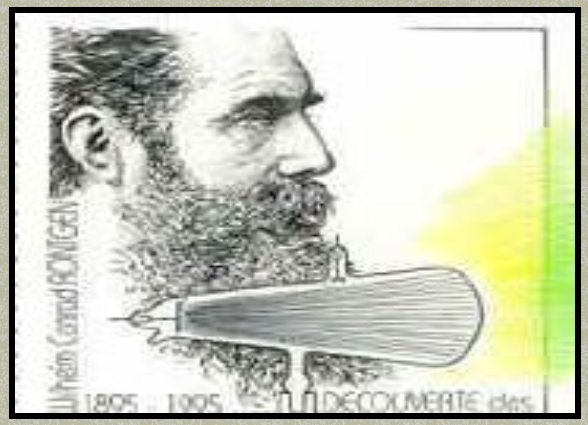
HISTORY OF RADIOLOGY AND DENTAL RADIOLOGY

DR. NIKHIL DIWAN
MDS-I

DISCOVERY OF X-RAYS

THE DISCOVERY

- Friday, November 8th,1895.
- Prof. Wilhelm Conrad Roentgen, inadvertently discovered x-rays while studying cathode rays.
- Element of luck and scientific insight led to the discovery.



HISTORY OF RADIOLOGY

AN OVERVIEW

1770

- JEAN ABBE NOLLET studied high tension discharges.
- used iron chains which carried high potential to evacuate glass vessels.
- "Electric egg" - direct descendant of the discharge tube.

1785

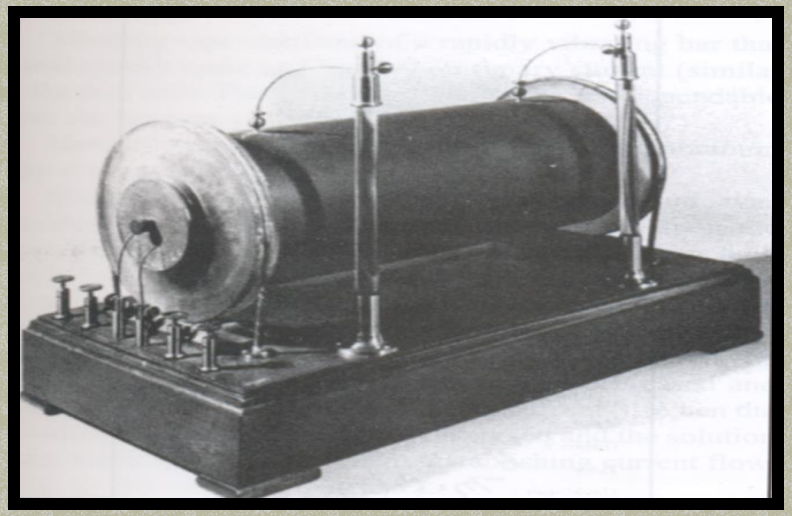
- SIR WILLIAM MORGAN.
- Investigating discharge of high tension currents in perfect vacuum.
- First man to produce x-rays while studying current.

1785

- SIR WILLIAM MORGAN.
- Investigating discharge of high tension currents in perfect vacuum.
- High vacuum – no discharge.

1831

- MICHAEL FARADAY described electromagnetic induction.
- N.Tesla constructed high tension coils and Rhumkorff modified it as convenient source of intermittent high voltage.



1831

- MICHAEL FARADAY proposed voltaic arc was accompanied by fluorescence of gas- Fourth State of Matter.

1838

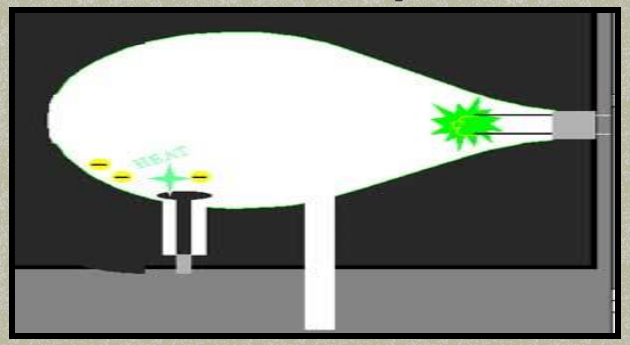
- HEINRICH GEISSLER improved von Guericke's tube and supplied to JULIUS PLUECKER who worked on cathode rays.
- Observed that discharges had magnetic field.

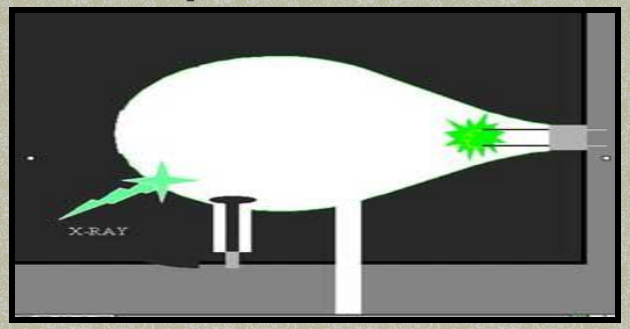
1869

- JOHANN WILHELM HITTORF improved vacuum pumps.
- Observed that fluorescent discharge increased in size as the tube was evacuated.
- Identified the source as cathode and coined the term cathode rays.

1880

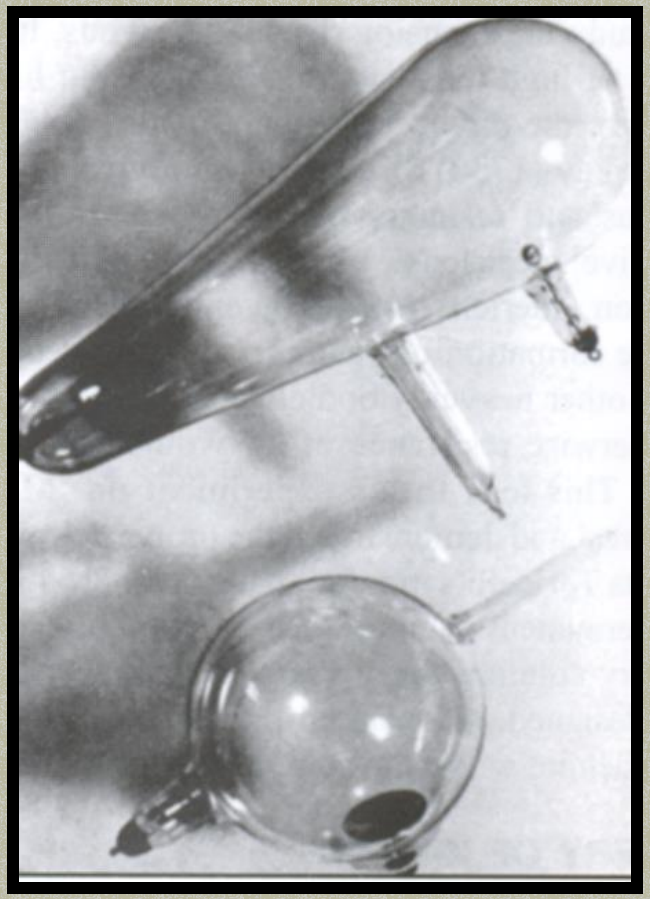
- SIR WILLIAM CROOKES.
- Cathode rays have momentum and energy and were streams of charged particles.
- Referred to a molecular and emissive ray which was noticed as causing fog and blackening on freshly opened photographic plates.
- Indirectly referred to x-rays.





1880

Redesigned
HITTORF
CROOKES tubes



1880

- PHILIP LENARD.
- used pentadecyl paratolyketon as fluorescent material.
- LENARD RAYS – cathode rays as passed beyond discharge tubes causing fluorescent screens to glow.

1880

- PHILIP LENARD.
- proposed "INVERSE SQUARE LAW"- demonstrated effect of Lenard's rays on photographic emulsion with change in distance.

RECOGNITION OF X-RAYS

1895, NOVEMBER 8, FRIDAY

- PROF. WILHELM CONRAD ROENTGEN.
- both the genius of a scientific investigator and the right set of circumstances.

PROF. WILHELM CONRAD ROENTGEN

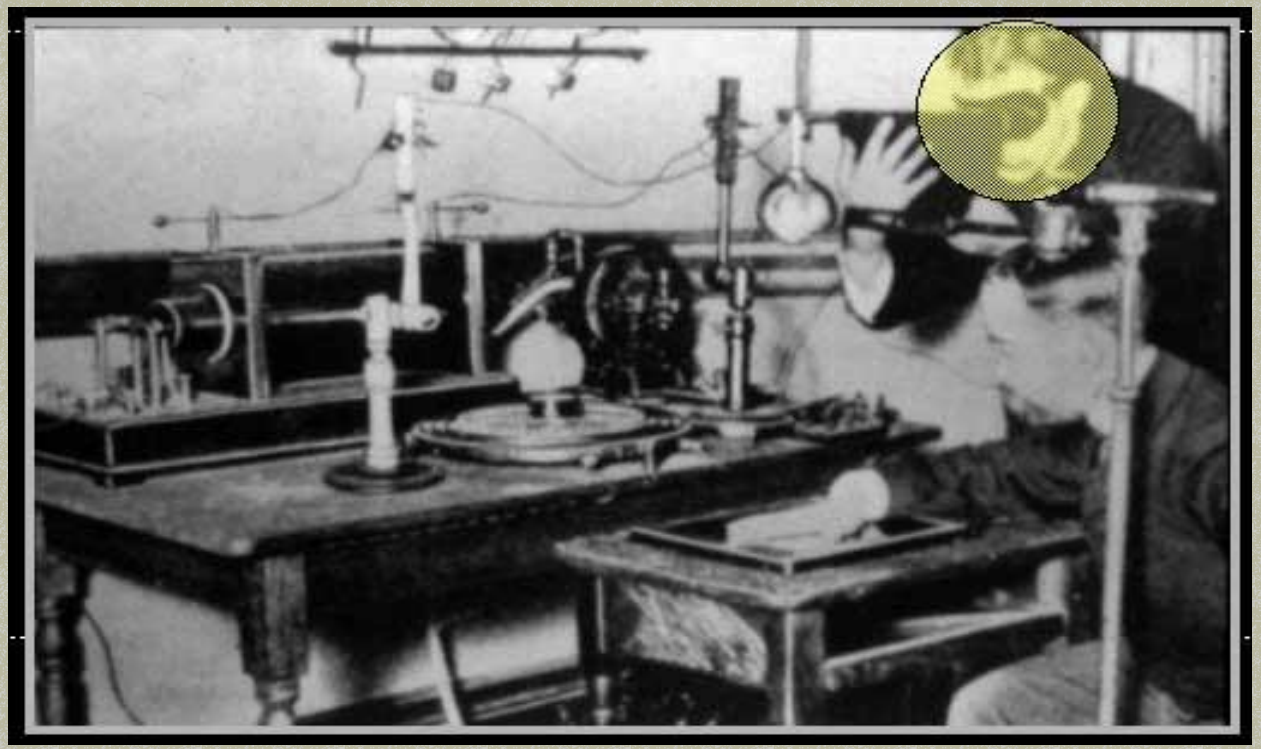
- Born on the Lower Rhine and brought up in the Netherlands
- Physicist from Physical Institute of Julius Maxmillan University of Wurzberg, Bavaria.

1895, NOVEMBER 8, FRIDAY

- ROENTOGEN was studying invisible light rays emanating from Hittorfs Crookes tube by enclosing it in heavy black paper.

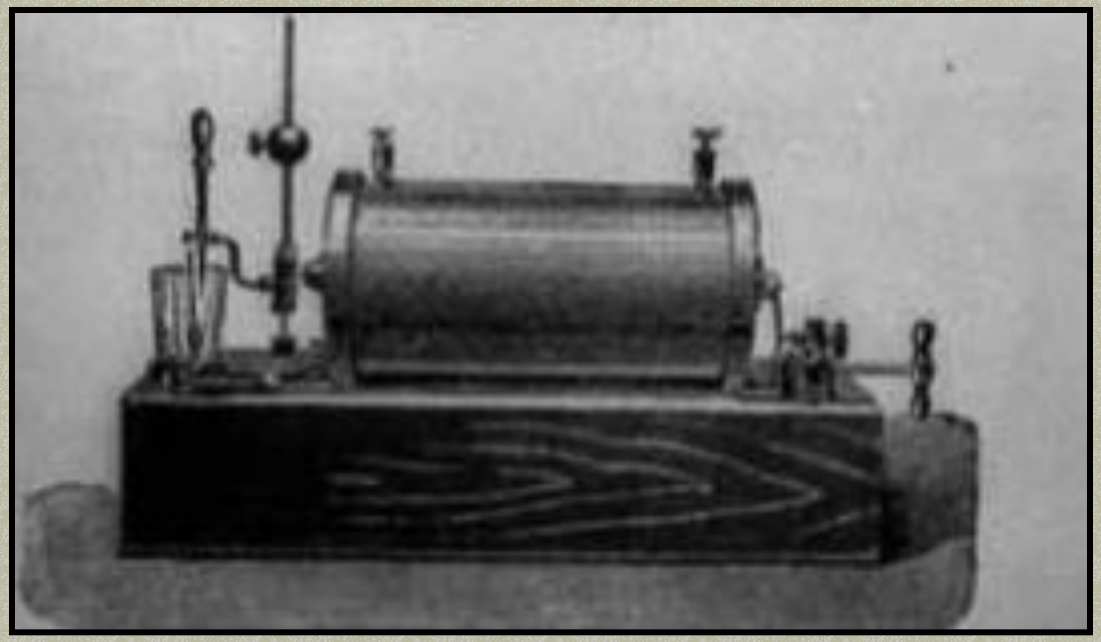
1895, NOVEMBER 8, FRIDAY

THE EXPERIMENT

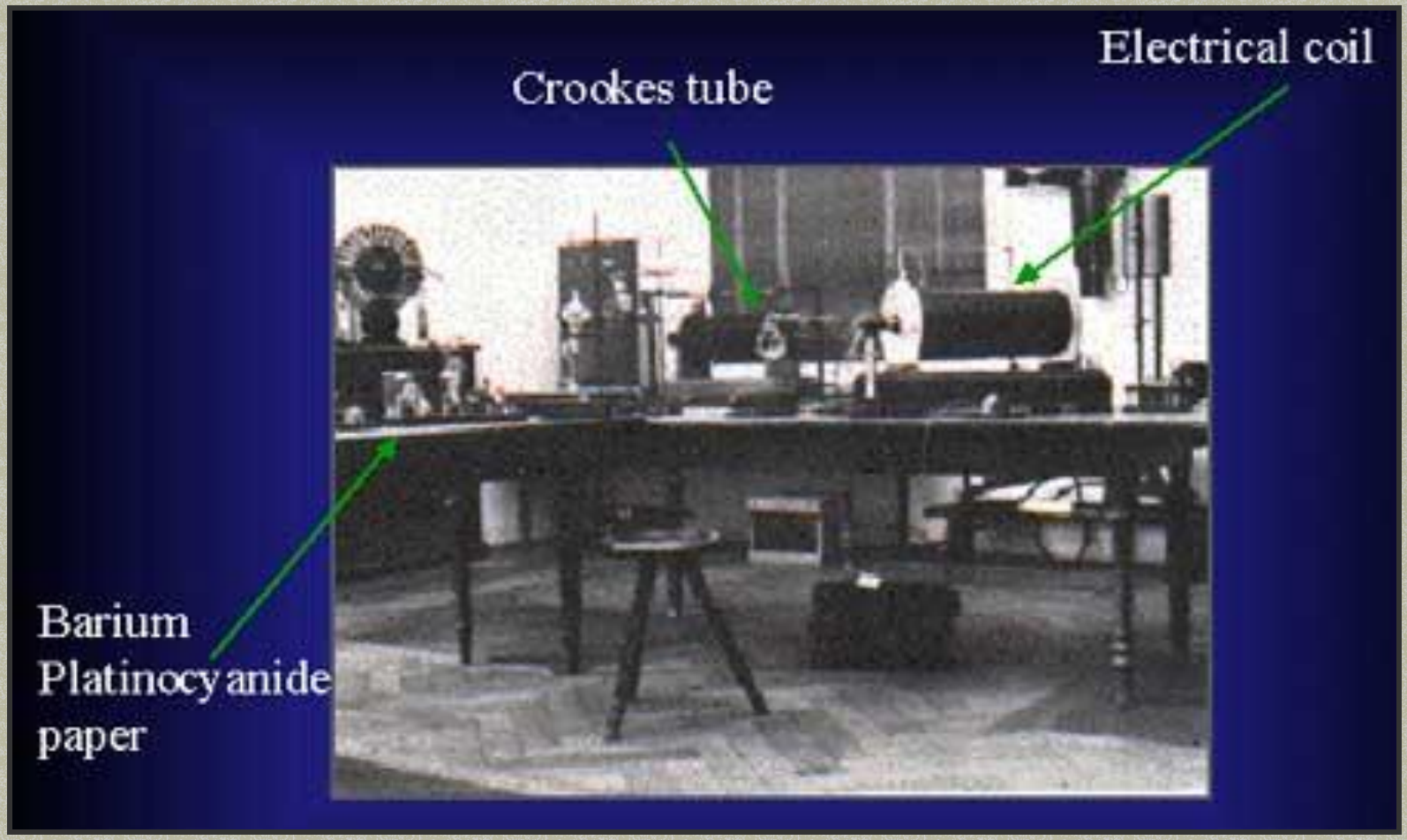


1895, NOVEMBER 8, FRIDAY

- Applied power to electrodes with a Rhumkorff induction coil.



1895, NOVEMBER 8, FRIDAY



1895, NOVEMBER 8, FRIDAY

- To his surprise he noticed a faint glow on a table some distance from the tube.
- Roentgen realized that the distance between the tube and the screen was well beyond(6 to 8 cm)that the cathode rays could be detected. He quickly realized that he was observing a new form of energy.

1895, NOVEMBER 8, FRIDAY

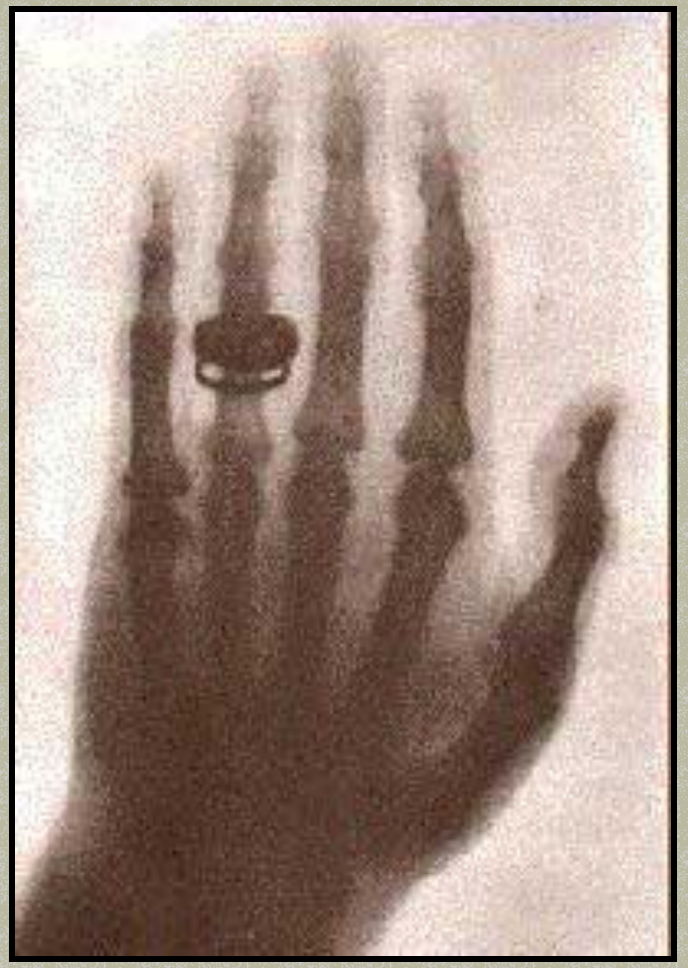
- He unintentionally placed his hands between the tube and a screen.
- The observations of faint but startling image of the bones of his hand was the beginning of radiology.

PROF. WILHELM CONRAD ROENTGEN

- Encountered with "x-rays" while studying cathode ray emissions.

PROF. WILHELM CONRAD ROENTGEN

- 15 min exposure time.
- First radiograph
- of MRS. BERTHA
- ROENTGEN'S hand.



“A VAGUE PREMONITION OF DEATH.”

MRS. BERTHA ROENTGEN

INITIAL RESPONSE

- Roentgen was vilified for inventing a machine that could see through women's dresses.

PUBLICATIONS

PUBLICATIONS

- *A NEW KIND OF RAYS – A PRELIMINARY COMMUNICATION*
- December 28,1895, Wurzburg Physical Medical Society.

PUBLICATIONS

- *2. A NEW KIND OF RAYS – CONTINUED*
- March 9,1896. Wurzburg Physical Medical Society.

PUBLICATIONS

- *3. FURTHER OBSERVATIONS ON A KIND OF NEW RAYS*
- March 10,1897. Journal of Prussian Academy of Sciences, Berlin.

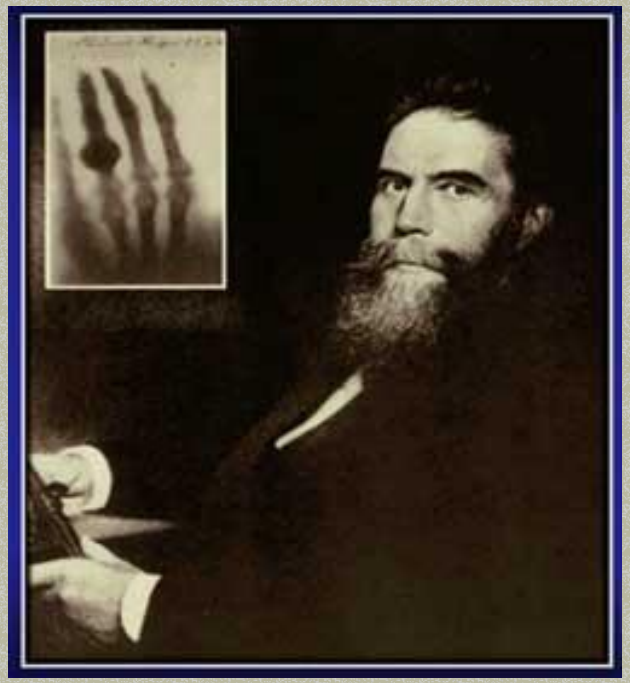
HONOURS CONFERED

- FIRST NOBLE PRIZE IN PHYSICS – 1901.
- M.D. DEGREE –MAXMILLAN UNIVERSITY IN WURZBURG.
- RHUMFORD GOLD MEDAL OF THE ROYAL SOCIETY.
- IRON CROSS FROM HINDENBURG
- OTHER AWARDS.

PROF. WILHELM CONRAD ROENTGEN

- First industrial radiograph- Roentgens shotgun

PROF. WILHELM CONRAD ROENTGEN



1855-1923
DIED OF
CANCER

PROF. WILHELM CONRAD ROENTGEN

- Roentgens studies appeared in America and Europe and advertisements announced businesses in Roentgen photography with appointments being made for x-ray sittings.

DEVELOPMENTS IN DENTAL RADIOLOGY

DENTAL USE OF X- RAYS

February, 1896

- Prof. WILHELM KOENING in Frankfurt.
- Made 14 radiographs.

February 1896.

- DR.OTTO WALKOFF, Dentist in Brunschweig, Germany and FRIEDRICH GIESEL (radiochemist).
- Made a radiograph of his molars
- Required 25 min. exposure.
- In April 1896, demonstrated the technique to German dentists.

DR.OTTO WALKOFF

- Described the discomfort to remain motionless in a dental journal.
- Appeared as silhouettes of teeth on a black background.

January 1896.

- FRANK HARRISON, Dentist in Sheffield, England.
- Dental radiograph using 10 mins.
- X-ray images demonstrating pulp chamber.
- Reported occurrence of radiation injuries in July 1986.

April 24,1896

- WILLIAM J. MORTAN - Physician in U.S.
- Announced at a meeting of New York's Odontological Society
- -radiographs of teeth possible.
- -showed dental radiographs made on skull.

JULY 1896

- DR. C. EDMUND KELLS with Prof. BROWN AYRES, professor in Physics at Tulane University, took first intraoral radiograph on live person using Rhumkorff coil and Hittorf's tube.

DR. C. EDMUND KELLS

DR. C. EDMUND KELLS

- Father of dental radiology.
- Presented first dental clinic to demonstrate use of new rays at the Southern Dental Association meeting in Ashville, North Carolina.

DR. C. EDMUND KELLS

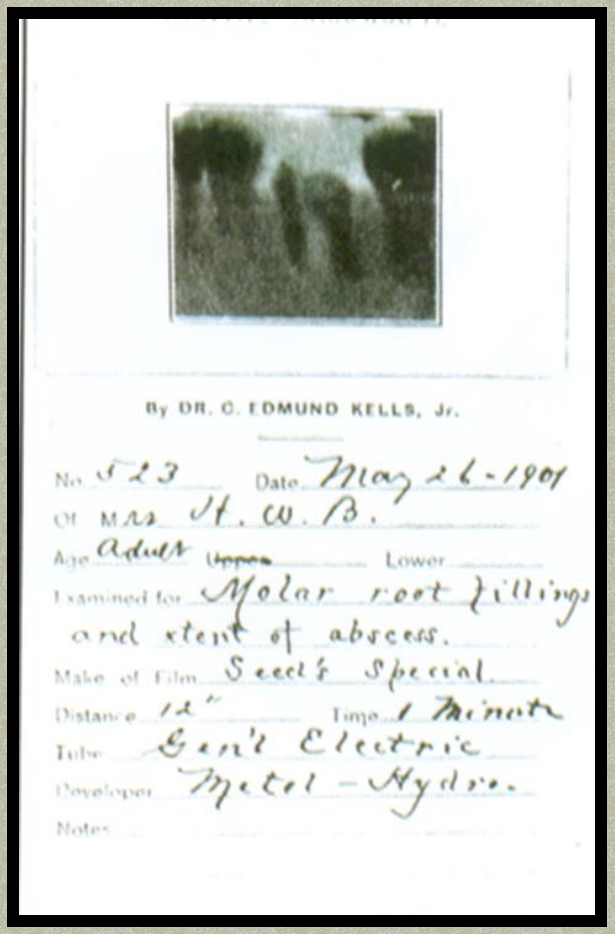
- **Presented first dental clinic to demonstrate use of new rays at the Southern Dental Association meeting in Ashville, North Carolina.**

DR. C. EDMUND KELLS

- Published an article in August 1899 in DENTAL COSMOS mentioning the importance of keeping the object and film at right angles to the source using a film holder

DR. C. EDMUND KELLS

Dental x-ray records made by Kells in 1901



By DR. C. EDMUND KELLS, Jr.

No. 523 Date May 26-1901

Of Mrs H. W. B.

Age Adult ~~Upper~~ Lower

Examined for Molar root fillings and xtent of abscess.

Make of Film Seed's Special

Distance 12" Time 1 Minute

Tube Gen'l Electric

Developer Metol-Hydro.

Notes

DR. C. EDMUND KELLS

- Multiple exposures caused development of several cancers of his hand in 1912.

DR. C. EDMUND KELLS

- Had 35 operations and several amputations.
- Ended his life with bullet in brain on may 7,1928.
- Kells' autobiography, "Three Score Years and Nine," published in 1926.

DR. C. EDMUND KELLS

- Shortly before his death, he wrote his last article from a hospital bed in New York. In it were the following remarks: "Do I murmur at the rough deal the fates have dealt with me? No, I can't do that. When I think of the thousands of suffering patients who are benefited every day by the use of X-ray I cannot complain. That a few should suffer for the benefits of the millions, is a law of nature."

APPARATUS USED BY RADIOCHEMIST

- X- ray machine
- X- ray tube
- Adjustable tube stand
- Darkroom

X- ray Machine

Had three components:

- Induction coil.
- The interrupter or Rheotome.
- The Rheostat.

X- ray Machine

Induction coil-

- Provided potential current to tube.
- Depended upon number of turns between these coils.

X- ray Machine

- INTERRUPTER OR RHEOTOME
- Created rapidly succeeding impulses necessary for constant flow of current.

X- ray Machine

RHEOTOME TYPES:

1. Mechanical type.
   a) Vibrating type.
   b) Mercury type.
2. Electrolytic type.

X-RAY TUBE

- Fixed or stationary vacuum type.
- Quality of beam had to be adjusted.
- Each tube had to be tested for its penetrating qualities.

Testing x- ray tube

1) By observing resistance in the secondary circuit of the transformer

high vacuum - high resistance –

high penetrating x-rays.

low vacuum - low resistance –

low penetrating x- rays.

Testing x- ray tube

- 2) By observing spark across the spark gap-
- - 3 to 4 inches spark- soft x- rays
- - 7 to 8 inches spark- hard x- rays
- - 4 to 7 inches spark- normal x-rays

Testing x- ray tube

- THOMAS ALVA EDISON invented the Fluoroscope- checked by placing operator's hand.
- BECK introduced Osteoscope- checked by placing articulated skeletons hand and forearm.

Testing x- ray tube

- BENOIST RADIOCHROMATOMETER- a penetrometer - measured maximum penetrating power of x- ray beam.
- QUALIMETER - measured the resistance in the secondary circuit of the transformer.
- MILLIAMPEREMETER developed by SNOOK in 1904

X-RAY TUBES

- Focus tubes
- Gas tubes
- Regulator tubes
- Self regulating tubes

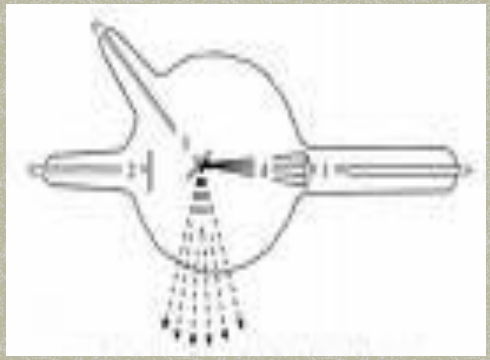
FOCUS X- RAY TUBE

- Designed by SIDNEY ROLAND, REGINALD, A.A. JACKSON.
- Cup shaped cathode.
- Very small platinum anode.
- Anode placed at 45 degrees from cathode rays.

FOCUS X- RAY TUBE

- ADVANTAGES:
- Small anode- sharp pictures.
- Cathode rays on pointed target, so glass wall of bulb would not get overheated.

GAS TUBES



- Gas tube Gang.
- Erratic performance-

  low vacuum- Slow tube- no x-rays emitted

  more vacuum- hard tube- no x-rays radiated
- Had appendix or protuberance with a screw or metal cap.

REGULATOR TUBES

- Introduced in 1896.
- Had elongated side arm.
- Release cap containing potassium carbonate.
- Heated with an alcohol tube to produce gas.

SELF REGULATING TUBES

- Developed by H.L. SAYEN.
- Second pair of electrodes embedded in potassium carbonate which released gas.

SELF REGULATING TUBES

- Vacuum increase- current would arc between electrodes- heating potassium carbonate- released gas.

Setting the tube

- Operator's hand used.
- Conditions adjusted until sharp images of bones cast on screen.

Setting the tube

Prolonged tests resulted in burns to the operator's hand which eventually progressed to malignancy and death.

Vacuum tubes

J. E. LILIENFLED, an Austrian, in 1911, developed a tube based on field current principles.

Operation described as "ticklish".

Leaking of charges on a pointed cathode– LILIENFLED EFFECT.

1912- patent applied.

TRANSFORMERS AND RECTIFIERS

- In 1907,HOMER CLYNDE SNOOK introduced closed core oil bath cooled transformer with mechanical rectifiers.
- Interrupterless transformers- tube operated on both halves of A.C. cycle.
- In 1915, SAUL DUSHMAN developed electronic rectifier- Kenotron.

GOLDEN AGE OF RADIOLOGY

Demise of gas tubes

- IN 1880, THOMAS ALVA
- EDISON described the
- emission of electrons
- from a hot filament-
- EDISON'S EFFECT

Demise of gas tubes

- IRWING D. LANGMUIR, employee of General Electric Co. Research Lab., demonstrated that emission of electrons from a filament can be controlled by varying the current that heated the filament.

Demise of gas tubes

WILLIAM DAVID COOLIDGE- Director of Research Lab at General Electric Co. Developed hot cathode tube.

COOLIDGE TUBE

In 1918, compiling these postulates, Coolidge developed a hot cathode tube using a tungsten coil as source of electrons (cathode)

COOLIDGE TUBE

A leaded glass tube with a lime glass window to serve as a port for the x-ray beam

BETTER THAN LILIENFLD'S HOT CATHODE TUBE

- greater flexibility in the quality and quantity of x-rays produced
- greater tube stability during production of x-rays
- smaller tube size
- longer tube life
- direct operation from a transformer
- Prototype of today's tube

Unsafe dental x-ray setup

SHOCK PROOF DENTAL X- RAY SET UP

- The tube and high voltage component were placed in an oil filled grounded compartment that also acted as a radiation shield.
- The oil served as an electric insulator and a coolant.
- Some of the later models of this machine are still in use today.

X-RAY FILMS

- KELLS ANDROLLINS used photographic film
  advts : adaptibility to tissues
  safety from breakage
- First dental radiograph was on small glass plates
  -Hand made
  -Lacked sensitivity.

1896- WILLIAM J. MORTAN used roll film manufactured by Eastman Kodak co.

X-RAY FILMS

- 1896- WESTON A. PRICE a Cleveland dentist designed a celluloid based film.
- 1913- hand wrapped moisture proof dental x-ray film packet containing two films.

X-RAY FILMS

- 1919– first machine wrapped x-ray film packet called REGULAR FILM from Kodak

  -single emulsion film

  -relatively slow

  -but produced sharp images

X-RAY FILMS

- 1920- cellulose nitrate base used

  -highly inflammable

  -emitted large quantities of poisonous gas on burning.

X-RAY FILMS

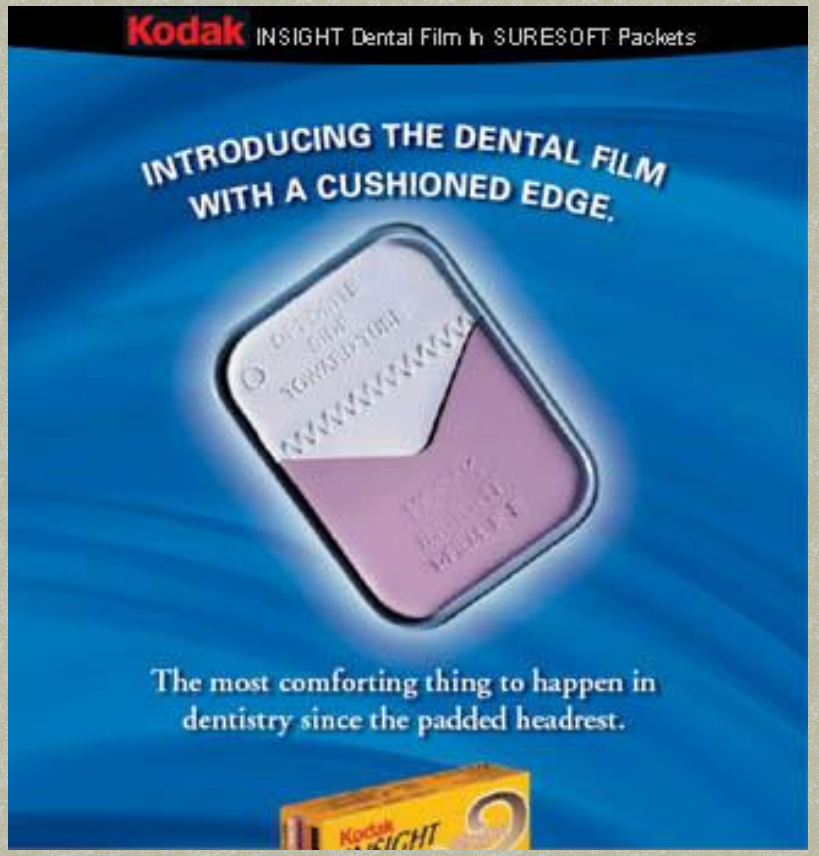
- 1924- non-inflammable cellulose triacetate base
  - -expensive
  - -could break

FILMS X-RAY

- 1925-double layered emulsion
  - -radia-tized film by kodak
  - -doubled the speed
  - -reduced exposure by fifty percent

X-RAY FILMS

- 1940- ultra speed improved radia-tized film
- 1960- used dacron as base (stronger and thinner films)
- 1980– ektaspeed launched by Kodak



EVOLUTION OF PROCESSING

- In 1903, Dr. Kell's introduced processing tanks.
- In 1909, tank development, standardized developing solutions and procedures introduced.

EVOLUTION OF PROCESSING

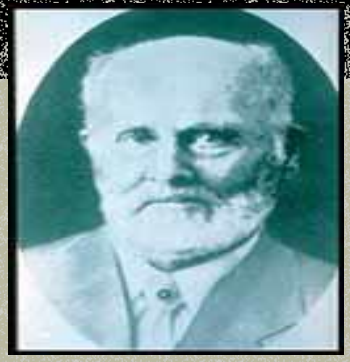
- In 1910, AUTOMATIC PROCESSOR'S introduced.

EVOLUTION OF PROCESSING

- In 1918, EASTMEN KODAK CO. developed darkroom with tank processing.

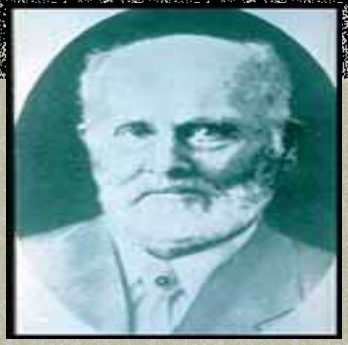
GROWTH OF DENTAL RADIOLOGY

WILLIAM HERBERT ROLLINS



- Father of radiation protection
- trained in medicine and dentistry
- more than 300 publications.
- developed new dental instruments,
- Introduced new procedures and materials.
- improved cameras, lenses and radios.

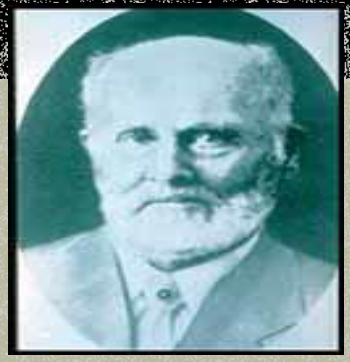
WILLIAM HERBERT ROLLINS



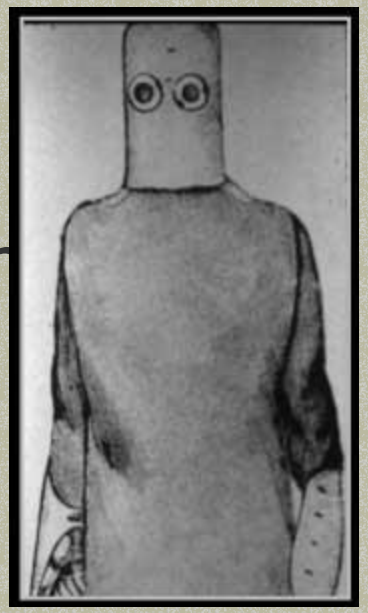
- first to suggest use of radium in the treatment of cancer.
- warned against dangers of radiation
- first to use filters, collimators recommended long tfd to improve quality.

CANCER PATIENT
BEING IRRADIATED

WILLIAM HERBERT ROLLINS

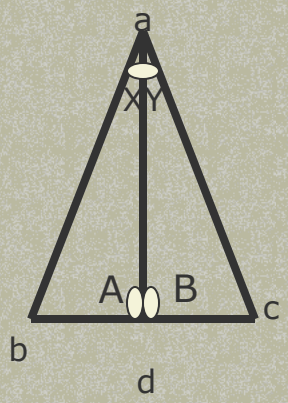


- recommended patient safety,draping of patient with non-radiable material,using two intensifying screens.
- NOTES ON X-LIGHT in 1904.
- suggested that safe and
- harmless dosage of radiation
- to be determined.



CIEZENSKI

- In 1901, proposed the rule of Isometry. (applied for Bisecting Angle Technique).
- Two triangles are equal when they share one complete side and have two equal angles



SIDE ab= side ab
LA=LB
LX=LY

DR. C.EDMUND KELLS

- presented first x-ray lab in 1903 – The New Orleans X-ray Laboratory.
- work confined to skiagraphs and fluoroscopic examination.
- first stereoscopic radiographs taken.

WESTON A. PRICE

- In 1897, developed flexible rubber gloves.
- In 1904, formulated the paralleling angle technique and the bisecting angle technique.
- Founder member of American Roentgen Ray Society.

FRANKLIN W. CORMACK

- First dental x- ray unit manufactured in Germany.
- In 1910, opened the
- first dental laboratory in
- San Francisco.

HOWARD RILEY RAPER

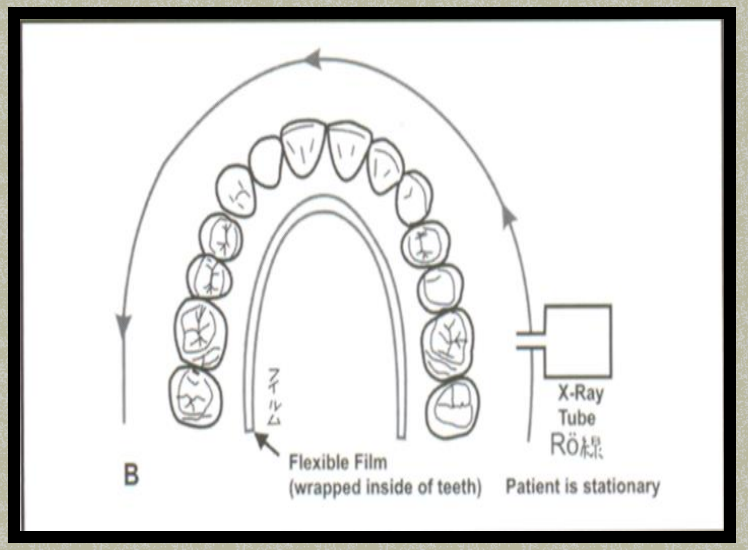
- In 1909, initiated the first course in Radiology.
- In1916, published papers in Dental Items Of Interest.
- In 1916, published first book Elementary And Dental Radiology.
- Created a new discipline- RADIODONTIA.

HOWARD RILEY RAPER

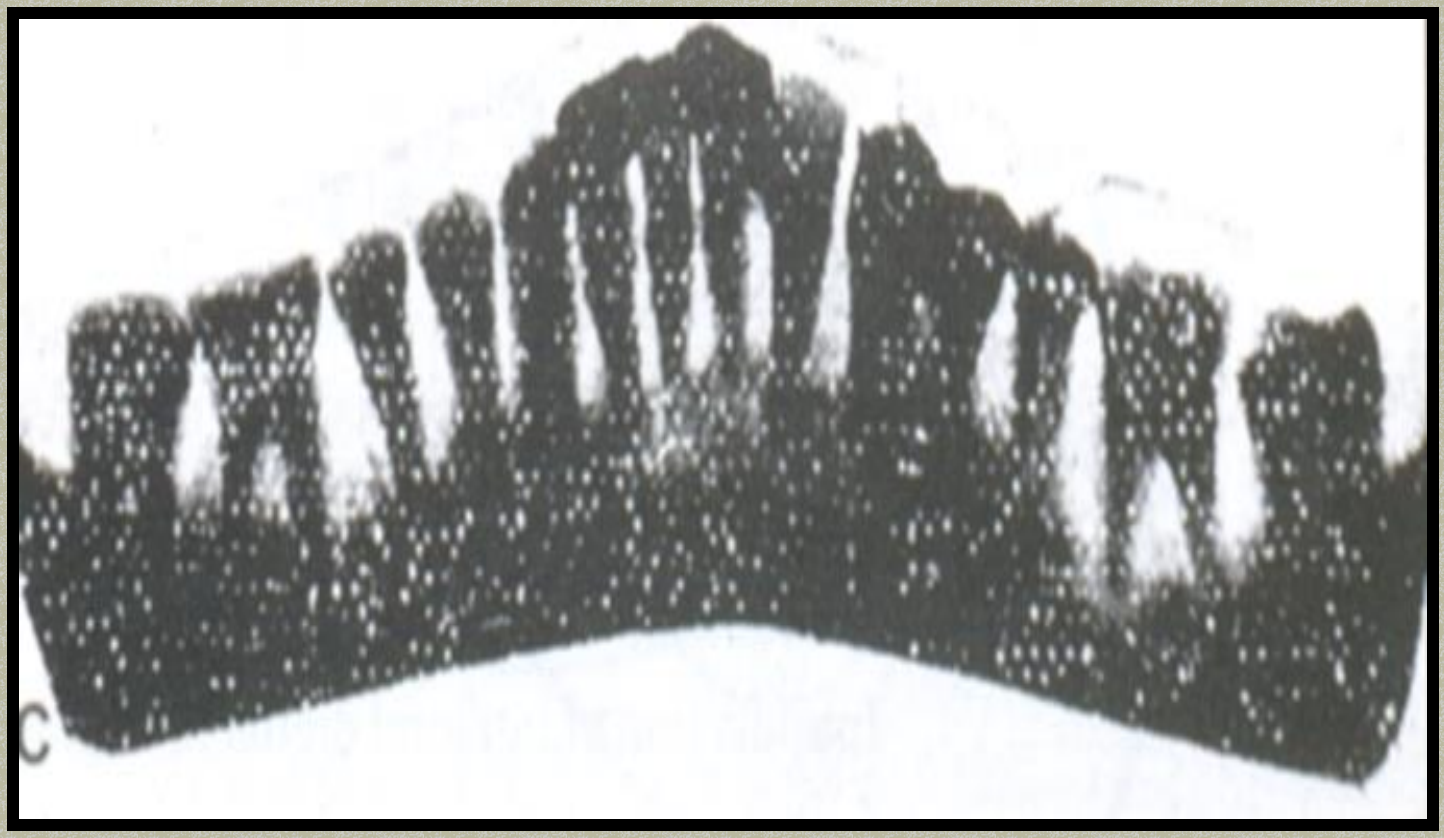
- In 1918, introduced an Angle Meter, mounted on x-ray tubes.
- In 1925, introduced the Bite-Wing technique.

DR HISATUGU NUMATA

- In 1933-34 proposed rotational panoramic radiography.



Mandibular radiograph taken by Numata's method

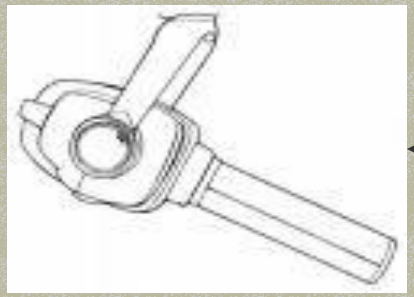


Yrjo.V. Paatero

- In 1946, proposed a slit beam method of panoramic radiograph dental arches.
- Known as Father of Panoramic Radiography.

DR. GORDON FITZGERALD

- In 1940, designed a long cone for long technique.
- published an article in JADA in 1947.



← Long cone technique

RECENT ADVANCES

- In 1960, S.S. WHITE Co. first marketed a panoramic x- ray machine.
- In 1949, American Academy of Dental Radiology formed.
- In 1968,International Association of Dento-Maxillo Facial Radiography formed.

PANOREX

RECENT ADVANCES

- Tomography
- Steroscopy
- Scanography
- Digital imaging
- Computed tomography
- Magnetic resonance imaging
- Radionucleotide imaging
- Ultrasonography
- Electronic thermography
- Dental xeroradiography

MRI

CT

RVG

HISTORY OF DENTAL RADIOLOGY IN INDIA

RADIOLOGY IN INDIA

- First x- ray machine imported by an chemist in 1902.
- First x- ray machine installed at Lady Hardinge Hospital in 1918.
- First dentist practising radiology- Rai Bahadur Hari Ram, in1932.
- First exclusive radiology practise- Dr.S.C.Sen in 1933.(also a founder member of Indian Radiological Association).

RADIOLOGY IN INDIA

- Dr.Diwan Chand Agarwal,Dr.R.K.Handa, Dr.R.C.Goulatia,Dr.R.M.Sharma and Dr.Roshan Lal migrated from Pakistan in 1947- laid the foundation of radiology in the North.
- The Barnard Institute of Radiology, in Chennai, trained dentists in postgraduate studies.

DENTAL EQUIPMENT

- In 1952, Lady Harding Medical College and Irwin Hospital only had equipped Radiology Department.
- Safdarjung Hospital had only one x-ray unit.

INDIAN RADIOLOGICAL & IMAGING ASSOCIATION

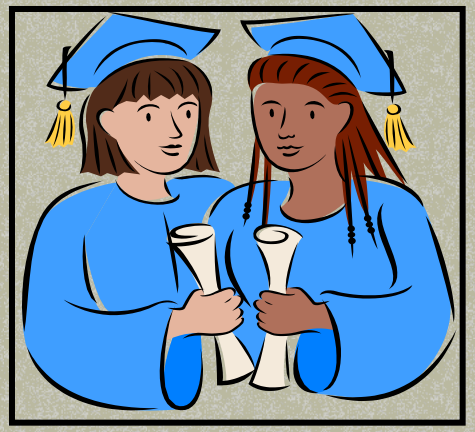
- Indian Radiological Association- Founded in 1931 by Dr.Alit Mohan Bose and Dr.Subodh Mitra.
- First meeting held on 21st April 1931.
- Registered in March 1937 with 24 members.
- Renamed as INDIAN RADIOLOGICAL & IMAGING ASSOCIATION.

The Indian Journal Of Radiology & Imaging

- Started at Chennai in 1947.
- Editors-Dr.Rama Rao and Dr.K.M.Rai.
- Shifted to Mumbai in 1950, edited by Dr.K.P.Modi.

The Indian College Of Radiology & Imaging

- Dr.P.K.Haldar and Dr.K.N.Kamdar evolved the concept.
- Many illustrious leaders have served the ICRI.



THANK YOU