

**NATIONAL HEALTH AND NUTRITION
EXAMINATION SURVEY III**

X-ray Procedures Manual

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1. INTRODUCTION

1.1 General Overview of the X-ray Component

NIAMSD has requested and is supporting the inclusion of an arthritis component in NHANES III, both to update national prevalence data from earlier surveys of disease, risk factors, and outcomes, and to provide a baseline population for conducting followup studies. This latter aspect is of particular interest because there are many unanswered questions regarding risks for disease progression, disability and mortality that can be addressed best in this study.

Arthritis is recognized as a major public health problem. Arthritis and related musculoskeletal disorders are frequently chronic, disabling and painful. It is estimated that the total economic cost to the U.S. of musculoskeletal conditions was over \$65 billion in 1984. Indirect costs from lost earnings and services represent a high proportion of these costs. These diseases represented the second most common cause of comorbidity in the Framingham Study.

The ideal mechanism for measuring the incidence and prevalence of these chronic conditions and their impact is through a survey which includes a physical examination, radiographs, laboratory tests and other procedures on a broad representative sample of the population. Case identification of the arthritides is a major concern to those interested in obtaining complete and accurate figures. Many individuals do not know and therefore cannot report on what specific rheumatic disease affects them. The American Rheumatism Association definitions of a case are based on highly structured diagnostic criteria which, for osteoarthritis and rheumatoid arthritis, require radiologic evidence. With the emphasis in this survey on the health of the elderly, NHANES III provides a particularly appropriate context and population for the study of musculoskeletal conditions.

The major diseases to be identified are rheumatoid arthritis, osteoarthritis and gout. Cases will be defined by use of questions on characteristic symptoms of the various disease; a physician's examination focusing on pain, tenderness, swelling and deformities of specified joints; x-rays of the hands and wrists, and knees; and various serological analyses, including rheumatoid factor and C-reactive protein.

In addition to assessing the prevalence of the rheumatic disease, it is important to measure the

burden of the diseases on the daily life of individuals. This information is necessary to establish health priorities and to monitor the effectiveness of interventions in rheumatic disease. A series of questions that cover mobility, physical activity and ability to care for oneself are included to determine the extent of functional impairment. Future followup of NHANES III examinees will provide needed information on the role of rheumatic disease in the development of impairments.

1.2 General Overview of Procedures

In order to support information regarding arthritis in examinees in the study, x-rays of the wrists and hands, and knees will be conducted on all examinees sixty years of age and above. The x-rays will be taken in the following positions and sequence. A straight PA (posterior-anterior) of the hands and wrists with both members on the same film. A straight AP non-weight bearing view of the knees. A lead apron or gonadal shields will cover the SP at all times while being x-rayed. All films will be developed and ascertainment of standard of quality made prior to the examinee leaving the MEC.

Although these tests may appear simple, accurate measurement depends on many factors. This section of the manual has been devised to help you understand how to accurately obtain x-rays of the hands, wrists, and knees. Standardized procedures have been established for this survey. Because the measurements must be obtained in a uniform manner for each subject, it is critical that you always follow these procedures.

1.3 Overview of the Skeletal System

Approximately 206 bones make up the skeleton. They are disposed in a midline axial segment, that is the head and trunk, and in an appendicular portion, the upper and lower limbs.

Bones perform several functions.

- They contribute to the form of the body, as well as provide it with support and protection. For instance, the skull, thoracic cage and pelvis are sturdy encasements for the brain, heart and lungs, and reproductive organs, respectively.
- Another function of bone is to serve as a site of blood formation. In the adult, red blood cells are produced exclusively in the marrow cavities of certain bones.
- Bones are essential for body movement. Most muscles attach to bone for leverage in moving the body.
- Bone is a storehouse for inorganic minerals, such as calcium, phosphorus, and possibly magnesium and sodium.

1.3.1 Classification of Bones

Bones are long, short, flat or irregular in shape. Most bones of the extremities are long bones, ranging from the short terminal phalanx of the little finger to the femur (thigh bone). Long bones consist of a shaft and two extremities. The shaft, or diaphysis, is cylindrical and encloses an elongated marrow cavity. The extremities, or ends, of long bones are called epiphyses.

Short bones have approximately the same dimensions in all directions. The cube-like bones of the wrist and ankle are examples of short bones.

Flat bones are those with two surfaces roughly parallel and close to each other, as in the sternum, the scapula and most skull bones.

Bones that fit none of the above categories are called irregular bones. The vertebrae, with projections extending from their bodies, are good examples.

1.3.2 Anatomy of the Wrist and Hand

1.3.2.1 Wrist

Eight carpal bones are present in the wrist. Sliding joints between them permit only slight movement between individual bones but allow multidirectional movement of the entire wrist joint (Exhibit 1-1). Bones of the proximal row from the lateral to the medial side are the scaphoid, lunate, triangular and pisiform. Bones of the distal row are the trapezium, trapezoid, capitate and hamate.

1.3.2.2 Hand

Five metacarpal bones form the skeleton of the palm of the hand (Exhibit 1-1). Proximally they articulate with the distal row of carpal bones. Distally each metacarpal enlarges to form a prominent head for articulation with a proximal phalanx of a finger.

Fourteen phalanges form the finger bones, three for each finger and two for the thumb.

1.3.3 Anatomy of the Knee

The knee is the site of junction between the thigh (femur) and the calf (tibia and fibula). The patella is situated at the front of the knee at the anteroinferior aspect of the femur (Exhibit 1-2). This is a somewhat flattened triangular bone which lies embedded in the tendon of the quadriceps femoris muscle and is the largest sesamoid bone of the body.

Exhibit 1-1. Skeletal components of the hand and wrist

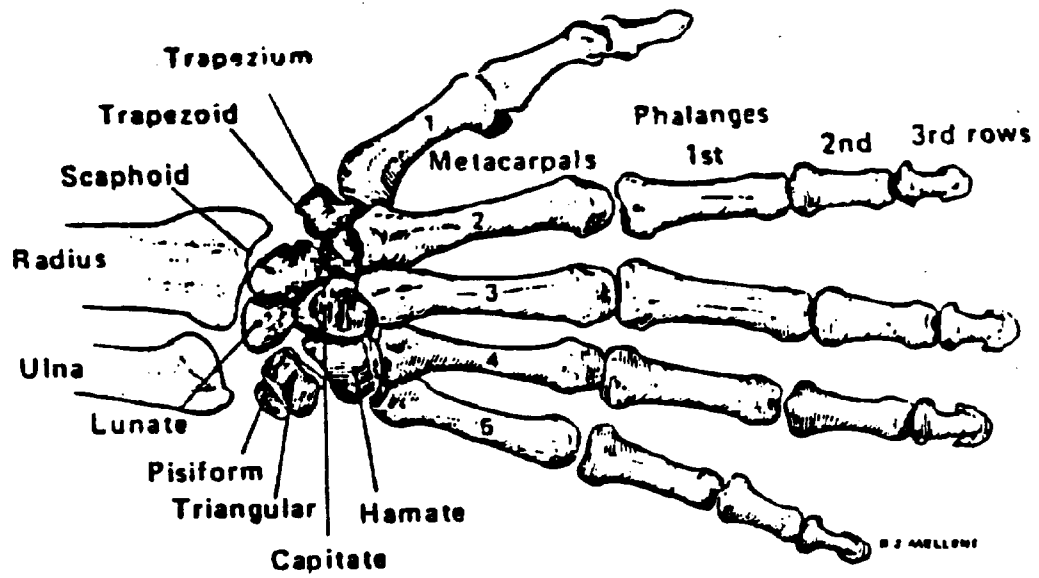
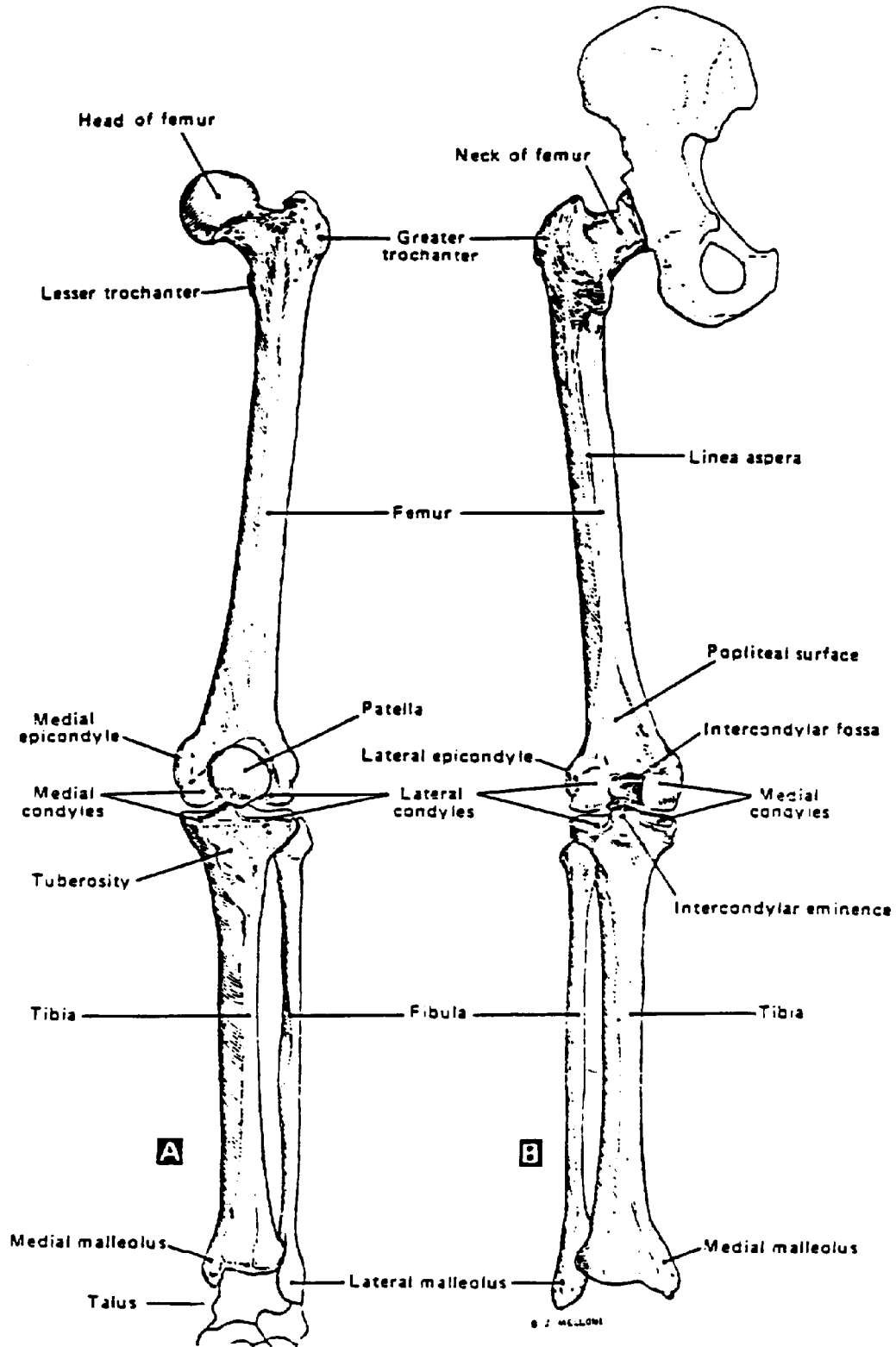


Exhibit 1-2. Skeletal components of the knee



1.4 Method of Radiology

There are two general types of x-ray procedures: radiographic examinations and fluoroscopic examinations. Radiographic examinations, which will be used in this study, employ x-ray film and usually an x-ray tube mounted from the ceiling on a track that allows the tube to be moved in any direction. Such examinations provide the radiologist with fixed photographic images. Fluoroscopic procedures are usually conducted with an x-ray tube located under the examining table. The radiologist is provided with moving, or dynamic, images portrayed on a fluoroscopic screen or television monitor. Radiographic examinations will be utilized in NHANES III.

To produce a satisfactory x-ray, one must supply the x-ray tube with a high voltage and a sufficient electric current. X-ray voltages are measured in kilovolts peak (kVp). One kilovolt (kV) is equal to 1000 V of electric potential. X-ray currents are measured in milliamperes (mA), where the ampere (A) is a measure of electric current. Normal household current is a few amperes. The prefix kilo stands for 1000; the prefix milli, for 1/1000, or 0.001. The voltage and the current create the power to drive the x-ray tube to produce x-rays which then penetrate that part of the body to be examined, and imprint the x-ray film.

2. EQUIPMENT

2.1 Description of Exam Room in MEC

The x-ray component utilizes two rooms in trailer #3 of the MEC. The x-ray room contains the Centrix III x-ray unit. This room is also shared with the electrocardiogram and fundus photography components. The second room is the dark room in which x-ray film is developed. This room also contains the Picker X-ray Generator and is protected from the x-ray room by a lead filled wall. The X-omat developer film deposit and the x-ray view boxes are located in the hallway next to the darkroom.

2.2 Description of Equipment and Supplies

Centrix III Universal X-ray Unit
Picker BG X625 X-ray Generator
X-omat Developer
Densitometer
Stationary Grid 14 x 17"
Stationary Grid 10 x 12"
Film Cassette Fine Screen 10 x 12"
Film Cassette Fine Screen 14 x 17"
T MAT L Film 24 x 30 cm
T MAT L Film 35 x 43 cm
Lead Markers and Holder
Right Film Markers (pink)
Left Film Markers (yellow)
X-ray Film Jackets 14 1/2" x 17 1/2"
Kodak RP X-omat Fixer and Replenisher
Kodak PP X-omat Developer
Lead Apron/Body Shield
Gonadal Shields
Scotch Brite Pads
Processor Filters
Black China Markers
Pillow/Pillowcase
Stethoscope
Blood Pressure Cuff
Mercury Collectors
Mailing Envelopes

2.2.1 Centrix III X-ray Unit

2.2.1.1 Description

The Centrix III X-ray Unit (Exhibit 2-1) is a flexible system suitable for use with both standing and recumbent patients. The x-ray tube is permanently centered on the bucky, and the Film/Focus Distance (FDD) is motor driven with a range from 40" to 72" (100 cm to 200 cm). The arm on which the tube and bucky are mounted is pivoted at its center, and the whole arm may be moved vertically. The vertical and rotational movements are locked electromagnetically. The gurney is independent of the unit and moves easily on lockable casters.

2.2.1.2 Major Movements

There are three major movements of the Centrix III. They are arm rotation, film-focus distance adjustment and vertical movement of the arm (Exhibit 2-2). The major movements of the unit can be controlled from two areas; the tubehead controls and the central control panel (Exhibit 2-2). However, the x-ray unit will stay in the horizontal position to take the hand and wrists, and the knee x-rays.

- **Arm Rotation**

While switch (A) or (D) is pressed, the arm can be turned in either direction. Releasing the switch applies the brake. The angle can be read from the scale on the vertical carriage.

- **Film-Focus Distance**

The film-focus distance is adjustable from 100cm to 200cm. By pressing the top of switch (B) or (F), distance will be increased; by pressing the bottom of the switch it will be reduced. Releasing the switch applies the brake.

The distance can be read from the scale on the rotating arm. Note: The tube and the bucky move simultaneously.

- **Vertical Movement of Arm**

While switch (C) or button (E) is pressed, the vertical carriage can be moved upwards or downwards. Switching off applies the brake.

Exhibit 2-1. Centrix III X-ray unit

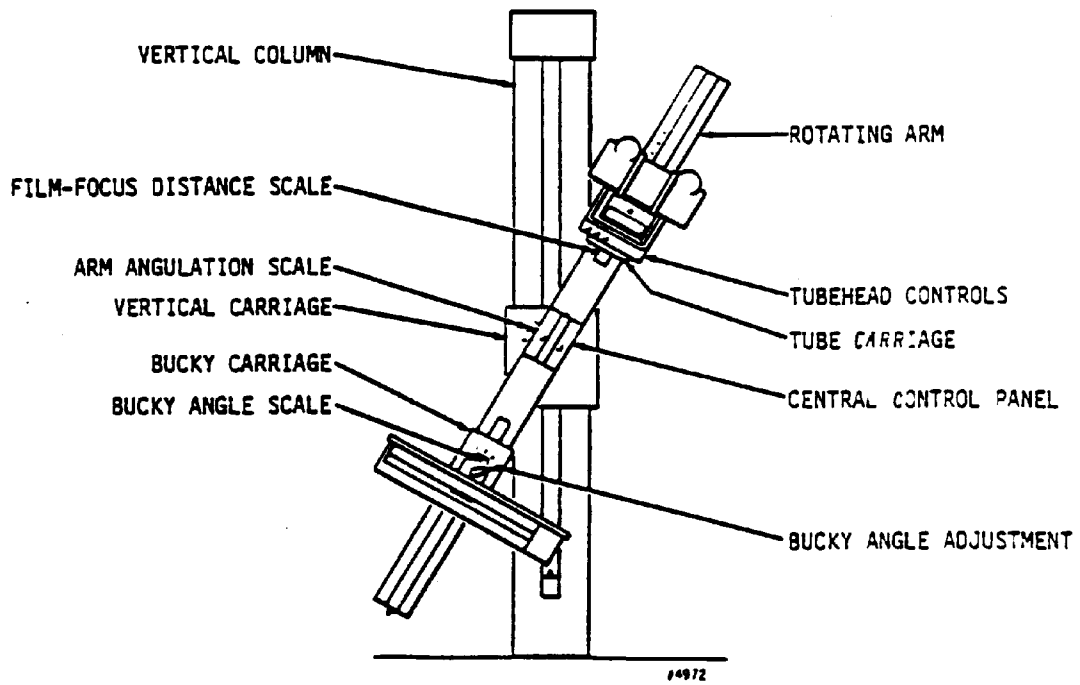
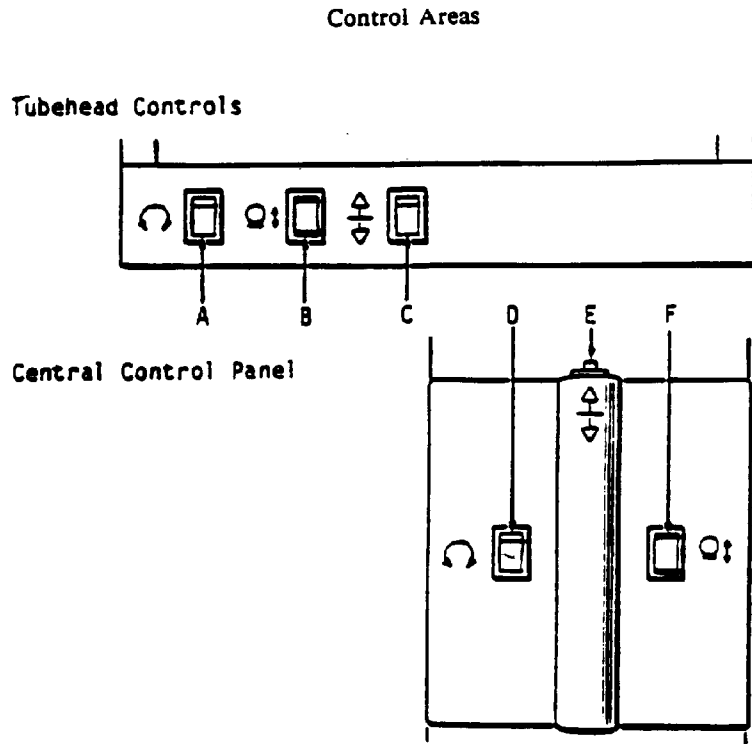
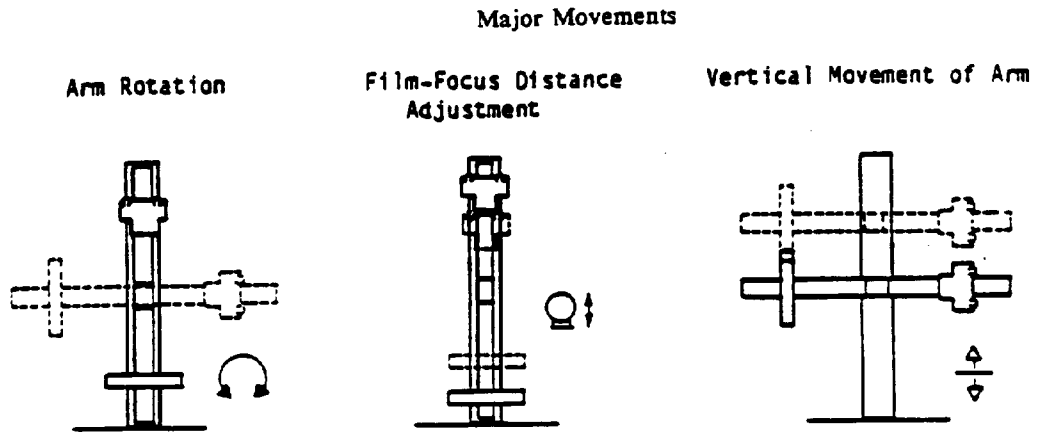


Exhibit 2-2. Major movements and control areas



2.2.1.3 Other Movements

■ Bucky Adjustments

The bucky rotates in both directions up to a maximum of 45°. To change its angle, release the lever, turn the bucky to desired position and lock the lever again. The bucky can be locked in all positions and there is a stop in the central position.

The bucky angle is shown on the scale on the bucky carriage, up to 30E (Exhibit 2-3).

2.2.1.4 PBL (Positive Beam Limitation) III Collimator (Exhibit 2-4) Controls and Indicators

The collimator is used to restrict the x-ray beam, which reduces the volume of tissue irradiated and also reduces scattered radiation.

- **READY** - This is a dual section lamp indicator. The left side will illuminate GREEN when the transverse shutters are properly positioned. The right side will illuminate GREEN when the longitudinal shutters are properly positioned. When either or both sides are not lit, the EXPHOLD lamp will be lit and x-ray exposure is prevented.
- **EXPHOLD** - This lamp remains RED until the shutters are correctly positioned; when the vertical SID is at other than 40" SID: when horizontal SID is at other than 40" or 72" SID, or when the mirror/filter is out of the beam and the generator voltage is set above 49kV. While the EXPHOLD lamp is lit, x-rays are not generated. This lamp goes out only when the ready lamp is on or the collimator is in the manual mode.
- **MANUAL** - This lamp lights AMBER when the tube/collimator assembly is tilted more than 10 degrees from horizontal or vertical, the film is not in the bucky, or the cassette tray is not properly inserted in the bucky.
- **LIGHT** - This button lights the projection lamp. The lamp is timed and turns off automatically.
- **LEFT SHUTTER KNOB** - This control moves the transverse shutters. In manual control, the shutters may be moved the full range. In the automatic mode, the shutters may only be moved in a direction to decrease the x-ray field size.
- **RIGHT SHUTTER KNOB** - This control moves the longitudinal shutters, and operates the same as the transverse knob.

Exhibit 2-3. Bucky carriage scale

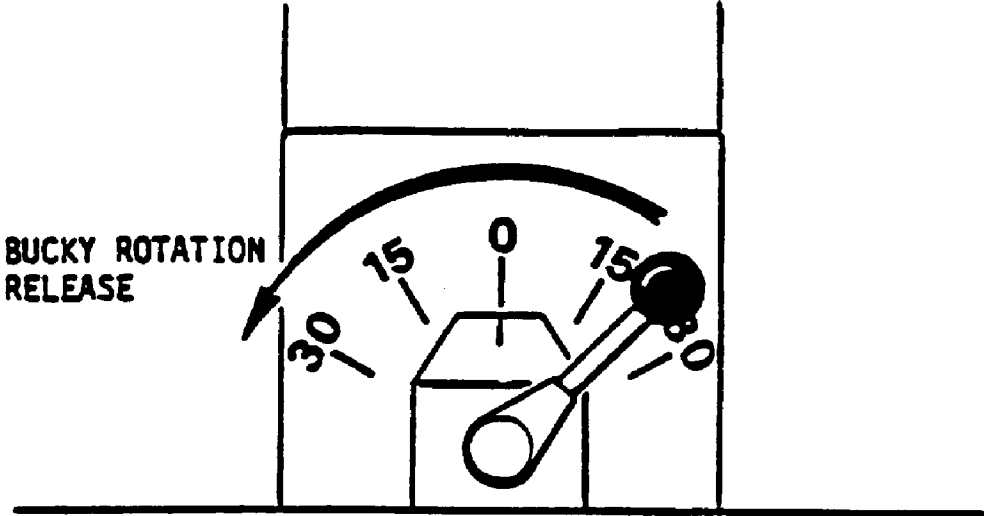
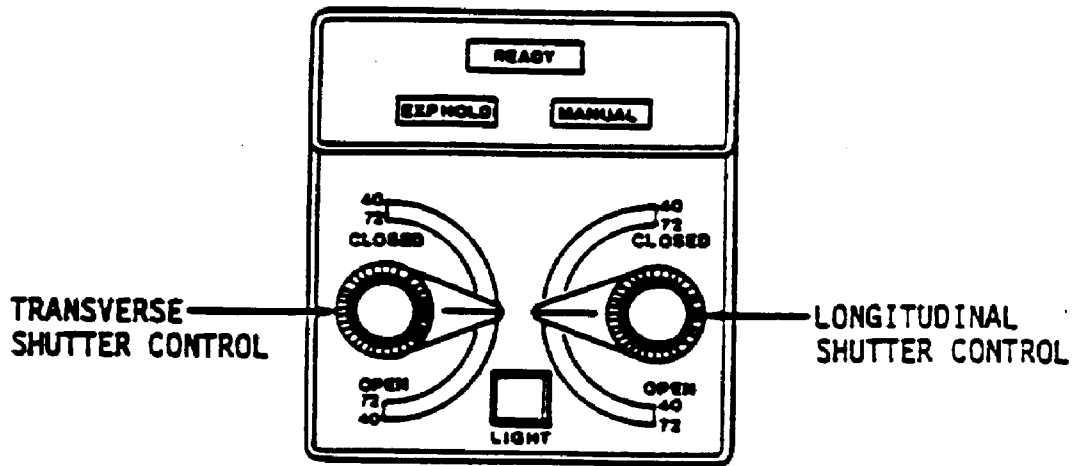


Exhibit 2-4. PBL III collimator



2.2.2 X-ray Generator (Controls)

2.2.2.1 Description

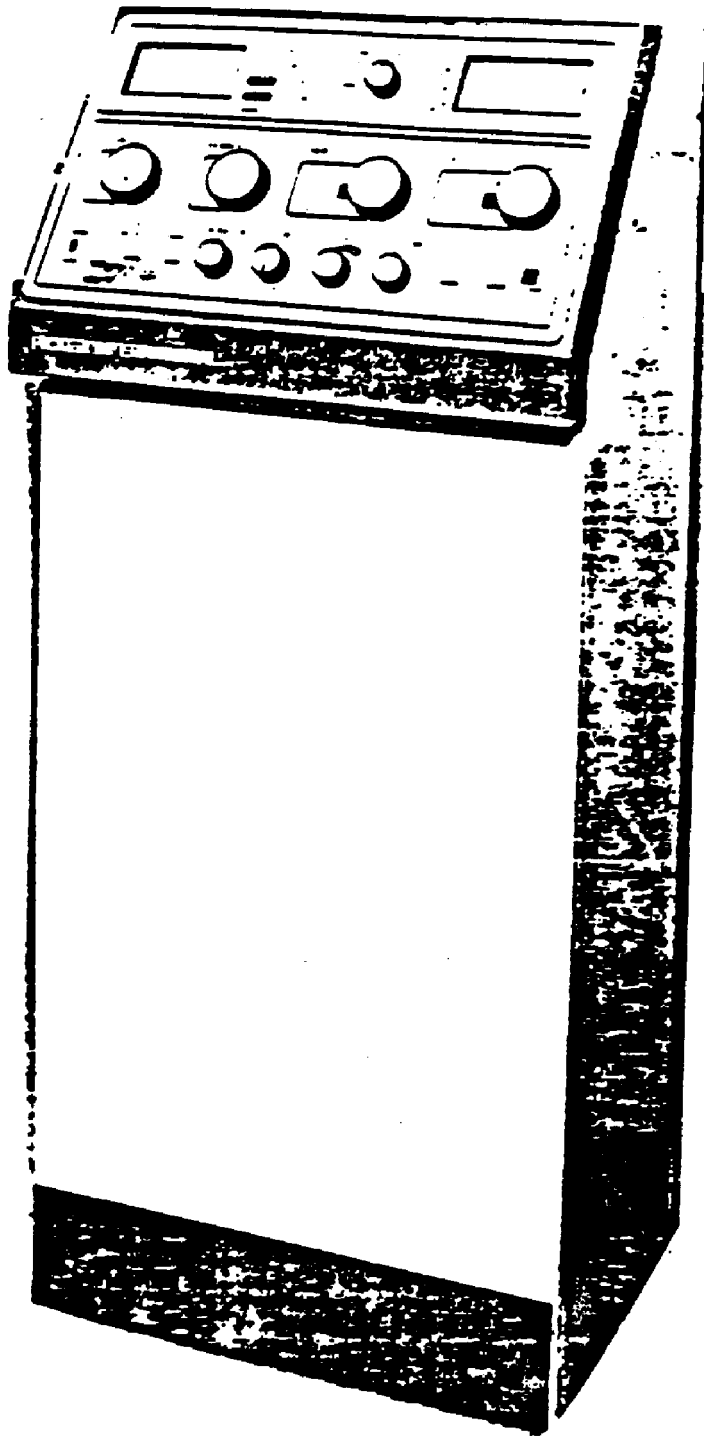
The x-ray controls (Exhibit 2-5) for this study, is a medium capacity, single phase diagnostic unit. Power is provided to the x-ray tubes by selecting one of five station switches (four of which have A.E.C. capability) which are set up by the serviceman to suit individual installation requirements. Motor driven switching is used in the undertable/overtable tube selection on the R/F control to provide power for radiography, fluoroscopy and spotfilm techniques.

The X-ray Control provides:

- State-of-the-art solid-state circuitry for greater reliability.
- Digital timer provides 18 precise exposure values from 1/120 to 6 seconds.
- Pre-reading voltmeter (kV) and two selector switches with six and twelve positions, respectively, provide 72 accurate increments of voltage without the need for separate line voltage compensation.
- Eight step current selector switch (mA) provides selection of focal spot and x-ray tube current.
- Sensitive circuit breaker provides instantaneous x-ray tube protection when overloading occurs.
- High voltage transformer with full-wave, solid-state rectification.
- Visual and audible exposure indicators.
- Automatic Exposure Control (A.E.C.).
- Control provided for both table and auxiliary.
- Convenient exposure switch on control front panel.

Note: The line voltage monitor is located on the wall near the breaker. It is independent of the control. It measures voltage coming into the MEC.

Exhibit 2-5. X-ray controls



2.2.2.2 Control Panel (Exhibit 2-6)

Controls and indicators on the control panel are used for the following purposes.

■ Controls

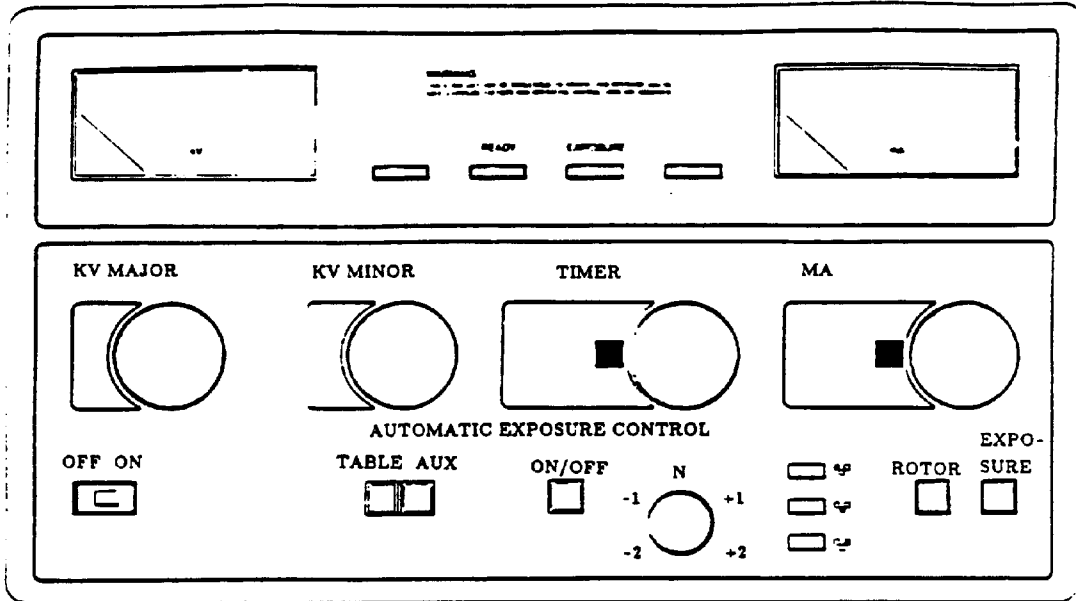
1. **On/Off:** Turns generator power On or Off. Illuminates when ON.
2. **Bucky:** Pushbutton selector for either table or auxiliary bucky. The table button should be pushed when using AEC, otherwise it should be on auxiliary.
3. **kV Major:** Rotary selector of radiographic kVp in increments of approximately 20 kVp.
4. **kV Minor:** Rotary selector of radiographic kVp in increments of approximately 2 kVp.
5. **mA Selector:** Provides selection of x-ray tube, small and large filament currents as given below.

small	25 mA
small	50 mA
small	100 mA
large	200 mA
large	300 mA
large	400 mA
large	500 mA
large	600 mA

You will always use the 500 mA filament current.

6. **Timer:** Provides the selection of eighteen position radiographic exposure values from 1/120 to 6.0 seconds (in impulses of 1/100 second for 50 Hz operation). When setting the timer for 4 mAs, use the 1/120 seconds value, when setting the timer for 8 mAs, use the 1/60 seconds value.
7. **Rotor:** Pushbutton switch to start rotor and pre-exposure. When pushed this boosts the tube.
8. **Exposure:** Pushbutton switch to initiate exposure when the pushbutton is depressed. If the switch is released during an exposure cycle, the exposure will automatically be terminated.

Exhibit 2-6. Control panel



■ Automatic Exposure Control

1. **AEC On/Off:** When ON is selected, the Automatic Exposure Control (AEC) is activated and the exposure will be terminated by the AEC. With the pushbutton on OFF the x-ray control uses conventional timing.
2. **Field:** Provides selection of left, right, or center fields; or any combination of the three; one of these switches must be depressed to obtain AEC operation.
3. **Density:** Five position AEC density switch which provides radiographic density variation between - 100% and +100% in steps as follows:

-2	(-100%)
-1	(50%)
N	(Normal)
+1	(+50%)
+2	(+100%)

4. **Ready:** When illuminated, indicates system is ready for an exposure to be initiated. If the selected combination of kVp, mA and time exceeds the permissible x-ray tube rating, the READY indicator will extinguish and the exposure circuit will be disabled until a combination within the tube limitations is selected.
5. **Exposure:** Illuminated for the duration of exposure. Audible signal will sound continuously during the exposure cycle.
6. **kV Meter:** This meter indicates voltage readings from 25 kVp to 125 kVp.
7. **mA Meter:** Indicates selected current 10% on a long exposure. On a short exposure the meter will only be partially deflected, due to the response time of the meter.
8. **AEC:** When illuminated, indicates that A.E.C. has been selected and x-ray control is in the automated exposure mode.
9. **Backup Time:** Illuminated when AEC is terminated by an energy limit signal, the level of which is determined by the current, voltage selection; or 600 mA limiter. When this occurs, subsequent exposures cannot be made until disable logic has been reset by switching the x-ray control or AEC OFF then ON.

2.2.3 Kodak RP X-omat Processor (Exhibit 2-7)

The Kodak RP X-omat processor, processes or develops all films designed for rapid processing with Kodak RP X-omat Developer Replenisher and Kodak RP X-omat Fixer and Replenisher, or their equivalents. See "Beginning and End of Stand Procedures" for setting up and closing down the X-omat Processor.

2.2.4 Densitometer

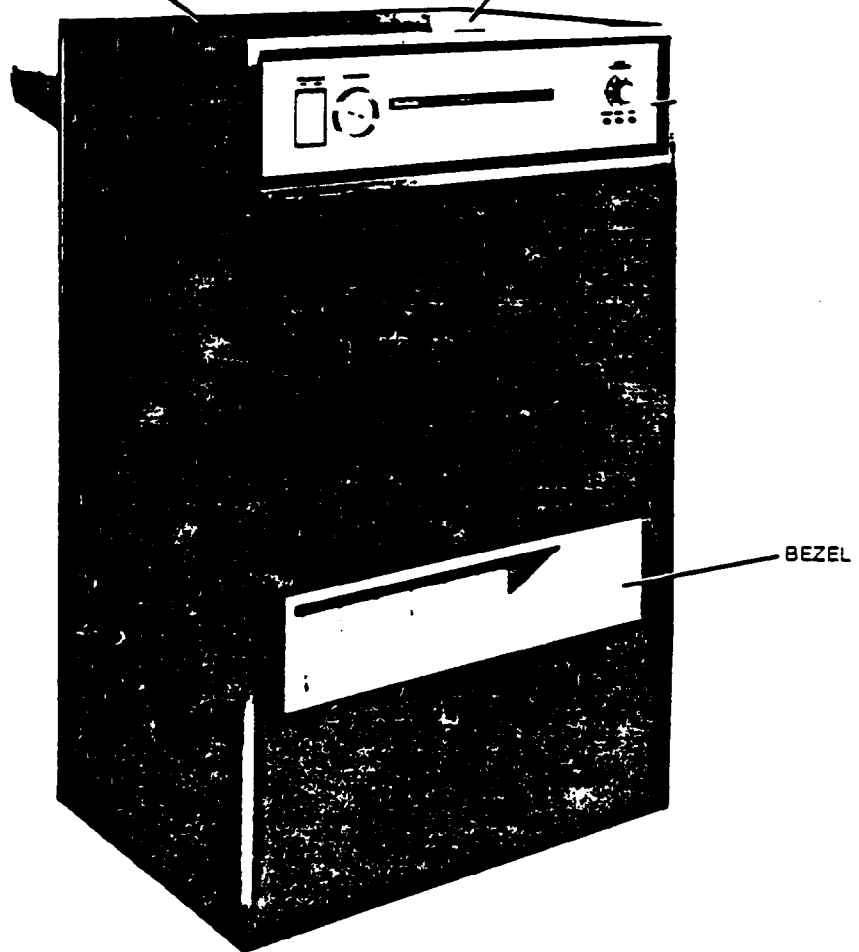
A densitometer is used to study the relationship between the intensity of the exposure of the film and the blackness after processing (sensitometry). In order to do this, two pieces of apparatus are needed: an aluminum step wedge, sometimes called a penetrometer, and the densitometer. The steps involved are:

- First, the film under investigation is exposed through the aluminum step wedge at some standard technique (for example, 70 kVp with 2.5 mm A1 total filtration). When processed, the x-ray film will have areas of increasing density corresponding to sections of the step wedge with decreasing thickness. The step wedge is fabricated so that the intensity of exposure to the film under each step can be determined.
- The processed film is analyzed in the densitometer, a device that has a light source focused through a pinhole with a light-sensing device positioned on the opposite side of the film. The x-ray film is positioned between the pinhole and the light sensor, and the amount of light transmitted through each segment of the radiograph is measured. These data are recorded and analyzed and when plotted result in a characteristic curve.
- It is not the absolute exposure that is of greatest interest but rather the change in density over each exposure interval.
- The useful range of radiographic densities is approximately 0.25-2.5. However, approximately 75% of all radiographs show image patterns in the range of 0.5-1.25 optical density.

Exhibit 2-7. Kodak X-omat processor

COVER ASSEMBLY
Includes: HANDLE
SCREW (2)
WASHER (2)

HANDLE
SCREW (2)
WASHER (2)



2.3 Equipment Set-up Procedures

2.3.1 Beginning of Stand Procedures

2.3.1.1 X-omat (Exhibit 2-7)

- a. Match the X-omat transformer taps with the incoming line voltage. Normally the biomedical engineer will do it at the beginning of each stand.
- b. Pull all the roller racks (Exhibit 2-8). Examine them for chemical residue, and scrub the rollers clean using a Scotch Brite pad. Be careful not to use the Scotch Brite pad on any metal part of the racks. Replace the racks.
- c. Close the drain valves for the developer, fixer, and wash insert tanks located under the feed tray in the darkroom (Exhibit 2-9).
- d. Turn on the main power breaker located on the wall in front of the X-omat and the circuit breaker located beneath the feed tray in the darkroom (Exhibit 2-9).
- e. Fill the X-omat insert and replenish the tanks with water at 90 F. Allow the unit to replenish itself for several minutes. See that no leaks are present. Drain the water.
- f. Replace the developer filter. Make sure cover is securely fastened.
- g. Mix the developer and fixer chemicals according to the manufacturer's directions in the replenisher tanks provided. Transfer enough of the chemical mixture into the insert tanks starting with fixer, then developer. Add eight ounces of developer starter to the developer insert tank. Mix more developer and fixer chemicals in the designated replenisher tanks. The inside lid of the replenisher tanks should be in contact with the chemical solutions in order to avoid evaporation.
- h. Check the water pressure at the sink value. The gauge should read approximately 60 psi. If it doesn't, have the MEC manager check the water filter.

Note: The MEC's periodically will be in locations where water pressure is ≤ 60 .

- i. Check that the developer temperature gauge reads 35 C (95 F).
- j. Check that the dryer temperature gauge on the front of the X-omat is set at approximately 125 F.

Exhibit 2-8. Roller racks

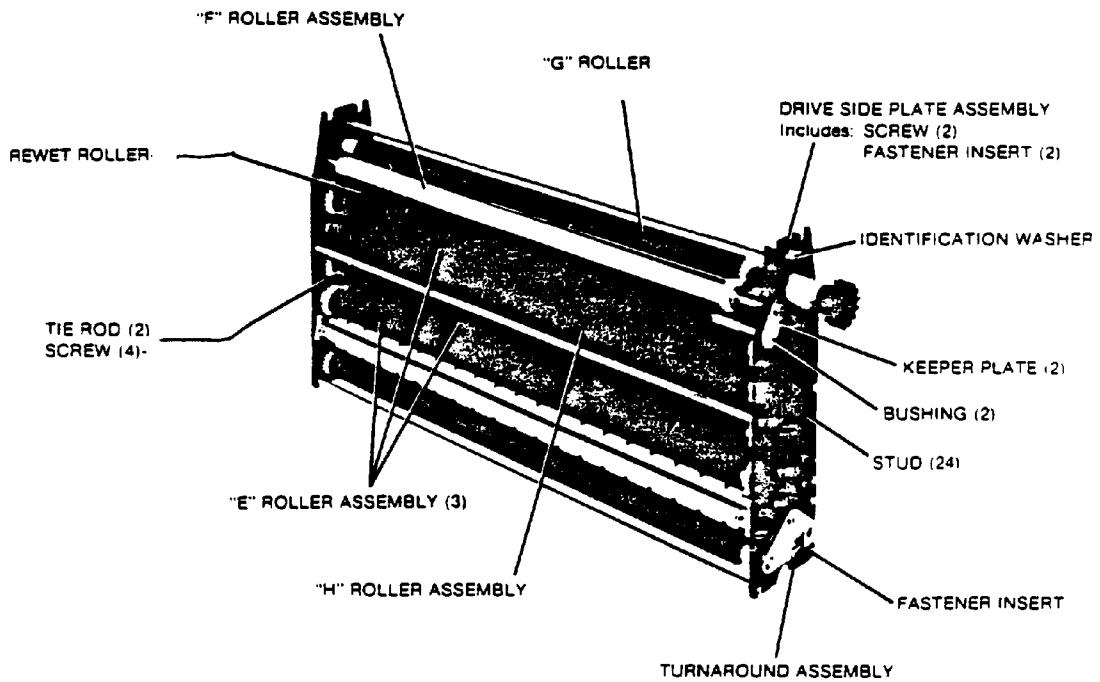
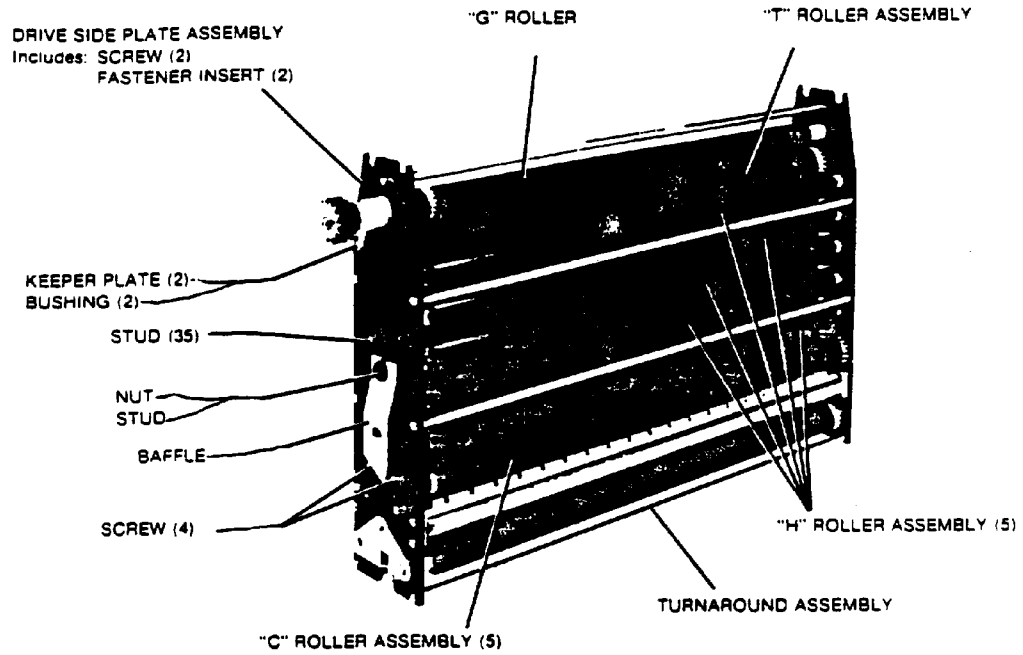


Exhibit 2-8. Roller racks (continued)

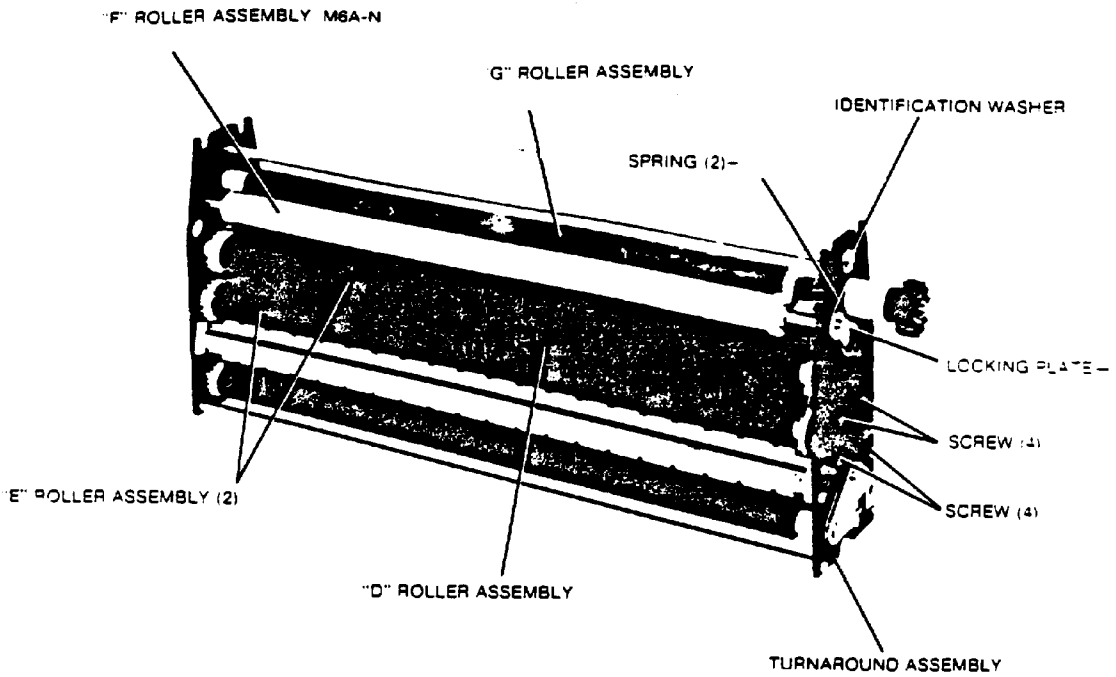
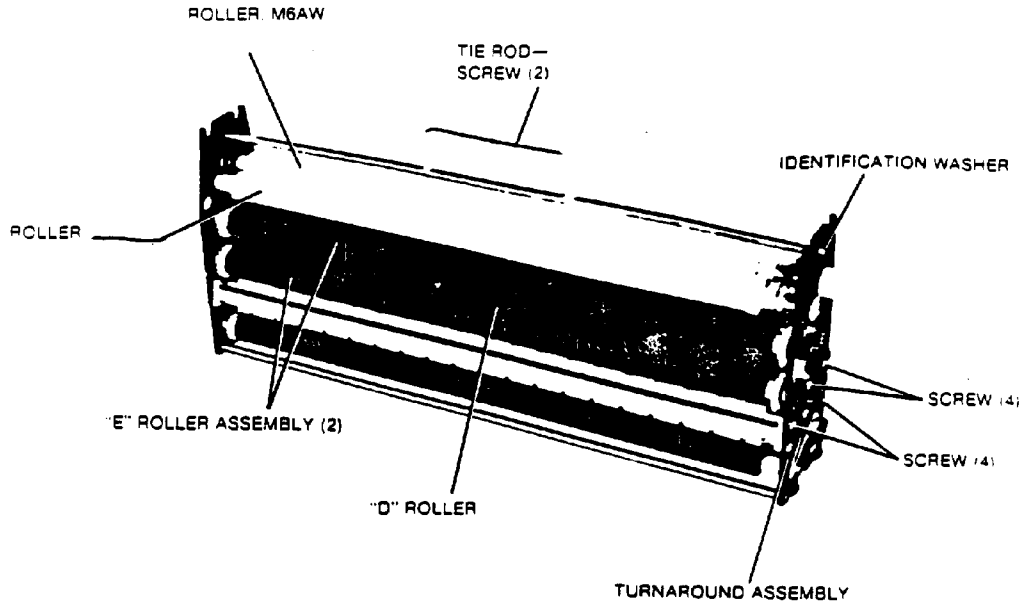
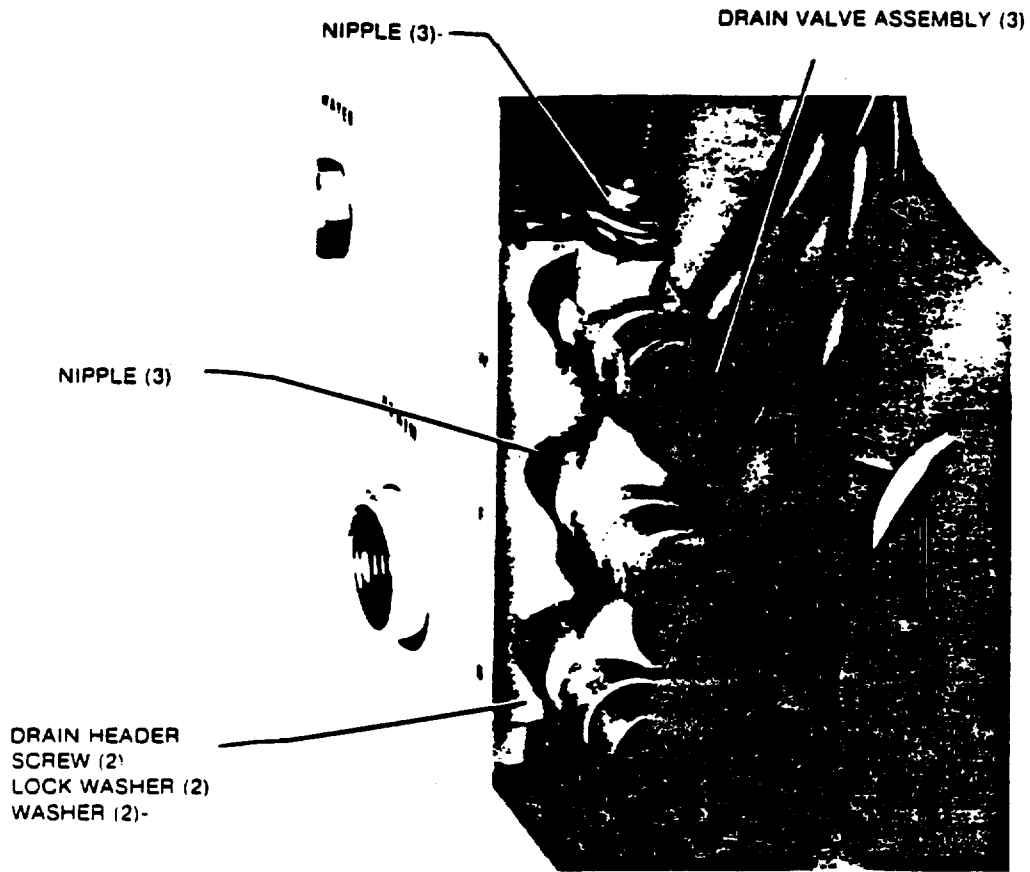


Exhibit 2-9. Drain valves



2.3.1.2 X-Ray Darkroom

- a. Unlock the film bin.
- b. Plug the darkroom safelight into the wall outlet and turn the light on.
- c. Open all the film cassettes and check for loose felt edging or loose intensifying screens.
- d. Clean the screens with screen cleaner and gauze only as needed. Check for dirt on the screens by using a blacklight wand to inspect the screens. The screens will fluoresce in the presence of a black light and any irregularities on the screens can be detected.
- e. Check both the dark room and the film bin for light leaks as follows:
 1. Turn out the lights (including the red light) and remove a film from the bin. Place your hand on the film for a few seconds. Next, process the film. If an outline of the hand appears on the processed film, then a light leak exists. If no image appears, repeat this process with the red light on.
 2. Keeping the lights out, take a film out of its box (inside the film bin) and place it along side the box. Close the film bin and turn the lights on. then turn the lights off, remove the film and process it. If the film appears to be foggy then the film bin has a leak. Notify the MEC manager of any leak, who in turn should notify the biomedical engineer.
- f. While processing a film, check that the safelight and accompanying bell signal are functioning properly. If the safe light does not work, replace the bulb. Be careful with the red filter. A high wattage bulb may crack the lens. Notify the MEC manager if lens is cracked, who should inform the biomedical engineer.

2.3.1.3 X-Ray Room

Unpack all x-ray supplies and set-up x-ray room to facilitate an efficient use of workspace. Keep in mind that two other components share this limited space and placement of supplies should be coordinated among all three components.

2.3.2 Calibration Procedures and Checks

2.3.2.1 Exposure Calibration

On setup day and any other day when the x-ray machine may not be operating properly, a calibration check on exposure factor should be made as follows:

- a. Place a 24 x 30 cm cassette in the holder.
- b. Attach the step wedge to the image receptor panel, thin side up, in the center of the light field.
- c. Make a manual exposure at the following factor: 70 kVp, 200 mA, 3/20 second, 30 mAS.
- d. Label the calibration films with the stand number, stand location, date, technician number.
- e. Process film.
- f. Take densitometer readings at steps 2, 5, and 8 on each film.
- g. Compare the density readings with standard film taken at the time of installation. The variation between the shades of gray on a given step should be within one density step. If not, recalibrate. If the problem persists, inform the biomedical engineer in headquarters.

2.3.2.2 Processor Calibration

A processor calibration check should be made once a week.

- a. Plug the sensitometer into a power outlet in the darkroom and close the darkroom door as though you were going to process film.
- b. Place a processor check film lengthwise as far back as it will go under the metal holding tongue of the sensitometer.
- c. Depress the exposure button on the sensitometer momentarily, then release it. Do not hold the exposure button down; doing so will make multiple exposures.
- d. Remove the film and place it lengthwise in the X-omat processor.
- e. Meanwhile, insert sensitometer calibration strip into the sensitometer and take a series of 9 readings. Turn the knob on the sensitometer until the digital readout matches the actual value on the calibration strip. Repeat for all gradations on the strip.

- f. Remove the film from the processor bin and place in the sensitometer and take readings at steps 3 and 7. Also take a background reading on film 1" above densitometer imprint and 1" from the border.
- g. Compare density readings with densitometer calibration strips obtained the previous week and a standard strip. If there is a large variation or a trend in values, repeat the calibration. If the problem persists, inform the MEC manager and the biomedical engineer.

2.3.2.3 Collimator Check

- a. Place a loaded cassette in the bucky.
- b. Make an exposure and process the film. The exposed area on the developed film should be centered on the film so that the unexposed border is even on opposite edges of the film. If not, inform the biomedical engineer at headquarters.

2.3.2.4 Tube Warmup Procedure

At the beginning of each exam session or any time the x-ray unit has been turned off for two hours or longer, it is necessary to warm up the machine before making full exposures.

- a. Set the following exposure factors: 70 kVp, 200 mA, 2 sec.
- b. Activate the rotor, and make one exposure; pause five or ten seconds, and then make another exposure.

2.3.3 Daily Procedures

2.3.3.1 Preparation for Radiographic Exposure

1. Switch on the x-ray control by selecting POWER OFF-ON switch to ON.
2. Depress AUX pushbutton.
3. You will normally be using the conventional timing, therefore, select required exposure time using TIMER selector switch.
4. Select the required mA using mA selector switch.
5. Observe kV meter and select required voltage using MAJOR and MINOR kV selector switches.
6. X-RAY CONTROL READY FOR AN EXPOSURE - At this point, the READY indicator should illuminate. If not, x-ray tube overload condition exists and kV, TIMER or mA should be reselected. When correct (within the x-ray tube's limitations), the READY indicator will be illuminated. NOTE: In borderline situations, the READY indicator will flicker. If this occurs, readjust kV selectors to increase kV if at lower limit and decrease kV if at 50 kV or at upper limit. Usually the necessary correction will be obtained by adjusting kV MINOR selector.

2.3.3.1.1 Automatic Control

Automatic exposure control (AEC) will not be the normal mode in which x-rays will be taken in the mobile examination center. With the AEC feature, sensors terminate the exposure when an x-ray of optimum quality has been obtained. Therefore, the radiation exposure to the SP is kept to a minimum. If for some reason you do use the AEC, use the following guidelines:

- a. Depress the AEC button on the x-ray control panel to activate the AEC.

- b. Set the correct exposure for the part of the body to be x-rayed turning the exposure dial to one of the five density selections. The same setting will generally be used for PA and lateral views.

AEC Selection

-2 (50% less than normal)
-1 (25% less than normal)
N (normal)
+1 (25% greater than normal)
+2 (50% greater than normal)

- c. When taking a lateral film, depress the left or right sensor (topmost and bottommost of the three sensor selection buttons). When taking a PA film, depress the center sensor (the center of the three sensor selection buttons).

2.3.3.2 Procedure for Exposure Using Panel Pushbutton

1. When the READY indicator is illuminated, depress and hold the ROTOR and EXPOSURE pushbuttons.

IMPORTANT: The exposure command will be immediate when the rotor pushbutton has been depressed 1 (one) second prior to depressing the exposure pushbutton. If only the exposure pushbutton is depressed, exposure will result automatically, after a delay of approximately 1 (one) second for rotor to attain operating speed.

2. During a long exposure, the mA meter will indicate the selected mA. On a short exposure, the response time of the meter is too slow for the meter to reach final values, therefore, only a partial deflection of the pointer will be observed.
3. If the mAs pushbutton is depressed before the ROTOR and EXPOSURE pushbutton are depressed, the mA-mAs indicator will display value (mA x time) and will continue to do so while the mAs and EXPOSURE pushbuttons are held in, even after the exposure is terminated. Refer to Reference Data for mA, TIMER and mAs values.
4. When it is necessary to withhold exposure until the precise moment of examinee immobilization desired to obtain a sharp radiograph, the ROTOR pushbutton will have to be depressed and held for at least 1 second before the EXPOSURE pushbutton is depressed.

This allows the x-ray tube rotor to attain operating speed.

NOTE: During the exposure cycle, the EXPOSURE indicator will be illuminated and a constant audible signal will sound. The end of exposure is indicated by the audible signal stopping and indicator extinguishing.

2.3.3.3 Procedures for Loading and Unloading the Cassettes

To load and unload the cassettes it is necessary to be in the dark room. Use the following procedure.

- Close the dark room door and pull the "black out" curtain across the door.
- Turn on red light.
- To load the cassette, open the cassette, the Kodak lanex fine grain screen will already be on either side of the cassette. Place the TML film between the two screens and close the cassette. **ALWAYS LOAD THE cassette in the darkroom.**
- To unload the cassette use the same procedure, removing the film and placing it in the processor.
- Reload the cassette after removing the film.
- Have the cassettes loaded prior to the SP entering the room, as this will save time.
- Rotate the cassettes as much as possible.

2.3.3.4 Procedure for Processing the Film

In order to process the film:

- Open the cassette, in the dark, with the red light on and remove the films.
- Place film in the processor film guide (Exhibit 2-10).
- Reload cassette with new film and place in x-ray holder.
- Approximately one - two minutes later the processed film will be deposited in the receiving bin (Exhibit 2-11).
- Remove the film, make sure it is dry and check for quality.
- Do not handle the films more than necessary.
- Place in examinee envelope.

Exhibit 2-10. Film guide

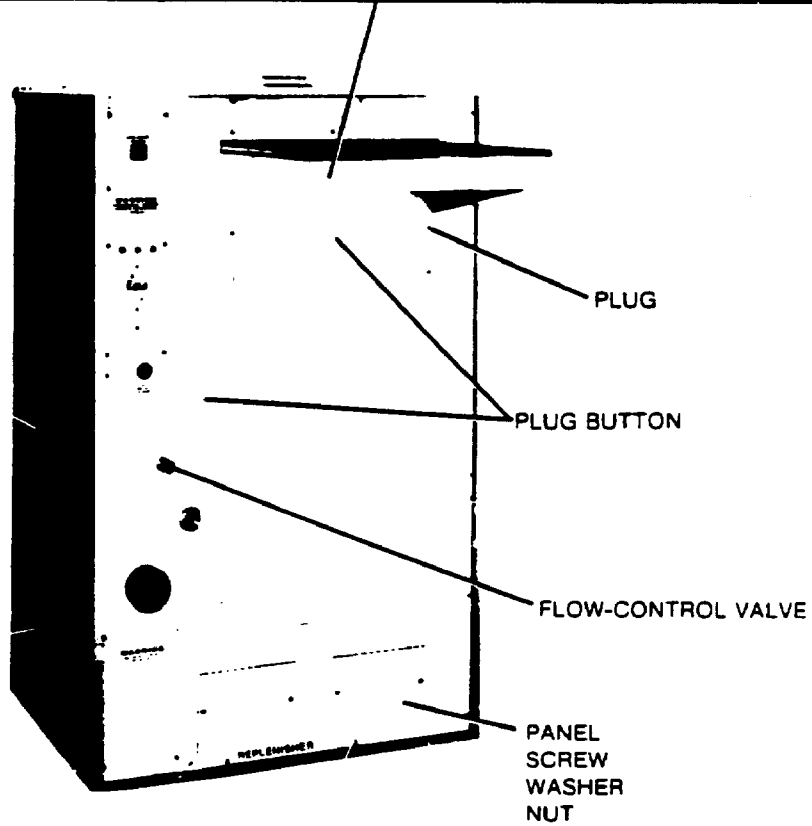
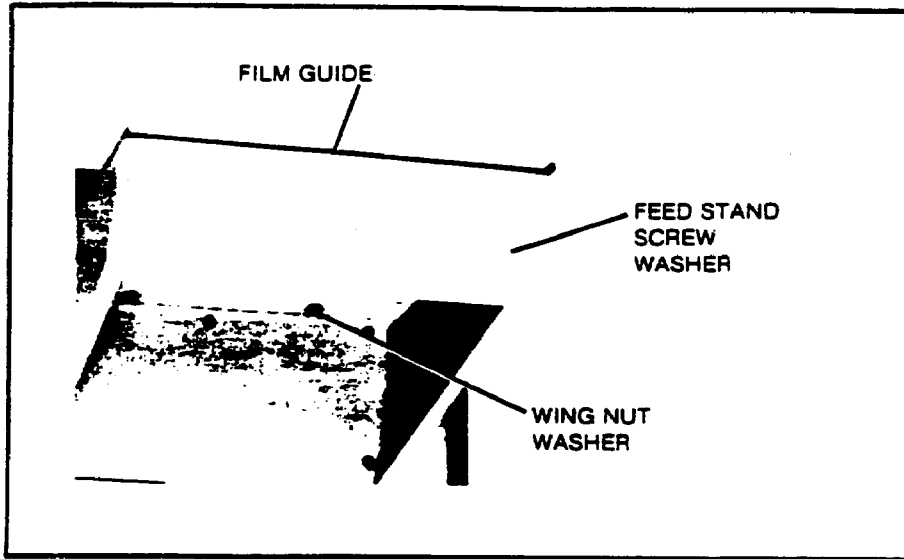
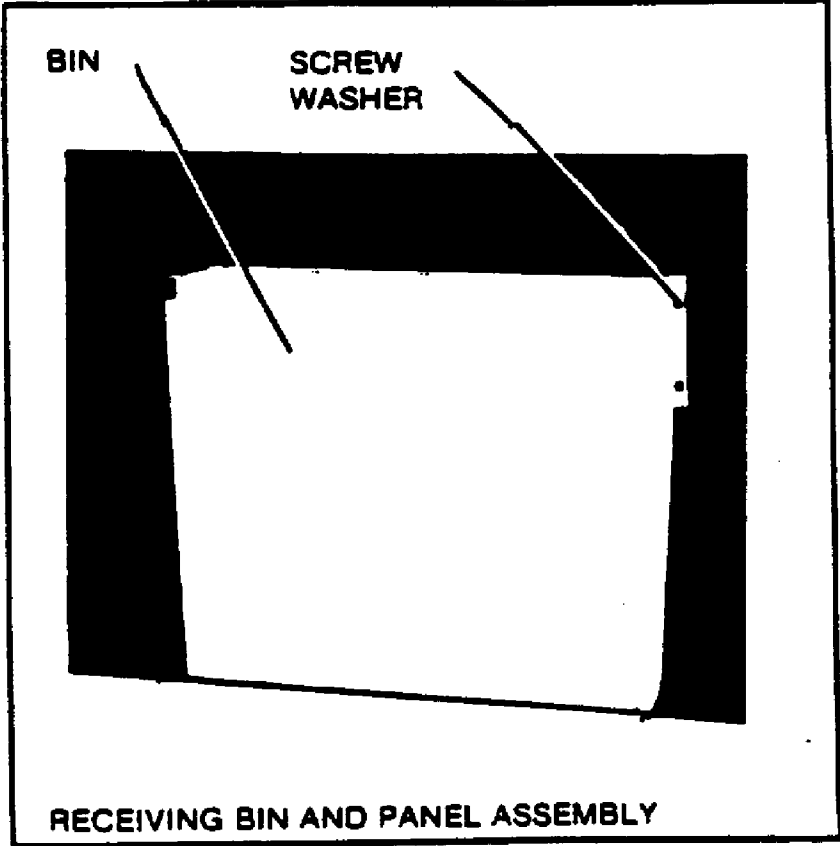


Exhibit 2-11. Receiving bin



2.3.3.5 End of Day Procedure

- a. Turn off the x-ray machine, then turn off power at the breaker in the dark room.
- b. Turn off the X-omat switch in the dark room, then turn off the breaker above the X-omat.
- c. Close the water valve and open the wash drain valve located behind the panel under the X-omat feed tray in the dark room.
- d. Remove, rinse, and replace cross-over racks.
- e. Replace the cover of the X-omat, but leave it vented approximately two inches.

2.4 Maintenance Procedures

2.4.1 Maintenance of X-Ray Unit

The inspection procedures listed in the following table should be performed by the technician at the time intervals indicated.

INSPECTION REQUIREMENTS

TEST ITEM REQUIREMENTS	TIME INTERVAL	INSTRUCTIONS
Radiation Leakage	1 month	1-Look for physical damage that could affect radiation shielding (i.e., hole in the wall, broken window, broken collimator glass or shutter, any type of damage which would allow radiation leakage from the room or the machine).
OPERATION IN PBL (Automatic Operation)	Daily	1-Ensure that the x-rays are inhibited when in the Positive Beam Limitation (PBL) model and not at 40" or 72" SID. 2-Ensure that x-rays are inhibited when EXPHOLD lamp is illuminated RED.
Mirror/Filter out of Beam	Daily	1-When collimator filter is off, and kV is greater than 49kV, exposures must be inhibited. The READY light will turn off.

2.4.2 Maintenance of Control Panel

The maintenance required to maintain this x-ray control is:

- Wipe down the x-ray control unit with 409 and a soft cloth every day before leaving.
- NEVER OPEN the x-ray control unit.
- NEVER place food or drink on the X-ray Control Unit.

2.5 End of Stand Procedures

2.5.1 X-omat

- a. Empty the replenisher tanks; rinse, and refill them with hot water.
- b. Open the drain valves in the dark room and drain the fixer, developer, and water. Close the drains and fill all three insert tanks with hot water. Add a dilute solution of developer and fixer systems cleaner to the appropriate insert tank. Remove and dispose of the developer filter. Secure the trap lid.
- c. Remove the two crossover rollers, detector entrance roller assembly, and the squeegee or dryer roller assembly; and clean them using water and a **Scotch Brite pad**. Be careful not to use the Scotch Brite pad on any metal part of the racks.
- d. Replenish the X-omat water until it appears clear in the insert tanks.
- e. Drain the insert tanks by opening the drain valves. Remove the developer, fixer, and washer transport rollers. Scrub the insert tanks to remove all chemical deposits. Rinse and fill the insert tanks with hot water. Repeat the previous step. Be sure there is sufficient water in the replenisher tanks that air is not drawn through the pumps.
- f. Drain all the tanks and wipe out the insert and replenisher tanks by inserting a film into the film guide and taping the rack edges to the guide so that there will be a constant replenishing of the system. (Remember to remove this film).
- g. Scrub the transport rollers and gears with a Scotch Brite pad until all deposits are removed; rinse them and stand them up to dry.
- h. Clean the area where the replenisher tanks sit and the shelf where the blower motor sits (accessible when the rear panel is removed).
- i. Remove, rinse and wipe down the dryer air tubes and dryer transport rollers. Replace them in the X-omat.

- j. Replace the transport rollers in the correct insert tanks. Replace the crossover and squeegee assemblies.
- k. Replace the detector entrance roller assembly in the machine.
- l. Replace the X-omat cover; and clean the outside of the X-omat, loading table, and dryer bin.
- m. Check that the water valve is closed.
- n. Close the drains. Turn the power off both at the main breaker and at the unit breaker under the feed tray.

2.5.2 X-Ray Dark Room

- a. Lock the film bin.
- b. Check to see that the duplicator is secured on the floor.
- c. Put the small film separators on the floor and secure them in place.
- d. Remove everything from the shelf and put it all on the floor. Place the 35 x 43 cm cassettes between the wall and film bin and secure them.
- e. Close the door and make sure it is secure.

2.5.3 X-Ray Equipment

All equipment should be secured and supplies packed and placed in designated storage areas.

2.6 Inventory of Equipment and Supplies

Periodic inventory of x-ray equipment and supplies should be completed as indicated in the Standardized Procedures. Any pieces of equipment that are missing should be reported to the MEC manager.

3. EXAMINATION PROTOCOL

3.1 Eligibility Criteria

All SP's 60 years and older are eligible for the x-ray component which includes x-rays of the hands and wrists, and knees. SP's under the age of 60 are not eligible to participate in this component.

3.2 Pre-examination Procedures

- a. Properly identify SP and enter ID number into the automated system and/or hard copy log.
- b. Explain the procedure to the SP.
- c. Prepare identification marker with the SP number and the date.
- d. Have the SP remove jewelry from the area of interest.
- e. Select adequate film size and load cassette (if not done previously).
- f. Check that the ECG machine and Fundus camera are properly shielded by lead sheets.

3.3 Examination Procedures

3.3.1 Manual Control

Manual control will be the normal mode in which the x-rays will be taken in the MEC. When using manual control, use the following guidelines:

<u>View</u>	<u>Imaging System Recommended</u>	<u>kVp</u>	<u>mAS</u>	<u>FFD</u>
1. PA hand wrist	Kodak Lanex fine double screens & TML film (no grid)	50	5	40"

2. AP knee	Kodak Lanex reg. double screens & TML film (phototimed with 12:1 stationary grid)	60	15*	42"
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* Estimated MAS with photo-timing. Dose may be reduced.

3.3.2 Hand and Wrist X-rays

- a. Position the SP on the stool at the side of the gurney in such a way that it will not be necessary for the SP to assume a strained or uncomfortable position.
- b. Place a 24 x 30 cm cassette on the gurney at a location and angle that will allow the SP to be positioned most comfortably.
- c. Shield the SP with the lead apron.
- d. Have the SP rest his/her forearms on the table and place both hands (palmar surface down) flat on the cassette. For the examination of both hands and both wrists, each hand should be correctly and separately positioned. The hands must not be cupped and the fingers must be straight unless there are deformities that prevent holding them straight. The fingers should be slightly separated but not widely apart. The forearms should be absolutely flat -- namely, the elbows should be resting on the table. This positioning is for the purpose of preventing rotation distortion, particularly of the joint spaces, as may happen when both sides are placed on the film for simultaneous projection.
- e. Place markers in correct location.
- f. Ask the SP to relax his/her hand to avoid motion. Involuntary movement can be prevented with the use of adhesive tape or positioning sponges. A sandbag may be placed over one distal forearm.
- g. Center the x-ray beam on a line drawn between the mid-points of the right and left 3rd metacarpals (middle knuckle).
- h. Instruct the SP to remain perfectly still while you make the exposure from the control booth.
- i. Select proper exposure factors and set control panel (mA + S + kVp).
- j. Press ROTOR button.
- k. Once ROTOR is up, press EXPOSURE button.
- l. Take cassette into darkroom.

3.3.3 Non-weight Bearing Knee X-rays

- a. Select appropriate cassette.
- b. Assist SP to sit on table (use stool) and position SP so legs are straight.
- c. Place 35 x 43 cm cassette with stationary grid (on top of cassette) under both knees crosswise.
- d. Slightly rotate toes inward if needed to place knees in perfect AP position.
- e. Place markers in correct location.
- f. Shield SP with lead apron.
- g. Direct the x-ray beam and center it midway between knees at the level of the apices of the patella.
- h. If both knees will not fit on one film, x-ray each knee separately using a 24 x 30 cm film for each knee.
- i. Instruct SP to remain perfectly still while you make the exposure from control booth.
- j. Select proper exposure factors.
- k. Complete exposure.
- l. Take cassette into darkroom.

3.3.4 Examination Form

3.3.4.1 Automated System

The automated system verifies that appropriate x-rays were taken on SP's and, if necessary, explains why x-rays were not taken. The system also provides a basis for handling the inventory of completed x-ray films.

All automation activities in the MEC use standardized screens to begin and end their processes. These are called the introductory and results screens.

Introductory Screen

The introductory screen collects information identifying the technician and the SP. It presents the examinations to be done in this MEC room so that each can be selected for data entry as exams are given. If an examinee is 60 years or older, "x-rays" will appear as a choice on this screen; if the SP is younger, the choice will not appear, preventing data collection.

To complete the introductory screen, the technician enters his/her tech # and the SP identification number. The rest of the identifying information will then be provided on the screen by the automated system. The technician should verify this information with the SP. The introductory screen appears as follows:

Introduction

Technician		Examinee	
Tech# <u>1001</u>		Sample# <u>6060600</u>	
Name <u>Bob Murphy</u>		Name <u>Old Person</u>	
		Age <u>60</u>	Years/Months <u>Y</u>
		Sex <u>M</u>	

Procedures

<u>Xray</u>	
_____	_____
_____	_____
_____	_____

Data Collection Screen

Once the x-ray exam has been selected from the introduction screen, the main data collection screen will appear. This screen will look as follows:

Name xray person Sample# 6060600

JOINT RADIOGRAPHS

Name of Xray -----	#Takes -----	Previous takes on this person -----
Hands/Wrists	—	<u>0</u>
Knees, non-weight-bearing	—	<u>0</u>

On this screen the technician merely enters the number of "takes" or films taken for each joint. The maximum entry allowed is two takes for the same joint. Retakes, the second film on the same joint, are only done when the first film is not useable; duplicate films are not needed unless indicated by special SP circumstances (i.e., large SP).

Any data already entered for this SP will be displayed as "previous takes." This occurs when the SP had previously completed some portion of the procedure.

Results Screen

When the screen is advanced, the results screen will display as follows:

Name xray person Sample# 6060600

Examination results

Select one

- Test done
- Test incomplete
- Test not done

Comments:

This screen is the same for all examinations. If "test done" is selected, the introductory screen appears. Since there are many reasons for a test to be incomplete, if "incomplete" or "not done" is selected, the following screen appears:

Name xray person Sample# 6060600

Examination results

Select one

- Hardware malfunction or lack of supplies
- Insufficient time available or room not available
- Examinee refused or uncooperative
- Examinee unable to physically cooperate
- Comments

Comments:

The technician then selects the appropriate reason for an incomplete exam.

3.3.4.2 Hard Copy Examination Form

If at any time the automated system is not properly functioning, the technician will record the results of the x-ray exam on a hard copy data form (Exhibit 3-1).

The x-ray exam form is divided into three sections, the I.D. section, the data collection section, and results section.

- Enter the technician ID number and SP ID number or label in the first section.
- Enter the total number of takes for each x-ray procedure. One film or take for each x-ray listed is expected. However, sometimes an exposure must be taken more than once if the original one is unsatisfactory. (The number of takes must not exceed two for each x-ray listed).
- Select the final result of the examination. If "test incomplete" or "test not done" is selected, complete the reason why the test was not done.
- Provide any specific comments pertaining to the x-ray exam procedure.

Hard copy data forms should be maintained until the automated system regains functioning or until directed by the MEC manager. The MEC manager will also instruct technicians how to process completed hard copy data forms.

3.4 Post Examination Procedures

- a. Remove lead apron from SP.
- b. Assist SP off x-ray table.
- c. Complete x-ray data in automated system and/or x-ray hard copy log.
- d. Close darkroom door and window. Pull black-out curtain across the door.
- e. Open cassettes and remove film from cassettes.
- f. Place films on silver tray of the processor and start processing.
- g. Reload cassettes.

Exhibit 3-1. Hard copy data form for x-ray results

**JOINT RADIOGRAPHS
AGES 60 AND OLDER**

STAFF NO _____		NCHS ID NO _____	
1.	<u>X-RAY PROCEDURES</u>	<u>TAKES</u>	
	A. Hands/wrists	_____	
	B. Knees, non-weight-bearing	_____	
2.	RESULTS OF EXAMINATION:	1	<input type="checkbox"/> Test done
		2	<input type="checkbox"/> Test incomplete
		3	<input type="checkbox"/> Test not done
3.	REASONS TEST INCOMPLETE OR NOT DONE:	1	<input type="checkbox"/> Hardware malfunction or lack of supplies
		2	<input type="checkbox"/> Insufficient time available or room not available
		3	<input type="checkbox"/> Examinee refused or uncooperative
		4	<input type="checkbox"/> Examinee unable to physically cooperate
		5	Comments: _____

- h. Check that all cassettes are reloaded and properly shut, the film bin door closed and the bell has run on last film in processor before leaving the darkroom.
- i. Retrieve and review films for quality and proper positioning.
- j. Direct SP to next examination component.
- k. Place all films taken for SP, whether useable or not, in a labeled jacket.
- l. Ensure that MEC physician reviews all x-rays for both technique and abnormal finds before SP leaves MEC.
- m. Note: If for any reason, a SP refuses to have the x-rays taken, notify the MEC manager. He/She will be sure that the SP understands what the procedure includes. If the refusal is firm, note the reason in the automated system and/or comments section of the x-ray hard copy log.

3.4.1 Standards of Quality for Hand, Wrist, and Knee X-rays

The technician must check each film for the following standards to evaluate the quality of the films.

3.4.1.1 Hand and Wrist X-ray

- No rotation of the hand:
 - Concavity of the metacarpal and phalangeal shafts should be equal on both sides.
 - Amount of soft tissue should be equal on both sides of the phalanges.
 - If the fingernail is visualized, it should be in the center of the distal phalanx.
- Metacarpophalangeal and interphalangeal joints should be open, indicating that the hand was placed flat on the cassette.
- Fingers should be separated slightly so their soft tissues do not overlap.
- All anatomy distal to the radius and ulna should be included.
- Radiographic quality should demonstrate soft tissue and bony trabeculation.

3.4.1.2 Non-Weight Bearing Film of Both Knees

- Knees should not be rotated.
- Both knees should be demonstrated.
- Knee joint space should be centered to the exposure area.
- A large enough film should be used to demonstrate the longitudinal axis of the femoral and tibial shafts.

4. LOGS AND RECORDS

4.1 Daily Appointment Schedule

During NHANES III, a hard copy daily appointment schedule will be provided for each component which will be generated by the automated system.

The Daily Appointment Schedule will provide information for several uses. A copy of the schedule will be given by the coordinator to the health technician for the next day. The form will provide the name, age and sample number of each SP for that day. This list can be used to verify the X-Ray Daily Log. It also lists the number of SP's that are expected for the session. In most cases the number of SP's per session will be ten.

4.2 X-Ray Daily Log Sheet

The Daily Log Sheet is maintained by the MEC automated system. In addition, a hard copy X-Ray Daily Log Sheet will be maintained (Exhibit 4-1). The purpose of the X-Ray Daily Log Sheet is to document what has been done by the x-ray technician as well as to note out-of-ordinary circumstances and events.

For each x-ray session, the technician should begin a new page by entering the date, session, location and stand number at the top of the form on the lines provided. The rest of the page should be used to record the information requested about each SP. That information includes the following:

SP # - Place an SP sticker or enter the SP number.

Age - Enter age of SP.

Sex - Enter sex of SP.

Examiner ID # - Record technician ID number.

Time In/Time Out - Record time SP entered x-ray component area and time SP left.

Exhibit 4-1. X-ray daily log sheet

Health and Nutrition Examination Survey III
X-RAY DAILY LOG SHEET

Location _____ Stand No _____ Date ____/____/____ Session: AM PM EVE

SP ID #	Age	Sex	Examiner ID #	Time In/Time Out	Hands/Wrists	Knees	Status Code	Comments
1.				____/____				
2.				____/____				
3.				____/____				
4.				____/____				
5.				____/____				
6.				____/____				
7.				____/____				
8.				____/____				
9.				____/____				
10.				____/____				

Hands and Wrists - Place a check mark in the space provided if x-ray of the hands and wrists has been obtained. If not, note why in the comments section.

Knees - Place a check mark in the space provided if x-ray of the knees has been obtained. If the knees x-ray was not obtained, make a note as to why in the comments section.

Status Code - Choose one of three status codes. Code (C) indicates a "completed" exam, (PC) indicates a "partial complete" exam, and (NE) indicates "no exam." (PC) and (NE) both require reasons for the assigned codes in the comments section. The comments section is also used to record any unusual circumstances.

Log pages are retained until the end of the stand. At that time, the log pages are sent to the home office.

4.3 Shipment of Forms and Data

4.3.1 Transmittal Forms

The automated system is designed to produce a computerized transmittal form which should accompany all shipments of x-rays and other data items. A detailed discussion on generating transmittal forms and hard copy transmittal forms is provided in Standardized Procedures.

4.3.2 Shipment of X-rays

All x-rays taken for each SP should be stored in x-ray film envelopes labeled with the SP number and date of procedure. The film envelopes are then shipped weekly to a designated evaluator/consultant. Shipping instructions and destination for individual data items will be provided by the MEC manager.

5. QUALITY CONTROL

5.1 Quality Control Procedures

To ensure complete and accurate data collection and to document the data collection process, a variety of quality control procedures have been developed for this survey. This section describes procedures to be followed by you and the radiology consultant.

5.1.1 Automated System

Each entry keyed into the system should be carefully reviewed before continuing on to the next screen. If any entry error is noted after the transaction has been completed, record the error on the hard copy log and notify the MEC manager.

5.1.2 Hard Copy Exam Form

After completing a hard copy exam form, review the form for accuracy and legibility before the SP leaves the x-ray area.

5.1.3 Hard Copy of the Daily X-Ray Log

After filling in information on the hard copy of the X-Ray Daily Log, the technician should review the log for completeness, accuracy and legibility before the SP leaves the room so that missing information can be retrieved, if necessary. The technician should make the following checks:

On all pages, see that:

- All appropriate items/columns have been completed;
- No conflicting information has been entered; and
- All entries are legible.

5.2 Review, Observations and Replications

The MEC physician will review all x-rays for both technique and abnormal findings. If the MEC physician has any questions about technique he/she may request a retake of the view. Abnormal findings will require an expedited reading by the contract radiologist. Films will be flagged and express mailed to be read on a high priority basis by the radiologist.

Ongoing review of all x-ray films by the contract radiologist will provide continuous feedback on individual technicians' techniques.

The radiology consultant will periodically observe a sample of x-rays taken by the technician. Using an observation checklist, the consultant will observe whether all appropriate x-rays were taken, whether the procedures for the taking of the x-rays were strictly followed, including the position of the SP and position of the x-ray equipment for each part of the body being x-rayed. Any deviation from standard procedures will be noted by the consultant, as well as any problems that arise.

Variations in procedures and problems will be reviewed with the technician at the end of the day. If problems or other issues are considered to be serious by NCHS or the radiology consultant, retraining will be scheduled.

The radiology consultant will also review a sample of the X-Ray Daily Log Sheets for completeness and accuracy.

Since it is impractical to ask an SP to submit to two complete x-ray sessions by two technicians, replicate x-rays may be conducted on the dry run at the beginning of a stand.

5.3 Refresher Sessions

Refresher sessions may be periodically scheduled to update the technicians on the x-ray procedure or changes in protocol.

6. SAFETY PROCEDURES

Due to the fact that overexposure to x-rays can have serious detrimental side effects, all suggested protective procedures and precautions will be taken in NHANES III to protect the SP's and the technicians.

6.1 Protection of the Examinee

For the NHANES III, the SP will be protected from unnecessary radiation during the x-ray examinations by certain design features of the x-ray equipment and by specially fabricated auxiliary apparatus.

6.1.1 Equipment and Apparatus Design

Those features of radiographic and fluoroscopic equipment that are designed to reduce SP dose will also reduce technologist exposure. This aspect of radiation control has been kept in mind when considering SP protection.

6.1.2 Filtration

For the NHANES III, a minimum of 2.5 mm A1 equivalent total filtration will be used on radiographic tubes operating above 70 kVp. The purpose of this filtration is to reduce the amount of low-energy radiation (soft x-rays) reaching the SP. Since only penetrating radiation is useful in producing an x-ray image, nonpenetrating soft radiation is absorbed and contributes only to SP dose and not to the radiographic image. In general, the higher the total filtration, the lower will be the SP dose.

6.1.3 Collimation

Collimation is extremely important in SP protection and will be utilized as part of the NHANES III. The x-ray beam will always be collimated to the region of anatomic interest. The larger the useful x-ray beam the higher will be the examinee dose. Restricting the x-ray beam by collimation reduces not only

the volume of tissue irradiated but also the absolute dose at any point because of the accompanying reduction in scatter radiation. Reduction of scatter radiation also contributes to increased image quality by increasing radiographic contrast.

6.1.4 Specific Area Shielding

In specific area shielding, part of the primary beam is absorbed during the examination by shielding a specific area of the body. Gonad shielding is a good example of specific area shielding and will be applied in the NHANES III with the use of contact shields or a lead apron. Shielding will be used at all times that an examinee is being x-rayed in the MEC.

6.1.5 Image Receptors

The speed of an image receptor can greatly influence examinee dose. Newly developed rare earth screens in conjunction with matched photographic emulsions show relative speeds of up to twelve times of that for a conventional calcium tungstate screen-film combination. Rare earth screen-film combinations that will reduce examinee dose to one fourth will be used in the NHANES III with no loss of diagnostic information. Higher examinee dose reductions are possible, but the quality of the image would be compromised somewhat by radiographic noise.

6.1.6 Radiographic Technique

Good radiographic technique tends to produce a quality image while reducing the examinee dose. Ideally, the higher the voltage the lower will be the examinee dose. This is so because of the inverse relationship between voltage and current. However, as voltage is raised and the current lowered, the image contrast is reduced thus possibly reducing the acceptability of the exposure. For example, mammography could be done at far lower examinee doses if the operating voltage were increased. However, the radiographic contrast would be very poor and the image would contain less diagnostic information. In general, the highest practicable voltage with an appropriately low current will be employed in all examinations.

6.1.7 Exposure Limitation

More than two x-rays in each position are not taken on any one SP. The taking of extra films should occur very rarely. All repeated films for an examinee are placed in the x-ray jacket. If more than one film per position is taken for an SP, the radiologist will select the best one to evaluate.

6.2 Protection of Technician - Equipment and Apparatus Design

Particular safeguards and attention will be exercised by technicians during x-ray sessions.

6.2.1 Protective Apparel

A leaded apron and gloves will be available with each MEC unit and will be used whenever the technician takes an exposure and is not behind a protective barrier.

6.2.2 Protective Barriers

During radiography the technician will be positioned behind the control booth barrier which contains lead.

6.2.3 Personnel Monitoring

Perhaps the single most important aspect of a radiation control program is a properly designed personnel radiation monitoring program. Three types of radiation measuring devices are used as personnel monitors -- pocket ionization chambers, film badges, and thermoluminescent dosimetry badges.

The film badge will be the device used in NHANES III. The design of the film badge has undergone many refinements; and it can measure not only the quantity of radiation but also the type of radiation, the approximate energy, and the direction. Consequently it is very important that such a monitor be properly handled and worn.

Each shipment of personnel monitors will be accompanied by a control badge. The control badge will be stored in a location distant from any radiation source. Individual radiation monitors will not leave the MEC. The badge will be worn unshielded, at the collar region. New badges will be required every three months. When the new ones are received, the used badges will be returned to headquarters for evaluation.

6.2.4 Pregnant Technicians

Should the health technician become pregnant during the field period of the study, it will be her responsibility to inform the MEC manager when she discovers or suspects that she is pregnant. The pregnant technologist will be provided with a second radiation badge with instructions to wear it at waist level. The radiation monitoring report associated with this badge will reflect that it is a fetal dose monitor.

6.3 SP Movement and Positioning

The technician must be aware of the SP's condition positioning him or assisting him onto the gurney. In many cases, this will dictate the positioning technique used. The SP may not be able to achieve a certain position; consequently, the technician will have to use good judgment and common sense to get the radiograph while at the same time making the SP as comfortable as possible.

6.4 Emerging Procedures

All SP emergencies should be handled as discussed in the Standardized Procedures. Equipment failures and emergencies should be immediately reported to the MEC manager and biomedical engineer.