INTERNATIONAL ATOMIC ENERGY AGENCY
UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION

INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS
34100 TRIESTE (ITALY) - P.O.B. 586 - MIRAMARE - STRADA COSTIERA 11 - TELEPHONE: 2240-1
CABLE: CENTRATOM - TELEX 460392-1

H4.SMR/167 - 6

SCHOOL ON PHYSIC IN INDUSTRY

27 January - 14 February 1986

PHYSICS IN INDIA

presented by

D.D. BHAWALKAR
BARC
Trombay, Bombay 400085
India

PHYSICS IN INDIA

(With Emphasis on
PHYSICS IN INDUSTRY & TECHNOLOGY)

Historical Background (Before 1947)

Teaching of Physics in India

Physics Research in India

Very few research institutes in India before independence (before 1947)

Even then India produced great physicists.

Raman — discoved Raman Effect

Bose — Bose Einstein Statistics

Saha — Saha equation

After independence (1947)

Science was made an "Organized National Activity".

Physics Education

Universities (About 110)

Institutes of Technology (5)

Institute of Science (1)

Others e.g. Regional Engineering Colleges, etc. (>20)

Physics is taught at MSc level in about 95 Universities.

Note that the number of years a student spends to get MSc degree is 17.

10 + 2 + 3 + 2
School ↑ BSc MSc
Higher Secondary

No. of students passing MSc (Physics)
every year ≈ 2500 - 3000

What do they do later?

Physics Research in Universities

Physics Dept. in all Universities / others have research programmes of varying sizes.

Total no of PhD students ~ 700 ?

Average time for obtaining PhD ~ 4 yrs.

Given below are examples of some research areas. (List is not exhaustive - either in the listing of universities or areas of research, and is only meant as typical examples of university research)

Univ. of Bombay -	Particle Physics, Solid State Physics. - -
Univ of Calcutta -	High energy physics, Optics - -
Univ of Delhi -	High Energy physics, Solid State Physics - - -
Univ of Cochin -	Atomic and Mol. Physics, Solid State Phys. - -
Hyderabad central University -	Quantum Optics, - - .
Univ of Madras -	High Energy Physics - - .
Univ of Punjab -	Nuclear Physics, Plasma Physics
Banaras Hindu Univ.-	Spectroscopy, Solid state Physics - - - .
Univ. of Nagpur -	Solid state Physics, X-rays,
Univ of Poona -	Physics Education, Nuclear physics - - .
etc etc etc	

INDIAN INSTITUTES OF TECHNOLOGY

DELHI - Solid state Physics, Opto Electronics, Thin Films, Lasers

KANPUR - Spectroscopy, Lasers, Nuclear Physics, High energy physics

MADRAS - Solid state Physics, Low temp physics,

etc etc

INDIAN INST. OF SCIENCE

- Centre for Theoretical Studies Magnetism, Classical mech. High Energy Phy.
- Material Science.

etc etc

Govt. Research Laboratories

1. Dept. of Atomic Energy

i) BHABHA ATOMIC RES. CTR., BOMBAY

Variable Energy Cyclotron Centre, Calcutta

High Altitude Res. Lab., Srinagar

CENTRE FOR ADVANCED TECHNOLOGY - INDORE

ii) TATA INST. OF FUNDAMENTAL RES.
BOMBAY.
Bangalore
Ooty
Hyderabad.

iii) SAHA INSTITUTE OF NUCLEAR PHYS.
CALCUTTA.

iv) INDIRA GANDHI CENTRE FOR ATOMIC RESEARCH. Kalpakkam (Madras)

(Formerly Reactor Research Centr.)

v) Institute of Physics, Bhuvaneshwar

vi) Mathematical Sciences Inst., Madras

2. Dept. of Space

i) Vikram Sarabhai Space Centre.
Trivendram.

ii) Physical Research Laboratory
Ahmedabad.

iii) Space Application Centre.
Ahmedabad

iv) Indian Space Research Org.
Bangalore

3. Council for Scientific and Industrial Research.

Laboratories mainly for Physics Research are -

i) National Physical Laboratory, Delhi

ii) Indian Institute of Astrophysics, Bangalore

iii) Central Scientific Instruments Organization, Chandigarh

iv) Central Glass & Ceramic Res. Inst. Calcutta.

4 Defence R&D Organization

Laboratories mainly for Physics Research are

i) Solid State Physics Lab., Delhi

ii) Defence Science Centre, Delhi

iii) Instrument Research Developement Establishment, Dehradun.

5. Others.

i) Raman Research Inst., Bangalore.

ii) Indian Association for Cultivation of Science, Calcutta.

I will now take two laboratories and describe some of their work. Since I am from the Dept. of Atomic Energy I am more familiar with laboratories under this Dept. Hence I have selected BARC and TIFR.

This school is on "Physics in Industry" whereas my talk is on "Physics in India". To do justice to both I will talk about basic research at TIFR and applied research at BARC. This does not mean that no basic research is done at BARC or no applied research is done at TIFR. Because of limitation of time I have selected only these areas from the two institutes.

TATA INSTITUTE OF FUNDAMENTAL RESEARCH

TIFR — Founded July 1945.

Purpose for founding TIFR in Dr. Bhabha's words - "..... When nuclear energy has been successfully applied for power production, India will not have to look abroad for experts but will find them ready at hand."

Philosophy of Growth - Find people and build programmes around them.

T. I. F. R.

1. Run like an academic institute

Various groups are as follows

A) Theoretic Physics — Important Research

i) High Energy Phys. [Top Quark

ii) Nuclear Phys.

iii) Solid State Phy

B). Astrophysics

i) Cosmology — Early Universe

ii) Solar Physics

iii) Theoretical Astrophysics

iv) Quasars

v) Gravitation [Measurement of G

$G = G_0[1+\alpha e^{-r/\lambda}]$

C) Astronomy

i) Radio Astronomy - 600 M Radio Telescope

ii) I.R. Astronomy

D) Cosmic Rays

i) High Energy Physics — Proton decay

ii) Low Energy Physics — Anuradha

E) Solid State Physics

i) Low Temp Physics

ii) Magnetism

iii) Nuclear spectroscopy

F) Atomic & Mol. Physics

G) Chemical Physics.

Bhabha Atomic Research Centre

BARC has 3500 scientists and engineers of which about 700 are physicists.

A) Nuclear Physics Div.

- Nuclear Physics
- Solid State Physics
  - Magnetic material
  - Superconductors
- Accelerator physics

B) Neutron Physics Div.

- Neutron physics - neutronics
- High pressure physics
- Crystallography - (Biological molecules)

C) Spectroscopy Div.

- Spectroscopy of Atoms, molecules, ions, radicals in gaseous, liquid and solid state
- Raman & Laser spectroscopy
- Analysis
- Optics & optical instrumentation

D) Laser Division -

- Laser Fusion
- Nonlinear Optics
- Laser physics & technology
- Laser applications.

E) Plasma Physics Div.

- MHD
- Low temp plasma - physics & technology
- Electron Beams - relativistic & nonrelativistic physics & technology

F) Technical Physics and prototype engineering division.

- Vacuum physics, technology & instrumentation.
- Low temp technology
- Crystal growth
- Instrumentation & devices

G) Training Division —

Physics for Industry and technology at BARC.

Examples -

A) Vacuum Physics & technology

Physics-programme
- UHV
- Adsorption, absorption desorption etc
- Surface studies
- Instrumentation.

Applications to Industry & Technology

Vacuum pumps, Vacuum components, Vacuum Gauges — 10^{-6} Torr Range.

Knowhow given to IBP.

TV picture tubes
Bulbs
Vacuum coating — Reflectors for motor headlamps
Jewellery

Cryocontainers.

'OPERATION FLOOD' - Programme of Indian Dairy Developement Board, to improve milk production in India through cross breeding.

For artificial insemination, the semen has to be stored at liquid nitrogen temperature. Large number of cryocontainers are required.

Two examples from technological applications

Problem- To coat aluminium film on a 2.3 meter dia 4.5 Tonne wt glass mirror for Indian telescope.

Solution- Build the coating plant.

Vacuum Coating plant is 2.8 meter dia x 3 m long. Vac ~ 10^{-6} Torr.

Ion cleaning facility.

Diffusion pump - 90 cm dia

Problem - Testing of satellite components in space environment.

Solution - Space simulation chamber.

Size - 3 meter dia X 3.5 meter long

Vac - 10^{-6} Torr OIL FREE

Turbomolecular pump + Cryosorption pumps

Temp. -20 to +70

Design BARC. . Manufacture- IBP

With the success of this we are now undertaking design & fabrication in India of an even large space simulation chamber for testing INSAT satellites.

Size. Dia - 9 meters
Length - 10 meters
Vac - 10^{-9} Torr
Solar simulator

Cost. $ 4 million.

Fall out of Vacuum physics and technology programme -

Components- Vac pumps, gauges etc
(Sputter ion pumps - 10^{-10} Torr)
Application in synchrotron radiation sources)

Devices - G.M. Counters
Used routinely in
Steel industry
Paper industry
Oil exploration etc.

Instruments - Scanning Auger Microprobe
Surface studies

Mass spectrometers

etc.

Plasma physics applications

Plasma Torch for cutting, welding and spraying

Specifications - Power - upto 100 kW

Plasma Temp - ~ 10,000 K

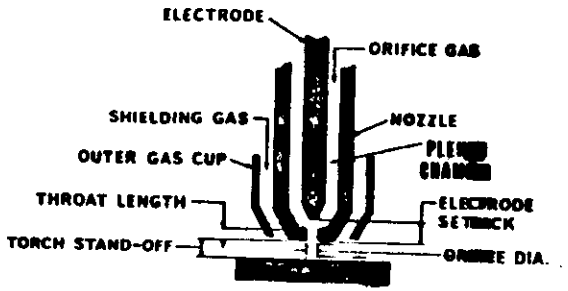


Figure 1 ·General View of a Plasma Torch.

For the Variable Energy Cyclotron it was necessary to cut 40 mm thick S.S. plate in a circle of 3 meter dia.

Knowhow given to industry.

Plasma gun spraying of ceramics.

Electron Beam Technology -

Physics - REB for Fusion.

Technological Fall outs -

EB for welding, melting.

EB characteristics

Electron Energy	10-50 keV	30-200 keV
Beam Power	5 - 100 kW	30 - 200 kW
Beam dia	1-10 mm	0.1 - 5 mm
Power density	10^3-10^5 w/cm^2	10^5-10^8 w/cm^2
Applications	Melting Heat treatment	Welding Drilling

Some Typical Applications of E.B. Welding

achine used:- Chamber type, H.V., Partial
'acuum E.B.W. Machine devaloped in house.

lain Specifications :-

Chamber Size – 1000 X 1000 x 1500 mm.

X-Y Manipulator - Travel 700 (X), 500 (Y)
Speed 20-200 cms/min.

Rotory Manipulators - Max. Load - 500 kg.

Three - Vertical, Horizontal & Universal

Speed – 1-10 RPM. Max. Load - 100 kg.

Electron Gun - 150 kv, 40 mA. Triode Type.

Max. Penetration – 50 mm in steel.

Chamber Pressure - 5×10^{-3} torr

Pump Down Time - 5-10 minutes.

Spot Size – <0.5 mm at modarate power
≃ 1.0 mm at full power.

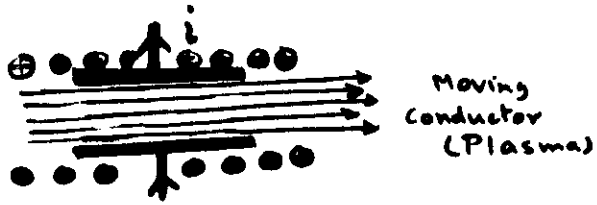
Working Distance – 100 – 700 mm from chamber top.

Viewing System – Co-axial telescopic
With 10 x magnification

Slides no. 5, 6, 7, 8, 9

2. Magnetohydrodynamic (MHD) power generation.

Principle- Faraday Law



A 5MW MHD plant working on coal has been built jointly by B.A.R.C. and BHARAT HEAVY ELECTRICALS Ltd.

Laser R & D

Separate talk on Lasers in Industry when work at BARC in this area will be covered.

Applications of Nuclear Physics in Industry - Developement at BARC.

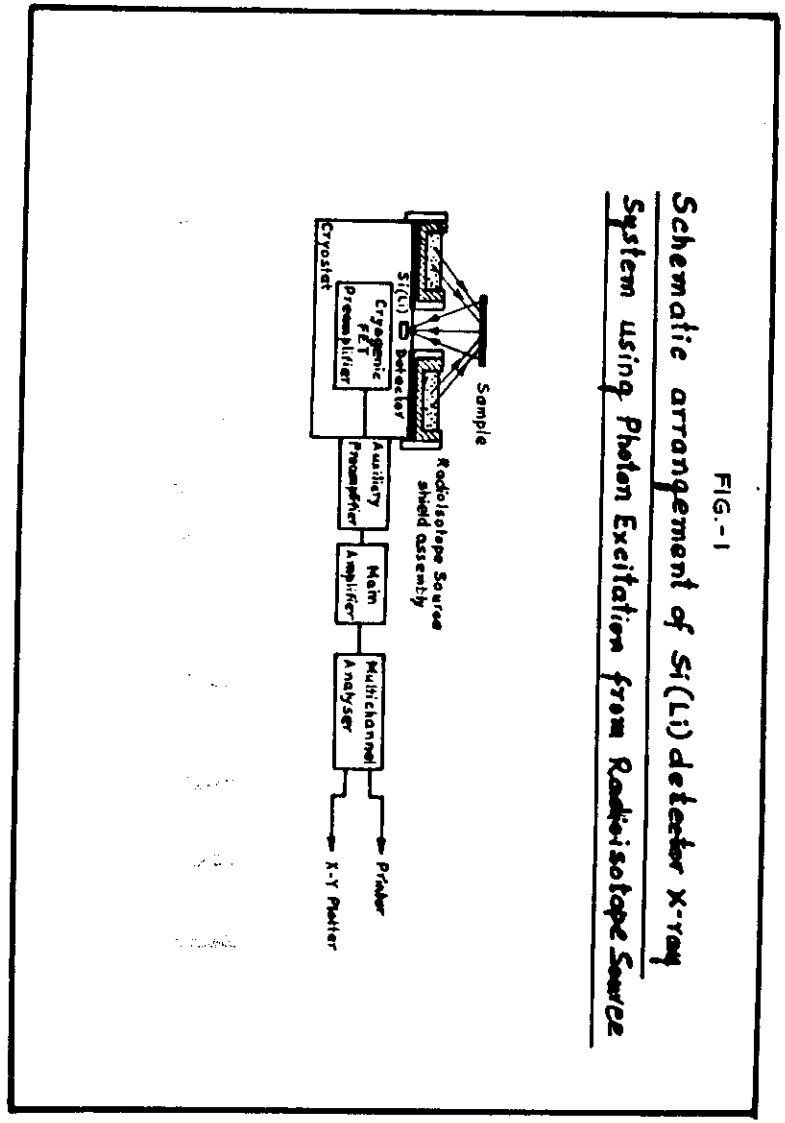
Several well established applications which I will only mention.

* Nuclear Power
* Radioactive tracers
* Radioactive pharmaceuticals
* Sterilization of medical products by γ rays
* Neutron and γ ray radiography
* Improved agricultural products
* Neutron scattering for basic studies etc, etc.

Some not yet widely used in industry

* X ray fluorescence for chemical analysis
* Ion implantation in semicond.

etc etc.



Some examples of samples analyzed are shown in the next few projections.

1. X-ray spectrum of S.S. Alloy
2. Part of a machine
3. Tobacco
4. Fish.

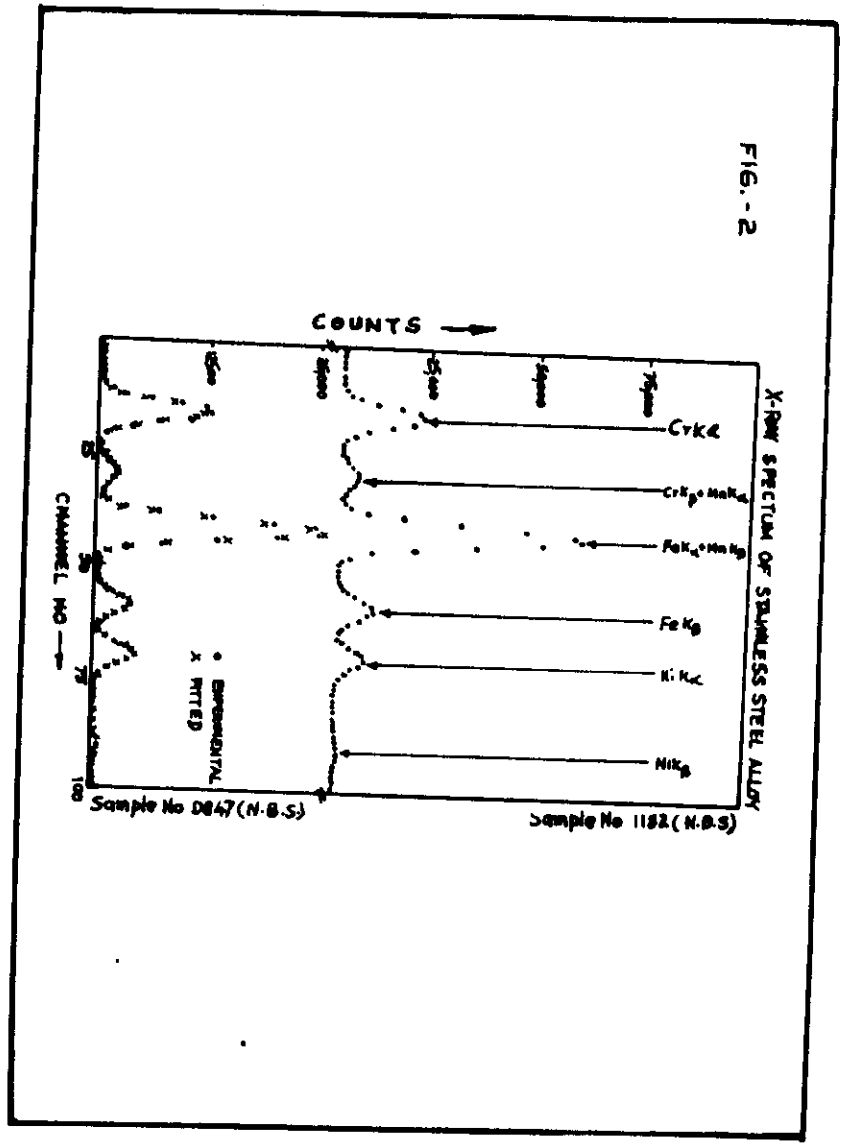
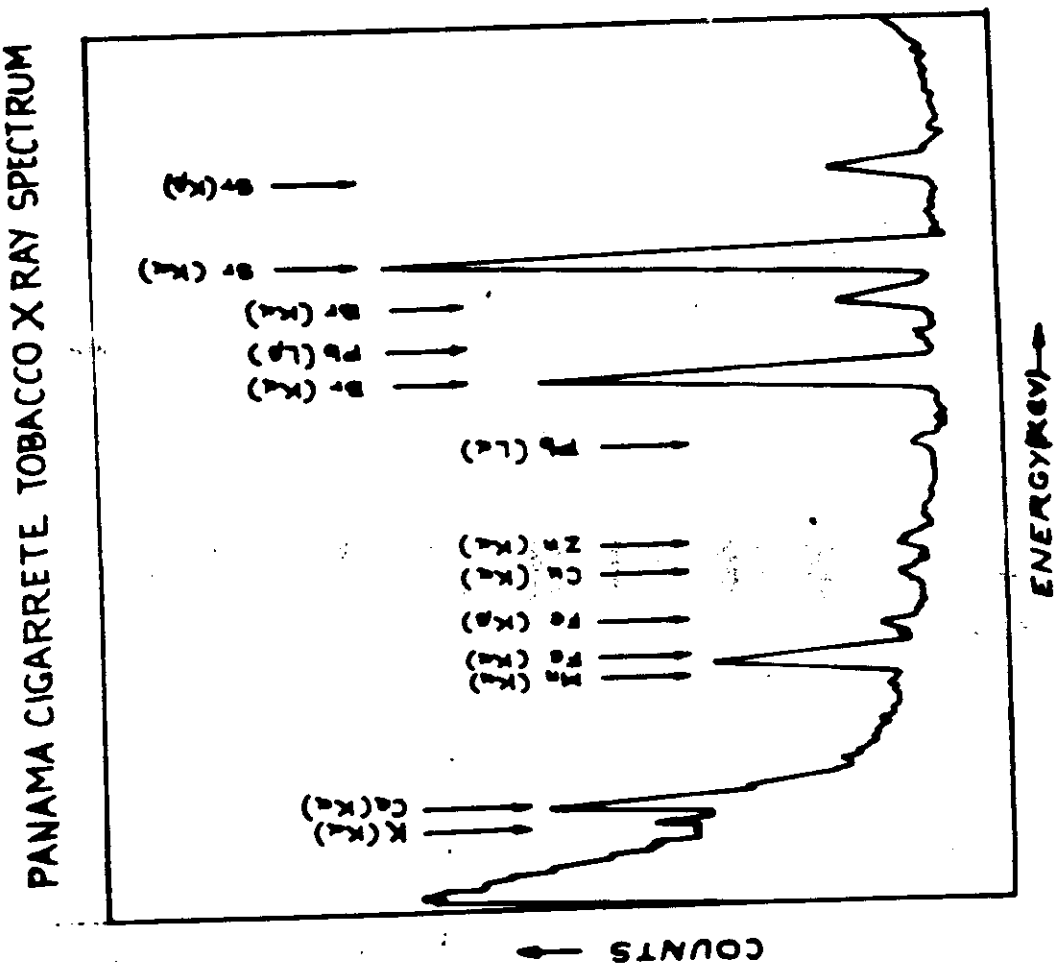
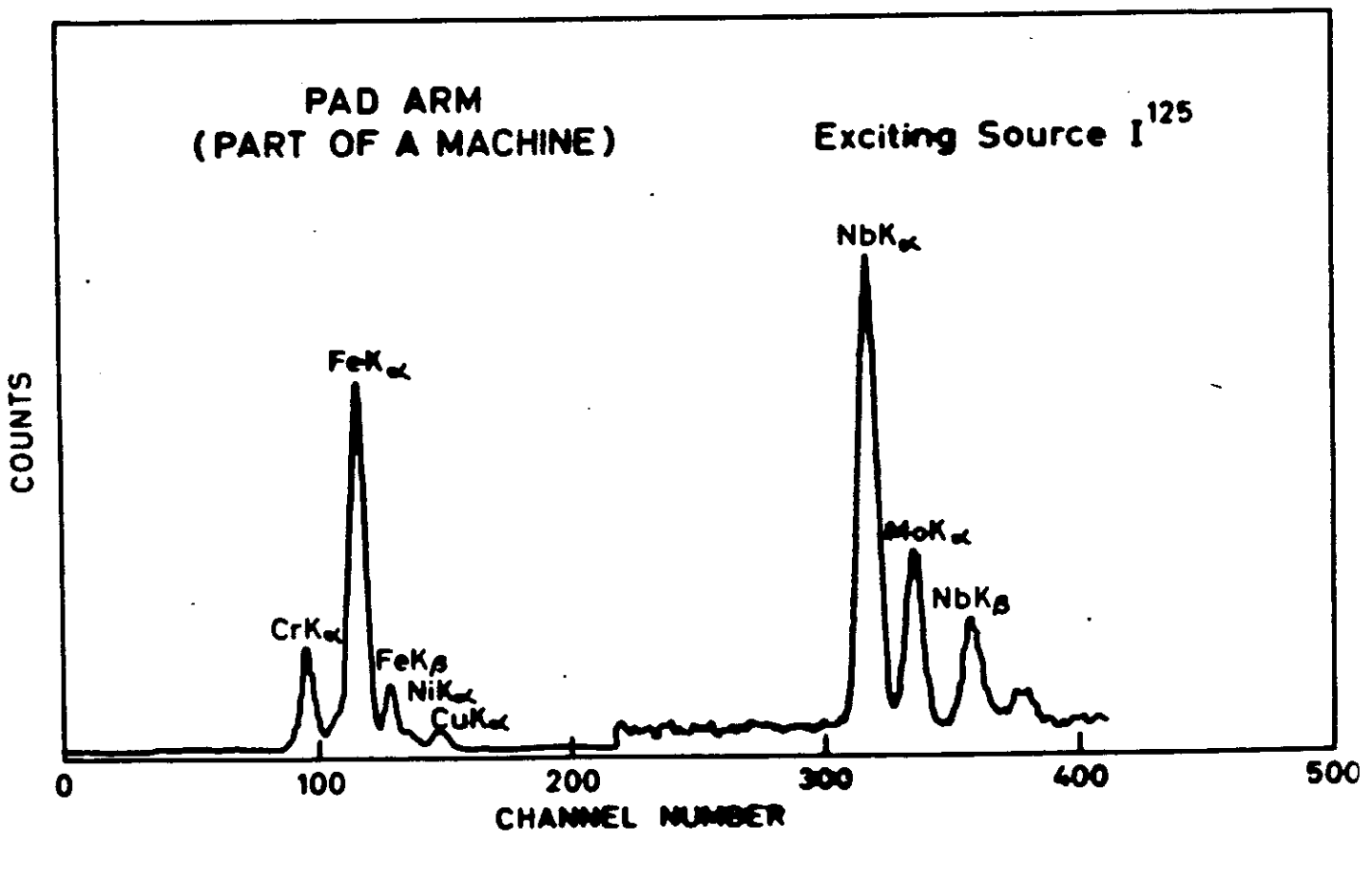


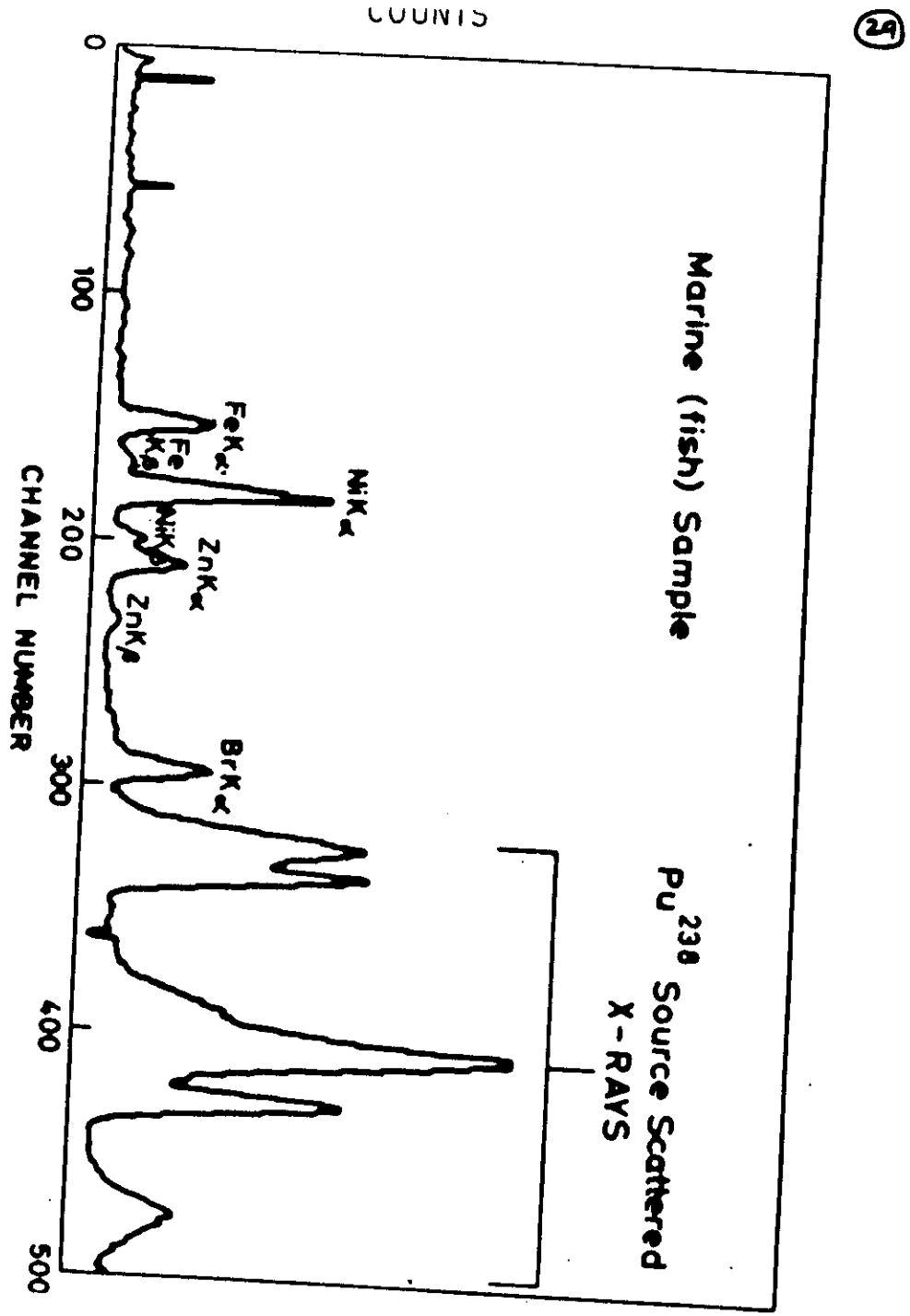
FIG. - 2

(28)


PANAMA CIGARRETE TOBACCO X RAY SPECTRUM
COUNTS
ENERGY (KeV)

(27)


PAD ARM
(PART OF A MACHINE)
Exciting Source I125
COUNTS
FeKα
NbKα
MoKα
NbKβ
CrKα
FeKβ
NiKα
CuKα
0
100
200
300
400
500
CHANNEL NUMBER



Problem -

Why is physics not effectively used in Industry in India ?

Physicists' problem -

1) Developement is considered inferior to research . (As pointed out by Dr. Keller in his talk)

2) Problems of industry are not challenging enough to be of interest to a physicist.

Industrie's problem

1) The knowhow developed by the physicist is laboratory knowhow. To make it into industrial knowhow needs lot of hand work - bullwork - . The scientist finds this bullwork uninteresting and industry does not have the infrastructure for it

2) Competion with foreign knowhow and foreign products.