APPH 226:
Timing Circuits, AEC and APR

Objectives: 1.3, 2.4, 5.8, 10.2

MRT Program

Time

- **Why is exposure time important?**

- X-ray quantity is directly proportional to the mAs
- Directly affects exposure
- Controls how long electrons will be crossing over to the anode

Exposure Timers

- Timer circuit is a component of the x-ray circuit
  - Directly affects the number of x-rays being produced
- Purpose: 'make or break' the high voltage across the tube
- Located on the primary side (lower voltage is easier to control than high voltage)
    - All types of timers are controlled by the technologist, except for one specific type, which is automatic

Types of Timing Circuits

- Four types of timing circuits:
  - Synchronous*
  - Electronic *
  - mAs*
  - AEC**

*controlled by the technologist

**automatic

Synchronous Timers

- Synchronous motor
  - a special type of electric motor which drives a shaft at exactly 60 revolutions per second (rpm)
- When used as a timing mechanism in an x-ray unit, the shaft turns a disk which is connected to on/off switches
- Exposure time selected will determine the time it takes for the disk to move from the on switch to the off switch
- Can recognize an x-ray system that uses this type of timer because of the timing intervals
  - The shortest exposure time possible is 1/60 s, and timing intervals increase by multiples thereof (1/30, 1/20 etc)
  - Cannot be used for serial exposures, needs to be reset in between

Electronic Timers

- Most sophisticated, expensive and accurate
  - Almost all modern units will utilize this type
- Complex circuitry based on time required to charge a capacitor through a variable resistor
- The exposure will terminate as soon as the capacitor receives its pre-programmed charge
  - How it works:
    - For a 1 second exposure, resistance is increased so it takes 1 second to charge the capacitor
    - For a 1 ms exposure, there is almost no resistance so that the capacitor is charged very quickly and the exposure is terminated by the timer
- Wide range of time intervals can be selected
- Very accurate down to intervals as small as 1ms
- Can be used for rapid serial exposures
  - Ideal for interventional radiography

mAs Timer

- Variation of the electronic timer, but it monitors the current passing through the tube and will terminate the exposure when the set mAs is achieved
- Designed to safely provide the highest tube current and shortest exposure for the mAs selected
- Located on the secondary circuit (high voltage) side because must monitor the actual tube current
  - Found on falling load generator systems

AEC (Automatic Exposure Control)

- Device that measures the quantity of radiation reaching the image receptor
- Automatically terminates the exposure as soon as the IR has received the required amount of radiation
  - Controls this by breaking the timer circuit
- Serves the same role as an exposure timer
  - Only factor it controls is time
- Operates differently, instead of the technologist pre-setting the time, it uses the patient's body part as the variable to determine when the exposure should be terminated
  - Technologist sets which 'cell' is active

Purpose of AEC

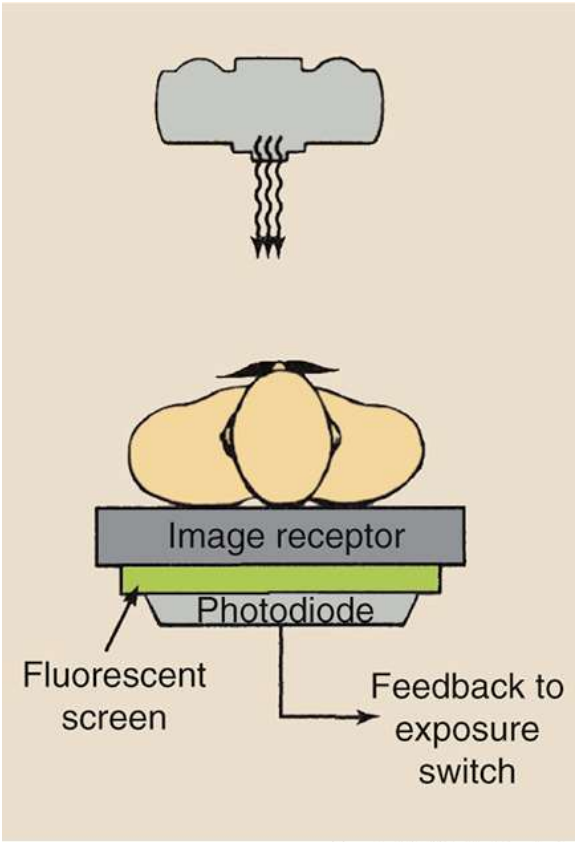
- Eliminate the 'guessing' for technical factors
- Setting a manual technique requires technologist to:
  - Select exposure time that they think will produce sufficient radiographic density
  - Measure the thickness of the patient and 'guess' the technique required
  - 'guess' at the density of the tissues within the body

Types of AEC

- Two types of AEC devices:
  - Photodiode / Phototimer
  - Ionization Chamber
    - Main difference between the two types is the location of the device in relation to the IR, one is exit type, and one is entrance type

Photodiode / Phototimer

- Positioned as exit type of device
- Behind IR
- Photodiode converts light to electrical energy
- Once certain charge has been reached, exposure is terminated
- Becoming obsolete



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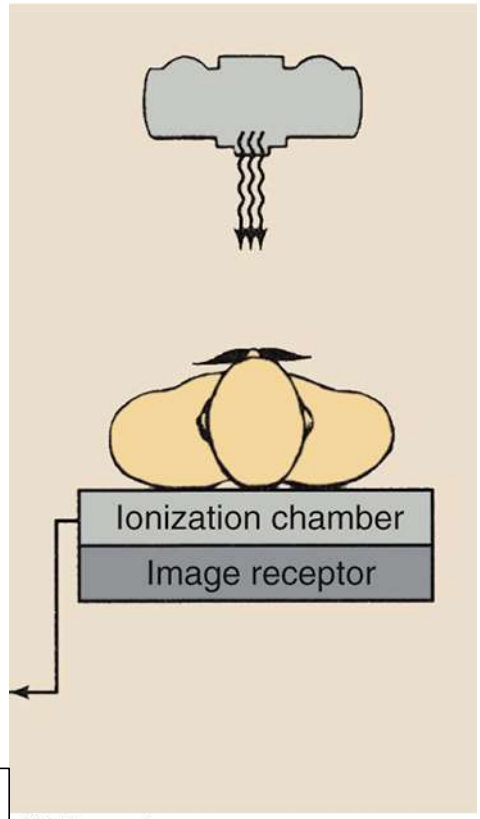
Bushong Fig 5-10

Ionization Chambers

- Most commonly used today in modern imaging systems
- Located between patient and the IR
- Flat parallel plate ionization chamber
  - Radiolucent – does not interfere with image
- X-ray beam travels through the patient and tabletop before striking the chamber
- Entrance type – IR positioned after the ion chamber

Ionization Chambers

- Chamber is a hollow cell containing air
- Air inside the cell becomes ionized as it is struck by radiation – creates an electrical charge
- Ionization is directly proportional to the amount of radiation received
- When predetermined charge has been reached, exposure will terminate

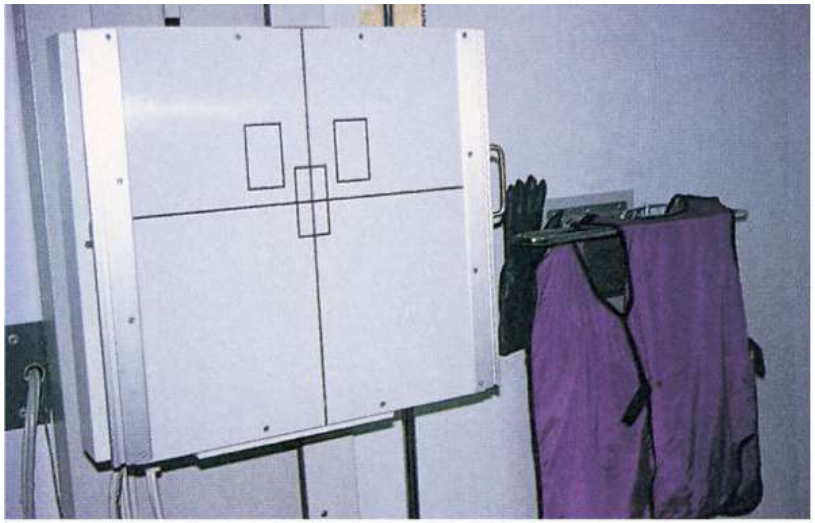


Bushong Fig 5-10

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AEC Selection

- Different configurations
  - Usually have 3 detectors/cells/chambers
  - Center
  - Left and Right
    - Slightly higher than the center cell, and off centered to each side



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Choosing the Correct Configuration

- Various combinations of the AEC chambers can be selected
  - Can select any one cell, combination or all three
- APR can also select configuration
- When more than one cell is selected, the average signal from all cells is used
- This can be over-ridden if needed
  - i.e. AP Pelvis with metal hip replacement

Back Up Timer

- Protects the patient from overexposure
  - Due to equipment failure, or technologist error
- SC 35 states that the mAs cannot exceed 600 mAs for one single exposure
- Usually set to 1.5 times the expected length of exposure
  - Maximum time is 6 seconds
- Often it is automatically done when APR is used

AEC operation

- When AEC is first installed, it must be calibrated
- Exposures are taken using test tools, and AEC is adjusted until the intensities on the IR are optimal
- Typically this is done by the service engineers

Density Control

- Regulates the radiographic density of the image
- Selection of 7 density steps
  - -3, -2, -1, 0, 1, 2, 3
- Each one is calibrated to increase/decrease the preset density of the image receptor by 0.1
  - About a 25% change in exposure from step to step
- Can be used to accommodate patient condition or over-ride AEC sensitivity issues
  - Not used to compensate for part thickness

Utilizing AEC

- Technologist needs to select:
  - kVp
  - mA
  - Set backup timer
  - Select which chambers to use
  - Density control

  - Or select appropriate APR (anatomically programmed radiography)

APR - Anatomically Programmed Radiography

- Refers to radiographic system that allows user to select a body part, and a preprogrammed set of exposure factors will be displayed for it
- Technique chart stored in the computer
  - kVp
  - AEC
    - Cell selection
  - mAs (if AEC is not selected)
  - Focal Spot Size

APR – Anatomically Programmed Radiography

- Controlled by computer circuit/chip that has been programmed with different exposure factors for specific position/projections of anatomic parts
- Once the part and position/projection has been selected, the technologist can make adjustments to the displayed exposure factors if they need to
- APR and AEC are not related, but often used in conjunction
  - i.e… an APR setting may utilize AEC

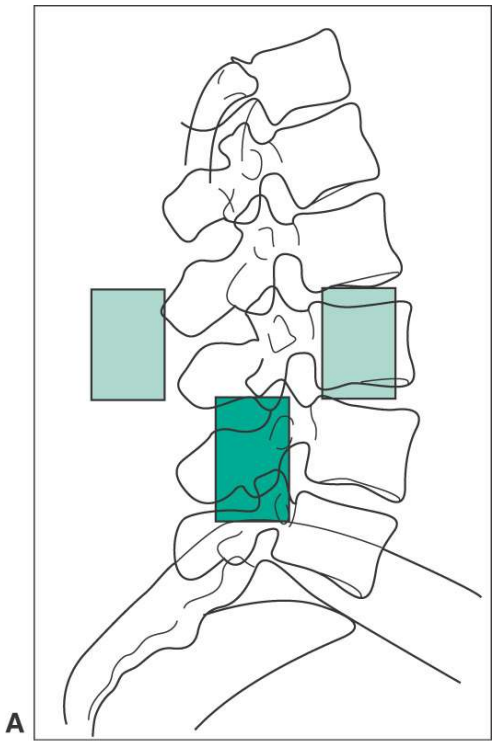
Positioning with AEC

- Technical factors are taken care of with AEC, but that doesn't mean all the work is done
- Positioning is critical to utilizing AEC properly
- Specific body part must be placed over the cell for appropriate exposure
  - If not, can result in over or under exposure
- Improper centering is the most common reason for repeats with AEC

Collimation and AEC

- AEC cannot tell the difference between useful beam and scatter radiation
- If the field size is too big
  - Too much scatter will cause the AEC to shut off prematurely
- If the field size is too small
  - AEC cell will take longer to receive enough radiation to end exposure
- If the field size is too small to cover the entire cell
  - AEC should not be used and a manual technique should be set

Positioning with AEC

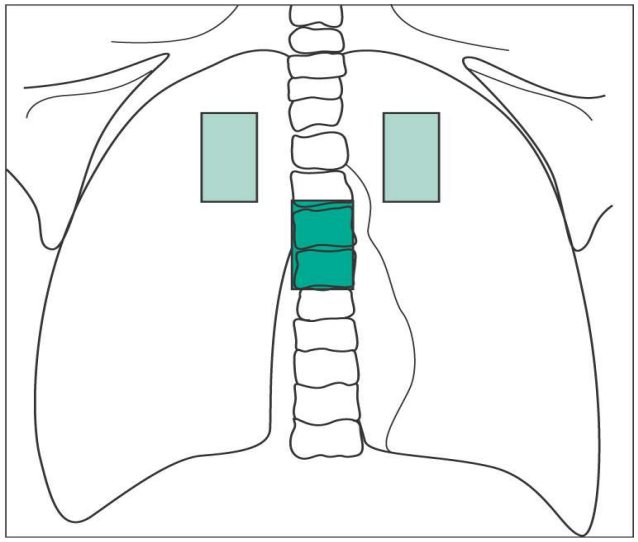


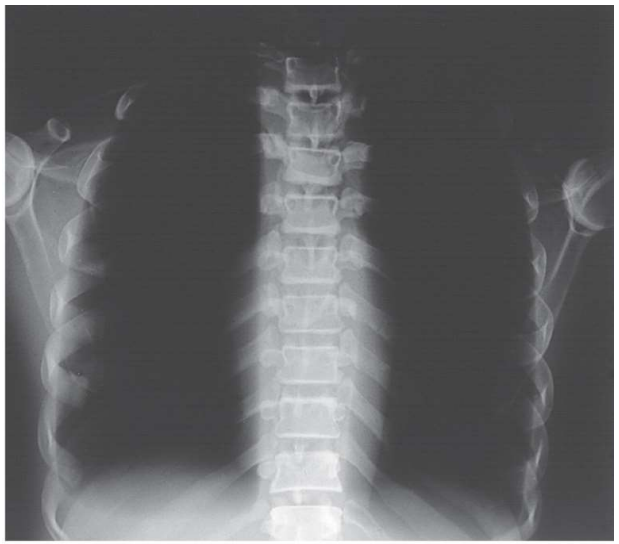
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Cell Selection

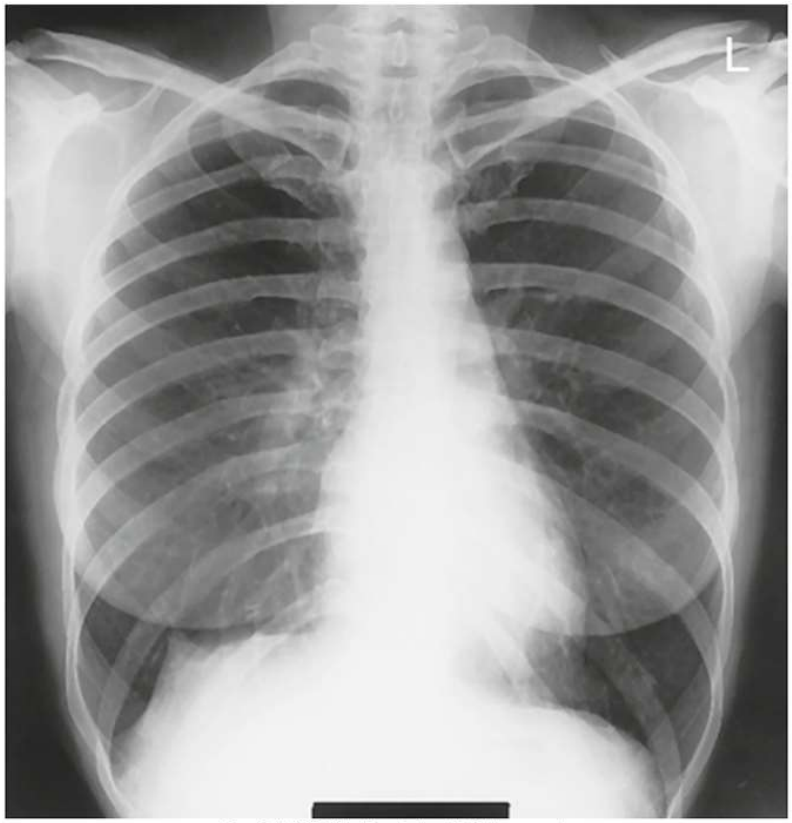
- Crucial to the exposure
- Improper cell selection can also result in over or under exposure
  - i.e. What needs to be visualized.. Bone? Air? Soft Tissue? Is there a surgical implant?


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Cell Selection

- Appropriate cell selection will produce optimal image quality



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Optimal Use of AEC

- Appropriate kVp selected for the area of interest
  - Based on contrast characteristics and penetrability of beam
- Precise centering
- Appropriate selection of cell
- Appropriate collimation to area of interest
- Positioning is critical to optimal utilization of AEC

Readings

- Bushong: Radiologic Science for Technologists 11th Ed
  - Pg 90-92
  - Pg 256-258