UCC
Coláiste na hOllscoile Corcaigh, Éire
University College Cork, Ireland

United Nations Educational, Scientific and Cultural Organization
International Year of Light 2015

UNESCO 2015 Year of Light Celebrations Plenary Speech, Oct. Islamabad, Pakistan.

INVENTING WITH LIGHT
A Personal Journey*

Nabeel A. Riza

Chair Professor of Electrical & Electronic Engineering and
Head (Dean) of the School of Engineering
School of Engineering
University College Cork (UCC)
Cork, Ireland

http://soe.ucc.ie

*** Dedicated to my late father, Mr. A. G. Riza, I942 Indian Civil Service (ICS) and Former Secretary of State Govt. of Pakistan.**

United Nations
Educational, Scientific and
Cultural Organization

International
Year of Light
2015

UNESCO Plenary Speech **2015**
Year *of LIGHT and LIGHT-based Technologies*

Symposium Chief Guest: Minister of Science and Technology, Government of Pakistan.

United Nations
Educational, Scientific and
Cultural Organization

International
Year of Light
2015

UNESCO Plenary Speech 2015
Year *of LIGHT and LIGHT-based Technologies*

Plenary Speech Abstract

This talk highlights the inventing process – the preparation involved and the key steps leading to greater achievements in order to unleash the power of light and photonic technologies. The journey has humble beginnings as a school student in Karachi and Lahore, and then goes onto foundational technology training sites in Chicago, Pasadena, and Schenectady, New York. The works of an optical inventor solving pressing problems in international level engineering, currently innovating in the pristine and inspiring environment of Cork, Ireland, are recounted here.

N. A. Riza Brief Biography

Nabeel A. Riza holds a Ph.D. from the California Institute of Technology (Caltech). His awards include the 2001 International Commission for Optics (ICO) Prize and 2001 Ernst Abbe Medal from Carl Zeiss Foundation-Germany and the Fellow awards from the IEEE, IET, European Optical Society, OSA, and SPIE. He has held positions at General Electric Corporate Research & Development Center (Schenectady, New York), Nuonics and CREOL, USA. In August 2011, he was appointed Chair Professor and Head of the Department of Electrical and Electronic Engineering (EEE) and Associate Member Tyndall National Institute, University College Cork (UCC), Ireland. In June 2013, he was appointed Head (Dean) of the School of Engineering, UCC. In January 2013 he authored his first textbook Photonic Signals and Systems: An Introduction, McGraw Hill, a book for students in science and engineering. He has published over 300 international journal and conference papers and holds 46 Patents. In 2015, he received the Honorary Fellow Award, the highest membership distinction of the Engineers Ireland Society.

United Nations Educational, Scientific and Cultural Organization

International Year of Light 2015

UNESCO Learning City Award for Cork, Ireland

Oct.1, 2015: Cork City receives a UNESCO Learning City Award at the UNESCO International Conference on Learning Cities in Mexico City. UCC is one of four partners in the Cork Learning City initiative.

11 other international cities also receive the award, with 600 political leaders, mayors, city education executives and civil society representatives from more than 90 countries attending the conference.

ucc
Coláiste na hOllscoile Corcaigh, Éire
University College Cork, Ireland

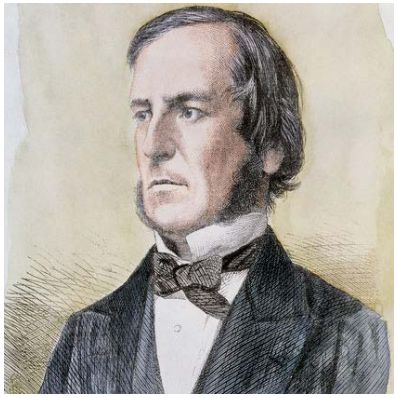
UNIVERSITY COLLEGE CORK , CORK, IRELAND.
Founded 1845

Home to 20,000 Students
(3000 International Students)

Main
Quad
UCC
Campus

Tyndall
National
Institute

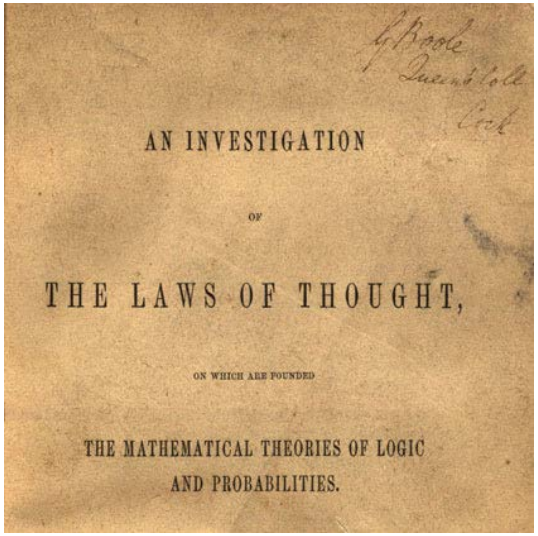
Home to George Boole



Born 2 November 1815

Died 8 December 1864

UCC Professor
of Mathematics *1849-64*



Boolean
Algebra

1854

UCC School of Engineering

Engineering since 1845

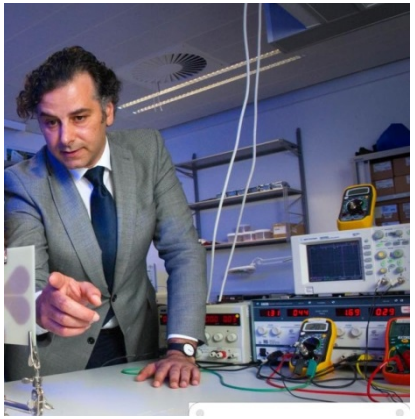
Home to ~ 800 Students

(~ 100 Staff)

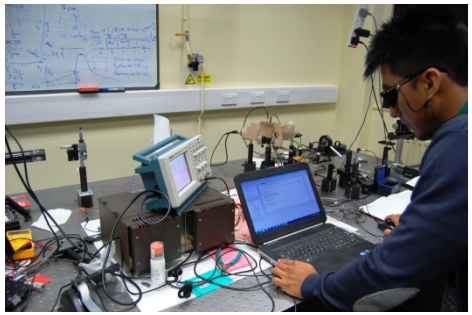
Home to Multiple Disciplines

- Cork Centre for Architectural Education
- Civil and Environmental Engineering
- Electrical & Electronic Engineering
- Energy Engineering
- Mechanical Engineering
- Process & Chemical Engineering

RF



Photonics



Ocean Energy

Robotics

WHY IS THIS SPEECH ON: "INVENTING WITH LIGHT A Personal Journey"

STATED SYMPOSIUM OBJECTIVE

"This event is intended to provide a platform for discussing advancements in the study of light and light-based technologies, and its role in sustaining and enhancing the quality of life on this planet."

MY LIFE'S FOCUS
SUSTAINING AND ENHANCING INNOVATION IN SCIENCE & TECHNOLOGY

THE QUESTION:

IN THE SPIRIT OF AL-HAZEN
CAN WE CREATE GREAT INVENTORS OF LIGHT AND LIGHT-BASED TECHNOLOGIES ?

WHAT IS AN INVENTION?

SOMETHING NEW → No One in the World
Has Proposed the Invention
Per Dated and Witnessed
Written, Video & Audio Records
(in Patents, Books, Papers, Presentations)

EXAMPLES OF INVENTIONS:

A New Physical LAW --- Force = Mass x Acceleration

A New Chemical Process ---- Chemical Vapour Deposition (CVD)

A New Made-Made Material --- Silicon Carbide, Synthetic Diamond

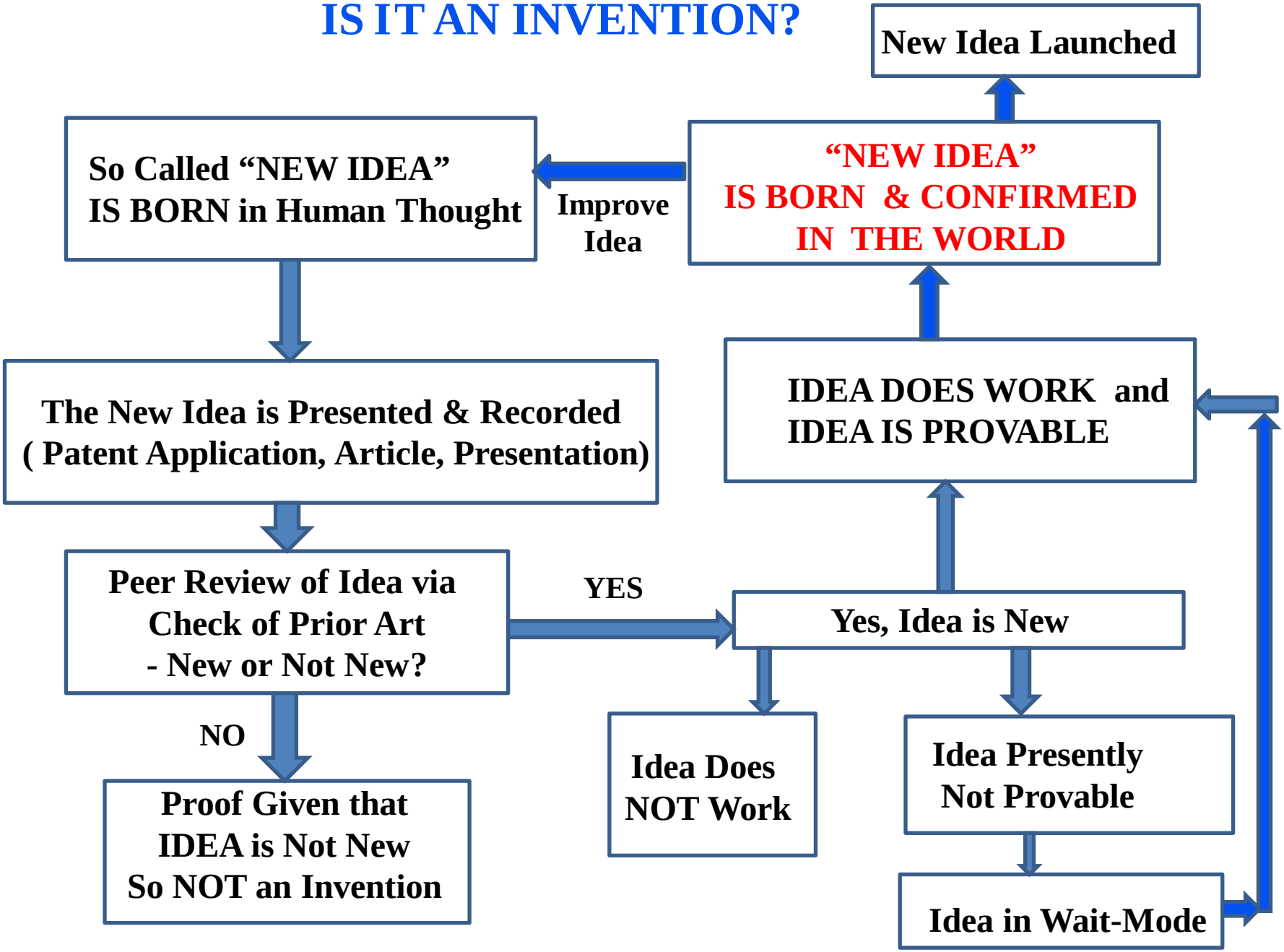
A New Design ---- Vacuum Sealing the Filament Light Bulb

A New Language --- Braille (Physical Bumps Coding); Morse Code

A New Concept --- The Internet (interconnected computers)

A New Contraption --- Radar, Television, Camera, Electronic Transistor

IS IT AN INVENTION?



AN INVENTION USING LIGHT

A NEW THERMOMETER IS NEEDED FOR DIRECTLY MEASURING GAS TEMPERATURE IN POWER PLANTS OPERATING OVER 1500 DEGEE-C.

Note: Present Thermometers Break-Down under the Extreme Long-Term Power Plant Conditions

Why?

OPERATING PLANT AT HIGHER TEMPERATURE LEADS TO BETTER SYSTEM EFFICIENCY & GREENER OPERATIONS

3 Patents awarded on the New Thermometer

N. A. Riza and * F. A. Perez, US Patent 7,327,472, Feb.5, 2008.
N. A. Riza and F. A. Perez, US Patent 8,035,822, Oct.11, 2011.
N. A. Riza and F. A. Perez, US Patent 8,096,704, Jan.17, 2012.

TRUE FRIEND → TRUST & BELIEF → CAN MAKE A NATURAL CO-INVENTOR

- **Dr. Frank Perez, Ph.D. Mechanical Engg. Caltech, Caltech Apartment-Mate (1987-89), Co-Founder KAOS Caltech Soccer Team, True Friend, and Colleague & Business Partner on Start-Ups Nuonics, Inc. and Nusensors, Inc.**

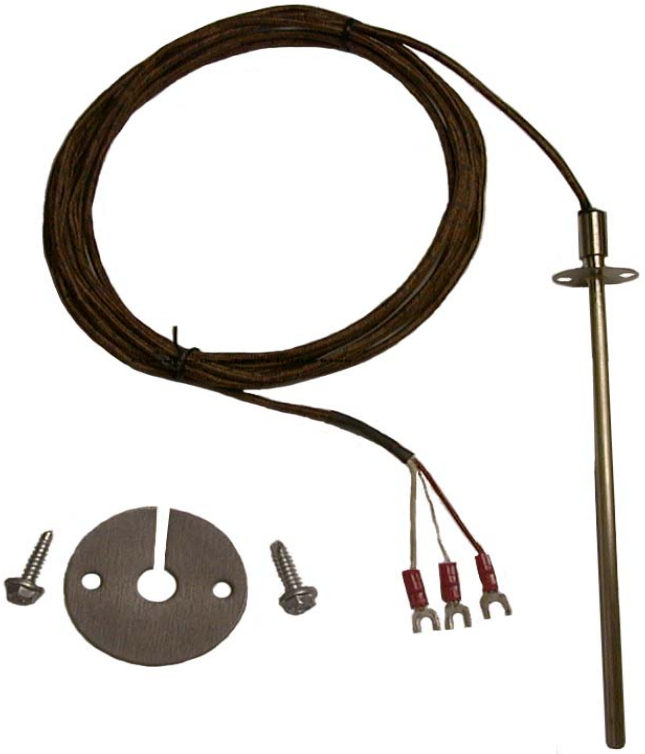
GE's H system Gas Turbine

Uses Firing Temperature of 1430 °C

R. Matta, et.al, " Power Systems for the 21st Century," GE Power Systems Publication GER3935B, Oct. 2000.

How does Extreme temperature Measurement get done today?

Platinum/Rhodium High Temperature Thermo-Couple (TC) All-Electrical Technology is used to Measure Extreme Temperature

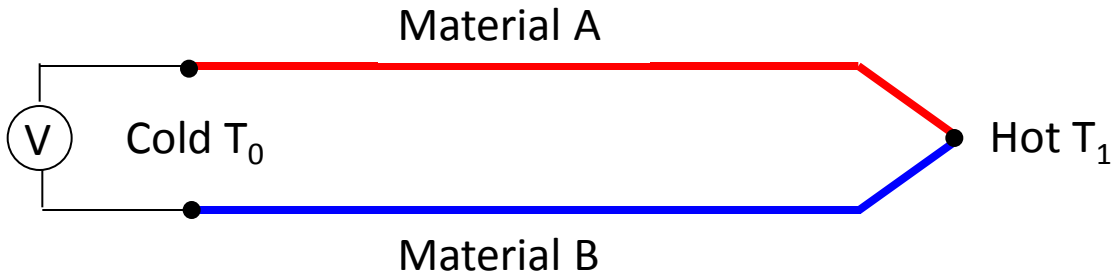


Note:
Need to Encase in Custom Magnesia (MgO) or Alumina Insulating Ceramics

TC Thermometers Break-Down under Next-Gen Design (> 1500 °C) Combustion Chamber Conditions

Image courtesy: Cybernetics Technical Industries Inc.

Thermocouple Design



- Dissimilar materials A and B

- Net EMF as measured by the voltmeter is a function of the temperatures T_0 and T_1 and composition of the two materials (Seebeck effect* --- Thomas Johann Seebeck 1821)

- Net EMF = $V_A(T_1,T_0) - V_B(T_1,T_0)$ measured in volts

EMF: Electromotive Force – Measure of Electric Potential/Voltage

*http://www.uni-konstanz.de/FuF/Physik/Jaeckle/papers/thermopower/node1.html

Is There An Extreme Temperature Sensor Design Without the TC & Optical Fiber Probe Packaging & Reliability Issues?

James Bond --- “ Diamonds Are Forever”

Movies Can Inspire an Invention!

Look for a Carbon Base Material – They are In-destructable!

RELIABLE OPTICAL CHIP SOLUTION: THICK SINGLE CRYSTAL SILICON CARBIDE

Melting Temperature ~ 2500 °C
Resistant to Chemical Attack (Acids, Hot Gases)

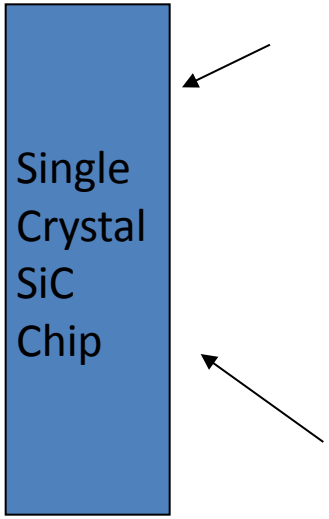
Mechanically Robust

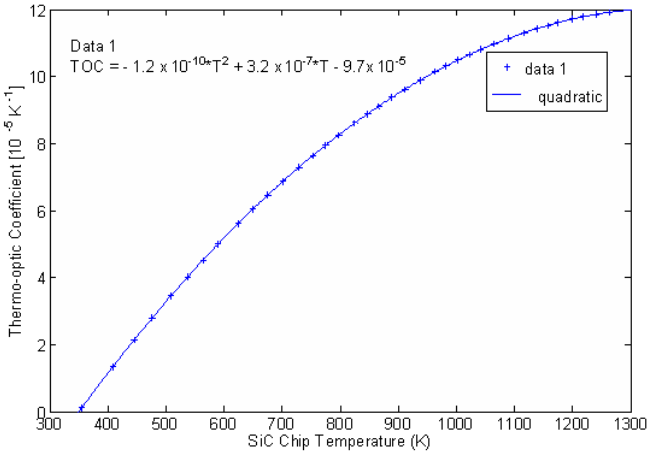
-- Handles 1 GPa (10,000 atm) Yield Stress
-- Allows Elastic Deformation in the Small Deflection Regime Due to Pressure

Excellent Atomic Scale Flatness
Minimal Optical Wavefront Spoiling

High 2.55 Refractive Index
Strong 20% SiC/Air Reflectivity
At EYE SAFE Infrared Band (1550 nm)

Natural Interferometer Chip





*** Refractive Index "n" Changes With Temperature T**
& dn/dT (Thermo-Optic Coeff.) Changes Quadratically with T

For SiC, can make the 2-Beam Interference Approximation:

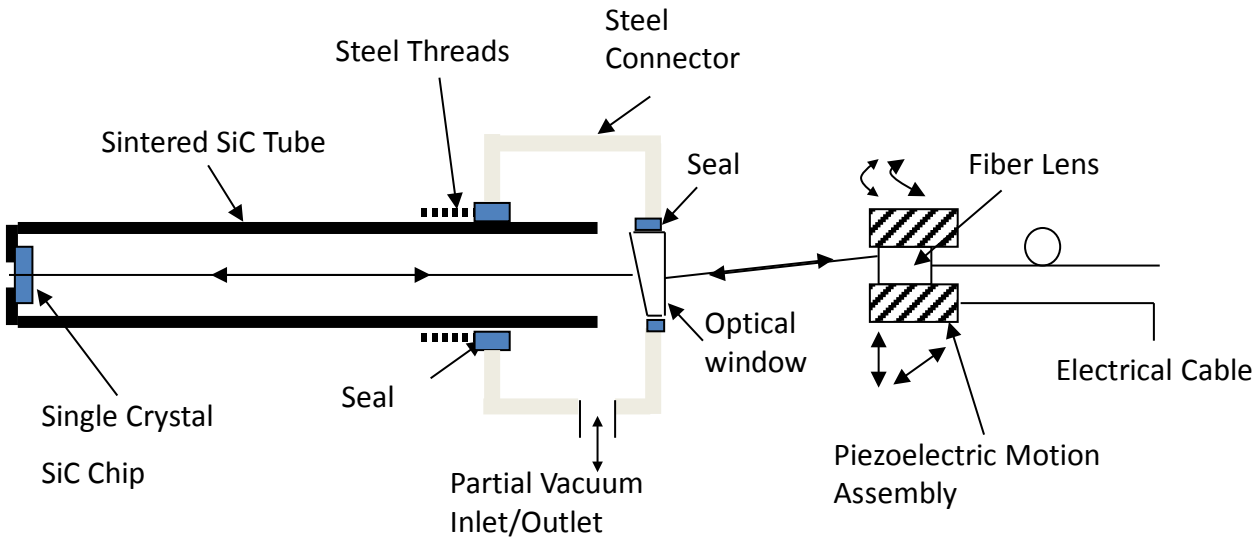
$$P_m = K \cdot R_{FP} \approx K\left[R_1 + (1-R_1)^2 R_2 + 2(1-R_1)\sqrt{R_1 R_2}\cos\theta\right] \quad \theta = \frac{4\pi n(T) d(T)}{\lambda}$$

What is new about our Thermometer?

Uses a Hybrid Access/Packaging Approach

Wireless + Wired Optics

Extremely Hot Thermal Isolation Cool Section



Summary: What is new about our approach?

- Single Crystal SiC + Sintered SiC Probe
- Single material (CTE matched) – Robust frontend for extreme zone
- Temperature Reading Independent of Intrinsic % Increasing Temperature Error

Eliminated Fundamental TC Limitations

Front-End Probe

Unassembled

Assembled

SIGNS OF A PURE INVENTOR OVER A LIFE-TIME

(Some Inherent & Some Developed Over Time)

- **LOVES WHAT HE/SHE DOES**
- **INDEPENDENCE OF THOUGHT AND ACTIONS**
- **FEARLESS – AT EASE AT BEING ALONE/ISOLATED- A LONE EXPLORER**
- **SELF BELIEF IN ONE'S STRENGTHS AND LIMITATIONS**
- **OBSERVANT OF EVERYTHING [Sight, Sound, Smell, Behaviour (human, animal), etc]**
- **HUNGER TO LEARN FROM ALL (Competitors, Friends, Strangers)**
- **ACCEPTANCE OF MISTAKES WITH HUMILITY**

SIGNS OF A PURE INVENTOR OVER A LIFE-TIME

(Some Inherent & Some Developed Over Time)

- **SHORT CELEBRATIONS OF SUCCESS AND DOWN TIME FOR FAILURES**
- **DEEP CONCENTRATION ABILITY AND ABILITY TO BLOCK-OUT (Trance)**
- **ABILITY TO CHANGE THOUGHT DIRECTIONS WITHOUT REGRET**
- **ABILITY TO FOCUS AND DEFOCUS WITH EASE (Switch between The BIG picture and The Super Zoomed-In View)**
- **SEEKS THE TRUTH WITH PROOF VIA HIS/HER INVENTION**
- **INNOVATION WORKS MOSTLY HAVE SINGLE INVENTORSHIP**
- **ENHANCED SENSE OF HUMOUR!! (State of a Relaxed Mind)**

Proof of Single Inventorship
(28 out of 46 Patents)

1. N.A. Riza, U.S.A. Patent No. 5,117,239, May 26, 1992.
2. N.A. Riza, European Patent No. 92303635.4, July 07, 1992.
3. N. A. Riza, U.S.A. Patent No. 5,187,487, Feb.16, 1993.
4. N. A. Riza, U.S.A. Patent No. 5,191,339, March 02, 1993.
5. N. A. Riza, U.S.A. Patent No. 5,231,405, July 27, 1993.
6. N. A. Riza, U.S.A. Patent No.5,274,381, Dec.28, 1993.
7. N. A. Riza, U.S.A. Patent No.5,274,385, Dec.28, 1993.
8. N. A. Riza, U.S.A. Patent 5,307,073, April 26, 1994.
9. N. A. Riza, U.S.A. Patent No. 5,329,118, July 12, 1994.
10. N. A. Riza, USA Patent No. 5,512,907, April 30, 1994
11. N. A. Riza, USA Patent No. 5,568,286, Oct.22, 1996.
12. N. A. Riza, USA Patent No. 5,694,216, Dec. 2, 1997.
13. N. A. Riza, USA Patent No. 5,731,790, March 24, 1998.
14. N. A. Riza, Patent No. 5,718,226, Feb.17, 1998.
15. N. A. Riza, US Patent 6,031,658, Feb.29, 2000.
16. N. A. Riza, Patent No. 6,222,954, April 24, 2001.
17. N. A. Riza, Patent No. 6,282,336, August 28, 2001.
18. N. A. Riza, Patent No. 6,360,037, March 19, 2002.
19. N. A. Riza, Patent No. 6,525,863, Feb. 25, 2003.
20. N. A. Riza, Patent No. 6,563,974, May 13, 2003.
21. N. A. Riza, Patent No. 6,687,036, Feb.3, 2004.
22. N. A. Riza, Patent No. 6,859,578 B2, Feb. 22, 2005.
23. N. A. Riza, Patent No. 6,885,807, April 26, 2005.
24. N. A. Riza, Patent No. 6,922,233, July 26, 2005.
25. N. A. Riza, US Patent No. 7,978,346, July 12, 2011.
26. N. A. Riza, US Patent 8,107,056, Jan.31, 2012.
27. N. A. Riza, US Patent 8,170,384, May 1, 2012.
28. N. A. Riza, US Patent 8,783,874, July 22, 2014.

INVENTOR OR OTHER?

NOT ANYONE

CAN BE

SHOULD BE

WILL BE

CAN BE TRAINED TO BE

AN INVENTOR

The Entire Bachelor's Degree Graduating Class of a University

Pure Inventors In the Class

SOCIETIES AND LEARNING INSTITUTIONS MUST FIND AND FOSTER INVENTORS FOR THE BETTERMENT OF HUMANKIND

INVENTORS - PAST and PRESENT
– CONNECTED BY THE KNOWLEDGE TREE –

Strangers Connected by:

- **Study the Same Field (e.g., Light, Computing)**
- **Study the Same Problem (e.g., Making a Better Liquid Crystal Optical Switch)**
- **Study at the Same Location (e.g., University, Corporation)**
- **Belong to the Same Culture (e.g., Country)**
- **Belong to the Same Tradition (e.g., Religion)**

Past Inventors - An Inspiration for Present Inventors

PERSONAL JOURNEY WITH INVENTORS - PAST and PRESENT

MY FIRST YEAR AT CALTECH

Photo: Caltech Class on Computation
May 31, 1985.

RICHARD FEYNMAN
(1918 – 1988)
Nobel Prize

Professor, Caltech
Co-Inventor of the
Quantum Theory
For Electrodynamics
(Light-Matter Interaction Explained via quantum fields)

My Course Instructor:
Computation Class 1985

PERSONAL JOURNEY WITH INVENTORS - PAST and PRESENT

FELLOW CALTECH ALUMNUS

CHARLES TOWNES
(1918 – 2015)
Nobel Prize

Ph.D. Caltech
Co-Inventor of the
LASER

Photo: Orlando, USA Jan. 11, 1999.

PERSONAL JOURNEY WITH INVENTORS - PAST and PRESENT

TEACHER @ CALTECH

Photo: Caltech EE 100 Year Celebration
Nov. 5-6, 2010.

WILLIAM BRIDGES
(1934 –)

Professor Emeritus, Caltech
Inventor of the
Argon Ion Gas Laser

My Course Instructor:
Guided Waves Class 1984-85

PERSONAL JOURNEY WITH INVENTORS - PAST and PRESENT

ROLE MODEL INVENTOR @ CALTECH

Photo: Caltech EE 100 Year Celebration
Nov. 5-6, 2010.

CARVER MEAD, Ph.D. Caltech
(1934 –)

Professor Emeritus, Caltech
Inventor * of the
HEMT Semiconductor Device
Amplifier Circuit used in RF Electronics
for cell phones, radar, and satellite communications

***Also Co-Invented**
VLSI Electronics Design

HEMT: High Electron Mobility Transistor

PERSONAL JOURNEY WITH INVENTORS - PAST and PRESENT

MY LAST YEAR AT CALTECH

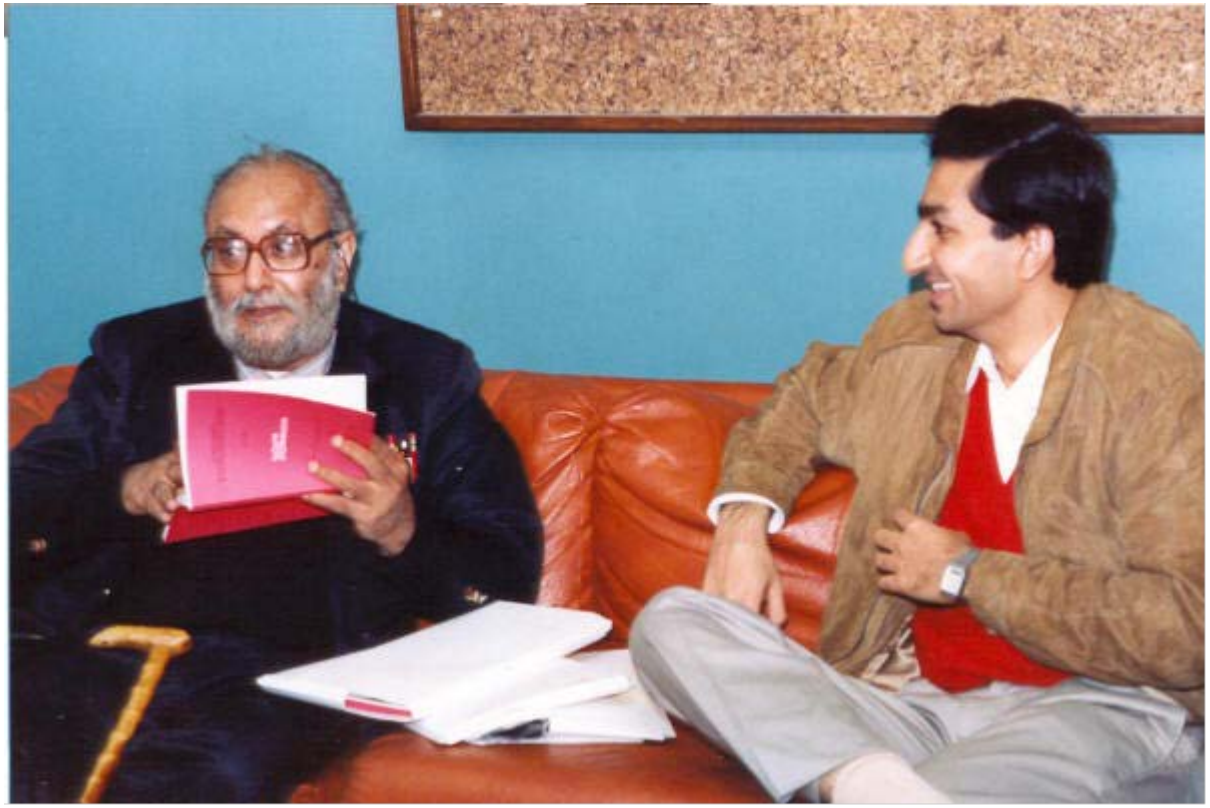


Photo: Caltech, 1989, The Year I completed my PhD from Caltech to start my independent invention-based career.

Born in Pakistan

ABDUS SALAM
(1925 – 1996)
Nobel Prize

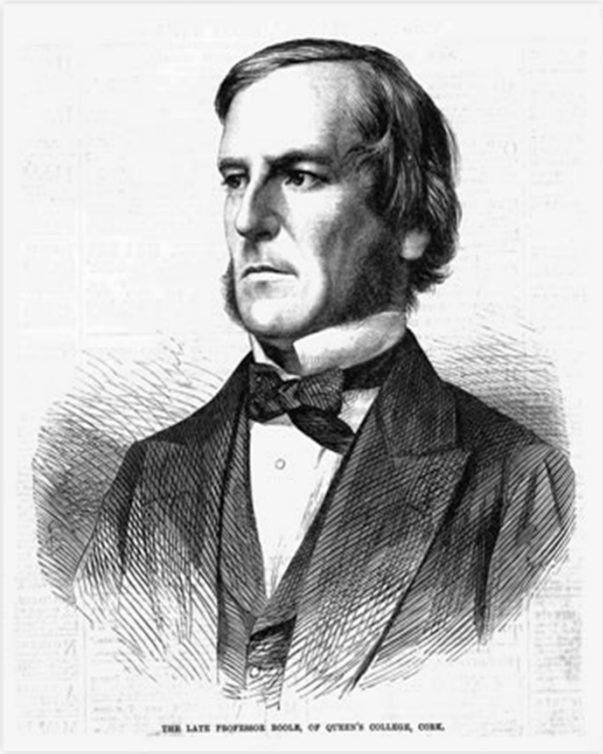
Co-Inventor of the
Theory Unifying the Electromagnetic Force with The Weak Nuclear Force

The Timing Was Perfect!

A Role Model For a Pakistani Student in his Formative Years

PERSONAL JOURNEY WITH INVENTORS - PAST and PRESENT

@ UNIVERSITY COLLEGE CORK (UCC), IRELAND



George Boole (1815 – 1864)

UCC CHAIR Professor (1849-1864)

Inventor of Boolean Algebra FOUNDATIONS OF DIGITAL COMPUTERS

PERSONAL JOURNEY WITH INVENTORS - PAST and PRESENT

@ UNIVERSITY COLLEGE CORK (UCC), IRELAND

John Tyndall
Born Ireland, 1820 – 1893

Discoverer of The Tyndall Effect
Light is scattered by very small particles in its path and SCATTERING IS STRONGER FOR SMALLER WAVELENGTHS

Demonstrator of the water light-pipe, a forerunner To The Optical Fibre

University College Cork is Home to the Tyndall National Institute

PERSONAL JOURNEY WITH INVENTORS - PAST and PRESENT

ACCLAIMED WORLD-WIDE AS THE FATHER OF OPTICS

Persian-Arab Muslim Scientist

ALHAZEN
(965 – 1039)

Inventor of the
Principle of Light Travels
In a Straight Line &
Design of the Pin-hole Camera

WHY DOES AN INVENTOR INVENT?

MOST HUMANS CAN BE MOTIVATED TO TRY INVENTING BY PROVIDING:

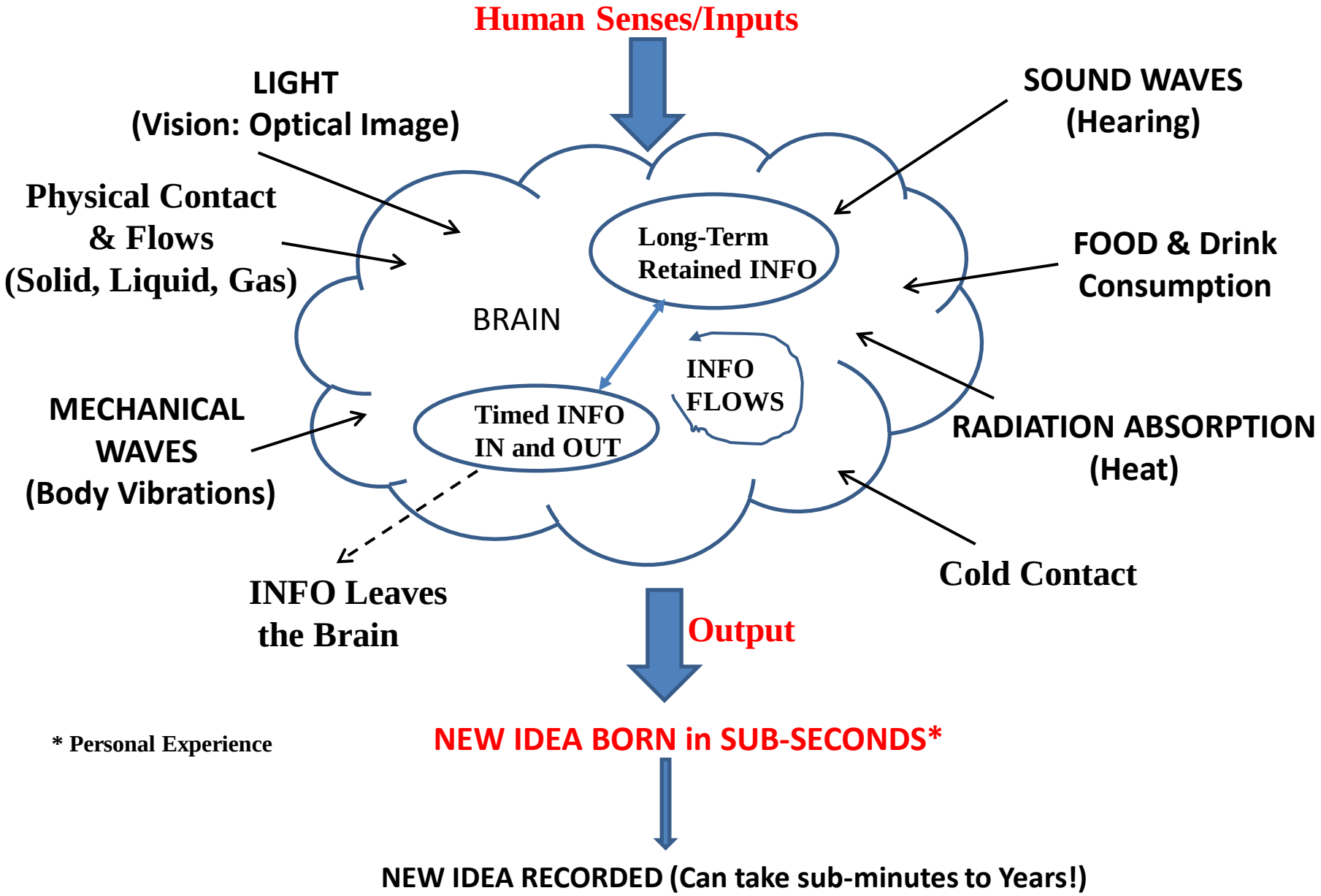
- **MONEY**
- **TITLES AND POSITIONS**
- **LOCAL, NATIONAL, INTERNATIONAL AWARDS/PRIZES**
- **SPECIAL WORKING ENVIRONMENTS**
- **FREE-TIME**
- **TRAVEL OPPORTUNITIES**
- **TEACHING TIME REDUCTION OR ELIMINATION FOR ACADEMICS**

ACCLAIMED URDU WRITER INTIZAR HUSSAIN (my Uncle) WHEN ASKED:

Why Does He Write? **He Replied: Do you Ask a Nightingale why it Sings!**
IT JUST DOES!

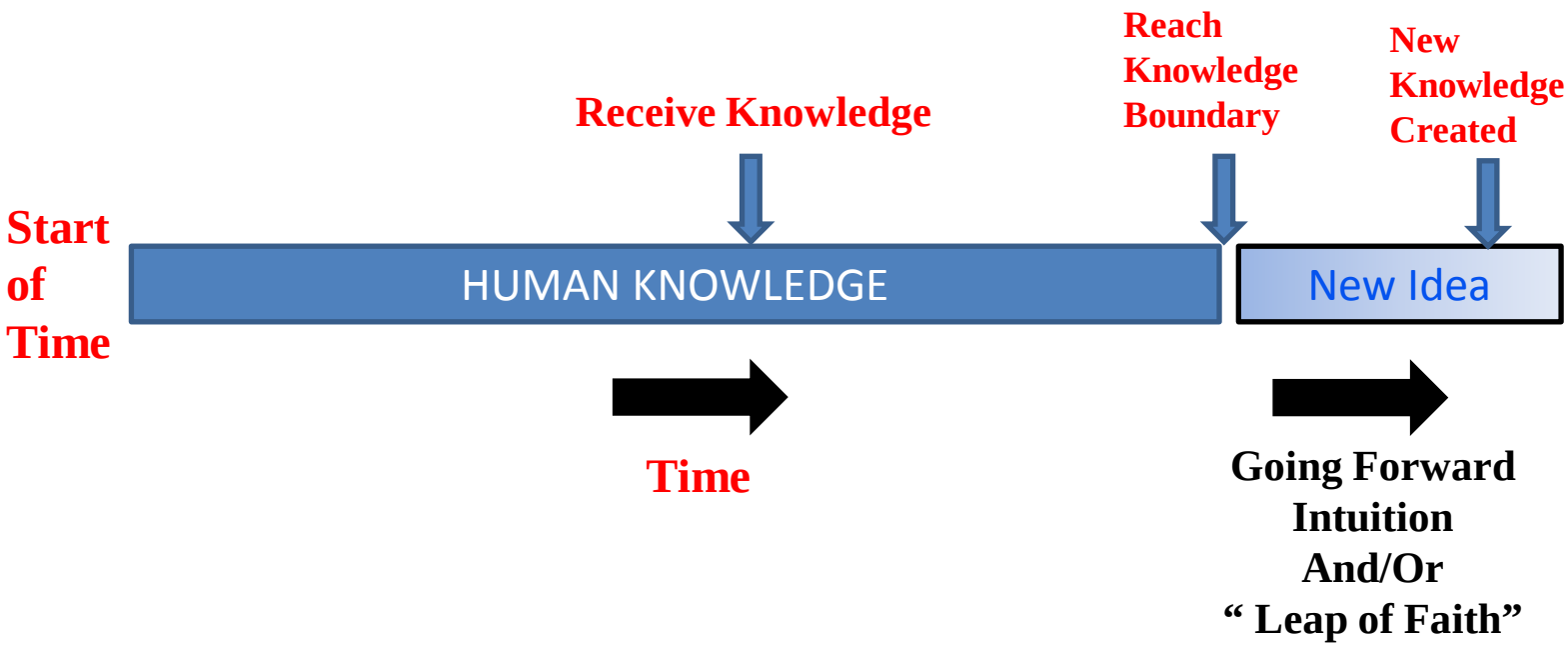
PURE INVENTORS WILL INVENT ANYWAY
AS THAT IS WHAT THEY NATURALLY LOVE TO DO!

HOW DOES AN INVENTOR INVENT?



* Personal Experience

Starting the Invention Process:
" INTUITION"
AND/OR Some times Like a Leap-of-Faith



Indiana Jones – The Last Crusade

The Ravine Crossing Scene

" BREAKING" THE INVENTION

WHEN AN INVENTION IS DECLARED, IT COMES UNDER CRITICISM

THE BETTER THE INVENTION, THE STRONGER THE CRITICISM

GENUINE CRITICISM MAKES THE INVENTION STRONGER FOR A LONGER REIGN

UNINFORMED CRITICISM DIVERTS AND DISTRACTS FROM THE INVENTION

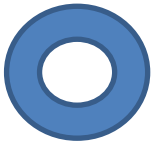
SIMPLER AND CLEARER THE INVENTION, THE HARDER TO "BREAK"
THE INVENTION REIGNS SUPREME FOR A LONG TIME

Example Inventions

The DOT

Connect Dots = Line
(A New Invention)

The Wheel

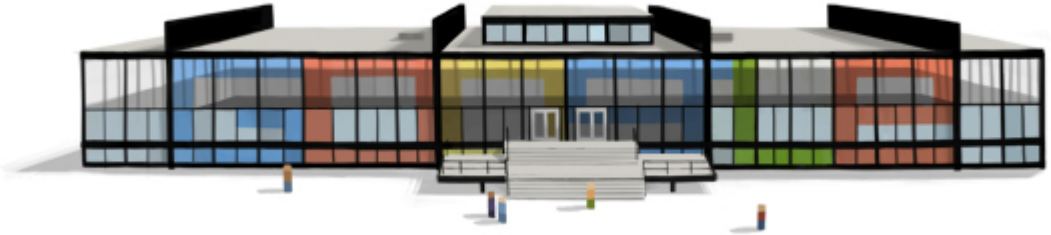


Ludwig Mies van der Rohe (1886-1969) – Inventor Architect

"Less is More*"

Finding Perfection in Purity

S. R. Crown Hall, The School of Architecture – A Mies van der Rohe Invention (1956)
Illinois Institute of technology (IIT)*, Chicago



Google Doodle March 27, 2012 Celebrating Mies's Birthday

**** Author: BS EE IIT 1984.**
Crown Hall Photo Courtesy of www.iit.edu.

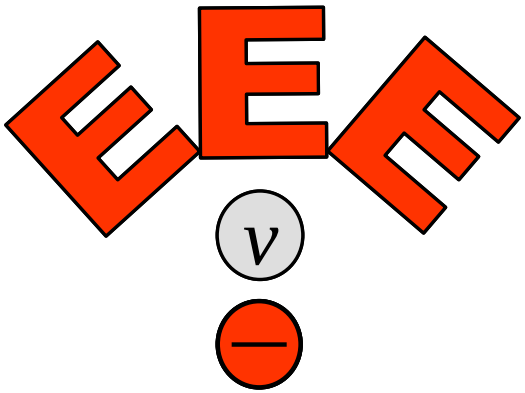
*** Mies's Quote in the New York Herald Tribune, 28 June 1959.**

EXPRESSING TECHNOLOGY VIA ART

A RECENT INVENTION *

GOAL:

DESIGN A SIMPLE YET UNIQUE LOGO WITH A POWERFUL MESSAGE



* July 2011 (Inventor: Riza) Place: Dublin-Cork Train Journey.

INVENTING FOR HIGHER EDUCATION IN PAKISTAN

The PATH to the LUMS School of Science & Engineering (SSE)

Pak-Millennium Conference 2002

Higher Education in Pakistan: Challenges for Reform

April 13-14, 2002
Massachusetts Institute of Technology &
Boston University
Boston, USA

CONFERENCE REPORT

Pak-Millennium Conference Committee
http://www.pak2000.org
The Boston Group
http://www.thebostongroup.org

Invited to Give a Speech on the Topic of "Money" in Higher Education

Delivered a " Plea" and Blue-Print for the Small Technological University Showing the Founder of LUMS that:

IT WILL MAKE EVERYONE MONEY
- Investors, Faculty, Students

6 Years Later
LUMS School of Science & Engineering First Class Starts in 2008

Presentation at the Pak-Millennium Conference on Higher Education in Pakistan, Boston, 2002.

Towards a World-Class Research University in Science and Technology- Money is Critical but Not Enough

PROOF OF INVENTION

By

Nabeel A. Riza

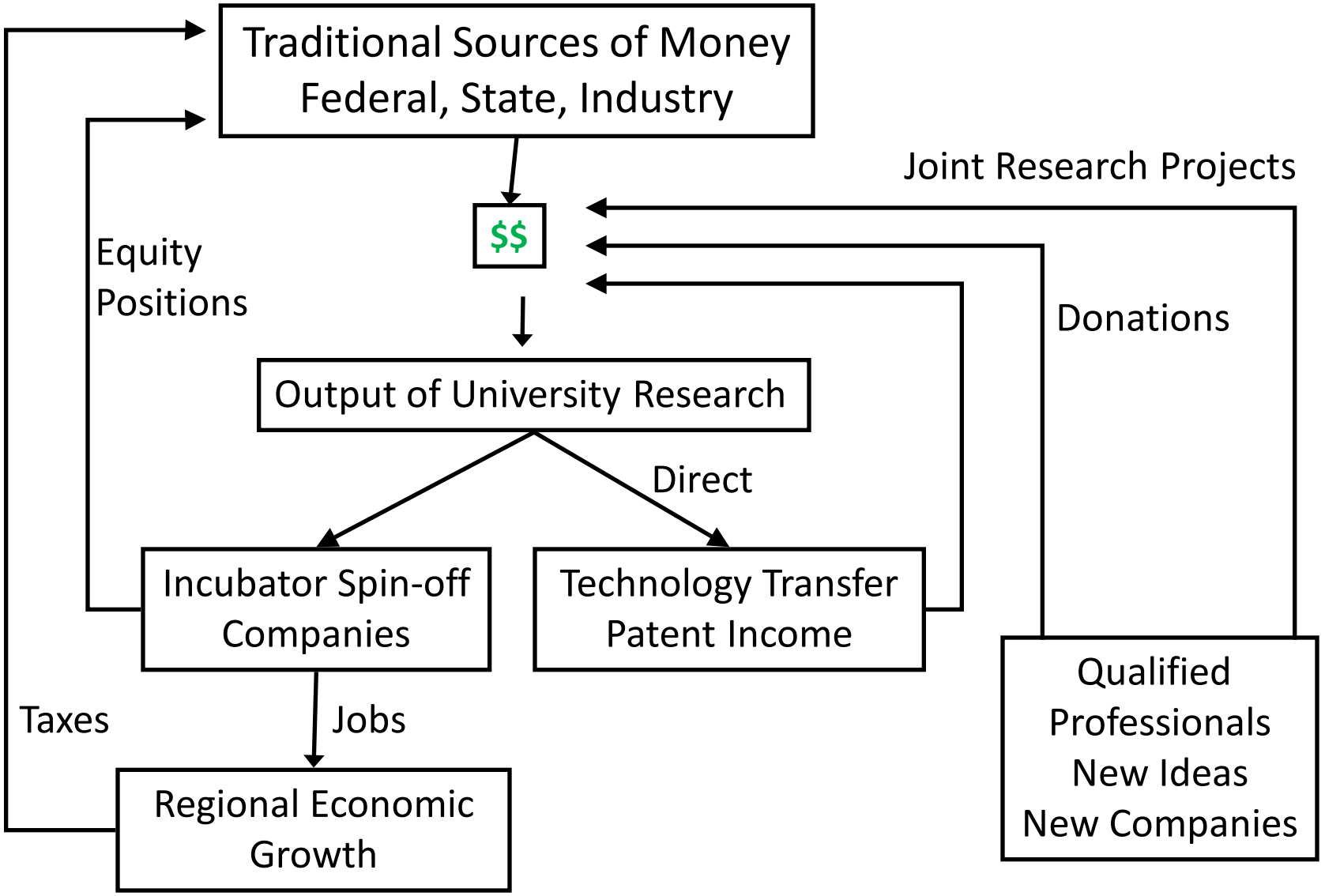
April 14th, 2002

Boston, USA

N. A. Riza is Full Professor at College of Optics/CREOL, University of Central Florida, USA and Founder of Nuonics, Inc.

Key Slide from the Presentation at the Pak-Millennium Conference on Higher Education in Pakistan, 2002.

Financial Engine of a Research University



A GREAT UNIVERSITY IS THE NECESSARY PRISTINE ENVIRONMENT TO CREATE INVENTORS

A Young Andrei Haeff as a Ph.D. student in Caltech's Kellogg Radiation Laboratory 1932. Dr. Haeff was also Research Fellow 1932-34 in Caltech's electrical engineering department

Photo: From IEEE Spectrum Sept. 2015.

FELLOW CALTECH ALUMNUS

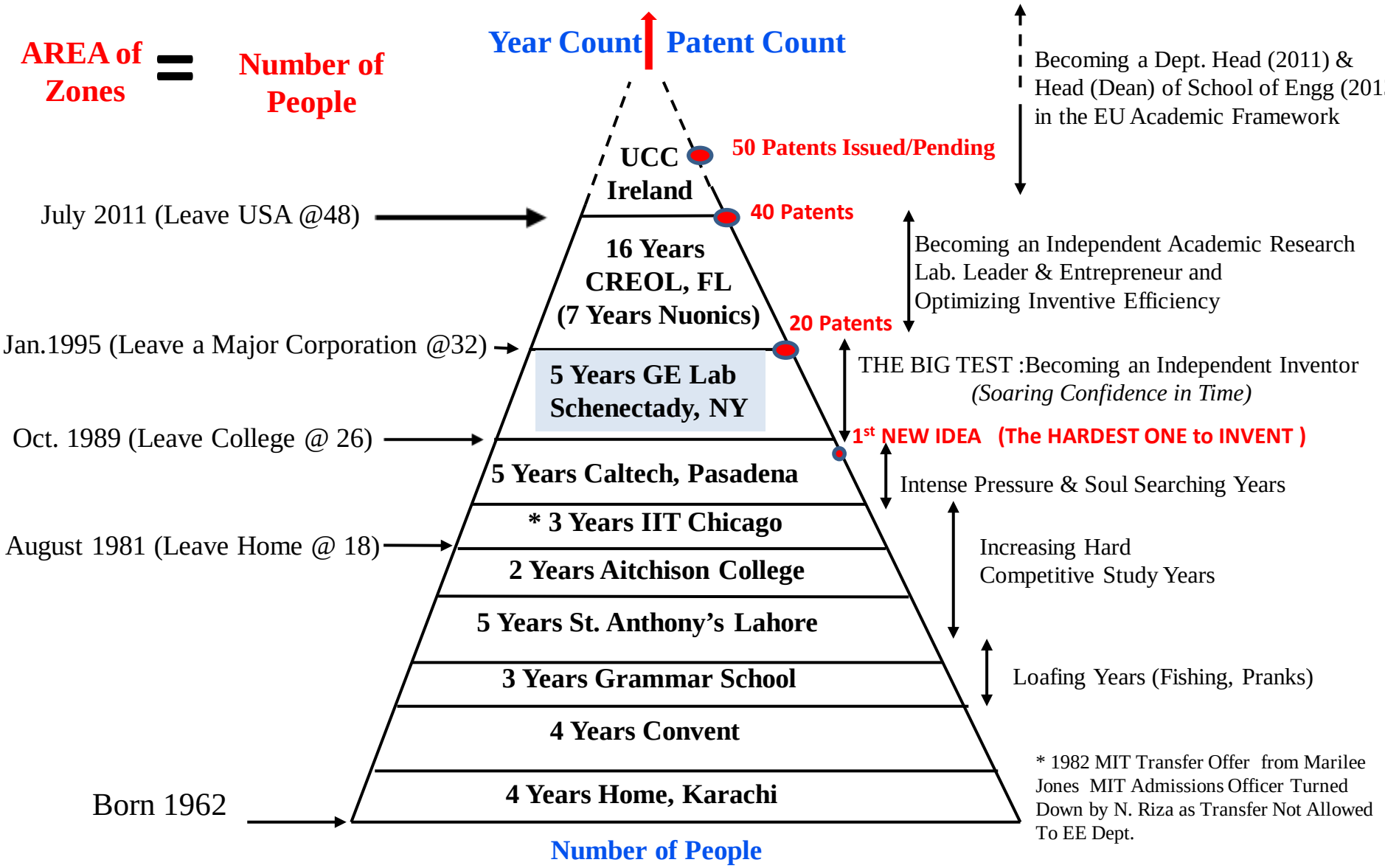
ANDREI V. HAEFF (Born Russia)
(1905 – 1990)
1st IEEE Harry Diamond Award

M.S. 1929, Ph.D. Caltech 1932
Inventor of the
TRAVELING-WAVE TUBE (TWT)

A vacuum tube microwave signal amplifier used in early telecommunications, radar, and television-broadcast systems

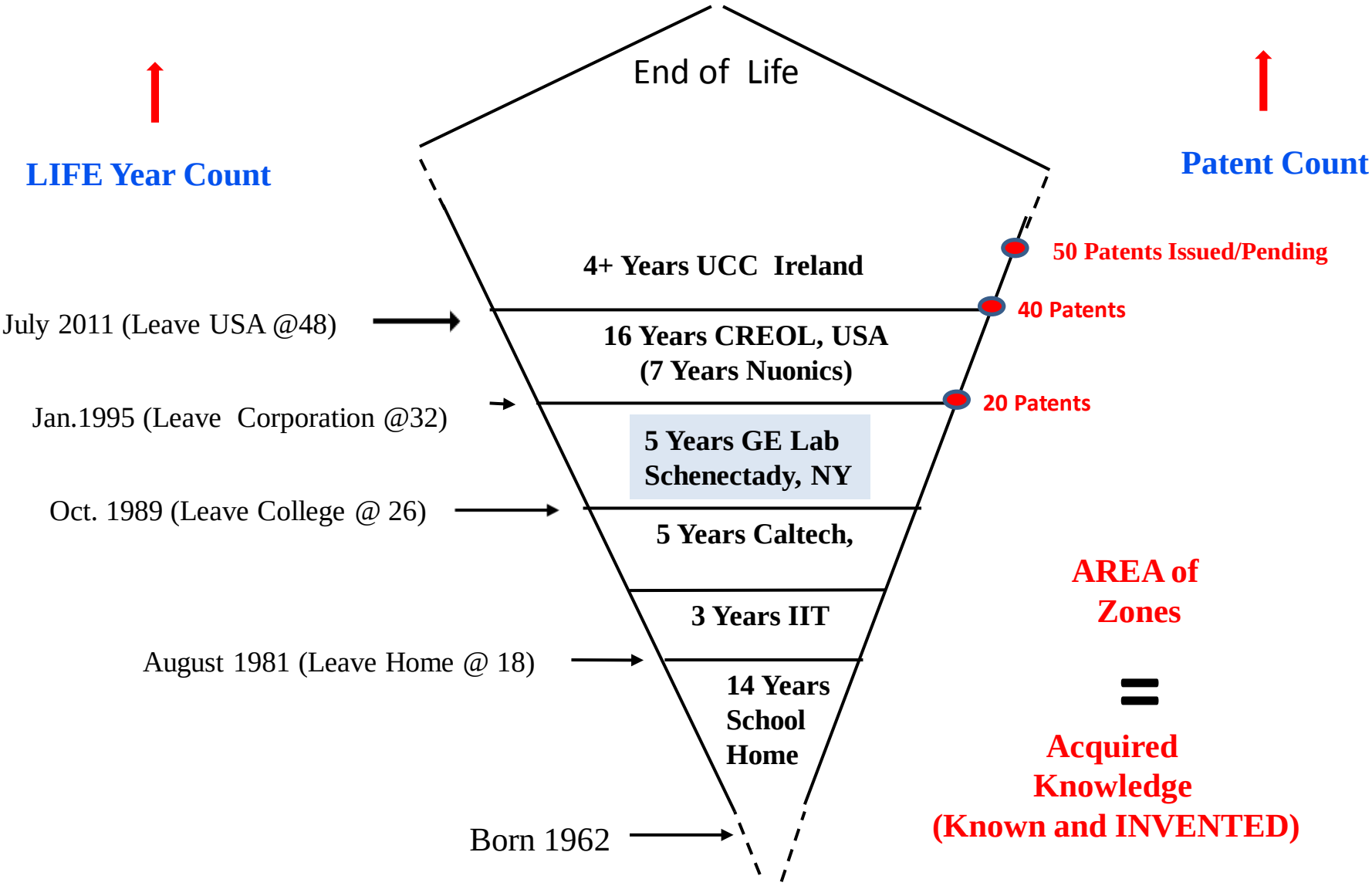
THE INVENTOR'S CLIMB

SMALL STEPS IN THE CLIMB FOR CLEAREST VISION

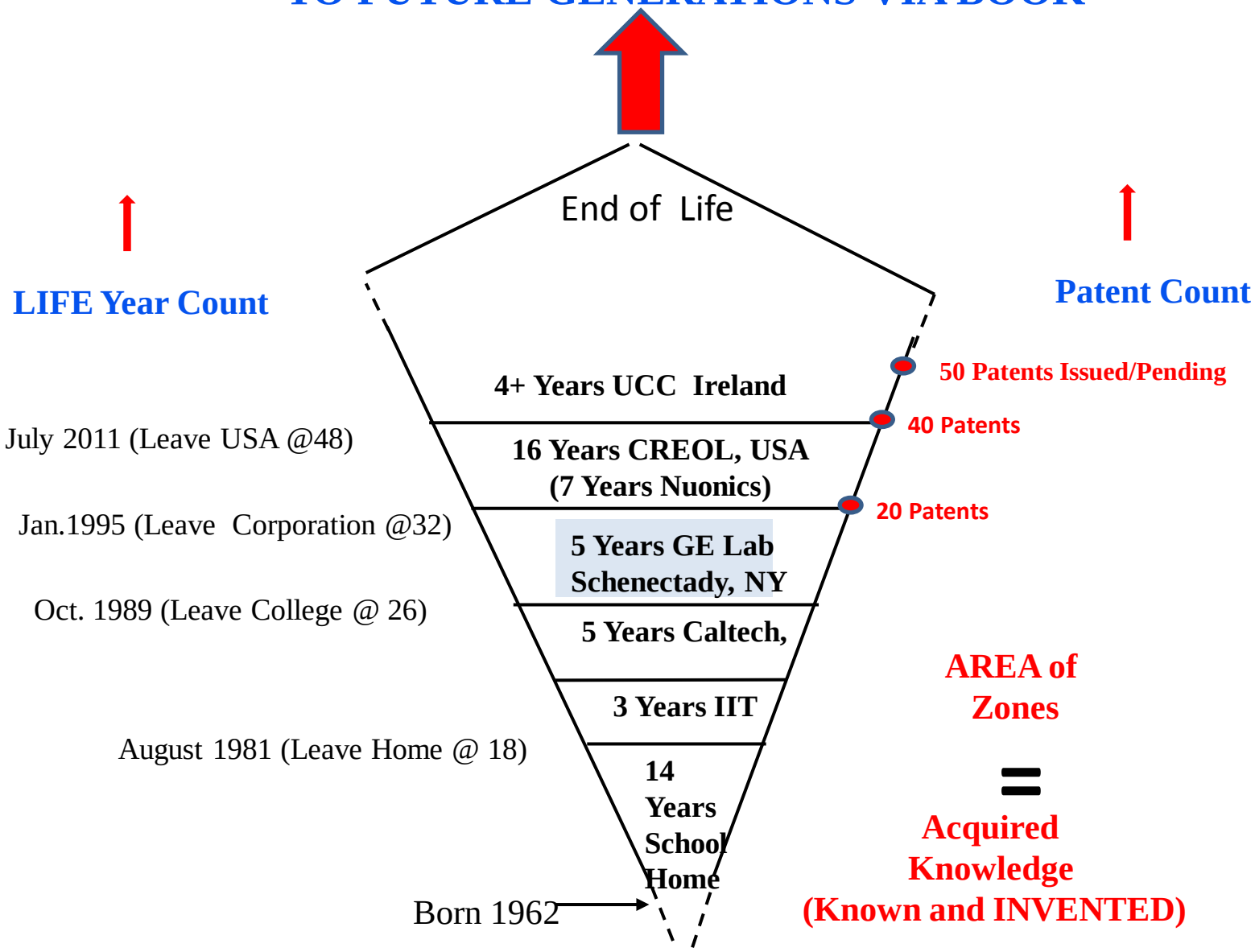


* 1982 MIT Transfer Offer from Marilee Jones MIT Admissions Officer Turned Down by N. Riza as Transfer Not Allowed To EE Dept.

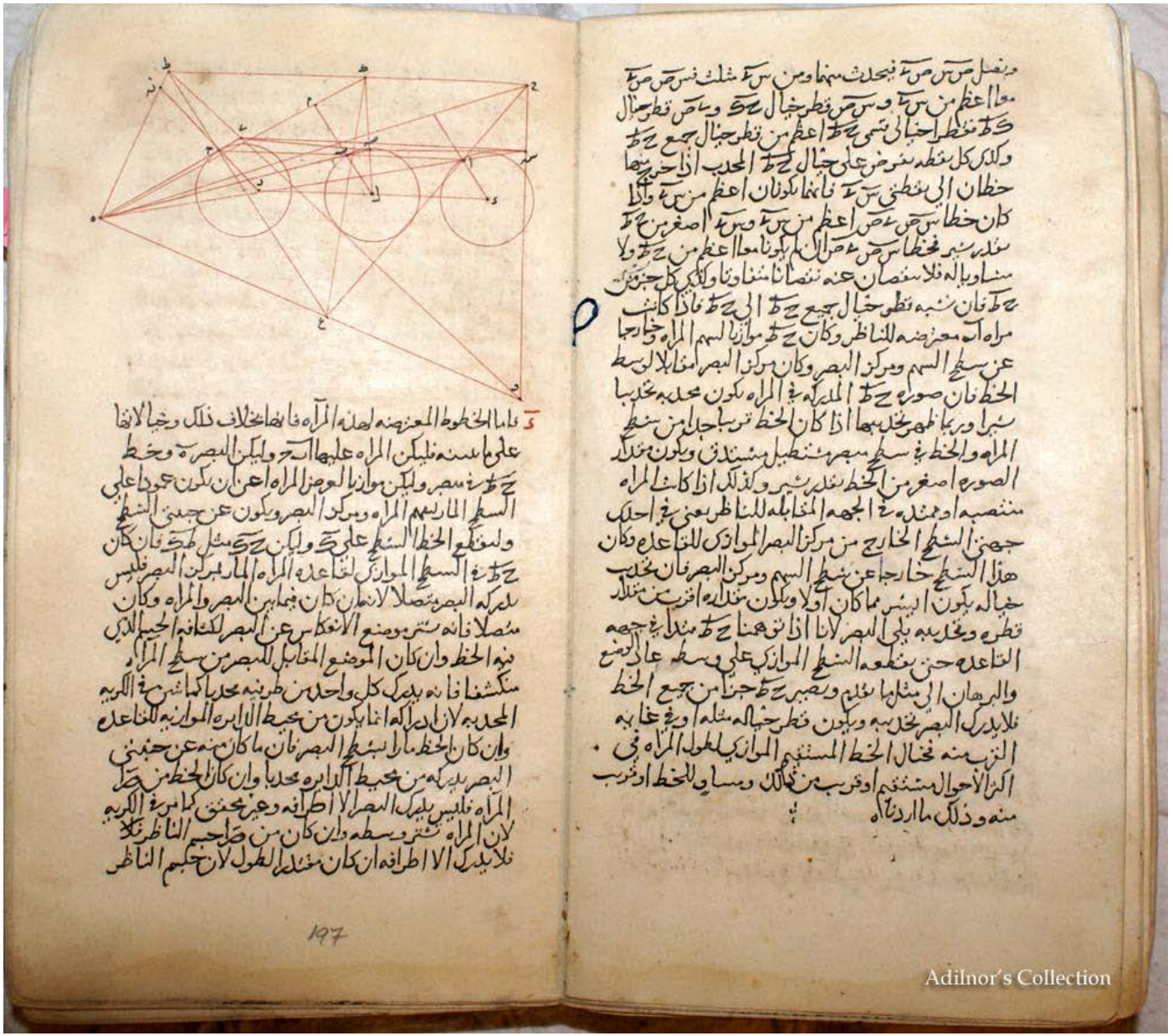
THE INVENTOR'S KNOWLEDGE CLIMB



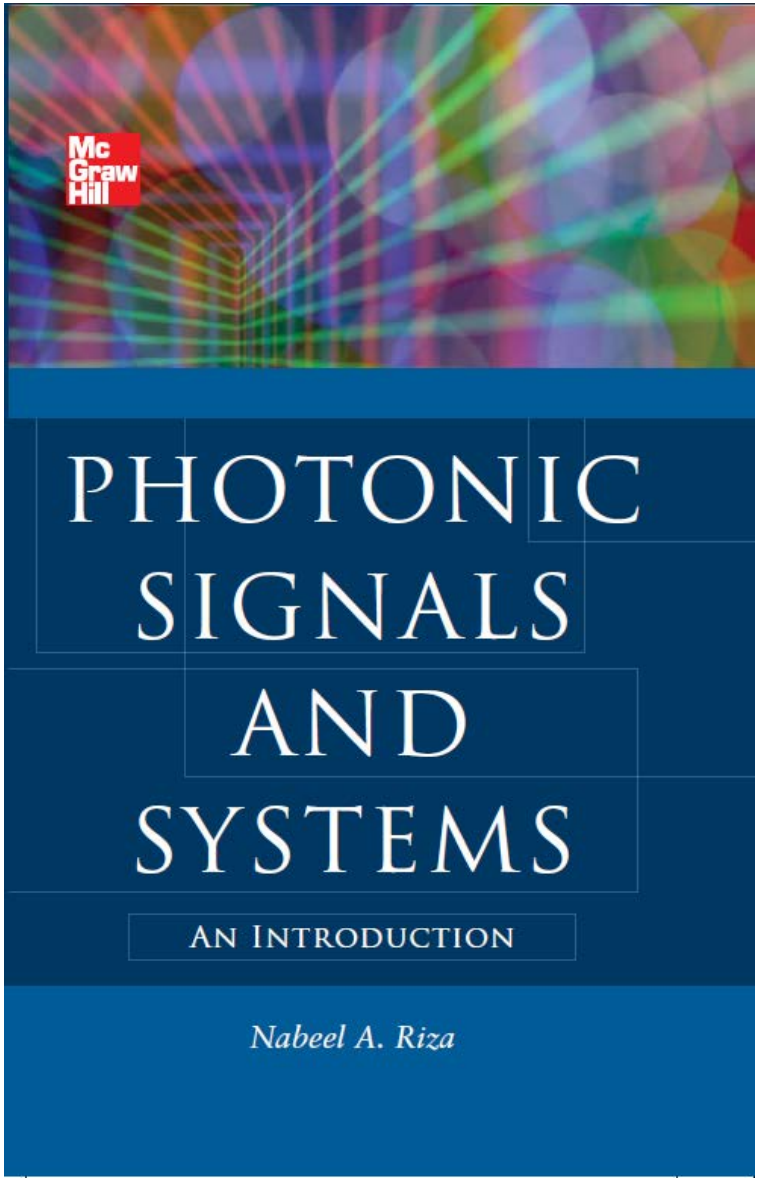
BEFORE END OF LIFE
TRANSFER INVENTOR'S KNOWLEDGE
TO FUTURE GENERATIONS VIA BOOK



1015 Al-Hazen Kitab-al-Manazir – First Book in Optics Published



2013 – The Tradition of Recording Optical Innovations in a Book Continues - Nabeel Riza's Textbook on Photonic Systems



Actions and Not Words – Educating the Next Inventors

Prof. Abdus Salam's Advice to Me (1989)

Remember to Help the 3rd World even if you need to make your Career Elsewhere.

*Sample of Ph.D. Students & Post-Docs (PD) Trained 1995-2015 from the 3rd World

From Thailand

Dr. Sarun (Ph.D.)
Director
Thai National
Lab. (NECTEC)
2005 Winner
ICTP/ICO Award
Abdus Salam ICTP
Trieste, Italy

From Pakistan

Dr. Junaid, M.Phil. QAU (PD) → GIKI EE Dept. Head/COMSATS

Dr. Zahid, M. Phil. QAU (Ph.D.) – Scientist MIT
Dr. Muzammil, BS NED (Ph.D.)
Dr. Sajjad BS Naval College/NUST (Ph.D.)
Dr. Farzan BS GIKI (Ph.D.)
Dr. Mumtaz (Ph.D.) BS Comp. Science 2004, LUMS → Started 2010
Dr. Azer BS GIKI (Ph.D.) → Started 2012

Asst. Professors LUMS SSE

2 SSE LUMS BS Graduates
Junaid Amin 2012 UCC EE PhD Student with FULL Scholarship → My UCC PhD Student
Joveria Baig 2014 UCC EE PhD Student with Full Scholarship → UCC PhD Student –Wife of Junaid

* A Special Thank You to **ALL** my Co-workers including colleagues at GE, Nuonics, & PIPS Lab. Undergraduate and graduate students and Post-Docs.

THANK YOU TO MY TEACHERS & MENTORS

Mr. Fardy (Science/Physics – St. Anthony's Lahore 1973)
Ms. Zareen Bashrat (Biology – St. Anthony's Lahore 1975-78)

Mr. Hafeez Farouqi (Maths – Private Tutor, Education Dept. Lahore– 1976-78)

Mr. A. D. Bhatti (Maths – Aitchison College – 1979-80)

Prof. Deborah Holdstein (English, IIT Chicago, 1981-84)
Prof. Thomas Wong (Electrical Engg, Circuits & Networks, IIT Chicago, 1981-84)
Prof. S. Meerkov (Electrical Engg, Controls, IIT Chicago, 1981-84)
Prof. H. Messenger (Electrical Engg, E & M, IIT Chicago, 1981-84)

Prof. E. Posner (Electrical Engg, Comm., Caltech, 1984-89)
Prof. C. Papas (Electrical Engg, E & M, Caltech, 1984-89)
Prof. D. Psaltis (Ph.D. Supervisor; Electrical Engg, Caltech, 1984-89)

Dr. Bruce Griffing (Lab. Head, GE Corp. Research Center, Schenectady, 1989-95)

Thank You
for the Invitation
to Celebrate

UNESCO 2015

Year *of LIGHT and LIGHT-based Technologies*