X-RAY CIRCUIT (Step-by-Step)

The X-ray circuit is what creates and controls electricity to produce X-rays.

Power Source

- Comes from the wall (standard electrical supply)
- Provides alternating current (AC)

**X-ray tubes need high voltage + controlled current, not raw wall power.

Autotransformer (kVp Selector)

- Adjusts voltage (kVp)
- Operator selects kVp → determines beam energy (penetration)
- Higher kVp = more penetrating X-rays
- Lower kVp = less penetration

High Voltage Transformer (Step-Up Transformer)

- Increases voltage dramatically (up to 100,000+ volts)
    - Gives electrons enough energy to travel from cathode → anode

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Filament Circuit (mA Control)

- Includes:
    - Step-down transformer
    - Filament (tungsten wire)

Function:

- Heats filament → releases electrons (thermionic emission)
- mA controls quantity of electrons
- More mA = more X-rays

Rectifiers

- Convert AC → DC (one direction only)
    - Electrons must move from cathode → anode only

Exposure Switch

- Starts the exposure in two stages:
    1. Prep (heats filament)
    2. Exposure (sends high voltage)

X-ray Tube

Cathode (Negative Side)

- Filament → produces electrons
- Focusing cup → directs electrons to focal spot

Anode (Positive Side)

- Target (tungsten)
- Rotates to spread heat
- Electrons hit target → energy converts into:
  - 1% X-rays
  - 99% heat

TUBE HEAT MANAGEMENT (VERY IMPORTANT)

**Since 99% of energy becomes heat, managing it prevents tube damage.

Why Heat is a Problem?

- Excess heat can:
  - Crack the anode
  - Melt the filament
  - Damage the tube housing

Heat Units (HU)

Heat is measured in Heat Units (HU)

Formula:

- Single phase:
  HU = kVp × mA × time
- Three phase / high frequency:
  HU = kVp × mA × time × correction factor

Example:

- 80 kVp × 200 mA × 0.5 sec = 8,000 HU

Anode Cooling

Rotating Anode

- Spins at high speed
- Spreads heat over a larger area

Benefit:

- Prevents localized overheating

Line Focus Principle

- Angled target:
  - Large actual focal spot (heat spread)
  - Small effective focal spot (image quality)

Tube Housing Cooling

- Oil surrounds tube:
  - Absorbs heat
- Cooling system:
  - Radiates heat into air

Cooling Charts
Used to determine:
- How long to wait between exposures

Prevents:
- Overheating and permanent damage

Techniques to Reduce Heat

Lower mA / time
- Reduces total heat produced

Use higher kVp, lower mAs
- Maintains image quality with less heat

Allow cooling time
- Follow tube rating charts

Avoid repeated exposures
- Especially high technique factors

CRITICAL LMRT EXAM POINTS

mA = quantity of X-rays
kVp = energy/penetration
Heat is the main limiting factor in X-ray production
99% of energy = heat
Rotating anode = heat distribution
Heat Units = measure of tube load

Anode Damage Risks
Too much heat can cause:
- Pitting of the target
- Cracks
- Reduced X-ray quality

Filament Damage
Excess current:
- Burns out filament
- Shortens tube life

Key Concepts to Remember
Controls:
- kVp → beam energy (quality)
- mA → quantity of electrons
- Time → duration of exposure

Heat Facts:

- 99% heat / 1% X-rays
- Heat must be:
    - Distributed
    - Absorbed
    - Dissipated

Quick Study Tips

- Think of the circuit in 2 sides:
    - Primary circuit (low voltage control)
    - Secondary circuit (high voltage to tube)
- Always connect:
  Higher technique = more heat

QUICK MEMORY TRICK
"kVp pushes, mA produces, heat limits"

Summary Flow:
Power → Autotransformer → Step-up → Cathode → Electron cloud → High voltage → Anode → X-rays