

SIR JAGADISH CHANDRA BOSE

Scientist Par Excellence: A Tribute

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Introduction:

India has been commemorating the 160th birth anniversary year of Sir Jagadish Chandra Bose (1858-1937), a scientist of great eminence well known for his contributions in many fields, particularly physical sciences and physiology and for the revival of scientific research in the country on modern lines in the pre-1900 era. IEEE deserves to be complimented for bringing out a Special Section of the *Proceedings of the IEEE* in 1998 [1] to commemorate the *Centennial of Solid-State Diode Detector* by giving due credit to J. C. Bose for its invention and use in his 60 GHz Microwave Spectrometer during 1896-98. The Special Section has also brought out the importance of this device in his microwave communication experiments in Calcutta in the pre-1900 period and its use in G. Marconi's highly successful, long-distance, trans-Atlantic radio communication experiment of 1901, which paved the way in the following years to establish radio as a major means of global communication. Besides, IEEE has also ensured in 2012 that J. C. Bose is included in the same *Hall of Fame on Radio* jointly with G. Marconi (*Italy*) and A. Popov (*Russia*), the only two other inventors recognized earlier. It is in this backdrop that the event organized by IEEE-India Council in Bangalore on 'Celebrating Sir Jagadish Chandra Bose' assumes much significance as it provides the present generation an excellent opportunity to pay respects and tributes to this great scientist. Besides being a *devoted researcher* in *cutting-edge* areas in multiple disciplines in those days, J. C. Bose was an inspiring teacher, a skillful experimenter who designed his own research equipment, a committed institution builder and a great humanist who believed that the benefits of science should reach out to the society at large. Thus, even today, J. C. Bose stands out as a *Role Model* for the younger generation intending to take up careers in academics and research work. These aspects are briefly covered in the Article along with the *lessons to be learnt* from the life and work of J. C. Bose.

J. C. Bose and his Career:

Looking at his intelligence and scholastic abilities in his childhood, parents of J. C. Bose sent him to Calcutta for high school education where better and more opportunities were available for this. This enabled him to proceed to England after his graduation from the Calcutta University for further studies at the famous Cambridge University in England. Here he became a student of Lord Raleigh, eminent Physicist and Cavendish Professor of Physics at the University. Lord Raleigh was much impressed by his intelligence, knowledge of Physics, devotion to studies and independence of thinking. This developed into a life-long friendship between the two greatly benefitting young J. C. Bose from the *mentoring, guidance and patronage* in his research work received from Lord Rayleigh throughout his career. After obtaining his *Natural Science Tripos* from Cambridge, J. C. Bose returned to Calcutta, where he was appointed as a faculty member in the Physics Department of Presidency College, Calcutta a prestigious college of long-standing. In this capacity he was engaged in both teaching and research and built many useful instructional facilities in the Physics laboratory at the College. Being an inspiring teacher, he was able to educate and train many young students to get interested in Physics studies and carve out productive careers in this subject area. Being interested and familiar with issues of contemporary relevance in electromagnetism, J. C. Bose pursued this area for his research work at the Presidency College. Box A presents a brief outline of major milestones in the life and career of J. C. Bose.

Box A: J. C. Bose-Life and Career: Major Milestones

1858, Nov. 30: Born in Mymensingh, East Bengal (in present-day Bangladesh),
Enlightened and encouraging parents, Well-known family background.

1870-76: Student at St. Xavier's School, Calcutta.

1876-80: Student at St. Xavier's College, Calcutta, obtained his B. A. Degree
from Calcutta University.

1880-84: Student at Christ Church College, Cambridge University, England,
under Lord Rayleigh, Cavendish Professor of Physics, obtained his
Natural Science Tripos from the University in 1884.

1885: Joined Presidency College, Calcutta as Officiating Professor of Physics; Promoted as Permanent Professor a few years later, became Senior Professor and continued until superannuation (1915) from Indian Educational Service; Emeritus Professor at Presidency College: 1915-20.

1896: Received D.Sc. Degree from the University of London, England on the Recommendation of Lord Rayleigh.

1896-98: Conducted pioneering mm-wave propagation experiments with certain polarizing crystals leading to development of 'solid-state detector for electrical disturbances' included in a seminal paper in the Proc. of the Royal Society, London in January 1897, named by him as 'Electric Eye', but by others in his time as 'Coherer', as 'Diode' years later.

1901: G. Marconi used the solid-state detector based on the work of J. C. Bose in Trans-Atlantic Radio Communication experiment.

1904: US Patent on 'Detector for Electrical Disturbances' granted to J. C. Bose.

1917: Knighthood conferred by the British Government.
Bose Research Institute the first such Institute in the country established in Calcutta, with J. C. Bose as its first Director.

1920: Elected Fellow of the Royal Society, London.

1927: Elected General President of the Indian Science Congress.

1937, Nov. 23: Breathed his last in Calcutta at the age of 79.

J. C. Bose and his Research:

In the physics of electromagnetism of the pre-1900 era, three path-breaking discoveries as follows stand out [1, 2]:

- a) *Electromagnetic Induction* by which relative motion between a magnet and a nearby conductor produces an electromotive force in the conductor and vice versa, i.e., magnetism producing electricity and electricity producing magnetism, discovered almost simultaneously in 1831 by Michael Faraday in England and Joseph Henry in U. S. A.
- b) *Electromagnetic Theory of Light* and the famous Field and Wave Equations of the electro-magnetic field postulated and explained in 1873 by James Clark Maxwell in England, based on Faraday's discoveries in electricity and his concept of electric and magnetic lines of force.
- c) *Experimental Researches* verifying Maxwell's Theory during 1887-89 by Heinrich Rudolf Hertz in Germany demonstrating the generation of electromagnetic waves and their transmission in free space over a few meters in the laboratory.

These discoveries attracted the attention of many scientists/investigators in the succeeding years to conduct further experiments on the Hertzian doublet and the radiation emerging from it as well as on antennas and wave propagation. J. C. Bose was also fascinated by this research direction and he took up his work on quasi-optical researches with electromagnetic waves at a wavelength of 5 mm (Frequency ~60 GHz). Through this he demonstrated in 1898 a microwave spectrometer containing transmitter, receiver, horn antennas and waveguides, which many years later turned out to be the essential parts of a millimeter wave / microwave communication link. The invention of the solid-state detector device came from his millimeter-wave propagation measurements through certain polarizing crystals by following the optics route. In particular, his seminal paper in 1897 'On the selective conductivity exhibited by certain polarizing substances' published in the Proceedings of the Royal Society, London [1] led directly to this invention. He had named this device as the 'electric eye' or 'artificial eye' as it was transforming the electromagnetic radiation of any wavelength impinging on it into an electrical signal. J. C. Bose also invented many other useful solid-state detector devices for 'wireless' waves in this period, known as 'self-restoring coherers'. He conducted much of his research in the area of millimeter wave and microwave physics wherein he is considered to be a pioneer. As an extension of these studies, J. C. Bose went on to the discovery of some similarity in the response of the living and the non-living and conducted path-breaking research work in the response phenomenon in plants and made many significant contributions in Physiological Science, particularly plant physiology.

J. C. Bose was a prolific writer and he travelled frequently to Europe and U. S. A. on various scientific missions and for technical lectures. He was a firm believer that scientific knowledge needs to be shared, as only through this means that the knowledge can grow and expand. It was with this conviction that J. C. Bose got immersed in disseminating his research contributions through lectures and publication of papers in learned journals for their wider utilization. It is interesting to

note that J. C. Bose had great reluctance in getting his research contribution patented to safeguard its intellectual property. This is because he was against any commercialization of science, which was gathering momentum in those days. However, it was only through the sage advice and insistence of his long-term friend, Swami Vivekananda that J. C. Bose was prevailed upon to patent his unique invention of ‘Detector for Electrical Disturbances’ in U. S. A. in 1904 as a one-time gesture. However, J. C. Bose ensured that a specific clause was included in the Bose Research Institute’s founding registration document (1917) that no member of the Institute may be allowed to apply for patent for any idea and/or device developed at the Institute!

J. C. Bose and his Friends/Admirers:

J. C. Bose had several friends and admirers, both in India and abroad, whom he considered to be instrumental in enhancing his scientific research and capabilities. They included eminent scientists, such as Lord Rayleigh, Lord Kelvin and Sir J. J. Thomson in England and great luminaries such as Swami Vivekananda and Nobel Laureate Poet Rabindranath Tagore in India to name a few. Each one of these had lasting impact on the career of J. C. Bose as can be seen below:

- a) *Lord Rayleigh, Cavendish Professor of Physics (1879-85) at Cambridge University* taught Physics to J. C. Bose and became his life-long friend, philosopher and guide. He was also responsible for patronizing the research contributions of J. C. Bose in the area of millimeter waves at the Royal Society, London, in the Victorian British Empire and in the western world.
- b) *Lord Kelvin, after whom the absolute scale of temperature (K) is named*, was a great admirer of the pioneering research work of J. C. Bose and also his patron in England and European countries. On his advice, J. C. Bose used a highly sensitive Kelvin Galvanometer in his revolutionary experiments as the end detector.
- c) *Sir J. J. Thomson, discoverer of the particle ‘electron’ in 1897* was an admirer of J. C. Bose and his pioneering contributions to millimeter wave communication. In his Foreword to a Book by J. C. Bose containing a collection of his papers (1926), Sir J. J. Thomson writes: “Another aspect of these papers is that they mark the dawn of the revival in India of interest in researches in Physical Science; this which has been so marked a feature of the last thirty years is very largely due to the work and influence of Sir Jagadish Chandra Bose”.
- d) *Swami Vivekananda, an erudite scholar and Indian religious leader*, a friend and admirer of J. C. Bose for many years had visited U.S.A (1893) and seen the benefits of science to mankind and the usefulness of patenting of scientific inventions. On his advice, J. C. Bose agreed to patent his pioneering development of the solid-state detector in spite of his committed reluctance to do patenting. Swami Vivekananda also made arrangements with his disciple, S. C. Bull in U.S.A. to endorse /file the patent application of J. C. Bose in 1901) and the U.S. patent was granted in 1904.
- e) *Rabindranath Tagore, Nobel Laureate (1913)* was also a friend and admirer of J. C. Bose for many years and they used to enjoy each other’s company whenever they met. Rabindranath Tagore utilized every possible opportunity to encourage J. C. Bose in his research work and to scale new heights in his ‘science’. On being informed of his path breaking invention of the solid-state diode detector in 1897 by J. C. Bose, Rabindranath Tagore sent him a congratulatory poem written in Bengali, especially suited for the occasion. An English translation of this poem is reproduced below as extracted from [1] which sums the warm feelings of the great poet towards J. C. Bose!

Box B: Congratulatory Poem composed by Poet, Rabindranath Tagore, NL

To: Professor Jagadish Chandra Bose

Across the oceans, on the western shore,
Reigns the temple of the Goddess
Of wealth of science.
There you have journeyed, my friend,
And returned richly crowned.
You anointed the motherland,
Modest at heart, poor and shy.

The great and the gloried
Of these far-off lands
Assembled and acclaimed
Your work in unison,
The words resounding their message,
Far and wide, the seas beyond.

Her eyes welled up in tears,
Mother sends you the Message
Of her humbled heart,
Through a poet of whom
The world of science has never heard.
Only in the inner self of yours,
Will these words echo
As gentle murmurs of
Mother's whispered tone.

19th July, 1897

Rabindranath Tagore

(English translation from Bengali by Sugata Basu Sengupta, July 1997; Reproduced from Proc. IEEE, Vol. 86, No.1, pp. 221-222, Jan. 1998)

Concluding Remarks:

As can be seen from this Article, J. C. Bose was indeed a great teacher, researcher and humanist of international fame and he brought glory to India through his scientific contributions in multiple fields and his concern for the society at large. He is truly a *role model* for any academic of 21st century India, as he demonstrated that both inspiring teaching and cutting-edge research can be handled by an individual at the same time with each one contributing to the quality and standard of the other. Besides, his thoughts on dissemination of knowledge with a view to permit it to grow freely at a rapid rate and his commitment not to commercialize knowledge are worthy of careful consideration by the present generation in the context of the on-going trends in globalization. These and other lessons learnt from the life, work and contributions of J. C. Bose during his time in the 19th-20th centuries are worth emulating in present-day India as well.

References:

- 1) P. K. Bandyopadhyay, *et al* (Guest Editors), Special Section on the "Centennial of the Semiconductor Diode Detector", Proc. IEEE, Vol. 86, No. 1, pp.218-285, January 1998.
- 2) B. S. Sonde, "100 Years of Radio:1895-1995, Some Reflections", Current Science, Vol.70, No. 4, pp.322-325, February 1996.

About the author



Prof. B. S. Sonde received his B.E. (Telecom) and M.Sc. (Engg.) degrees from the University of Pune (1958, 1959) and Ph.D. in Engineering from the IISc (1963). He was a member of the academic staff of IISc (1964-97) until his appointment as Vice Chancellor, Goa University (1997-2002). During this period, he was also appointed as Member of the Council of IISc (1998-2001). His fields of interest cover Microelectronics, Instrumentation, Digital Technology & Applications in Electronics and Communications, wherein he has trained scores of students for B.E., M.E., M.Sc.(Engg.) and Ph.D. Degrees of IISc, published over 90 papers in prestigious scientific/technical journals, a series of 10 text/reference books widely used in engineering education in India and also many technical reports.

He has been Chairman/Member of Advisory/Governing Bodies of many Institutions in India, including CSIR laboratories, ISRO centres, UGC, AICTE, NAAC, NBA, KSHEC and IITs/Universities. Prof. Sonde has been an invited speaker at many national/international Conferences. He has been a recipient of many awards, notably Ramlal Wadhwa Gold Medal of IETE (1978), Jaya Jayant Award for Teaching Excellence of IISc (1992), Distinguished Alumnus Award of College of Engineering, Pune (1994), Chapter Development Award of ISHM-The Microelectronics Society, USA (1996), Life-Time Achievement Awards of Instruments Society of India (2002), Systems Society of India (2010) and IETE (2013) and IEEE-Bangalore Medal of Honour (2018). Prof. Sonde is a Distinguished Fellow of IETE and SEE, Honorary Fellow of ISTE and a Senior Member (LS) of IEEE (USA). Prof. Sonde has been an active participant at Conferences/Symposia held by IETE, IEEE and other technical professional societies, edited/published many proceedings of such events and he has been closely connected with the development of quality higher education in general and electronics & communication engineering education, research and industry in the country.