Chapter 6

X-ray Circuit and Tube Heat Management

Learning Objectives

- Given an unlabeled x-ray circuit diagram, label the principle parts and state the function of each
- Explain what is meant by rectification and compare the three basic types
- Draw the voltage waveform for each of the following types: unrectified, half-wave rectified, full-wave rectified, three-phase rectified, and high frequency

Learning Objectives

- List the primary features of all x-ray control panels and discuss the principal differences between conventional and computerized control consoles
- Describe the components of the automatic exposure control system
- List five possible causes of x-ray tube failure and describe methods to prevent each

X-ray Circuit Sections

- Low Voltage
  - Supplies low voltage for operation of control console and for kVp selection
- Filament
  - Supplies and controls heat needed for x-ray tube filament thermionic emission
- High Voltage
  - Supplies high voltage to accelerate electrons for x-ray production

Clicker Question

The high-voltage x-ray circuit supplies voltage for:

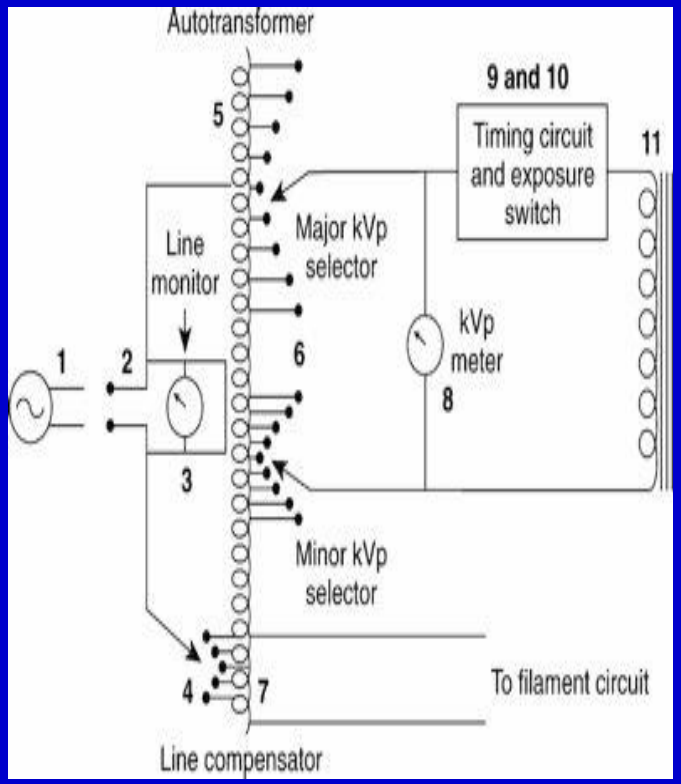
a) kVp selection

b) filament heating

c) acceleration of electrons for x-ray production

Low-Voltage Circuit Portion

1 = AC power source
2 = Main switch
3 = Line meter
4 = Line voltage compensator
5 = Autotransformer
6 = kVp selector
7 = Contacts for autotransformer
8 = kVp meter
9 = Exposure switch
10 = Exposure timer
11 = Primary of step-up transformer



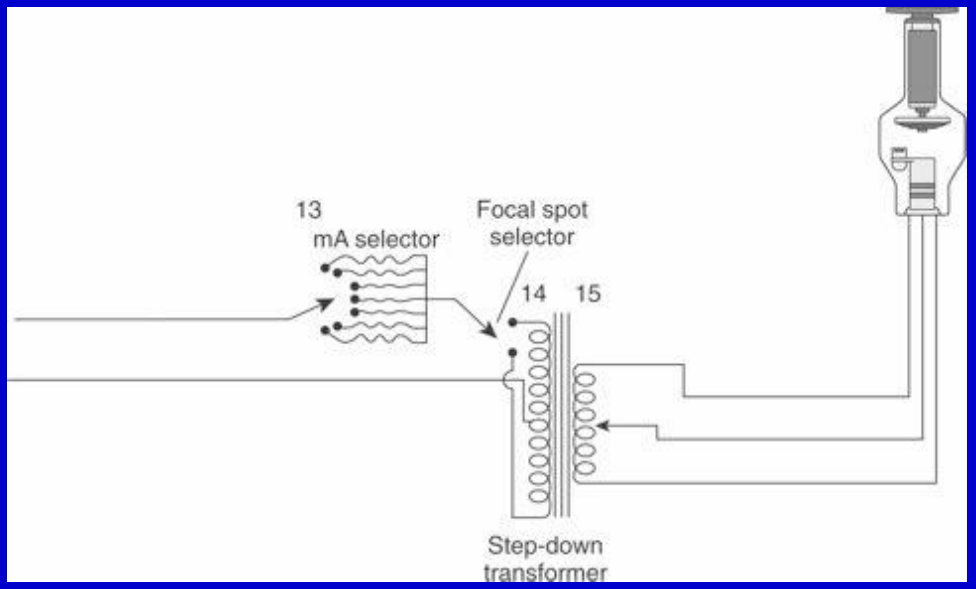
Filament Circuit

13 = mA selector

14 = Primary of step-down transformer

15 = Secondary of step-down transformer

16 = X-ray tube filament



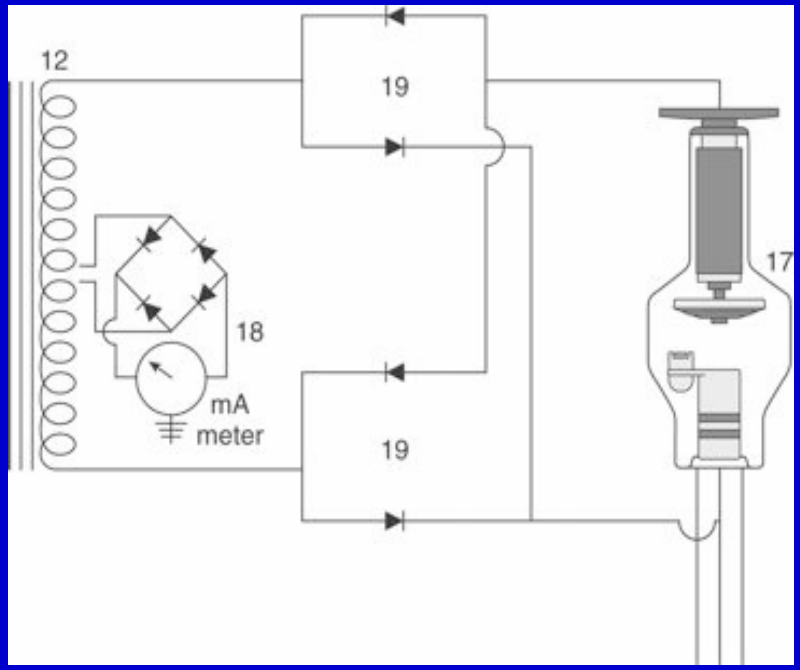
High-Voltage Circuit

12 = Secondary of step-up transformer

17 = X-ray tube

18 = Milliammeter

19 = Rectifier

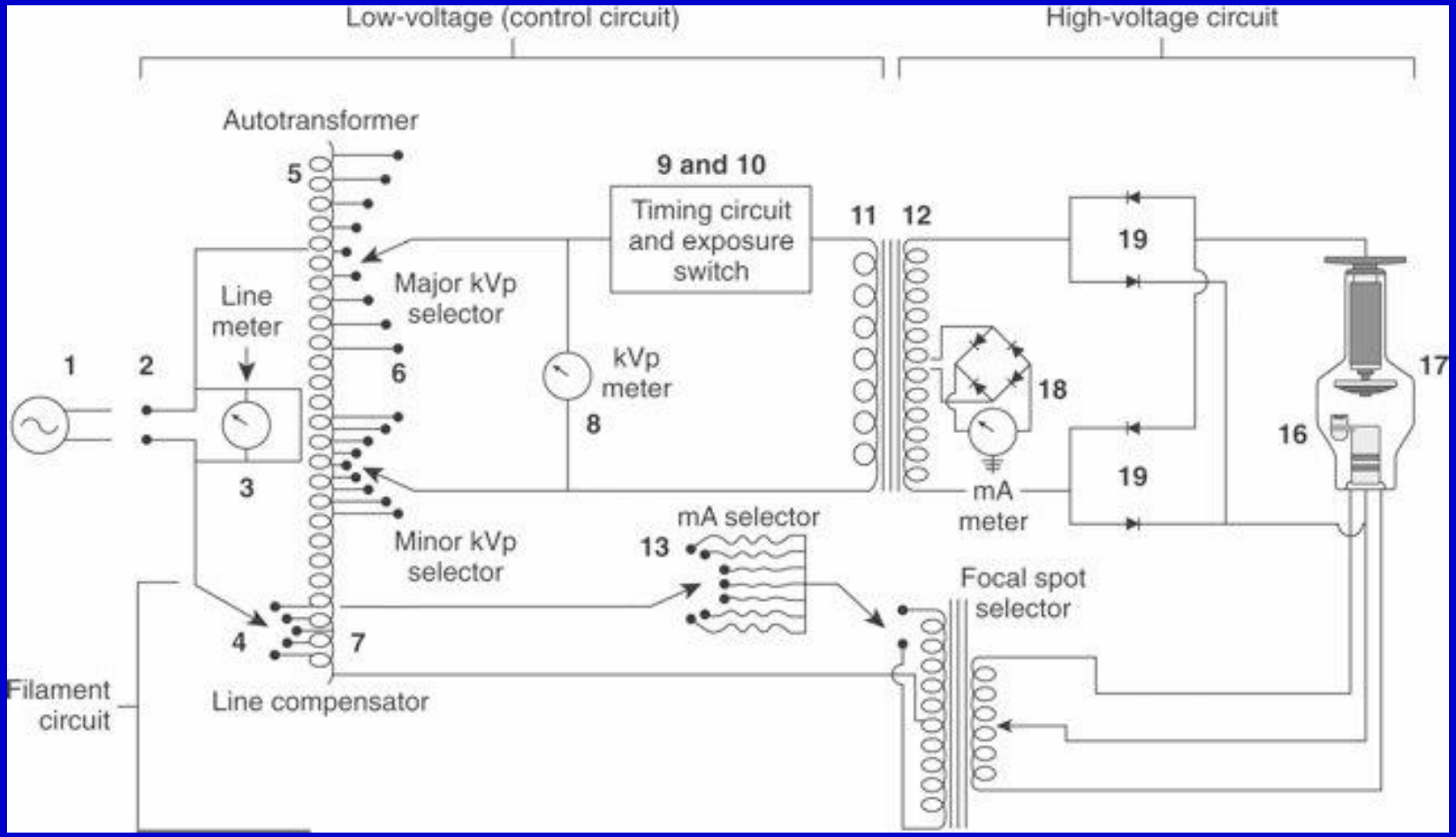


Clicker Question

The low-voltage circuit contains the:

a) rectifier
b) mA selector
c) exposure timer
d) step-down transformer

Complete X-ray Circuit

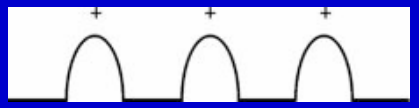


Rectification

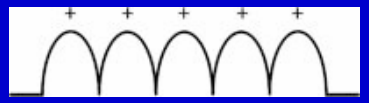
- Directs current flow through the x-ray tube so electrons flow from filament to target
- Types
  - Half-wave
  - Full-wave
  - Three-phase
  - High-frequency

Rectification Waveforms

- Half-wave



- Full-wave



- Three-phase

- High-frequency

Clicker Question

Rectification that uses the entire electric cycle for the production of x-rays is termed:

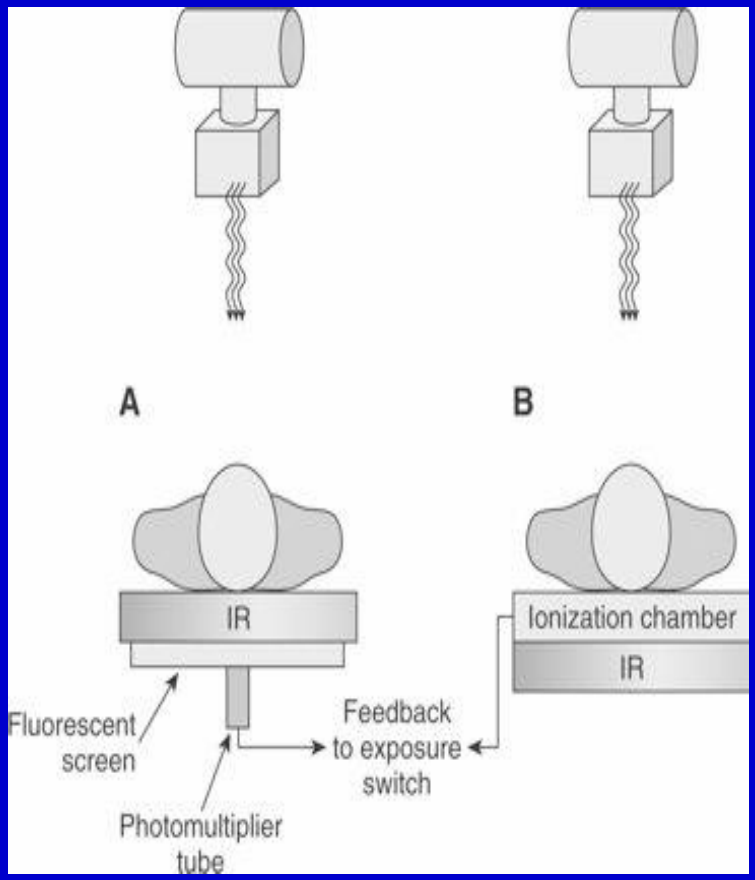
a) self
b) half-wave
c) full-wave

Control Panel

- Used to select mA, kVp, exposure time, and focal spot size
- Conventional
  - Knobs and switches used to set exposure factors
  - Dials and meters indicate settings
- Computerized
  - Buttons used to set exposure factors
  - Digital readouts indicate settings
  - May be APR or anatomically programmed

Automatic Exposure Control

- AEC automatically terminates the exposure when the appropriate amount of radiation has been detected at the IR
- Types
  - Phototimers
  - Ionization chambers



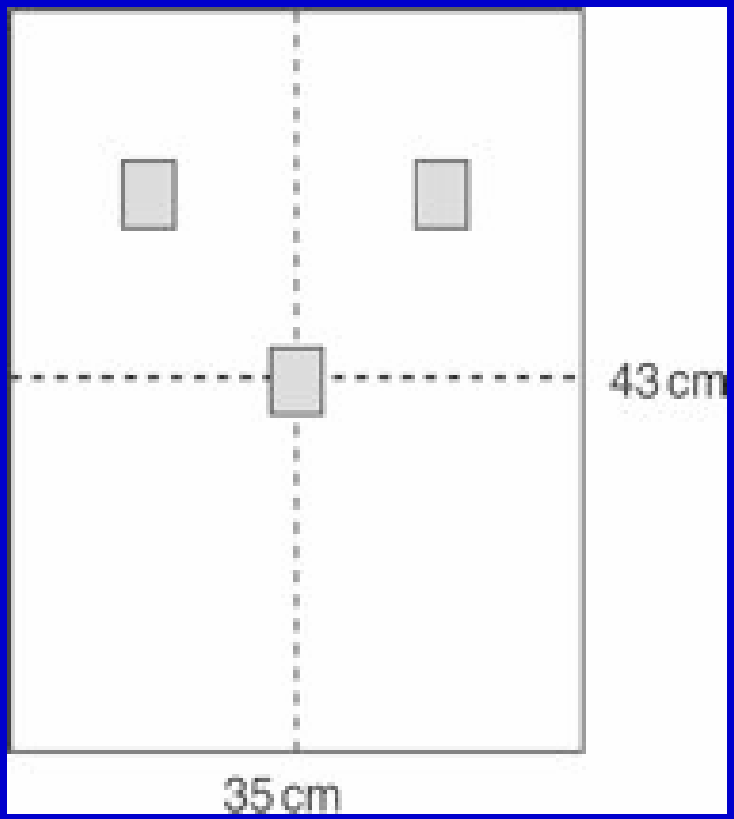
Clicker Question

The phototimer type of automatic exposure control is sensitive to:

a) x-rays
b) light
c) electrons

Automatic Exposure Control

- AEC detectors
  - Selection corresponds to body part and IR size
  - Examples: use center detector for knee and the two upper detectors for lungs



Automatic Exposure Control

- Backup Time
  - Prevents overexposure by setting a maximum exposure time should the AEC fail to terminate the exposure
  - Set backup time at 150% of anticipated exposure time

Making an Exposure

- Types of Switches
  - Hand held
  - Button or toggle
- Activating Switches
  - Rotor
  - Exposure

Causes of X-ray Tube Failure

- Failure may be caused by:
  - Making exposures with a cold tube
  - Making a rapid series of large exposures
  - Worn rotor bearings
  - Filament breakage caused by vaporization

Prolonging X-ray Tube Life

- Warm up cold x-ray tubes according to manufacturer instructions before use
- Do not prolong rotor time
- Avoid making a rapid series of exposures
- Consult the manufacturer's tube rating chart before making an exposure that might exceed the tube's heat loading

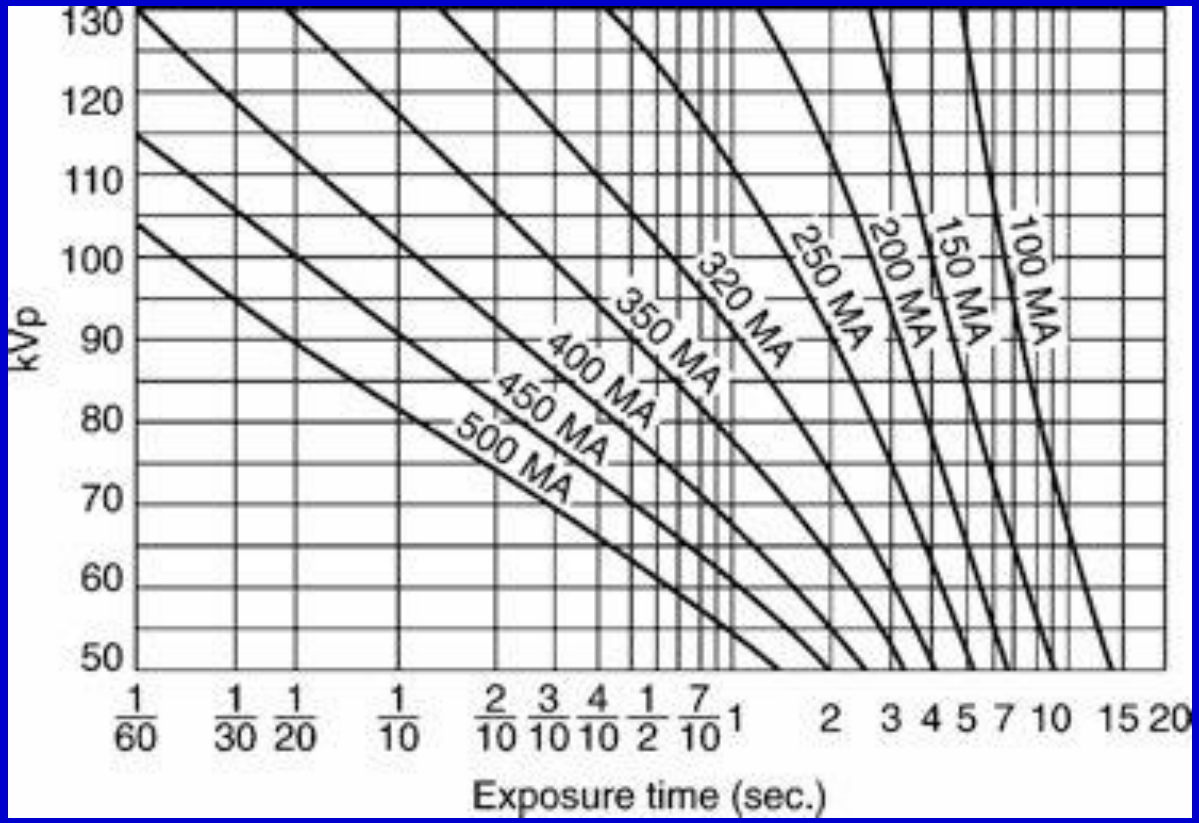
Clicker Question

Activating the rotor before you are ready to make an exposure shortens x-ray tube life from prolonged heating of the:

a) tube housing
b) target
c) filament

Tube Rating Charts

- Indicate maximum exposure values that can be used safely



Summary

- The three sections of the x-ray circuit are low-voltage, filament, and high-voltage
- Rectifiers direct current flow so that it is from filament to target
- Types of rectifiers include half-wave, full-wave, three-phase, and high-frequency

Summary

- Control panels may be conventional or computerized and are used to select mA, kVp, exposure time, and focal spot size
- AEC automatically terminates the exposure when the appropriate amount of radiation has been detected at the IR
- Many causes of tube failure such as excessive and rapid exposures and prolonged rotoring can be controlled by the limited operator