X-ray image intensifier

An **X-ray image intensifier** (XRII), sometimes referred to as a *C-Arm* or *Fluoroscope* in medical settings, is a highly complex piece of equipment which uses x-rays and produces a 'live' image feed which is displayed on a TV screen.

The term image intensifier refers to a special component of the machine, which allows low intensity x-rays to be amplified, resulting in a smaller dose to the patient. The overall system consists of an x-ray source, input window, input phosphor, photocathode, vacuum and electron optics, output phosphor and output window. It allows for lower x-ray doses to be used on patients by magnifying the intensity produced in the output image, enabling the viewer to easily see the structure of the object being imaged. They were introduced by Philips in 1955.

Clinical Applications of An Image Intensifier

An image intensifier or *II* is used in two ways:

• As a fixed piece of equipment in a dedicated screening room
• Mobile Equipment for use in theatre

Components of an Image Intensifier System

• C-Arm (encompasses the actual X-ray source and Image intensifier)
• Table
• Radiographic exposure and program controls
• Post processing software
• Viewing monitors

A Fixed Screening Room: Philips MultiDiagnost Eleva

Fixed Image Intensifiers

These are used in most x-ray departments as 'screening rooms'. The types of investigations for which this machine can be used for is vast. Examples include:

• Barium Studies (Swallows, Meals, Enemas)
• Endoscopy Studies (ERCP)
• Fertility Studies (HSG)
• Angiography Studies (Peripheral, Central and Cerebral)
• Therapeutic Studies (Line placements i.e. *Permacath / Hickman*, Transjugular Biopsies, TIPS Stent, Embolisations)
• Cardiac Studies (PTCA)
• Orthopedic procedures (ORIF, DHS, MUA, Spinal work)
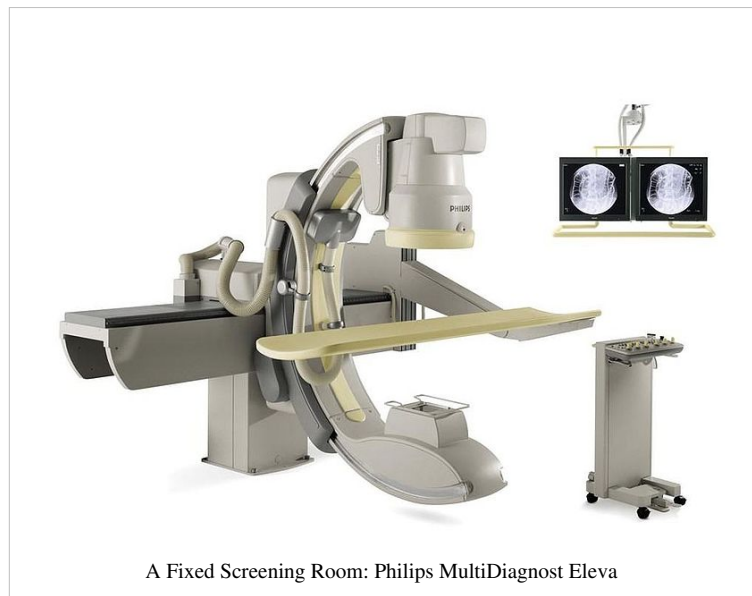
Mobile Image Intensifiers

General Configuration and range of movements

A mobile image intensifier generally consists of two units, the intensifier unit and the television or workstation unit. The intensifier unit consists of a C-arm with a variety of movements that allows for use in a variety of surgical procedures such as cardiology, orthopedics and urology. The C-arm has an image intensifier and an x-ray tube positioned directly opposite from each other. The c-arm is capable of many movements:

- Horizontal travel: about 200 mm
- Orbital travel: about 115 degrees
- Motorized vertical travel: 460 mm
- Wig-wag about +/-12 cm (entire C-Arm and Image Intensifier)
- C-arm rotation about the horizontal axis +/- 210 degrees

The c-arm must be compact and lightweight to allow easy positioning with adequate space to work around and a wide range of motion.

Workstation unit

Much of the operation of the machine is from the workstation unit. This has the following features:

- Various handles for movement and positioning
- Power switch and exposure switch
- Cable hanger
- Brake Pedal
- Controls for radiographic and fluoroscopic settings
- Various interconnect cables
- Hard disk and optical disk writer/rewriter
- DVD R/RW
- PACS system connection allowing access to patient information, annotation,
- Advanced image quality enhancement software such as noise reduction, zoom control
- Ability to save and swap images between monitors
- Contrast and brightness controls
- May have one or dual 17 inch or larger monitors
- Advanced image processing such as noise reduction

Types of x-ray Tube

Two types of x-ray tube may be fitted, fixed anode or rotating anode. Typical features of fixed anode tubes include:

- Typical anode heat capacity load 30,000 - 50,000 heat units
- Single or dual focused anode, with 0.5 by 0.5 mm focal spot for fluroscopic applications and

1.8 by 1.8 mm focal spot size for radiographic applications.

- The angle on the anode target of about 12 degrees.

Typical features of rotating anode tubes include:

- 0.3 mm focal spot for better image detail
- Typical anode heat rating of 300 000 heat units for longer exposure times
- Allows for a longer tube life

The housing also has a heat storage limitation, typically 1200-1250kHU
[1] [2]

Electronic Capabilities

The images can be manipulated in many ways on the computer screen. Examples of this are:

- Cine loop replay- Allows review of a dynamic scene without extra dose
- Cine Loop editing- Shorter loops can be made over review of a dynamic scene
- 16 Picture overview- For quick overview.
- Zoom- Fast magnification.
- Relative stenosis measurement- Can measure the distance of two vessels for vasuclar procedures.
- Test Annotation- To label all images

Generator and range of exposures

Modern systems use a digital high frequency generator with typically 20,000 cycles per second. The range of kVp settings may be from 40kV to 110kV. The tube current is typically 0.1mA to 6mA for fluoroscopy examinations. For radiographic mode the mA is fixed at about 20mA to 60mA. mAs values vary from 0.16 to 160 for radiographic application. The electronic timer varies from 0.1sec to 4.0sec for radiographic exposures.

Image intensifiers, size and features

They may be fitted with a range of different types of image intensifiers; typically 16 cm or 22 cm.

Typical specifications for a 16 cm intensifier are:

- Maximum resolution is 44 lp/cm at the centre of the screen.
- Anti-scatter grid of 8:1, focused at 90 cm.
- Removable cassette holder that is mounted on the image intensifier and holds a 24X30 film.
- Rotation 360 degrees

Typical specifications for a 22 cm intensifier are:

- Resolution is 44 lp/cm at the centre of the screen.
- Magnification mode - allows a maximum resolution of 51 lp/cm at the centre of the screen
- Stationary anti-scatter grid 10:1, focused at 90 cm.
- Removable cassette holder that is mounted on the image intensifier and holds a 24X30 film.
- Rotation 360 degrees

Flat Detectors - Image Intensifier Replacement

Flat Detectors are currently offered by Ziehm Imaging [3] and Philips Medical Philips Medical [4]. The Flat Detector (FD) will replace the Image Intensifier. The advantages of this technology include lower patient dose and increased image quality because the x-rays are always pulsed, and no deterioration of the image quality over time.

Type of TV camera and coupling to II

Older machines may have a vidicon type pickup tube, with direct fiber-optic coupling to the image intensifier. Modern machines may have a CCD camera.

Radiation safety features

- Last image hold, "freezing" the screen and availing for examining the screen without exposing the patient to unnecessary radiation.[5]
- Pulsed fluroscopy
- Single pulse fluroscopy mode
- Manual mode in order to reduce dose (ALARA)
- Fluoroscopy timer warning
- Movements of II allow distance between patient and image detector low, so therefore reducing dose to patient.
- Beam limitation devices to minimize beam area

Special features

- Real time viewing
- Remote control keypad
- Removable cassette holder, for both fluroscopy and plain film images

- Contrast correction
- Zoom
- Edge enhancement
- Digital subtraction
- Wheels fitted with cable deflectors

3D Imaging

Used for CT like imaging in the operating theatre environment.

- 3D Navigation
- Checking post surgical screw placement

See

- Ziehm Imaging [3]
- Siemens Medical [6]

Potential radiation safety issues

Failure of the x-ray beam collimation may lead to primary beam x-ray exposure outside of the image intensifier housing, potentially irradiating personnel. If the c-arm or fittings are damaged, the x-ray tube and intensifier may become misaligned, also leading to the potential for direct irradiation of personnel.

Technical Capabilities

Image intensifiers are usually set up for two purposes. For either plain fluoroscopy or digital subtraction angiography (DSA). All image intensifiers are set up with software capable of adjusting settings to suit different user requirements, depending on the procedure and body area being imaged. In simple flouroscopy for example, imaging of the throat would not require the same amount of exposure as that of the abdomen. And on DSA capable models, preset programs are available which enables the user to decide a rate of how many images or frames per second are acquired.

Future Developments

- Flat Panel
- Dual Head
- Low Dose Imaging
- Flat Detector currently offered by Ziehm Imaging [3] and Philips Medical Philips Medical [7]. The Flat Detector (FD) will replace the Image Intensifier. The advantages of this technology include lower patient dose and increased image quality because the x-rays are always pulsed.

External links

- Toshiba Medical Systems Europe [8]
- Ziehm Imaging [3]
- Philips Medical [9]
- Siemens Medical [6]
- GE Healthcare [10]
- Neutron [11] Australian C-arm Specialists
- An interactive experience of Imaging Departments [12]
- C-Arms: Strong Arm [13]
- Pain Management C-Arm information and services [14] Amber Diagnostics
- [15] NY State Society of Radiologic Sciences

- NEW and Remanufactured C-Arms for Pain Management [16] Integrity Medical Systems, Inc.

References

[1] OEC-DIASONICS, series 9400, date: 12/1991

[2] Product Brochure, Philips Medical Systems

[3] http://www.ziehm.com

[4] http://www.medical.philips.com/main/products/xray/products/c_arms/veradus/index.wpd/

[5] walterrobinson.com > Last Image Hold Feature (http://www.walterrobinson.com/images/Walt_PPT/ppt_pres/sld044.htm) Retrieved on April 3, 2010

[6] http://www.medical.siemens.com/

[7] http://www.medical.philips.com/main/products/xray/products/c_arms/veradius/index.wpd/

[8] http://www.toshiba-europe.com/medical

[9] http://www.medical.philips.com/uk/

[10] http://www.gehealthcare.com/uken/index.html

[11] http://www.neutron.com.au

[12] http://www.goingfora.com/radiology/index.html

[13] http://www.medicalimagingmag.com/issues/articles/2004-01_04.asp

[14] http://www.amberusa.com/c-arms/index.asp

[15] http://www.nyssrs.org

[16] http://www.integritymed.com

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