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Simple QC Test Tools for Diagnostic Radiology

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SIMPLE QC TEST TOOLS FOR DIAGNOSTIC RADIOLOG

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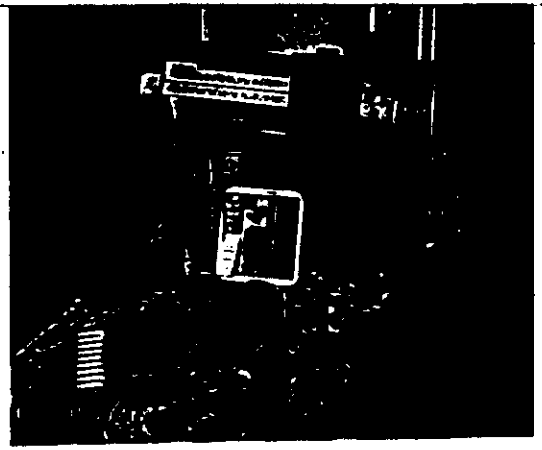
INTRODUCTION

A set of diagnostic radiology Quality Assurance test tools:

- Intended for developing countries
- Low cost (total materials cost approximately $200)
- Simple design, for use by radiographers
- Now undergoing field tests
- Additional test tools under development

QC TEST TOOLS BEING USED IN COSTA RICA



TESTS WITH MULTIPURPOSE PHANTOM

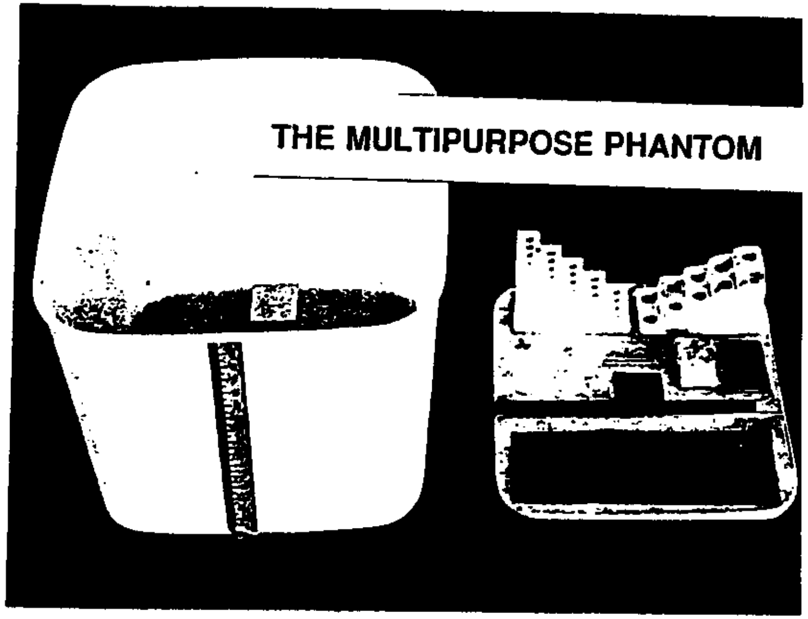
- Image quality (qualitative and quantitative) for:
  - * radiography
  - * fluoroscopy
  - * mammography
  - * angiography
- QC tests for conventional tomography
- Focal spot size test

TESTS WITH OTHER TOOLS

- Accuracy of the timer
- Accuracy of the set kVp
- Consistency of the output for standard exposure conditions
- Consistency of film + screen + processor, for standard conditions
- Grid alignment
- Film-screen contact

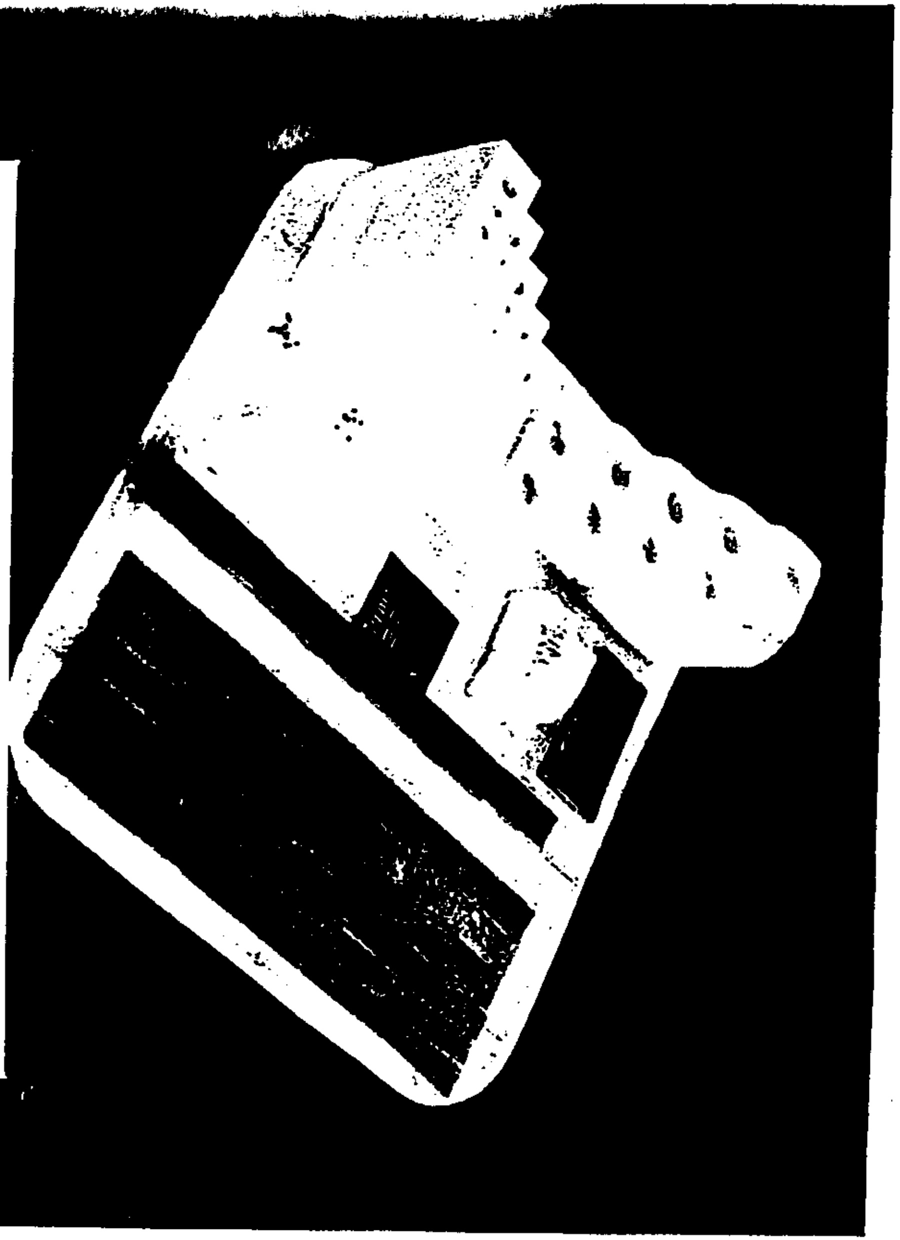
Test requiring no special tools:

- Collimator accuracy, including light/radiation coincidence.



THE MULTIPURPOSE PHANTOM

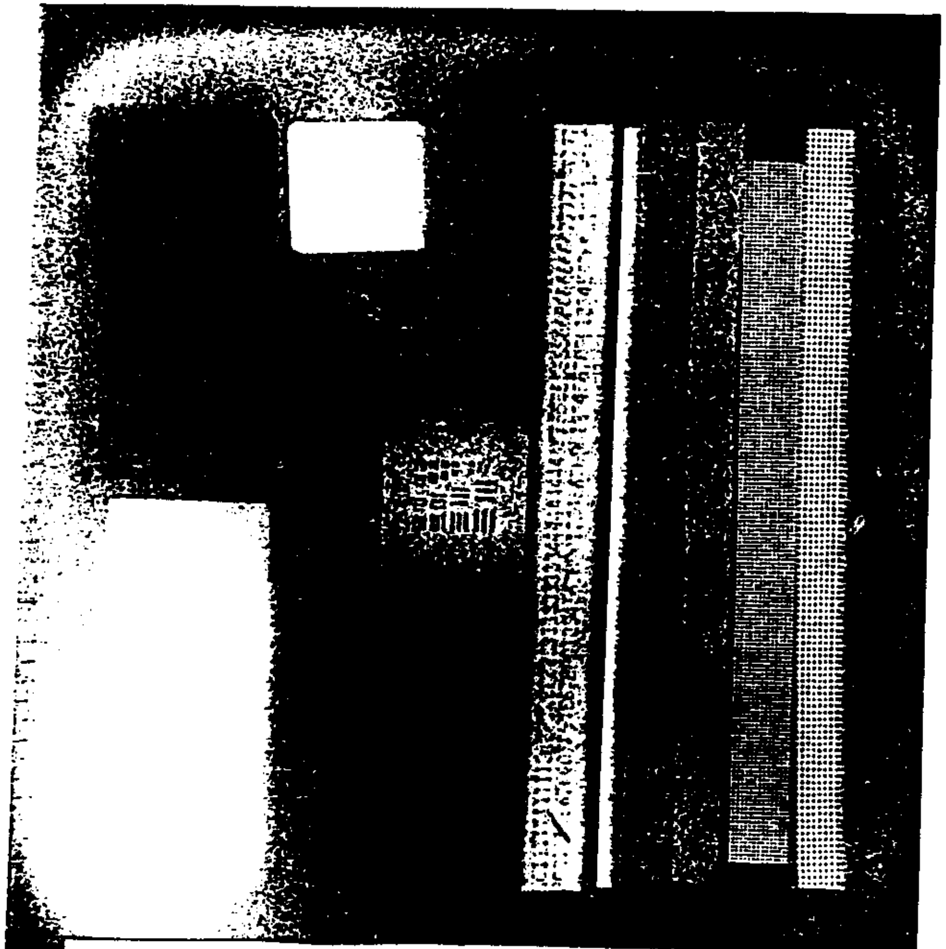
Measurements of image quality are made using the multipurpose phantom. The test objects are mounted on a plastic sheet that fits inside the eight liter plastic container, to which water is added to adjust "patient thickness".



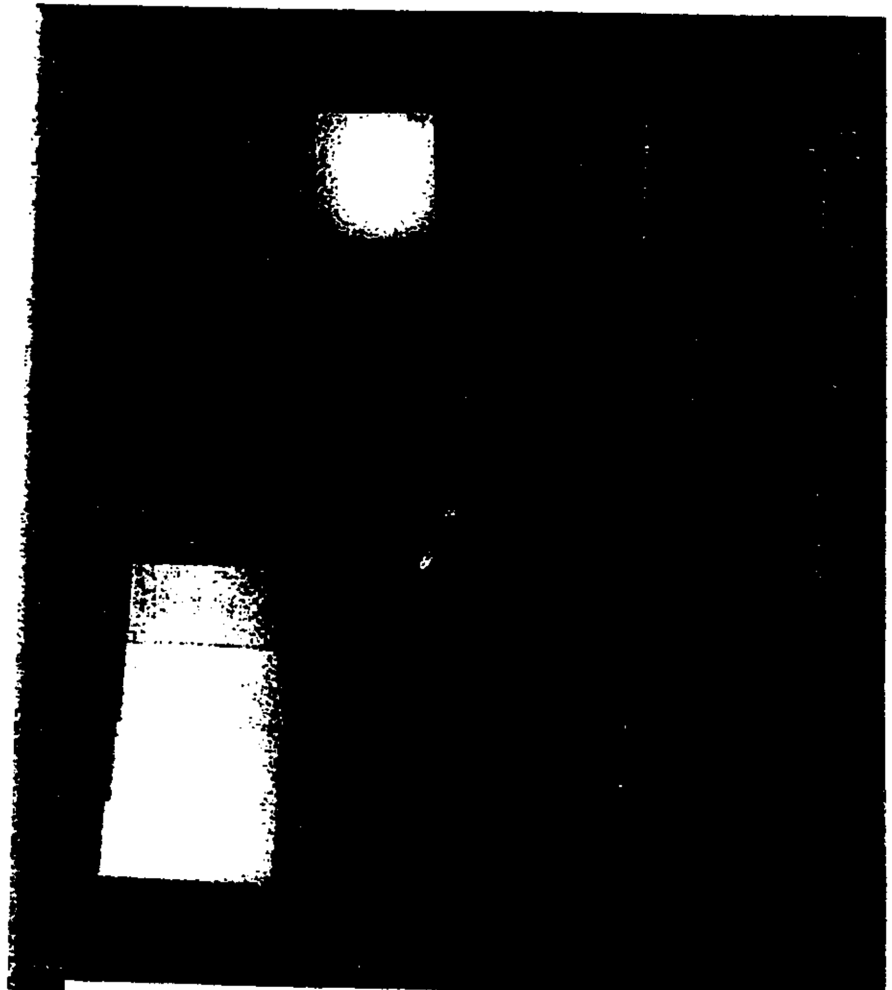
TEST PLATE FOR THE MULTIPURPOSE PHANTOM

THE MULTIPURPOSE PHANTOM INCLUDES:

- "Bone" step wedge with four holes in each step
- "Lung" step wedge with two holes in each step
- "Arteries" with contrast, four concentrations
- Human vertebra to demonstrate trabecular bone
- "Fat" cylinders, three sizes
- "Microcalcifications", four sizes
- "Fibrils", three sizes
- Lead block as weight and base + fog measurement
- "X-RITE" scale and steel rod for tomo tests
- Copper mesh, 4-6 sizes for fluoro and tomo tests
- Scale on container to measure "patient thickness" (water depth)
- Focal spot size test pattern



X-RAY IMAGE OF PHANTOM
(10 CM H_2O, 55 kVp, 10 mAs, 100 cm FFD)

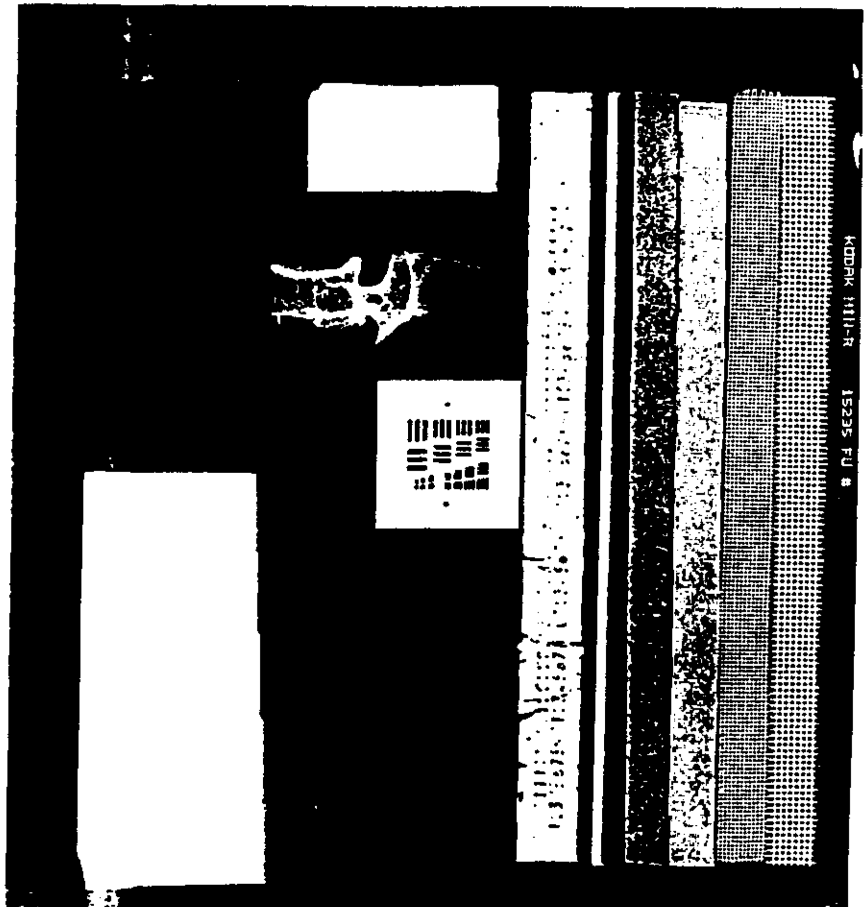


X-RAY IMAGE OF PHANTOM
(15 CM H_2O, 55 kVp, 10 mAs, 100 cm FFD)

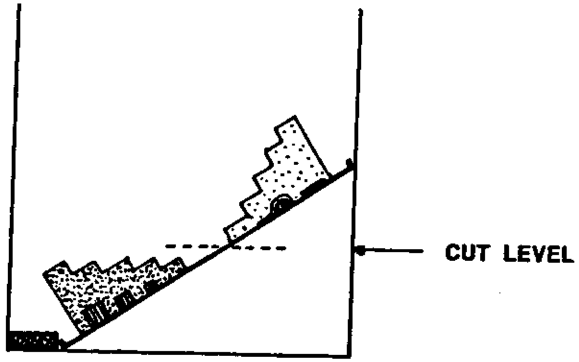
MAMMOGRAPHIC IMAGES

The mammographic test objects include "fat" (low density polyethylene cylinders), "microcalcifications" (Al_2O_3 grains) and "fibrils" (nylon filaments), each in a range of sizes.

30 kVp, 20 mAs, 70 cm FFD (no water)



30 kVp, 260 mAs, 70 cm FFD (3 cm water)



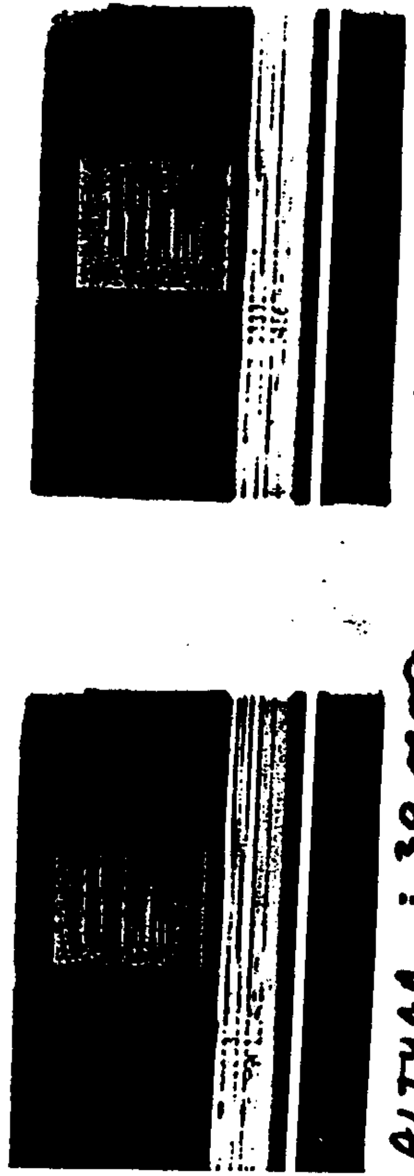
USE OF THE PHANTOM FOR QC OF CONVENTIONAL TOMOGRAPHS

The test plate is tilted so that "80" on the "x-rite" scale is 80 mm above the table. The travel of the x-ray source should be perpendicular to the ruler. The desired cut level is selected and an exposure is made. The center of the readable numbers indicates the height of the cut. The thickness of the cut is indicated by the total numbers that are clearly readable. The resolution at the cut is determined by observing the smallest wire mesh that is distinct. The steel rod produces a fan pattern that indicates the angle of the tomo motion.

SALA #7 17-3-88

20 mAs 70 KVP 0.8 Fino

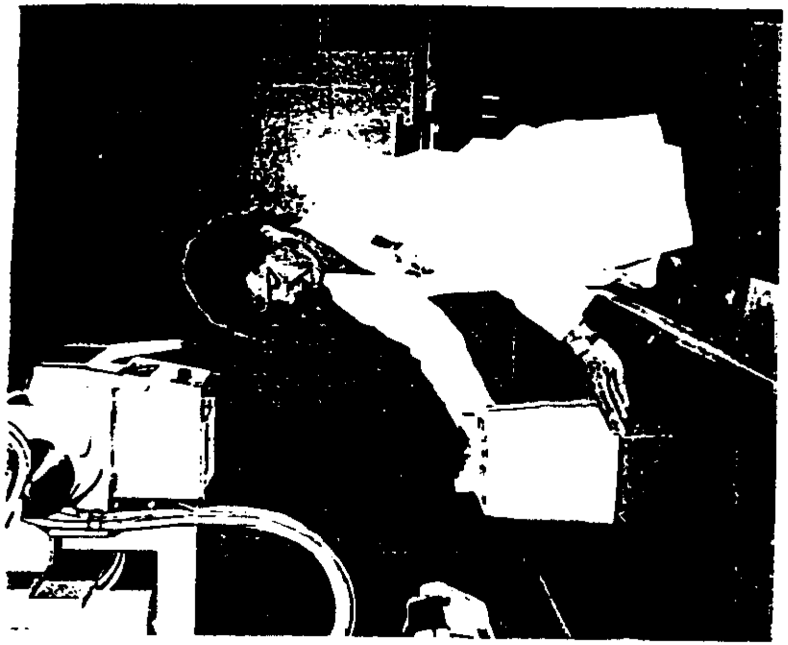
Pavera #1



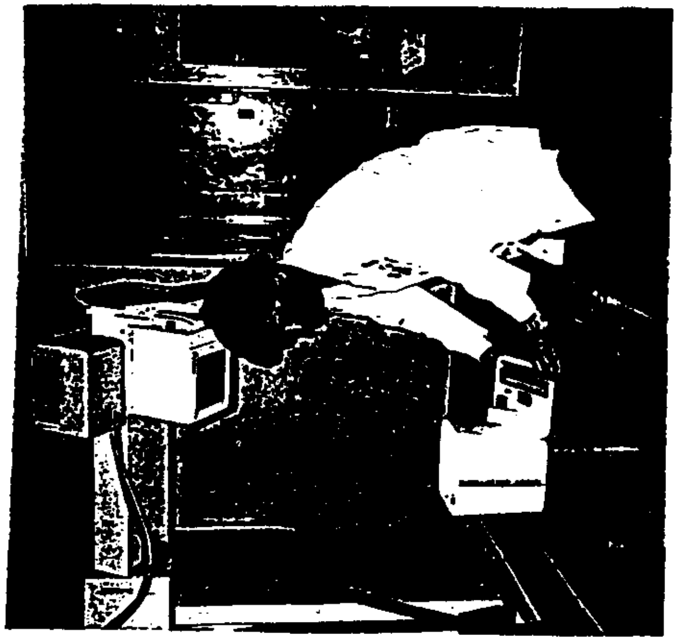
ALTURA: 30 mm. RESULTADO: 30 mm.

ALT.: 35 mm. RESULTADO: 35 mm.

X-RAY IMAGE TAKEN WITH A TOMOGRAPHIC UNIT
(Note: direction of tomo motion would be better if it were perpendicular to that used here.)



SETUP FOR FOCAL SPOT SIZE TEST



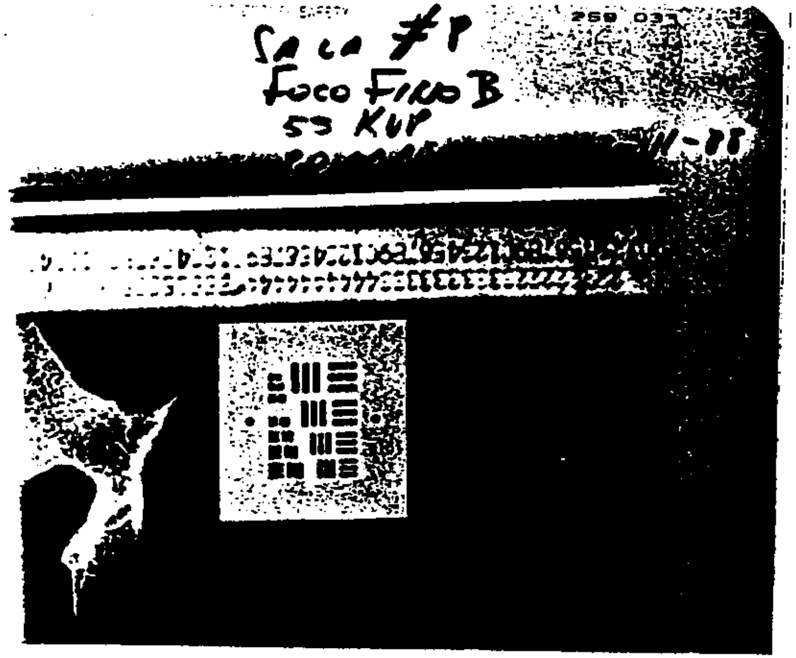
DEMONSTRATING TILT ANGLE FOR TOMOGRAPHIC TESTS
(for incorrect direction of motion, as in x-ray image)

FOCAL SPOT MEASUREMENT

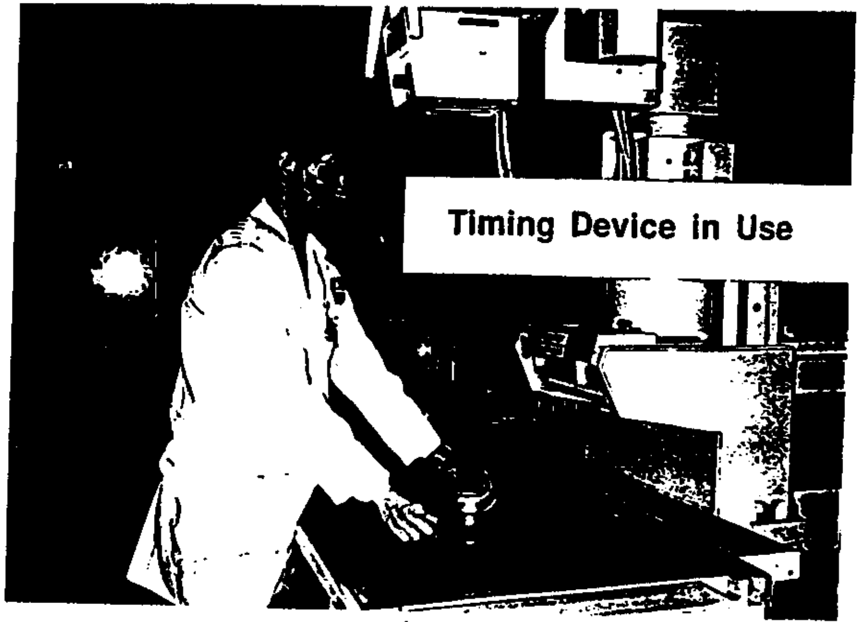
The user obtains a magnified image by placing the test plate on top of the inverted plastic container between the x-ray source and the nonscreen film.

The image is magnified. The user measures the distance between the two dots on the image, which are 2.0 cm apart on the test object. (In this image they are 2.7 c m apart.) The user does not need to use particular distances for the exposure nor determine the magnification.

The user determines the smallest pattern in which all six bars can be resolved (pattern #6 in this case, #1 is largest), selects the column in the calibration table corresponding to the dot separation (2.7 cm in this case), and reads the effective focal spot size.



X-RAY IMAGE FOR FOCAL SPOT MEASUREMENT

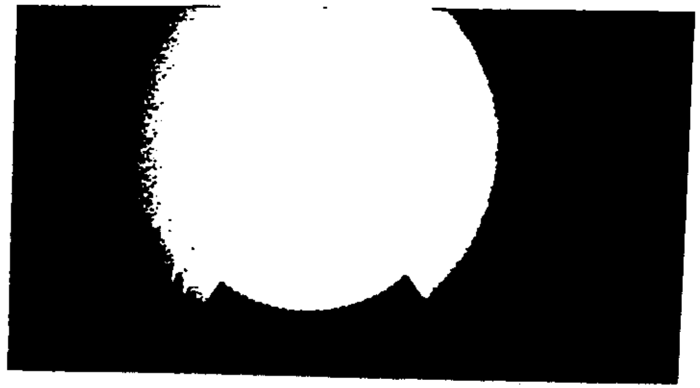


Timing Device in Use

TIMING DEVICE

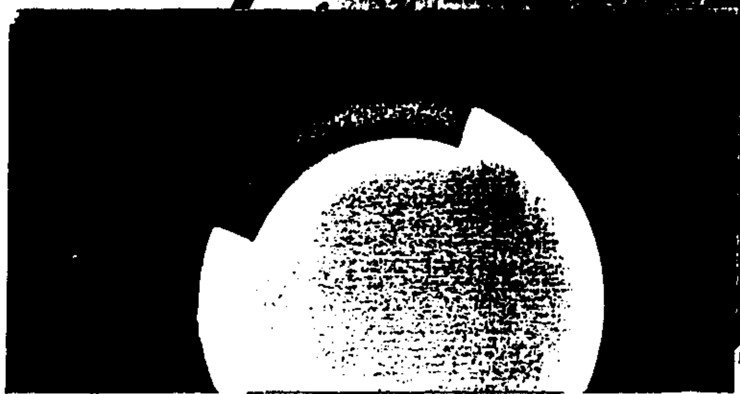
Exposure time is checked by means of a slit in a disc rotating at one revolution per second. A 360° protractor is included to determine the fraction of a second. In single phase units it is simpler to count the number of pulses in the image to determine the exposure time.

The image from a three phase unit should appear so uniform that it is not possible to count pulses. However, if one phase is defective, the non-uniformity indicates a defective voltage waveform (see examples).



Single Phase:
(24 pulses)/(120 pulses/s) = 0.20s

Malfunctioning Three Phase:
(65°)/(360°/s) = 0.18 seconds
(the set time was 0.2 s)



Normal Three Phase:
(85°*)/(360°/s) = 0.24 seconds
(the set time was 0.2 s)

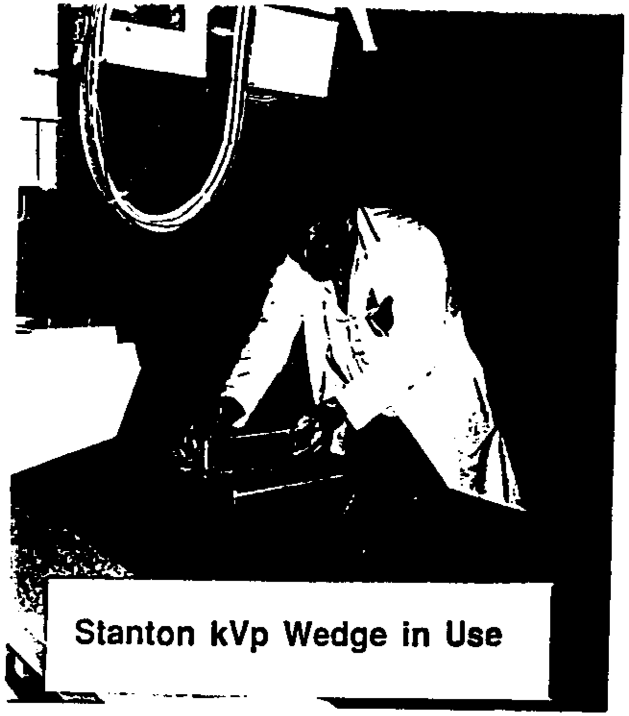
*It would be more accurate to subtract the width of the slit (about 2°); not doing so introduces less than 0.01s error. The correction should be used for very

WORK IN PROGRESS: INEXPENSIVE DOSIMETER

A dosimeter is necessary for both output and HVL measurements. (The constancy check of the film processor also requires knowledge of output constancy.) Two dosimeters are under development. Both types produce a voltage at the output terminals that can be measured with the simple digital voltmeter provided.

A. An electret dosimeter was used in the first kits. A teflon electret is charged with an inexpensive ion "gun", its charge is measured with an inexpensive electrometer before and after the exposure. The decrease in charge is a measure of the exposure. The determination of the dose required the understanding of more physics than we felt was desireable. A dosimeter that appears better suited is described below. The electret dosimeter can be made very sensitive to detect scattered radiation.

B. A diode dosimeter is now being developed. It has a pair of photodiodes, so that with appropriate absorbers (and calibration) it can also be used as a kVp meter.



Stanton kVp Wedge in Use

STANTON KVP WEDGE

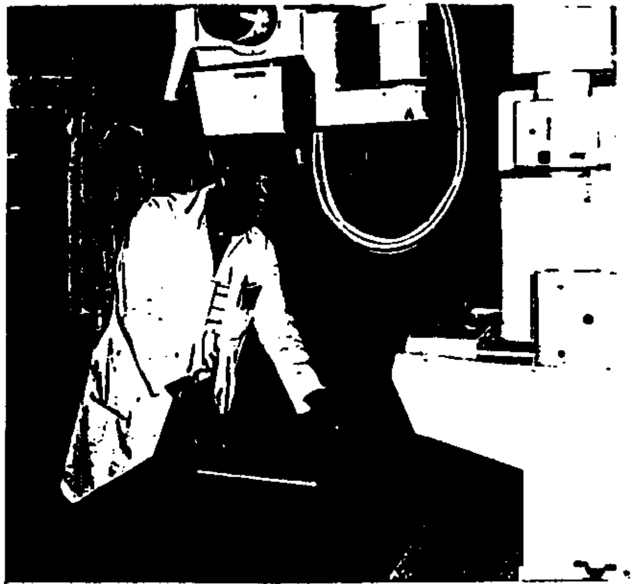
The measurement of kVp is done using a hardened X-ray beam to expose a Cu step wedge next to a thick layer of low density polyethylene, and finding the step whose film density matches the density under the polyethylene.[1] A calibration curve is provided. The technique is simple and reliable. The unit measures from 50 kV to over 100 kV.

1 Modified from the penetrameter described in: Thomaz Ghilardi and John Cameron, Med. Phys. 12 (2), 259-260.

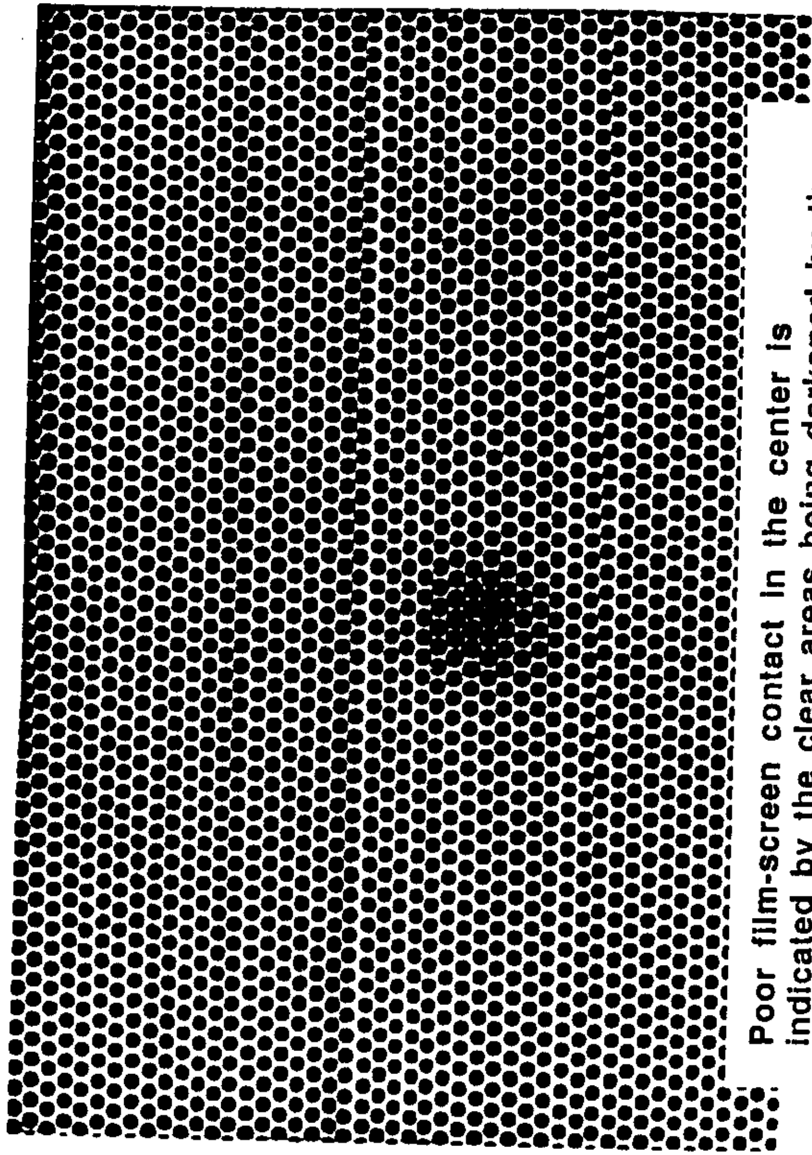
Stanton kVp Wedge Images
(set value: 60 kVp, set value: 70kVp)
(measured: 59 kVp, measured: 73kVp)

FILM-SCREEN CONTACT DEVICE

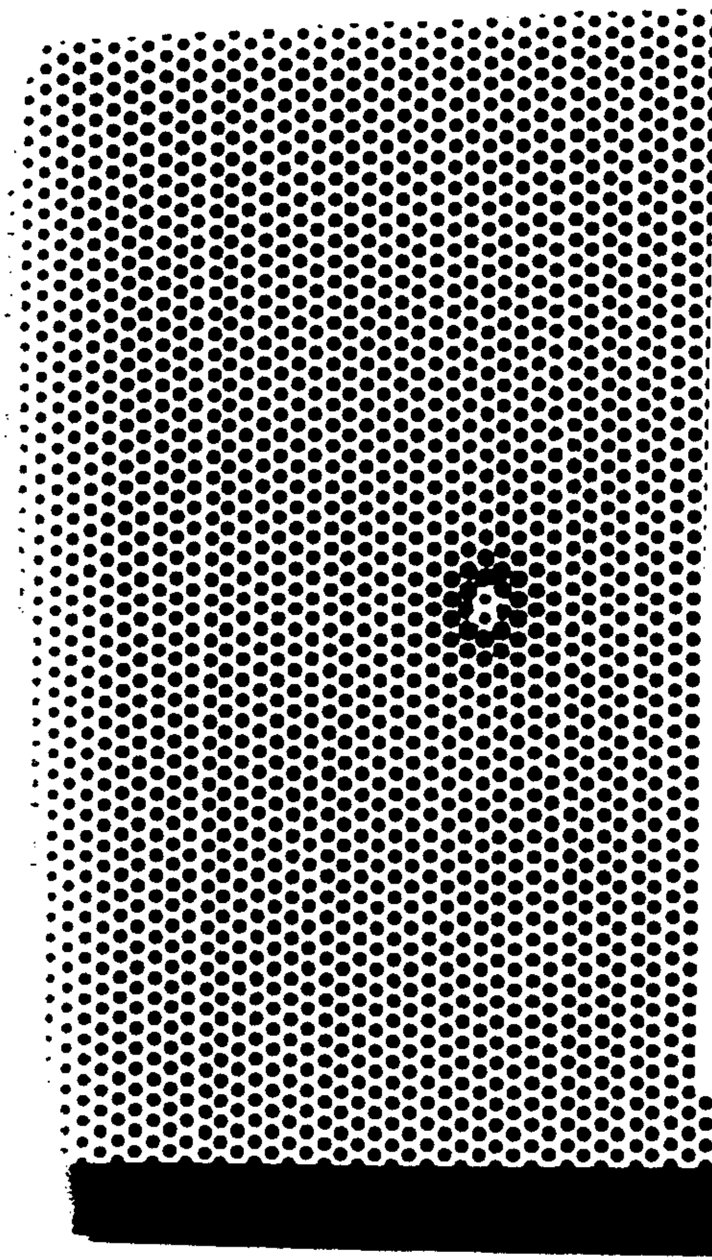
A perforated brass sheet is laid on the cassette; the clear areas around the holes are darkened by scattered light in the areas of poor contact. This technique is superior to the commonly used wire mesh.



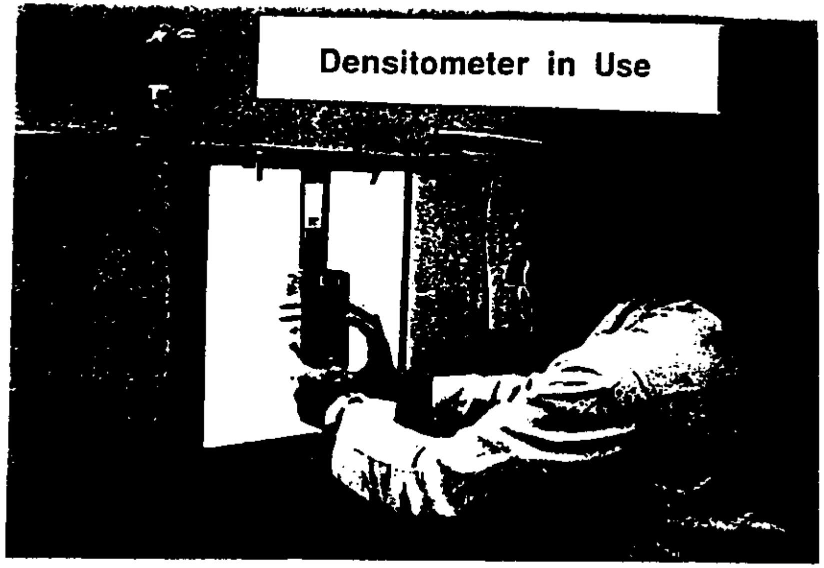
Film-screen contact device in use



Poor film-screen contact in the center is indicated by the clear areas being darkened by the scattered light.



The screen is defective near the edge. The reduced density indicates a lack of response which is abnormal. This was a new screen that had not been tested when it was received. In the center a piece of paper was placed between film and screen to demonstrate the effect of this type of artifact.



DENSITOMETER

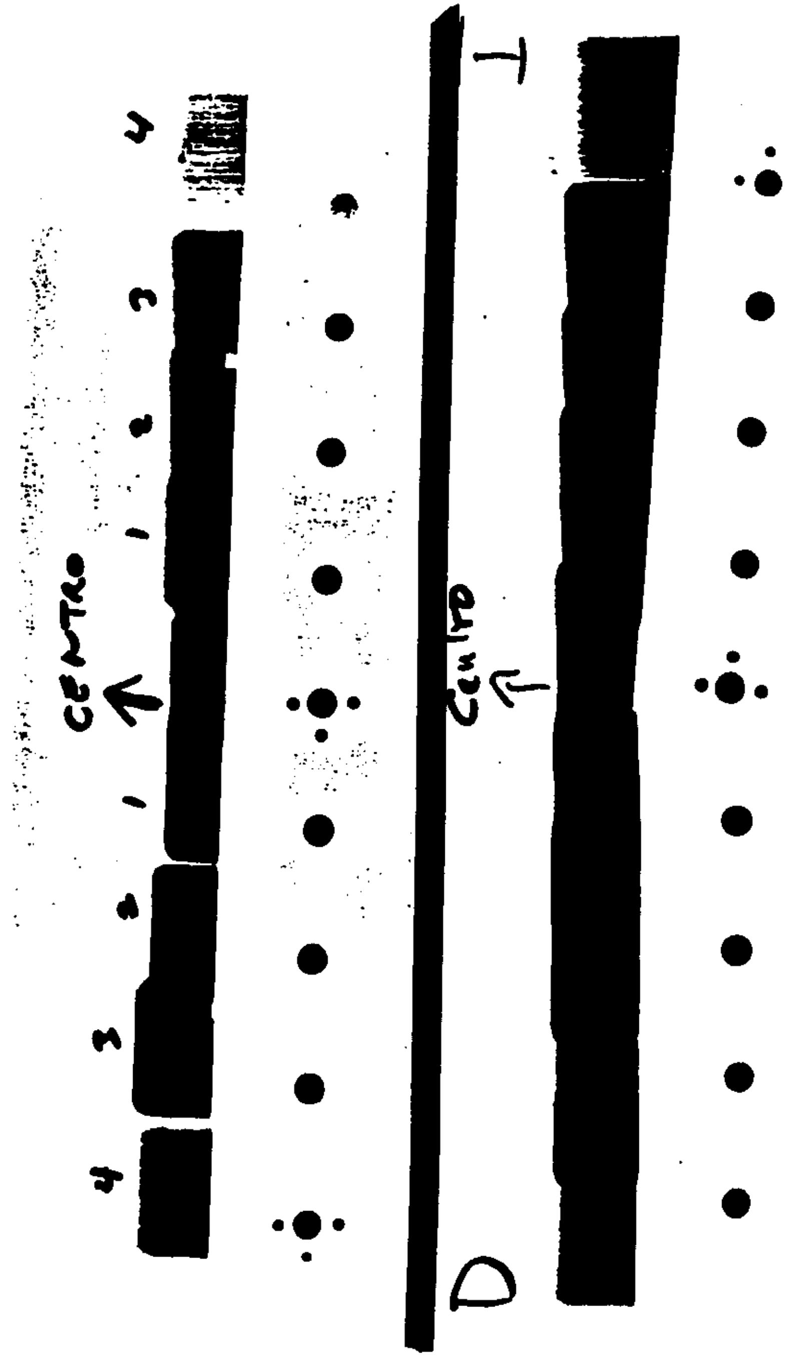
An optical densitometer is necessary for checking film processor constancy, as well as with the Stanton kVp wedge (described above). For many purposes it is not necessary to use the optical density as only relative densities are needed. However, a calibrated optical density step wedge is provided.

A photodiode extends from the end of the dosimeter box. An ordinary viewbox is used as the light source; the output is read in mV which can be converted to optical density using the calibration strip.

GRID ALIGNMENT TOOL

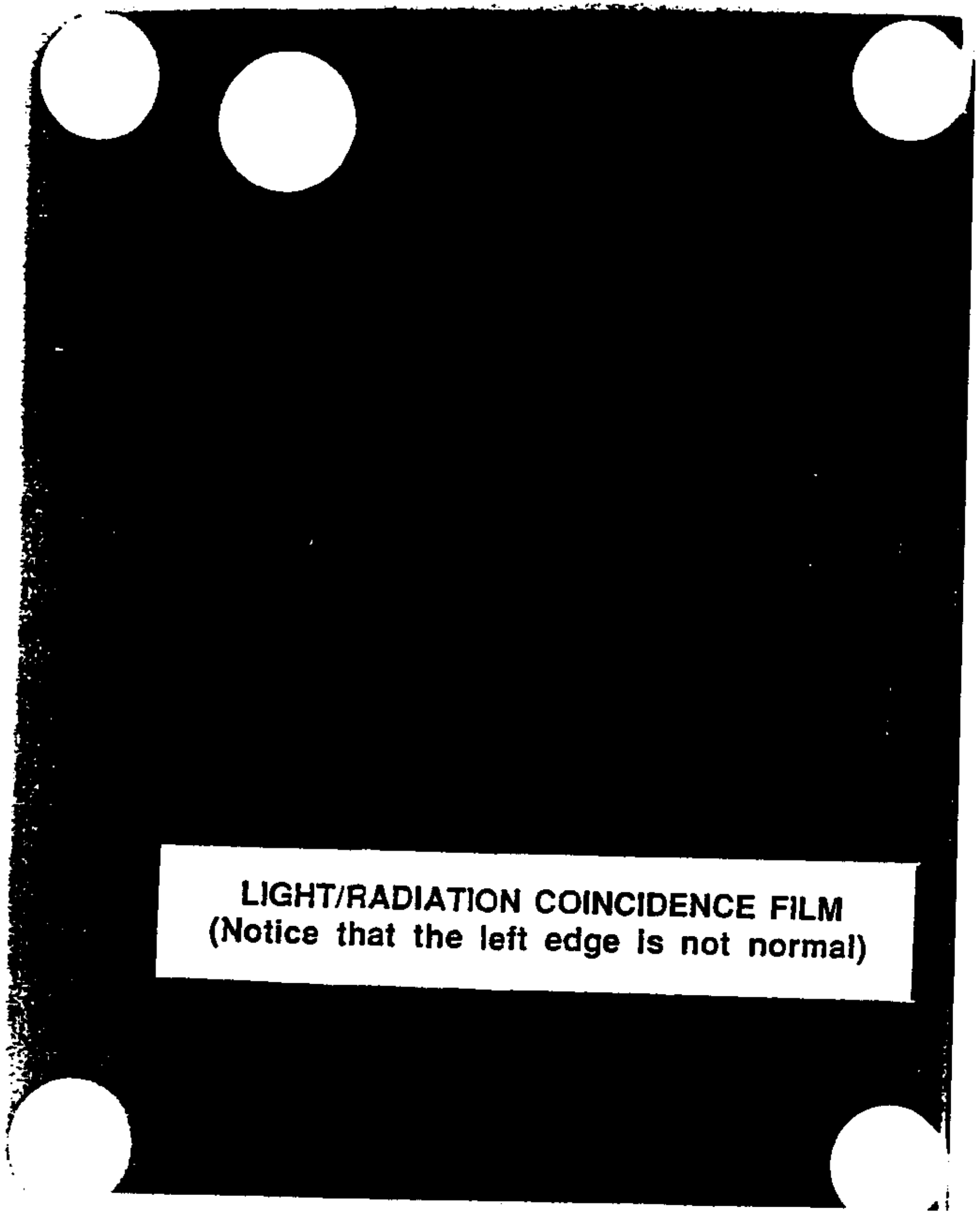
Multiple exposures are made, with the center of the x-ray tube placed in turn over each of several holes in a lead absorber while the other holes are covered.[2] The optical densities of the hole images are measured. For proper grid alignment, the greatest density is in the middle.

2 A commercial version is available from RMI.



X-RAY IMAGES USING GRID ALIGNMENT DEVICE
Upper: Grid center is to left of cassette center.
Lower: Same table, after repair
(8 mAs, 50 kVp, D=100cm)

Sala 5 Tubo 2. 19-9-88



LIGHT/RADIATION COINCIDENCE FILM
(Notice that the left edge is not normal)

OTHER ITEMS IN THE QC SET

The complete set also includes:

- An inexpensive digital multimeter, to measure the output from the dosimeter and the densitometer and for general laboratory use.

- A pocket calculator, preprogrammed to do standard deviations. This is important in checking the consistency of the output.

- An aluminum step wedge for film+screen+processor checks.

- Two lead sheet absorbers, for collimation with the timer and the Stanton kVp wedge and with the grid alignment tool.

- Instructions on how to use all items, including procedures for testing collimation and checking light/radiation coincidence.

FIELD TRIALS

Most of the items described here are being field-tested at four major hospitals in San Jose, Costa Rica by radiographers. They attended a two day QC course in January, 1988 given by P. Mora and J. Cameron. The radiographers have had several meetings with P. Mora since the course to evaluate their progress.

To date the results have been encouraging but a thorough evaluation of the field test will be made at the end of one year. The major complaint of the radiographers is the lack of time to make the QC tests.

Most of the sample films shown here were exposed in Costa Rica; as can be seen, several problems were found.

CONCLUSIONS

- Simple and inexpensive tools for the most common QC needs of diagnostic radiology are described. They appear to have a useful role in developing countries that are short of both money and medical physicists.

- Radiographers (x-ray technologists) can use these tools with a brief training course.

- With suitable encouragement, a QC program can be maintained in third world hospitals. The attitude of the radiologist(s) is important.

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