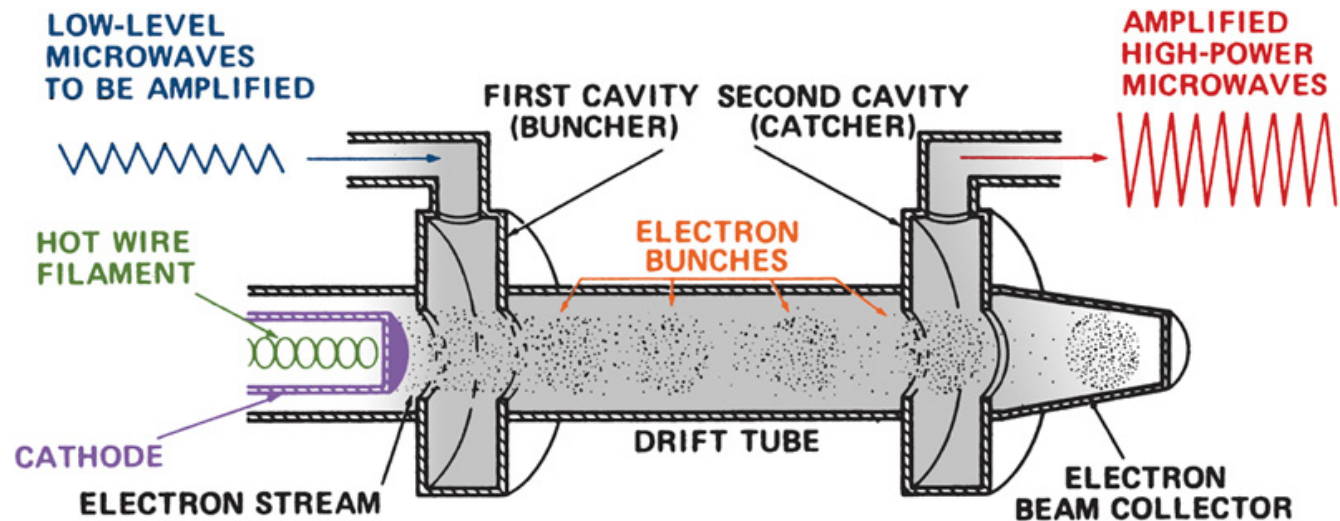


# Klystron

- = Microwave amplifier
  - Low power microwave input (RF driver)
  - Electrons travelling from cathode to anode are bunched in first cavity oscillating from input RF
  - Oscillations induced in catcher cavity from passing electron bunches
    - Deceleration of bunches results in power amplification



# Klystron

TABLE 5-3 · Clinac 1800, (VA8252) klystron operating parameters

Mode	Low mode	High mode	Unit
Frequency	2856 ± 2.5	2856 ± 2.5	MHz
Peak output power	3.0	5.5	MW
Peak beam power	7.5	11.5	MW
Gain at saturation	47	50	dB
Load VSWR	1.2	1.2	
Beam pulse width	5.8	5.8	μs
Repetition rate (max)	360	180	Hz
Peak beam voltage	110	127	kV
Peak beam current	72	92	A
Heater voltage	7.5	7.5	Vr.m.s.
Heater current	30 ± 3	30 ± 3	Ar.m.s.
Warm-up time	10	10	min
Efficiency	43	53	%

Amazing Klystron video:

<https://www.youtube.com/watch?v=Fvud81pYGOg>

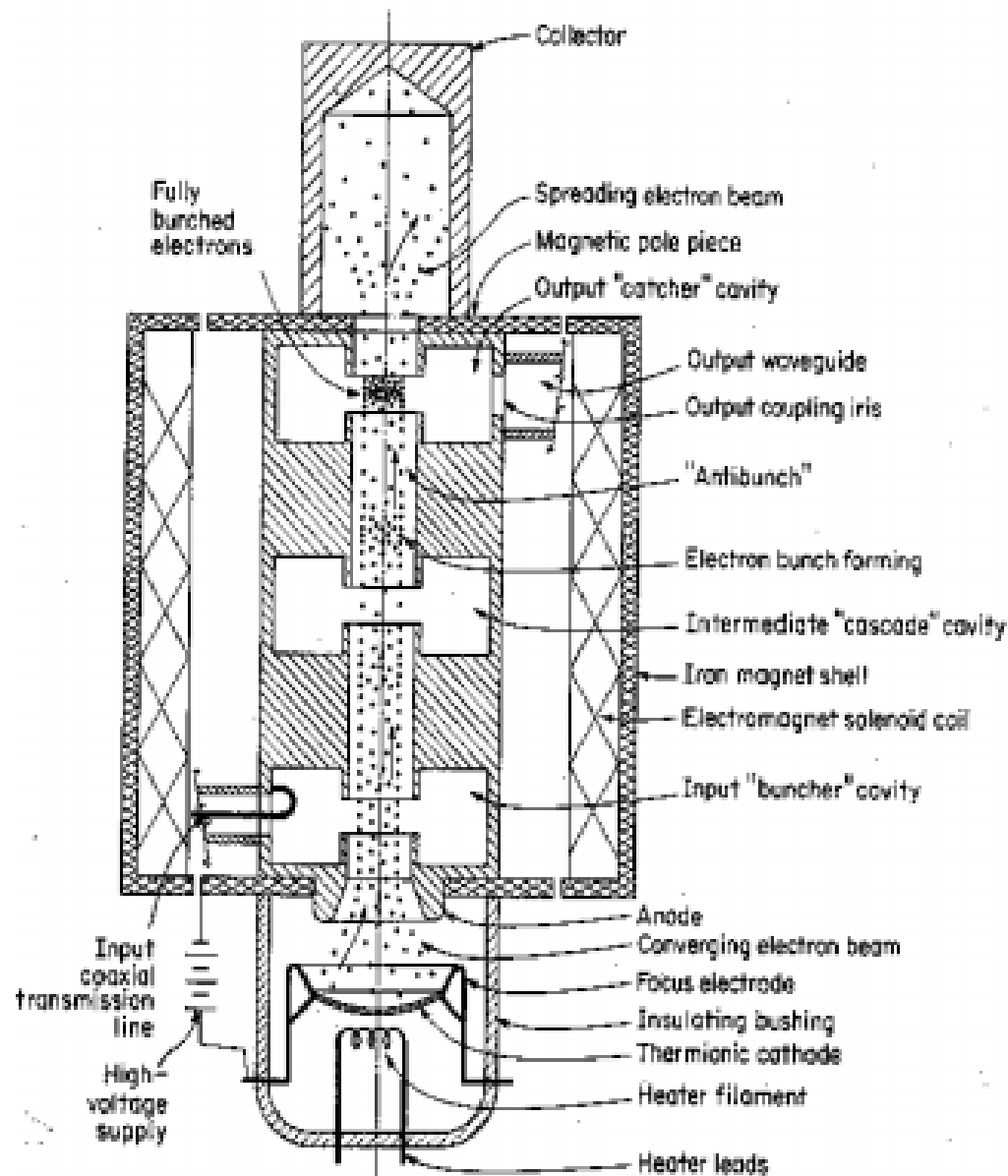


Figure 5: Cross-section through a klystron tube.

# Microwave System Comparison

## Magnetron

- Used in lower energy linacs (4-8 MeV)
  - Lower peak power (3-5 MW)
- Smaller
  - Can mount on gantry
- Lower operating voltage (~50 kV)
- Less expensive
- Less stable
- Shorter life

## Klystron

- Used in higher energy linacs
  - Higher peak power (5-7 MW)
- Requires RF input
- Larger/Bulkier
  - Must be in gantry stand, requiring rotating joint in waveguide
- Higher operating voltage (~100+ kV)
- Frequency more stable
- Oil tank insulation

## =Microwave amplifier

- Requires input of low power microwaves (RF driver)
  - At desired frequency of output, matching cavity resonant frequencies
  - Peak power  $\sim 300$  W, pulse width 12 micro sec
- Thermionic emission of electrons from cathode on one end of klystron tube
- RF input to first “buncher” resonant cavity
- Electrons velocity modulated as passing through first cavity, bunch in drift space
- Reach “catcher” cavity placed to have max electrons in bunches
  - Bunches induce oscillation in “catcher” cavity
  - Bunches are decelerated as passing “catcher” cavity and their kinetic energy is converted into microwave energy, resulting in amplified microwave output
- Peak power up to  $\sim 20$  MW
- 4 cavity klystrons used practically
- Electron catcher will generate x-rays (energy up to input voltage ( $\sim 50$ - $250$  kV))
  - Place in thin walled metal box to shield
- More stable b/c frequency determining and amplification functions are separated
- <http://users.ox.ac.uk/~atdgroup/referencematerial/The%20novices%20guide%20to%20electron%20linear%20accelerators.pdf>