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VP News

Inside

Ham Radio Promotional Activities at Vigyan Prasas

Vigyan Prasas has been organizing lectures and demonstrations on amateur radio (Ham Radio) on a continuous basis with an aim to make the younger generation aware about this wonderful scientific hobby. On October 19, 2001, nearly two hundred school children from various age groups along with their teachers from the Bal Bharti Public School, Ghaziabad, participated in such a programme. Students got hands-on experience in operating the ham radio set up and talked to other ham radio stations. The demonstration programme was assisted by VU3FUN, VU2OB, VU2XD and VU2SUH. A talk on amateur radio was delivered by Shri Sandeep Baruah, VU2MUE.

Similar amateur radio promotional programmes have been organized for the following schools and institutions: Mother International School (on November 3, 2001), IIT (on November 4, 2001), Guru Harkishan Public School, India Gate (on November 12, 2001).

Vigyan Prasas had assisted the celebration of 44th Jamboree On The Air (JOTA) of Scouts & Guides on October 20 & 21, 2001. Scouts & Guides from Kendriya Vidyalaya (KV) Air Force School, Tughlakabad along with their teachers visited the Vigyan Prasas Ham Radio facility and celebrated by talking to their counterparts in different parts of the world using Ham Radio.



Ham Radio Demonstration programme at Bal Bharti Public School

EDITORIAL

☞ **Riding on Radio Waves**

Part-2



☞ **Linus Carl Pauling**

The Greatest Architect
of Modern Chemistry



VP has also taken up the task of bringing hams in Delhi together once a month for a periodical interaction and to evolve a programme for disaster preparedness. Till now, seven get-togethers have been organized by Vigyan Prasas in which talks on topics of interest to radio amateurs have also been arranged. The get-together on September 16, 2001, was hosted by Bharat Scouts & Guides National HQ, in which Shri Atanu Dasgupta (VU2ATN) delivered a talk on "Homebrewing". Shri Rahul Kapoor (VU2YK) and Shri Rakesh Kapoor (VU2RAK) hosted the next meet of the

VP News Contd. on Page...18

... think scientifically, act scientifically ... think scientifically, act scientifically ... think scientifically, act...

Save That Drop

Water is a resource that defines not just the limits of sustainable development, but the very survival of human beings on this planet – the only planet known that supports life. The supply of fresh water is essentially limited, and the demands on available quantity of water have already reached precarious proportions. While the global population has tripled over the past seventy years, the use of water has grown six-fold! Only about 2.5 per cent of all water on the planet is fresh water which is essential for all human purposes – but only about 0.5 per cent is accessible ground water or surface water. World-wide, 54% of the annual available fresh water is being used at present. Assuming that the consumption per person remains steady, by 2025 we could be using 70% of the total because of population growth alone!

The World Population Report 2001 estimates that by 2025, as many as 3 billion people from 48 developing countries (India included!) will suffer from levels of water scarcity which may be acute to desperate! The world population today stands at 6.1 billion – twice the number it was in 1960. In 2000, 2.1 billion people from 61 countries were using less water than a basic daily requirement of 50 litres per capita per day. By 2050, 4.2 billion people accounting for about 45 per cent of the humanity will be living in countries that cannot meet the requirement of 50 litres of water per person each day! Incidentally, this minimal standard does not take into account other necessary uses of water – for agriculture, protection of ecosystem and industry.

There is no gainsaying the fact that the burden of the acute shortage of water is borne by the poor, especially in the far-flung rural areas. We continue to read the stories of our women in the rural areas trudging for several hours just for a pitcher or two of drinking water! The situation is worse in summer months. Cities are no exception either. With urban population increasing as a result of migration from rural areas, the municipal taps go dry for longer and longer periods every passing summer.

Why have we landed up in such a grim scenario? The reasons are not difficult to find. Despite the fact that the available ground water is limited, it has been

recklessly exploited over the years. We have also forgotten the traditional methods of rainwater harvesting, with few attempts to recharge the aquifers. Many countries, including India, use unsustainable means to meet their water needs. If more water is drawn than is replenished by natural processes, the excess is essentially "mined" from reserves. Agriculture and industry, in particular, divert large amounts of water with disastrous effects at times. Finally, there is the additional problem of pollution, especially in the developing countries like India. 90 per cent of sewage and 70 per cent of industrial waste is dumped annually into the surface water sources, especially the rivers and lakes. Alarming, indeed! No technology can increase the amount of fresh water available naturally. The quantity of water available today is the same as it was some 2000 years ago, when the world population was barely 3 per cent of today's 6.1 billion! Purely technological solutions to water scarcity are unlikely to have any significant effect. Desalinated sea-water is expensive. It now accounts for less than one per cent of the water people consume.

What is the solution then? Protecting water supplies from pollutants, restoring natural flow patterns to river systems, managing irrigation and chemical use, and curbing industrial pollution are vital steps to improving water quality and availability. In addition, what is needed is the revival of traditional water harvesting techniques. Surely, it would be too much to expect Government alone to accomplish much. It would require a continued joint effort by the Government and the people – especially through those non-Government organisations which are already engaged in promoting traditional water conserving techniques. This is only one aspect. The other aspect concerns concerted efforts at controlling the growth of population, educating the people on the importance and use of conservation techniques, and minimizing the pollution of water. True, this is a formidable task and a formidable challenge of the present century to science communicators. Indeed, this needs to become a part of the People's Science Movement. Let us save that drop of water we have borrowed from our children!

□ V.B. Kamble

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Riding on Radio Waves

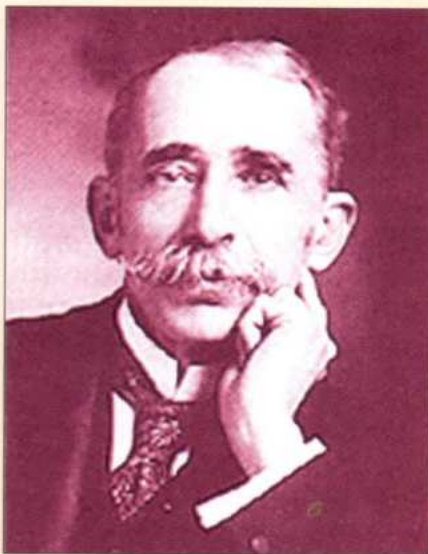
Part II

□ V.B. Kamble

In Part-I, we outlined the application of radio waves and the early attempts for their application in what was then called the "wireless" communication. We saw how from the early days of the spark chamber of Heinrich Hertz, and development of sensitive detectors by Bose, and the tuning technique developed by Lodge, along with experiments by Marconi made the first trans-Atlantic radio contact possible on December 13, 1901. In this part, we shall outline the history of radio during the century following this great event. Indeed, this is a saga over nearly one and a half centuries since Maxwell predicted the existence of electromagnetic waves in 1864.

Diode and Audion:

The next major event was the discovery that an electrode operating at a positive voltage inside the evacuated envelope of a heated filament lamp would carry a current. The American inventor Thomas A. Edison had noted that the bulb of such a lamp blackened near the positive electrode, but it was Sir John Ambrose Fleming, professor of electrical engineering at Imperial College, London, who explored the phenomenon and in 1904 discovered the one directional current effect between a positively biased electrode, which he called the anode, and the heated filament; the electrons flowed from filament to anode only. Fleming called the device a diode because it contained two electrodes, the anode and the heated filament; he noted that when an alternating current was applied, only the positive halves of the waves were passed – that is, the wave was rectified (changed from alternating to direct current). The diode could also be used to detect radio frequency wave and produced a pulsed direct current

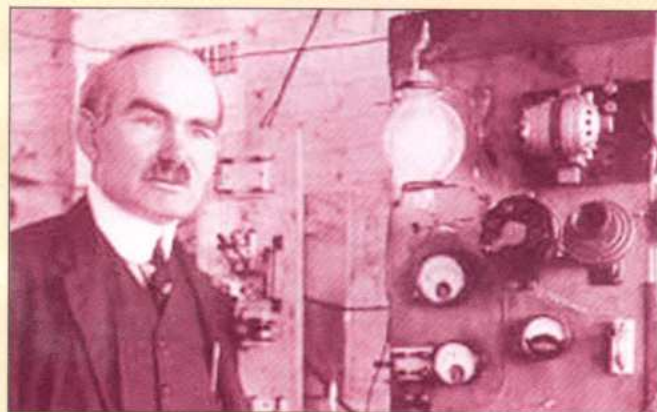


Sir John Ambrose Fleming

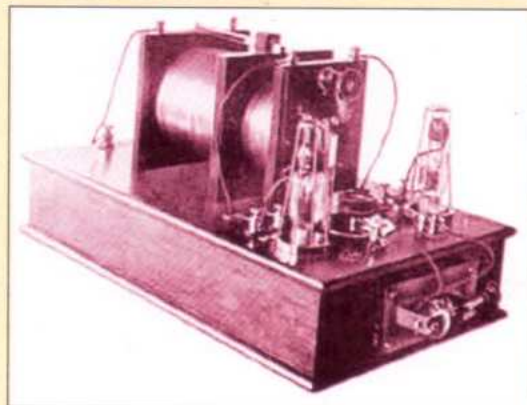
corresponding to the on and off of the Morse code transmitted signals. Fleming's discovery was the first step to the amplifier tube that in the early part of the 20th century revolutionized radio communication.

Fleming failed to appreciate the possibilities he had opened up and it was the American inventor Lee De Forest who in 1906 conceived the idea of interposing an open meshed grid between the heated filament and positively biased anode, or plate, to control the flow of electrons. De Forest called his invention an Audion (now commonly known as triode). With it he could obtain a large voltage change at the plate for a small voltage change on the grid electrode. This was a discovery of major importance because it made it possible to amplify the radio-frequency signal picked up by the antenna before application to the receiver detector; thus, much weaker signals could be utilized than had previously been possible. Among the major developments of the first two decades of the 20th century was De Forest's discovery in 1912 of the oscillating properties of his Audion tube, a discovery that led to the replacement of the spark transmitter by an electronic tube oscillator that could generate much purer radio waves of relatively stable frequency.

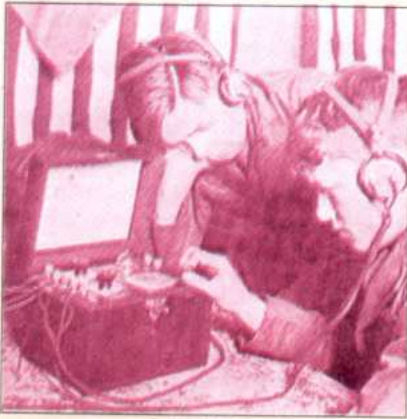
Lee de Forest's father was a minister and hoped that his son would follow in his footsteps. In order to be trained for this calling, de Forest left Alabama for prep school in Massachusetts. His life at school was hard, with chores as well as academics, plus work to supplement his scholarship. Besides, he was not well-liked there. Biographers report he was extremely concerned with getting recognition from his peers, an issue which lasted throughout



Lee de Forest with his transmitter



Audion Receiver 1907



Radio 1920s

his life. Alas, he only won acknowledgement as "homeliest boy in school."

Despite this, he was confident. During school, de Forest had tried to get money (and fame) by inventing things he might sell or enter in contests, but none were great successes. After receiving a PhD from

Yale in 1896 with a dissertation on radio waves, he developed an improved wireless telegraph receiver. By 1902, he had founded the De Forest Wireless Telegraph Company but like other firms he would start, it failed because of poor business practices.

De Forest was extremely creative and energetic, but often was unable to see the potential of his inventions or grasp their theoretical implications. While working on improving wireless telegraph equipment, he modified the work of other inventors and created the Audion, a vacuum tube containing some gas. It was a triode, incorporating a filament and a plate, like ordinary vacuum tubes, but also a grid between the filament and plate. This strengthened the current through the tube, amplifying weak telegraph and even radio signals. De Forest thought the gas was a necessary part of the system. In 1912, others showed that a triode in a complete vacuum would work far better.

This kind of "nearly getting it" would characterize de Forest's life. In 1912, he developed a feedback circuit, which would increase the output of a radio transmitter and produce alternating current. He didn't see the worth of his discovery, though, and by the time he applied for a patent in 1915, it

invention. His other major contribution was to the film industry. In the 1920s, he had been trying to use electricity to improve sound recordings. He found a way to record sound on film, again adapting the work of others and using his Audion. This led directly to the creation of motion pictures with sound. He achieved this in 1921 and tried to push his technology to the film industry. They resisted, but when they were finally won over, used a different method. The De Forest Phonofilm Corporation folded by 1925. Two years later *The Jazz Singer* appeared in theaters, the first feature-length "talkie." Ironically, the industry later reverted to the sound method De Forest first proposed.

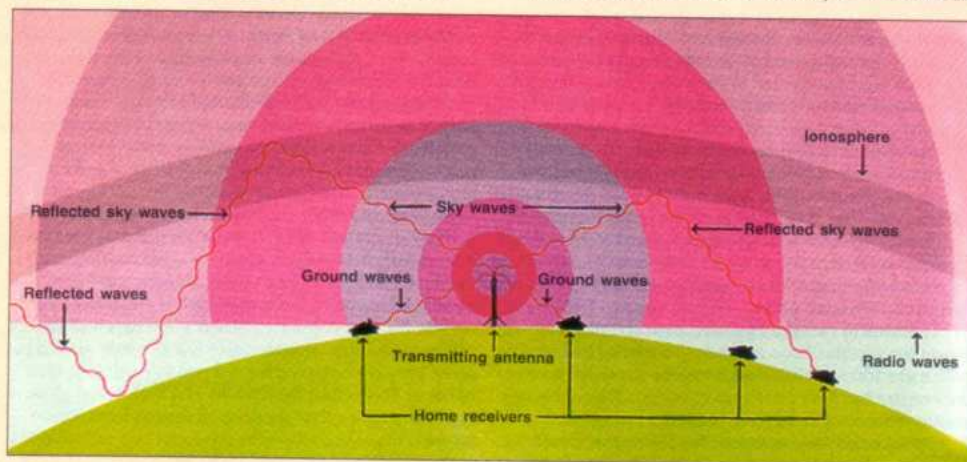
Throughout his tumultuous life — many failed businesses, ongoing lawsuits, patent applications, and four marriages — de Forest promoted radio and later television as a way to raise Americans' cultural awareness. In 1910, he attempted the first live broadcast from New York's Metropolitan Opera House (starring Enrico Caruso). In 1916, he pioneered radio news, broadcasting — although incorrectly — the results of the presidential election. He was disappointed with how radio and television evolved, however, and was deeply critical of its low standards. De Forest wrote an autobiography entitled *Father of Radio*, but did not get that recognition from the rest of the world. He is remembered as one contributor to an industry that was, in truth, the work of many people.



Radio 1940s

Discovery of the Ionosphere

Ionosphere is the region of the Earth's atmosphere in which the number of ions, or electrically charged particles



Ionosphere

had already been patented by E. Howard Armstrong. De Forest sued, with legal action lasting until 1934. He won, but the radio industry always credited Armstrong with the

— resulting from the action of extraterrestrial (primarily solar) radiation on the neutral atoms and molecules of the air — is large enough to affect the propagation of radio waves. The

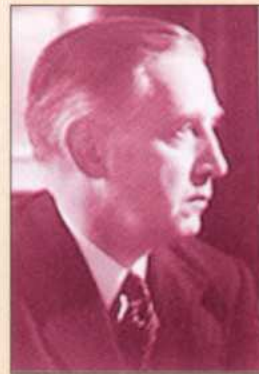
ionosphere begins at a height of about 50 km above the surface but is most distinct at altitudes above about 80 km.

Discovery of the ionosphere extended over nearly a century. As early as 1839, the German mathematician Carl Friedrich Gauss speculated that an electrically conducting region of the atmosphere could account for observed variations of the Earth's magnetic field. The notion of a conducting region was reinvented by others notably in 1902 by the American engineer Arthur E. Kennelly (1861 – 1939) and the British physicist Oliver Heaviside (1850 – 1925) to explain the transmission of radio signals around the curve of the Earth's surface, before definitive evidence was obtained in 1925. For some years the ion-rich region was referred to as the Kennelly-Heaviside layer (now called the E region of the ionosphere).

The ionosphere consists of three layers: the D region, the lowest, is strongly ionized during the day and is responsible for the attenuation of shortwave and broadcast band radio signals, an effect that largely disappears at night; the E layer, extending from 90 to 140 km, is a region of ionized molecules and strong electric currents; and the F region, from 140 km up, is characterized by ionized atoms and contains the stratum (designated as F2) in which ion concentration reaches a maximum. This layer is also called the Appleton layer after Sir Edward Victor Appleton (1892-1965) for his investigations of the physics of the upper atmosphere especially for the discovery of the so called Appleton layer. The E and F regions are responsible for the long distance propagation, by reflection, of radio signals in the short wave and broadcast bands. Ionization in the ionospheric region is chiefly effected by solar radiation at X-ray and ultraviolet wavelengths. The particles ionized are mainly molecular nitrogen and molecular and atomic



Sisir Kumar Mitra



Edward Victor Appleton

oxygen, but at a height of about 1000 km, there is a region in which hydrogen nuclei (protons) constitute the dominant ionic species. Kennelly noticed that Guglielmo Marconi's reception, in Newfoundland in 1901, of radio signals transmitted from England was received far better than was predicted by radio wave theory. The following year he postulated that the radio waves were being reflected back to Earth from an ionized layer in the upper

atmosphere. Shortly thereafter the British physicist Oliver Heaviside independently propounded the same theory, and the layer thus became known as the Kennelly – Heaviside layer.

It is interesting to note that Arthur Edwin Kennelly was born at Colaba, India. He was a U.S. electrical engineer who made innovations in analytic methods in electronics, particularly the definitive application of complex number theory to alternating current (ac) circuits. After working as an office boy for a London engineering society, as an electrician, and on a cable engineering ship, in 1887 Kennelly joined Thomas Edison's staff at West Orange, N.J., where he was chief assistant until 1894. Then, with Edwin J. Houston, he formed the consulting firm of Houston and Kennelly in Philadelphia.

Sisir Kumar Mitra (1890 – 1963) the Indian Physicist carried out important studies on the ionosphere. He set up an ionosphere field station at Haringhata near Calcutta, which was the first of its kind in India. He proposed a theory of "active nitrogen" to explain the luminescence of the night sky. He was the pioneer of radio physics in India.

Depending primarily on its frequency, a radio wave may travel from the transmitting to the receiving antenna in a number of ways. Figure 1 illustrates the main radio paths. Radio waves are sub-divided into several frequency bands

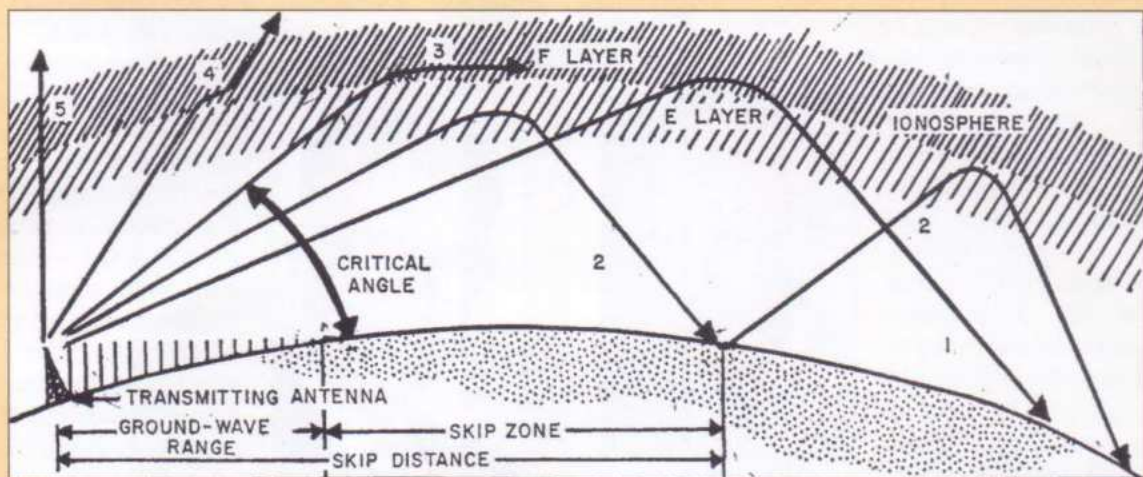


Figure 1 : Main types of radio paths

depending on their frequency range. Different frequency bands are utilized for typical applications as shown in the Table 1.

from Ballybunion, Ireland, to the U.S.

From 1920 onward radio made phenomenal progress through research activities in Europe, America, and Asia.

Frequency Band	Frequency Range	Wave length Range	Typical Uses
Very low frequency (VLF)	10 – 30 kHz	30000 – 10000 m	Long distance point-to-point communication
Low frequency (LF)	30 – 300 kHz	10000 – 1000 m	Marine, navigational aids
Medium frequency (MF)	300 – 3000 kHz	1000 – 100 m	Broadcasting, marine
High frequency	3 – 30 MHz	100 – 10 m	Communication of all types
Very high frequency (VHF)	30 – 300 MHz	10 – 1 m	Television, FM, radar, air navigation, short wave
Ultra high frequency (UHF)	300 – 3000 MHz	1 m – 10 cm	Radar, microwave relays, short distance communication
Super high frequency (SHF)	3000 – 30000 MHz	10 – 1 cm	Radar, radio relay, navigation, experimental
Extremely high frequency (EHF)	30000 – 300000 MHz	1 – 0.1 cm	Experimental

Table 1: The Radio Spectrum

Enter commercial companies

The first commercial company to be incorporated for the manufacture of radio apparatus was the Wireless Telegraph and Signal Company Ltd. (England) in July 1897 (later changed to Marconi's Wireless Telegraph Company, Ltd.); other countries soon showed an interest in the commercial exploitation of radio.

Among the major developments of the first two decades of the 20th century was De Forest's discovery in 1912 of the oscillating properties of his Audion tube, a discovery that led to the replacement of the spark transmitter by an electronic tube oscillator that could generate much purer radio waves of relatively stable frequency. By 1910, radio messages between land stations and ships had become commonplace, and in that year the first air-to-ground radio contact was established from an aircraft. In 1918 a radiotelegraph message from the Marconi long-wave station at Caermarvon, in Wales, was received in Australia, over a distance of 17,700 kilometres.

Though early experiments had shown that speech could be transmitted by radio, the first significant demonstration was not made until 1915 when the American Telephone & Telegraph Company successfully transmitted speech signals from west to east across the Atlantic between Arlington, Virginia, and Paris. A year later, a radiotelephone message was conveyed to an aircraft flying near Brooklands (England) airfield. In 1919 a Marconi engineer spoke across the Atlantic in the reverse direction

The invention of the electron tube and later the transistor (1948) made possible remarkable developments in fields such as control and computing as well as telecommunications.

Major breakthroughs in radio circuitry

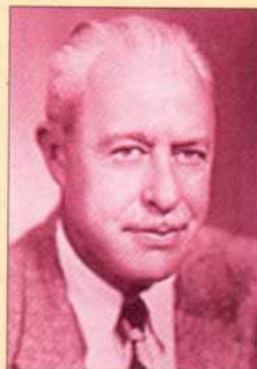
An electron tube or transistor, designated an active element, functions basically as an amplifier, and its output is essentially an amplified copy of the original input signal. The simplest amplifying electron tube is the triode, consisting of a cathode coated with material that provides a copious

supply of electrons when heated, an open-mesh grid allowing electrons to pass through but controlling their flow, and a plate (anode) to collect the electrons. The plate is maintained at a positive voltage with respect to the cathode in order to attract the electrons; the grid usually has a small negative voltage so that it does not collect electrons but does control their flow to the plate. The output voltage is usually many times greater than the input voltage to the grid. The tube must be pumped to a high degree of vacuum, or the plate current flow is very erratic.

Other electrodes, also in the form of open-mesh grids, may be included in the tube to perform various special functions. An example is the four-electrode tube known as the tetrode, in which an open-mesh grid (screen grid) maintained at a positive voltage is placed between plate and control grid. This reduces the effect of plate voltage on electron flow and increases the amplifying property of the tube. Introduction of a third grid, known as a



John Bardeen



Walter Houser Brattain



William Bradford Shockley

World in Your Shack !

Amateur radio is a hobby that enables one to communicate on specified bands of radio frequencies. Of course, one cannot talk business or politics; nor can one pass on a third party message. It is possible to exchange technical information such as a report on a newly fabricated transmitter or an antenna; or other information not in any way prejudicial to national security. For this purpose, there is a network of monitoring stations spread throughout the country that monitor all communication on the entire radio frequency spectrum.

Anyone above 12 years of age can obtain Amateur Station Operator's Licence after passing a qualifying examination conducted by the Ministry of Communication and then can set up a Ham Radio Station of his/her own. It is possible to establish an Amateur Radio Club Station with a licenced ham in charge of it. Every ham has a unique call-sign, or an identification sign, the prefix denoting the Country and the suffix, the individual, or the club. For example, in the call-sign of the NCSTC Amateur Radio Club, VU2NCT, at Technology Bhavan, New Delhi, VU2 denotes India, while NCT stands for the club.

The training comprises of basic radio theory, learning to communicate on Morse-Code, and rules and regulations for operating a ham radio station. The training may take about 10-12 weeks learn Morse-Code and radio theory if you have science background, it may take much less, only about 6-8 weeks.

Ham radio enables one to get introduced to a highly creative and a scientific hobby and to experiment in radio communication and electronics, besides getting the thrill of talking' directly to hams throughout the world. Truly, you have the whole world in your shack.

Ham radio equipment at the moment is not freely or readily available in our country. The cost of an imported set is around Rs. 40,000/- including the concessional customs duty at 15%. Only a licenced ham can import the ham equipment. This is one reason why quite a few hams prefer to build their own transceivers from old or rejected equipment, or what the hams -Fall "home-brewing".

Considering the utility and potential of ham radio, not only in emergency, but also as a means of triggering and promoting an interest in science and technology, Vigyan Prasar has been putting in efforts to popularise this hobby in the country.

The greatest service rendered by Amateur Radio is during the times of emergency or natural disasters like earthquakes, cyclones or floods in rescue and relief operations; as was witnessed during the supercyclone in Orissa or the recent devastating earthquake in Gujarat.

Vigyan Prasar maintains the NCSTC Amateur Radio Club VU2NCT and the Amateur Radio repeater station VU2DLR; and also runs training programmes for prospective hams. Vigyan Prasar aims to set up Amateur Radio Clubs in schools and especially in the disaster prone areas. Incidentally, the small family of Vigyan Prasar already has three hams, including the author of this article. Do write to us for more information.

suppressor grid, produces the pentode (five-electrode tube), which can provide even greater amplification.

The transistor, which has largely replaced the electron tube as the active element in low-voltage electronic circuits, is made from semiconductor materials-that is, substances that are neither good conductors nor good insulators. Two common semiconductor materials are germanium and silicon, to which small amounts of impurities such as indium, gallium, arsenic, or phosphorus are added to impart electrical charges to them. Arsenic and phosphorus, for example, provide extra negative charges, giving n-type (signifying excess negative charges) material; indium or gallium yield a shortage of electrons or an excess of positive charges or holes, giving p-type (signifying excess positive charges) material. A transistor is a sandwich of semiconductor materials with the same impurity in the two

outer layers and a different impurity in the centre layer providing current carriers of opposite charge to those produced by the outer layers.

A transistor is an amplifier of current; the vacuum tube, in contrast, is an amplifier of voltage. The transistor produces a very adequate supply of current carriers (electrons and holes) at room temperature and does not require a heated cathode like the vacuum tube. Thus the power required from the power supply is much reduced, much less heat is produced, and the transistors and their circuitry can be packed into a smaller space. Transistors are also physically much smaller than comparable electron tubes. Thus the transistorized portable radio can fit in a pocket in contrast to the cumbersome tube radio it has replaced.

Printed circuit boards and wiring, developed during 1940s, eliminated much of the hand work and helped manufacturing of radio communication equipment at highly economic rates. The development of integrated circuits in recent years have made the design even more compact. A large scale integrated circuit, also called a chip, can perform a large number of functions. Incidentally, a chip is also a fundamental unit of a computer.

Broadcasting a programme

During a radio broadcast, a microphone picks up speech and other live sounds that make up the program. An electric current runs through the microphone. When sound waves enter the microphone, they disturb the current in the microphone, creating vibrations in it that match the sound waves. These electric waves are used to produce the radio waves that make up the broadcast. In a similar way, equipment in the radio station changes the prerecorded sounds of a program into electric waves.

The electric waves representing the sounds of a program travel over wires to the control board. From the control board, the electric waves go to the transmitter. In some stations, the transmitter is in the same room as the control board, and the electric waves that make up the program travel between the two instruments over wires. Other stations have their transmitter far from the radio station, at the site of the transmitting antenna (the device that sends radio waves through the air). In such cases, the electric waves are passed to the transmitters either by wire or by a special beam of radio waves.

The transmitter strengthens the incoming electric waves representing the broadcast. The transmitter also produces another kind of electric waves called carrier waves. It combines the carrier waves with the electric waves from the radio studio. This 'modulation' of waves becomes the radio signal that brings the program to radios. The transmitter sends the radio signal to the antenna. The antenna, in turn, sends the signal out into the air as radio waves.

The main parts of a radio receiver include: (1) antenna, (2) the tuner, (3) amplifiers, and (4) the speaker.

The antenna is a length of wire or a metal rod that picks up radio waves. It may be entirely inside the radio, or part

of it may be outside the radio and connected to it, as is the case in automobile radios. When radio waves strike the antenna, they produce extremely weak electric waves in the antenna. However, an antenna receives radio waves from many stations at the same time. In order to hear a single programme, a listener must tune the radio to the desired station. The tuner is the part of the radio that makes it sensitive to particular frequencies, or channels of the stations that may be tuned in. The heart of a tuner is a radio part called a variable capacitor. This device consists of two sets of semicircular metal plates. The two sets mesh closely together. One set never moves. The other set shifts its

position when a person twists the tuning control. This shifting produces changes in the radio's circuits that make the radio sensitive to various frequencies.

Amplifiers strengthen the program signal selected by the tuner. The amplifiers in a typical radio are parts of what is called a superheterodyne circuit. In most radios sold today, the main operating parts of this circuit are transistors. These transistors may all be part of a single integrated circuit. Most radios made before 1950 used vacuum tubes.

In most modern radio receivers, reception is based on what is known as the superheterodyning principle. The incoming radio frequency is mixed (heterodyned) with the output of a local oscillator (LO), the frequency of which is adjusted so that the difference between it and the incoming signal is constant; the result is called the intermediate frequency (IF). Amplification is thereafter carried out at this intermediate frequency (IF). The signal next enters the detector. The detector removes the carrier wave from the signal and leaves only the audio frequency the part that represents the program. Finally, one or more AF amplifiers strengthen the audio frequency part of the signal and send it to the speaker. The speaker is the final link between the broadcasting studio and the listener. It changes the electric signal back into the original program sounds.

Broadcasting Services

It was in 1916 that David Sarnoff, then contracts manager to the American Marconi Company, recommended that transmitting stations be built for the purpose of broadcasting speech and music and that "a radio music box" should be manufactured for the general sale. His proposals were not implemented at once – partly because America's entry into World War I in 1917, but they proved highly practical. Technically, the first entertainment

Growth and Development of Radio in India

The first radio programme in India was broadcast by the Radio Club of Bombay in June 1923. It was followed by the setting up of a Broadcasting Service that began broadcasting in India in July 1927 on an experimental basis at Bombay and Calcutta simultaneously under an agreement between Government of India and a private company called the Indian Broadcasting Company Ltd.

When India became independent, the AIR network had only six Stations located at Delhi, Bombay, Calcutta, Madras, Lucknow and Tiruchirapalli with a total complement of 18 transmitters - six on the medium wave and the remaining on short wave. Radio listening on medium wave was confined to urban limits of these cities. As against a mere 2,75,000 receiving sets at the time of Independence, now there are about 111 million estimated radio sets in about 105 million household in the country. Now the broadcast scenario has drastically changed with 198 broadcasting centers, including 74 local Radio Stations, covering nearly cent-per-cent country's population.

broadcasting was done by the German Army in 1917, but, the first regular broadcasting station was KDKA in Pittsburgh, which started operations in November 1920. The service gained instant popularity, and the idea spread at once around the world. The medium-wave band of frequencies proved inadequate to provide sufficient broadcast channels. As a result, there was considerable development of the very high frequency (VHF) band after World War II. The greater availability of channel space in the VHF band allowed the use of frequency modulation (FM) techniques for broadcasting stereo programmes. Unless a satellite is employed, long distance broadcasting becomes

possible only by means of short waves – also called high frequency (HF) waves – which are reflected back to earth from ionosphere as noted earlier.

Broadcasting from a geo-synchronous satellite, which maintains a fixed position over a particular location on Earth, also is possible, but, the power supply and antenna size limitations on the satellite require the carrier frequency to be in the ultra high frequency range – also called microwaves, which can pass through the ionosphere without getting absorbed. Since the satellite is situated at a height of nearly 36,000 kilometres, the signal at the Earth's surface becomes rather weak. A sensitive receiver and directional antenna system is, therefore, essential. Such services have become available in recent years.

Broadcasting service in India was set up in 1927. The first radio programme was broadcast in June 1923 by the Radio Club of Bombay (see box).

Amateur Radio

Radio had already attracted numerous amateur enthusiasts and experimenters, and at the end of World War I, they were granted permission to communicate by radio with each other at the upper end of the medium wave band, and in the short-wave band, frequencies then thought to be useless for long distance communication! To distinguish them from professionals, they were called "radio amateurs". Amateurs in Britain and USA could establish radio contact across the Atlantic at wavelengths of about 100 metres throughout most of February 1925. As remarked earlier, Marconi also could pick up signals from a distance of about 3700 kilometres at about 100 metres wavelength around this time. Radio amateurs thus helped establish that short wavelengths could be used to provide a satisfactory service at great distances.

Sisir Kumar Mitra

Sisir Kumar Mitra was born in Kolkata on October 24, 1890. His father Joykrishna Mitra belonged to an orthodox Hindu family of Konnagar, a township near Kolkata in the district of Hooghly. His mother, Sarat Kumari, came from a Brahman family of Midnapore, well-known for its liberal outlook and progressive ideas, while his father was a school teacher, his mother studied in the Campbell Medical School for medical education. She passed the final examination in 1892 and brought an appointment in Lady Dufferin Hospital at Bhagalpur in Bihar, when the family shifted there. Sisir Kumar was admitted to the Bhagalpur Zilla School for receiving his first education.

Young Sisir Kumar's interest in science grew in years as he came across popular science articles published in Bengali Journals, many of which were written by Jagadis Chandra Bose. Sisir Kumar got himself admitted in Presidency College, Kolkata in 1908 in B.Sc. class where he came across Sir J.C. Bose and Sir P.C. Ray, the two pioneers of modern scientific research in India. His association with Sir J.C. Bose was responsible for his getting interested in radio waves. In 1912, he passed out of Presidency College taking his M.Sc. degree in Physics and topping the list of successful candidates. Mitra began researches on the diffraction and interference of light in the laboratory of Sir C.V. Raman. This was the time great scientists like M.N. Saha and S.N. Bose also worked at the University College of Science, Kolkata. He received his D.Sc. degree in 1919. In 1920, Mitra left for Paris to work under Prof. Charles Fabry in the University of Sorbonne on spectroscopy. Later, he joined the Institute of Radium to work under Madam Curie. This was the time research in radio circuits using vacuum tubes was going on at a feverish pitch in Europe and America. His association with Bose during his student days and intense activity in radio communication at that time decided his career in radio research.

Mitra returned to Kolkata in 1923 and was appointed Khaira Professor of Physics in Kolkata University. He took charge of organising the wireless section for teaching and research in this new field. Wireless laboratory was started for teaching and research in electron tubes and radio wave propagation. He took active interest in the development of broadcasting in India in its early stages. The broadcast transmitter in the country was installed in Calcutta in 1923 by a private firm called the "Indian States and Eastern Agency". Mitra was actively associated with the Radio Club of Bengal. He himself constructed a transmitter and installed in his laboratory. For some time, the Radio Club's transmitter and Mitra's transmitter were the only ones broadcasting regular programmes in the eastern region of India. These were what we call the amateur radio stations. With the formation of Indian Broadcasting Company in 1927, these amateur stations were closed down.

Mitra's researches were connected with several aspects of radio communication which included the physics of electron tubes and on high frequency discharge phenomena. During 1925-26, direct experimental evidence was obtained in England and in America of the existence of ionisation in the high atmosphere, which came to be known as ionosphere. These early experiments attracted the attention of Prof. Mitra. He inspired a small team of young scientists to take up this new line of work. He developed the first indigenous equipment for ionospheric studies by the angle of incidence method jointly with Dr. H. Rakshit. Investigations with these equipments contributed a great deal to the then existing knowledge of ionosphere. Besides giving a general picture of the ionospheric condition in a sub-tropical region of low latitudes like Kolkata, the experimental results threw considerable light on the effect of thunderstorms, magnetic storms and meteoric showers on upper atmospheric ionisation. In particular, the first successful explanation of the formation of the E layer at a height of 100 kilometres by solar ultra-violet radiation received wide recognition.

Prof. Mitra was also responsible for the establishment of Radio Research Board. He was the first Chairman of the Radio Research Committee formed in 1942 and continued in this chair in 1948. His treatise, the "Upper Atmosphere" received great acclaim. He established the first ionospheric field station in 1955. His interest also included the night sky luminescence, for which he developed a theory of "active nitrogen" in 1945. Prof. Mitra received many honours including the FRS in 1958 and Padma Bhushan in 1962. He died on August 13, 1963.

The need for economic operation, conservation of available frequency channels, and better rejection of noise led to the development of a mode of communication called the single side band (SSB) system. This important development by amateurs helped transmit speech at a power one third of the usual double side band (DSB) transmission. Modulating audio signals with a "carrier" radio frequency generates two side bands, one above the carrier frequency and one below it (hence the term double side band) along with the carrier. The speech signal information on such a system is present in either of the side bands. Elimination of one side band halves the frequency channel width as well as improving the strength of the signal with respect to the noise. This saves over two thirds of power. Eliminated side band frequency space can be used for another speech channel so that one transmission carries two different conversations simultaneously.

Even today, large numbers of enthusiasts are attracted to radio communication as a hobby. Indeed, many youngsters build an early interest in amateur radio into a career. Later, they may run into ideas which they try out in ham radio. A good example in the OSCAR series of satellites, initially put together by amateurs who worked in the aerospace industry and launched as payloads with other space shots. Today, a few Indian radio amateurs are working upon an Indian Amateur Satellite. Radio amateurs – or hams as they are called – communicate through a variety of techniques like radioteletype, slow and fast scan TV, packet radio etc. A few hams even have computers hooked to their radio. See box on how to become a ham.

Radio Communication Today

Applications of radio and its importance to human life needs no over-emphasis. Radio often implies communication through speech or Morse code. In fact radio communication, in general, may imply broadcast or two way communication using electromagnetic waves in any part of the radio frequency spectrum, and may involve wavelengths ranging from very low frequency (VLF) at 10-30 kilometres for long distance point-to-point communication to super high frequencies (SHF) at 1-10 centimetres or even less for radar, radio relay or satellite communication.

We have already mentioned the application of radio in broadcast services, entertainment and during relief operations following a natural or a man-made disaster. Widespread use of radio for personal communication involves citizen's band (CB) radio. Channels are made available for voice communication and remote control, such as opening of car doors. Cordless phones and mobile telephones involve frequencies in the VHF or UHF range. In industries, radio-frequency energy is of value in industrial heating applications, radio frequency electric furnaces, microwave ovens and so on.

However, the progress in the space sciences has been possible only through the application through the technique called radio telemetry. What it involves is the remote reading

of instruments taking measurements in conditions either dangerous to human life or in places inaccessible or not easily accessible. Information about solar radiation, solar wind, magnetic fields, and ionospheric soundings from probes in outer space is transmitted to the information centre on Earth through telemetry. Commands to satellites or space probes are also sent through telemetry. Indeed, radio has found applications in many fields besides communication and has accelerated developments in all branches of science; medicine, surgery, astronomy and mathematics all have benefited.

Radio astronomy, now an important branch of science, was born with the reception (1932) of appreciable 20 megahertz radio emissions from the Milky Way galaxy. In 1942 investigators measured radio emissions from the Sun. Subsequent work has shown that emissions reaching the Earth from outer space cover a range of at least 10 megahertz to 30 gigahertz. Well-defined sources of radiation have been discovered, and some have been associated with visible stars or have led to the discovery of hitherto unknown stars; but many of these quasars, as they are called, emanate from a part of space where no stars have yet been seen. Certain of the radio sources show a slow periodic variation in emission, and these have been named pulsars.

We have briefly outlined the development of radio communication and the discovery of ionosphere which took place during the golden decade. Since the days of Hertz, Bose and Marconi, newer means, methods and techniques have emerged. How easily we pick up mobile phone and talk anywhere in the world, or how fast we can send the information from one corner of the world to the other through the Internet. It is through the development in techniques of radio communication that applications of space science and technology in various spheres like remote sensing and satellite communication became possible. If it were not for

the communication satellites, like the INSAT series of geosynchronous satellites, linking and networking of different parts of our huge country could have proved extremely difficult. Lately, there has been an ingenious development in radio communication, the digital radio communication which also enables hooking the radio directly to your computer and transferring the data files - the WorldSpace satellite radio. Such satellite radios would prove to be a boon for development especially in the rural areas. It may also prove to be a boon in disaster management. It is the faster communication through radio that has saved innumerable lives after a disaster strikes - be it the devastating earthquake in Gujarat or supercyclone in Orissa. Radio will continue to serve the humanity.

President of the Royal Swedish Academy of sciences, H. Hildebrand had the following to say during the presentation speech of the Nobel award ceremony when the prize was conferred on Marconi and Braun in 1909:

'Research workers and engineers toil unceasingly on the development of wireless telegraphy. Where this development can lead, we know not. However, with the results already achieved, telegraphy over wires has been extended by this invention in the most fortunate way. Independent of fixed conductor routes and independent of space, we can produce connections between far-distant places, over far-reaching waters and deserts. This is the magnificent practical invention which has flowed upon one of the most brilliant scientific discoveries of our time.'
How True!

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A brief account of ham radio activity.

Riding on Radio Waves

Important terms used in connection with radio waves are given below. The terms given do not necessarily appear in the present article.

Amplifier : A device capable of increasing the magnitude or power level of a physical quantity, such as an electric current.

Amplitude modulation : Modulation in which the amplitude of a wave is the characteristic varied in accordance with the intelligence to be transmitted.

Antenna : A device used for radiating or receiving radio waves. Also known as aerial; radio antenna.

Audio frequency : A frequency that can be detected as a sound by the average young adult, approximately 15 to 20,000 hertz. Abbreviated af. Also known as sonic frequency; sound frequency.

Audio-frequency amplifier : An electronic circuit for amplification of signals within, and in some cases above, the audible range of frequencies in equipment used to record and reproduce sound. Also known as af amplifier; audio amplifier.

Audio-frequency oscillator : An oscillator circuit using an electron tube, transistor, or other nonrotating device to produce an audio-frequency alternating current. Also known as audio oscillator.

Audio signal : An electric signal having the frequency of a mechanical wave that can be detected as a sound by the human ear.

Broadcast : A television or radio transmission intended for public reception.

Broadcast station : A television or radio station used for transmitting programmes to the general public. Also known as station.

Broadcast transmitter : A transmitter designed for use in a commercial amplitude-modulation, frequency-modulation, or television broadcast channel.

Capacitor : A device which consists essentially of two conductors (such as parallel metal plates) insulated from each other by a dielectric and which introduces capacitance into a circuit, stores electrical energy, blocks the flow of direct current, and permits the flow of alternating current to a degree dependent on the capacitor's capacitance and the current frequency. Designated by C. Also known as condenser; electrical condenser.

Coherer : A cell containing a granular conductor between two electrodes. The cell becomes highly conducting when subjected to an electric field, and conduction can then be stopped by joining the granular.

Continuous wave : A radio or radar wave whose successive sinusoidal oscillations are identical under steady-state conditions. Abbreviated CW. Also known as type A wave.

Crystal : A natural or synthetic piezoelectric or semiconductor material whose atoms are arranged with some degree of geometric regularity.

Crystal detector : A crystal diode, or an equivalent earlier crystal-catwhisker combination, used to rectify a modulated radio-frequency signal to obtain the audio or video signal directly.

Crystal diode : A two-electrode semiconductor device that utilizes the rectifying properties of a pn junction or a point contact. Also known as semiconductor diode.

Crystal set : A radio receiver having a crystal detector stage for demodulation of the received signals, but no amplifier stages.

Current : The net transfer of electric charge per unit time; a specialization of the physics definition. Also known as electric current.

Demodulate : To recover the modulating wave from a modulated carrier.

Also known as decode; detect.

Detector : The stage in a receiver at which demodulation takes place; in a superheterodyne receiver this is called the second detector. Also known as demodulator; envelope detector.

Diode : A two-electrode semiconductor device that utilizes the rectifying properties of a pn junction or a point contact. Also known as crystal diode; crystal rectifier; semiconductor diode.

Dipole antenna : An antenna approximately one-half wavelength long, split at its electrical centre for connection to a transmission line whose radiation pattern has a maximum at right angles to the antenna. Also known as doublet antenna; half-wave dipole.

Double-side band : The two-side bands produced about the carrier frequency on modulating with the audio frequency containing identical information, one above the carrier frequency, and one below it. Both are mirror images of each other.

E layer : A layer of ionized air occurring at altitudes between 100 and 120 kilometers in the E region of the ionosphere, capable of bending radio waves back to earth. Also known as Heaviside layer; Kennelly-Heaviside layer.

Electromagnetic wave : A disturbance which propagates outward from any electric charge which oscillates or is accelerated; far from the charge it consists of vibrating electric and magnetic fields which move at the speed of light and are at right angles to each other and to the direction of motion.

Feedback : The return of a portion of the output of a circuit or device to its input.

F layer : An ionized layer in the F region of the ionosphere which consists of F_1 and F_2 layers in the day hemisphere, and the F_2 layer alone in the night hemisphere; it is capable of reflecting radio waves to earth at frequencies up to about 50 megahertz.

Ground wave : A radio wave that is propagated along the earth and is ordinarily affected by the presence of the ground and the troposphere; includes all components of a radio wave over the earth except ionospheric and tropospheric waves. Also known as surface wave.

Half-wave antenna : An antenna whose electrical length is half the wavelength being transmitted or received.

Half-wave dipole : An antenna approximately one-half wavelength long, split at its electrical centre for connection to a transmission line whose radiation pattern has a maximum at right angles to the antenna. Also known as doublet antenna; dipole antenna.

Induction coil : A device for producing high-voltage alternating current or high-voltage pulses from low-voltage direct current, in which interruption of direct current in a primary coil, containing relatively few turns of wire, induces a high voltage in a secondary coil, containing many turns of wire wound over the primary.

Kennelly-Heaviside layer : A layer of ionized air occurring at altitudes between 100 and 120 kilometers in the E region of the ionosphere, capable of bending radio waves back to earth. Also known as Heaviside layer; E layer.

Marconi antenna : Antenna system of which the ground is an essential part, as distinguished from a Hertz antenna.

Modulated amplifier : Amplifier stage in a transmitter in which the modulating signal is introduced and modulates the carrier.

Modulated carrier : Radio-frequency carrier wave whose amplitude phase or frequency has been varied according to the intelligence to be conveyed.

Modulated continuous wave : Wave in which the carrier is modulated by a constant audio-frequency tone.

Modulation : The process or the result of the process by which some parameter of one wave is varied in accordance with some parameter of another wave.

Morse code : A telegraph code for manual operating, consisting of short (dot) and long (dash) signals and various-length spaces; now used only for wire telegraphy.

npn junction : A junction transistor having a p-type base between an n-type emitter and an n-type collector.

pn junction : The interface between two regions in a semiconductor crystal which have been treated so that one is a p-type semiconductor and the other is an n-type semiconductor; it contains a permanent dipole charge layer.

pnp-transistor : A junction transistor having an n-type base between a p-type emitter and a p-type collector.

Radio : The transmission of signals through space by means of electromagnetic waves; usually applied to the transmission of sound and code signals, although television and radar also depend on electromagnetic waves.

Radio frequency : A frequency at which coherent electromagnetic radiation of energy is useful for communication purposes; roughly the range from 10 kilohertz to 100 gigahertz. Abbreviated rf.

Radio-frequency amplifier : An amplifier that amplifies the high-frequency signals commonly used in radio communications.

Radiotelegraphy : Telegraphy involving the use of radio waves in place of wire lines.

Radio telemetry : The presentation of data at a location remote from the source of the data, using radio-frequency electromagnetic radiation as the means of transmission.

Radiotelephony : Two-way transmission of sounds by means of modulated radio waves, without interconnecting wires.

Radio telescope : An astronomical instrument used to measure the amount of radio energy coming from various directions in the sky, consisting of a highly directional antenna and associated electronic equipment.

Radio transmission : The transmission of signals through space at radio frequencies by means of radiated electromagnetic waves.

Radio transmitter : The equipment used for generating and amplifying a radio-frequency carrier signal, modulating the carrier signal and intelligence, and feeding the modulated carrier to an antenna and radiation into space as electromagnetic waves. Also known as radio set; transmitter.

Radio wave : An electromagnetic wave produced by reversal of current in a conductor at a frequency in the range from about 10 kilohertz to about 300,000 megahertz.

Single-side band : Either of the two side bands produced on modulation of carrier frequency by the audio signal containing information, one above the carrier frequency or one below it.

Sky wave : A radio wave that travels upward into space and may or may not be returned to earth by reflection from the ionosphere. Also known as ionospheric wave.

Spark coil : An induction coil for producing spark discharges, as to initiate combustion in an internal combustion engine.

Spark transmitter : A radio transmitter that utilizes the oscillatory

discharge of a capacitor through an inductor and a spark gap as the source of radio-frequency power.

Superheterodyne receiver : A receiver in which all incoming modulated radio-frequency carrier signals are converted to a common intermediate-frequency carrier value for additional amplification and selectivity prior to demodulation, using heterodyne action; the output of the intermediate-frequency amplifier is then demodulated in the second detector to give the desired audio-frequency signal. Also known as superhet.

Telecommunications : Communication over long distances.

Telegraph carrier : The single-frequency wave which is modulated by transmitting apparatus in carrier telegraphy.

Telegraph transmitter : A device that controls an electric power source in order to form telegraph signals.

Telegraphy : Communication at a distance by means of code signals consisting of current pulses sent over wires or by radio.

Telephony : The transmission of speech to a distant point by means of electric signals.

Transistor : An active component of an electronic circuit consisting of a small block of semiconducting material to which at least three electrical contacts are made, usually two closely spaced rectifying contacts and one ohmic (non-rectifying) contact; it may be used as an amplifier, detector, or switch.

Transmitter : The equipment used for generating and amplifying a radio-frequency carrier signal, modulating the carrier signal and intelligence, and feeding the modulated carrier to an antenna and radiation into space as electromagnetic waves. Also known as radio set; radio transmitter.

Triode : A three-electrode electron tube containing an anode, a cathode, and a control electrode.

Tuned amplifier : An amplifier in which the load is a tuned circuit; load impedance and amplifier gain then vary with frequency.

Tuning : The process of adjusting the inductance or the capacitance or both in a tuned circuit, for example, in a radio, television, or radar receiver or transmitter, so as to obtain optimum performance at a selected frequency.

Tuning capacitor : A variable capacitor used for tuning purposes.

Vacuum tube : An electron tube evacuated to such a degree that its electrical characteristics are essentially unaffected by the presence of residual gas or vapor.

Valve : An electron device in which conduction of electricity is provided by electrons moving through a vacuum or gaseous medium within a gastight envelope. Also known as radio tube; tube; valve.

Wavelength : The distance between two points having the same phase in two consecutive cycles of a periodic wave, along a line in the direction of propagation.

Wave propagation : The process by which a disturbance at one point is propagated to another point more remote from the source with no net transport of the material of the medium itself; examples include the motion of electromagnetic waves, sound waves, hydrodynamic waves in liquids, and vibration waves in solids. Also known as propagation; wave motion.

Yagi antenna : An end-fire antenna array having maximum radiation in the direction of the array line; it has one dipole connected to the transmission line and a number of equally spaced unconnected dipoles mounted parallel to the first in the same horizontal plane to serve as directors and reflectors. Also known as Uda antenna; Yagi-Uda antenna.

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Linus Carl Pauling

The Greatest Architect of Modern Chemistry

□ Subodh Mahanti

It is when we take some interest in the great discoverers and their lives that science becomes enduring and only when we begin to trace the developments of ideas that it becomes fascinating.

James Clerk Maxwell.

The important thing in science is not so much to obtain new facts as to discover new ways of thinking about them.

William Lawrence Bragg in *Beyond Reductionism* (1968)

The personal lives of geniuses are as complex as those of ordinary mortals. Intellectual brilliance, after all, does not necessarily guarantee moral integrity, personal charm, political rectitude, or any other desirable character trait. So one should hardly be surprised that Linus Pauling's life and personality have been assessed in a myriad of ways by his contemporaries.

The one point on which no one disagrees is his brilliance as a scientist. Probably the most prolific and one of the best-known science writers of all time, Isaac Asimov, has called him "a first-class genius, "the greatest chemist of the 20th century". Pauling's numerous honorary degrees and awards confirm this judgment. His colleagues have honoured him at one time or another with every high honour in chemistry.

David E. Newton in his *Linus Pauling: Scientist and Advocate*, Universities Press (India) Ltd. 1999.

[The idea of writing on Pauling cropped up after writing on G.N. Ramachandran (Dream-2047, September 2001 Issue), who was greatly influenced by Pauling. We had reproduced the poem written by Ramachandran on Pauling. Moreover the year 2001 also happens to be the birth centenary of Pauling].

Linus Carl Pauling is the only person to have received two unshared Nobel Prizes – first in 1954 in chemistry for his 'research into the nature of the chemical bond and its application to the elucidation of the structure of complex substances', and the second one in 1962 in Peace for his ardent pacifist campaign against nuclear warfare. Pauling is widely regarded as one of the greatest scientists ever. Besides being the greatest architect of chemistry, Pauling was a founder of molecular biology and a pioneer in quantum mechanics. Pauling combined chemistry and physics to solve various puzzles related to the nature of chemical bond. As one of his biographers has written Pauling's understanding of the chemical bond and molecular architecture is probably unsurpassed in the history of chemistry. His ideas on chemical bonding are fundamental to modern theories of molecular structure. Pauling determined crystal structure by X-ray crystallography and the structure of gas molecules by electron diffraction. He ascertained the molecular cause of sickle-cell anaemia and his observation that a molecular disorder can explain the symptoms of an illness founded the discipline, molecular medicine. He developed an electronegativity scale to assigning electronegativities to atoms involved in covalent bonding. He extended the theory of covalent bonds to include metal and intermetallic compounds. It was Pauling who formulated the concept of resonance, a very important concept in structural chemistry. It refers to a state where none of the classical formulae of a chemical system is entirely consistent with observed properties. Pauling developed unique model building

techniques that he put to use in his studies of proteins and nucleic acids. He proposed helical structures for proteins based on polarity of the atoms in the peptide bond. His monumental text book, *The Nature of the Chemical Bond and the Structure of Molecules and Crystals*, first published in 1939, is even today a classic in its field. The book is one of the most important books in the history of chemistry. It has been translated in many languages.

Pauling is much known for his controversial thesis proposing that high doses of vitamin-C would help not only in the prevention of common cold but also in the prevention of cancer. In 1973, he founded the Linus Pauling Institute of Science and Medicine in Palo Alto, California. Outside his scientific works, Pauling took a vital interest in public affairs, especially in the movement for world disarmament. His book *No More War* (1958) was a plea for international peace. It was an instant best-seller. He strongly opposed nuclear testing. He could gather signature and support of 11,000 scientists for his petition against nuclear testing in front of the United Nations. Pauling was well-known for his independence, courage, fighting qualities, brilliant wit and vigorous enthusiasm for his work. Isaac Asimov called him 'a gentleman in highest sense of the word.' Pauling was a very controversial and outspoken person. His uncompromising nature was reflected even in his school days.

Pauling was born in Portland, Oregon, USA on 28th February 1901. His parents were Herman Henry William Pauling, a pharmacist and Lucy Isabelle Pauling usually called Belle. His father died when Pauling was 9 years old, forcing him to take up odd jobs to support his mother and sisters as well as pay for his education.

We are told that by the age of nine Pauling had read all the books available in his house. Pauling's father Herman Pauling, in his attempt to collect proper reading material for



Linus Carl Pauling

young Pauling, wrote to a local newspaper, *the Oregonian*: "I am a father and have an only son who is aged 9 years, in the fifth grade, a great reader and is deeply interested in ancient history..... In my desire to encourage and assist him in his prematurely developed inclinations I ask some of *the Oregonian's* interested readers to advise me regarding the proper or atleast the most comprehensive works to procure for him." we are told that Herman Pauling did not receive any response.

Pauling's interest in science developed at the very early age of 11. Pauling started collecting first insects and then minerals. It is said that he did not stop at collecting the objects but he proceeded to classify and catalogue them. However, in his own words Pauling was not successful as a collector. To quote Pauling: "I was not successful as a collector, but I got a book from the library on mineralogy and I copied out tables of properties, hardness and various properties, on to sheets of papers and glued the papers to the wall in my work room."

In 1914 Pauling graduated from the Sunnyside Grammar School and entered Portland's Washington High School. It is here that Pauling became interested in studying chemistry. He was influenced by one of his friends named Lloyd Jeffress, who had set up a small laboratory in the corner of his bedroom. Pauling became fascinated with chemistry after watching Jeffress conduct some simple experiments. To quote Pauling: "I decided then to be a chemist and to study chemical engineering, which was, I thought, the profession that chemists followed." Following his friend Jeffress, Pauling also built a small laboratory in the basement of his house. He carried out a lot of experiments on his own. He borrowed the chemicals needed for his experiments from a small chemical laboratory at the abandoned Oregon Iron and Steel Company in Oswego. This was possible because Pauling's grandfather was a night watchman at a nearby plant. Later recalling his early interest in chemistry Pauling would write: "I was simply entranced by chemical phenomena, by the reaction in which substances disappear and other substances, often with strikingly different properties, appear."

Here we will discuss in little detail how Pauling worked hard for continuing his education, with a view that it may act as a source of inspiration to younger people. Unlike

many fortunate children, Pauling had to arrange money himself for his studies. Before joining Oregon Agricultural College at Corvallis, Pauling was working at a machine shop, where he was earning \$100 a month and his employer had promised to increase his salary to \$250 a month provided he decided to stay there. Pauling's mother was

not in favour of his joining the college. As stated earlier Pauling's father died when he was nine years old. So his mother wanted Pauling to stay at home and help her financially as she still had two young children to raise. However, Pauling decided to join the college. Since his mother had no means to help him, Pauling had to earn enough to meet all his college expenses. The expenses were not very high. The college did not charge any tuition fees and the books were inexpensive. He lived in a cheap boarding house, where he shared a room with a fellow student. But still he had to work hard. Describing a job of delivering milk undertaken by him at the age of 18 he wrote: "a very hard job, working eight hours every night from about eight

o'clock to about four o'clock with a horse pulling the milk wagon and delivering milk to about 500 customers."

In spite of the hard work that he had to undertake to meet his college expenses, Pauling was able to impress his teachers and colleagues by his studies. He had very little social life. As his financial problem continued Pauling took up a job of paving-plant inspector of the State of Oregon during the summer of 1919. His job was to inspect new pavement and take samples back to the state laboratory for analysis. His salary for the job was \$125 per month. He lived in a tent with the workmen and ate with them. He sent almost his entire salary to his mother, expecting that his mother would be able to help him to return to Oregon Agricultural College for his junior year. However, the financial crisis grew worse. His mother was suffering from pernicious anaemia. So he was compelled to decide to continue to work as paving-plant inspector. But then he got an offer from Oregon Agricultural College to teach quantitative analysis in chemistry. The offer was really extraordinary considering the fact that Pauling was a student, who completed the course himself six months earlier. The salary for his new assignment was \$100-a-month. His duties were to supervise laboratories and give

Sickle-cell Anaemia: A Molecular Disease

Sickle-cell anaemia is a hereditary chronic blood disorder in which a person's blood cells contain an abnormal form of haemoglobin, the protein that transports oxygen and which become incapable of carrying oxygen efficiently. This often results in anaemia. When the blood is deprived of oxygen the abnormal haemoglobin crystallises and distorts the red blood cells into a sickle shaped. The presence of sickle cells in the blood with or without accompanying anaemia, is called sickle cell disease. The disease principally affects the black population of Central Africa. Three different types of individuals occur in such populations – those who have two genes for normal haemoglobin and therefore do not suffer from the disease; those with one abnormal gene and one normal gene and are likely to suffer from anaemia and those with two abnormal genes who suffer a chronic and eventually fatal form of anaemia.

Pauling thought that it was an abnormality in oxygen-carrying haemoglobin molecule found in red blood cells and not the abnormality of the red blood cells themselves that caused the sickle cell anaemia. Before turning to sickle cell anaemia Pauling was working in haemoglobin. Pauling and his student Dr. Harvey Itano demonstrated that haemoglobin found in people having sickle cell anaemia actually differ from normal haemoglobin molecule. Though the difference was very modest. Only one of a total of 146 amino acids in such haemoglobin molecule is incorrect. But such a single error was enough to alter haemoglobin and reduce its ability to transport oxygen.

lectures. He had to spend 40 hours a week with students. Besides his teaching assignment Pauling studied the works of two eminent chemists Gilbert Newton Lewis (1875-1946) and Irving Langmuir (1881-1957). Their works had a profound effect on Pauling. This had largely determined the course of his work for fifty years. As he later wrote by reading their works he developed "a strong desire to understand the physical and chemical properties of substances in relation to the structure of the atoms and molecules of which they are composed".

Pauling could begin his junior year in the college in the fall of 1920. On June 5, 1922 Pauling received his bachelor of science degree from the Oregon Agricultural College. Pauling failed to get Rhodes Scholarship inspite of being nominated by the faculty of his college with good recommendation. In the fall of 1922 Pauling enrolled as graduate student in the California Institute of Technology (Cal Tech) at Pasadena. Pauling's first choice was the University of California at Berkeley, where G.N. Lewis was the chairman of the department of chemistry, whose works had a decisive role on Pauling's scientific career. But Pauling did not get any response from Berkeley in time. His second choice was the University of California at Harvard but its scholarship offer was not matching Pauling's financial needs.

The California Institute of Technology was originally established in 1891. Before 1920 it used to be known by various names like Throop University, Throop Polytechnique Institute and Throop College of Technology. In its early years its academic reputation was not very high. It became a leading research institution largely because of the initiatives taken by George Ellery Hale (1868-1938), a member of the Throop Board of Trustees and then Director of Mount Wilson Observatory. In about 1907 Hale could persuade the other trustees to develop an outstanding institute for science and technology on their campus. Hale was also able to



Georg Ellery Hale

persuade some of the leading American researchers to come to Pasadena. Robert Andrews Millikan (1868-1953), who determined an accurate value for Planck's constant and originated the 'oil drop' experiment to measure electronic charge, left the University of Chicago in 1918 to become the first administrative head of the California

Resonance

Resonance means representation of the structure of a molecule by two or more conventional formulae. Whenever a molecule can be represented by two or more structures having the same arrangement of atomic nuclei but with different arrangement of electrons – there is resonance. In such a case the molecule is said to be a resonance hybrid of all these structures. The molecule is somewhere in between these structures and it cannot be represented satisfactorily by any one of them. For example, the formula of methanal or formaldehyde can be represented by $H_2C=O$, where there is a double bond in the carbonyl group. It is known that in such compound the oxygen atom carry some negative charge and the carbon has some positive charge. The true bonding in the compound is somewhere between $H_2C=O$ and the ionic compound $H_2C^+O^-$. The molecule is said to be a resonance hybrid of the two, indicated by $H_2C=O \leftrightarrow H_2C^+O^-$. The two possible structures need not contribute equally to the actual form. When the contributing structures are of about the same stability that is with same energy content, then resonance is important. The contribution of each structure to the resonance hybrid is dependent on the relative stability of that structure. If a particular structure is more stable it will make a larger contribution than the other structure(s). The resonance hybrid is more stable than any of the contributing structures. This increases in stability is called the resonance energy.

Institute of Technology. Millikan got Nobel Prize in 1923. Arthur Amos Noyes left the Massachusetts Institute of Technology in 1917 to establish the Gates Chemical Laboratory at Throop. It was Noyes who had chosen Pauling as a graduate student. Noyes knew Pauling before his coming to Pasadena. He had sent Pauling the proofs of his new chemistry text, *Chemical Principles*, with the instruction to solve all the problems in the first nine chapters which numbered more than 500. Pauling solved all the problems. This helped Pauling to develop a strong background in physical chemistry. After coming to Cal Tech, Pauling realized that he lacked on many counts in his training at Oregon Agricultural

College. To quote him : "There were so many gaps in understanding that ...often I did not know whether to attribute this failure to myself or to the existing state of development of science".

In March 1926 Pauling sailed for Europe, on a two year Guggenheim Fellowship. First he went to Munich to work with Arnold Sommerfeld (1868-1951) at his Institute of Theoretical Physics. At Munich he spent one year and wrote one of his most frequently cited research papers: "The Theoretical Prediction of the Physical Properties of Many-



Robert Andrews Millikan

Electron Atom's and Ions". From Munich Pauling went to Copenhagen to spend a year with Niels Bohr (1885-1962) at the Institute of Theoretical Physics. At Copenhagen Pauling worked with Samuel Abraham Goudsmit (1902-78) whose work on spectral analysis eventually led to the discovery of the electron spin or fourth quantum number. From Copenhagen Pauling went to the University of Zurich, where he

attended lectures by Erwin Schrodinger (1887-1961) and Peter Joseph William Debye (1884-1966). After completing his two-year European tour he came back to California Institute of Technology to join as Assistant Professor of Theoretical Chemistry and Mathematical Physics.

Pauling worked on a variety of problems in chemistry and biology. His early work in chemistry was on chemical bonding and molecular structure. Though Pauling consistently referred to himself as chemist or physical



Samuel Abraham
Goudsmit



Peter Joseph William
Debye

of the modern theory of chemical bonding including the concept of the 'hybridization of orbital,' central to the understanding the shapes of molecules; resonance, a state where a molecule has a structure between two or different conventional structures and electronegativity. His book *Introduction to Quantum Mechanics* published in 1935 was quite influential.

Pauling studied the denaturation of proteins by heat, acids, bases or chemicals such as urea. He gave a correct interpretation of denaturation of proteins by applying the concept of weak bonds – it is due to the loss of a set of hydrogen bonds necessary for the stabilization of protein's three-dimensional structures. It does not involve the breaking of a covalent bond in the molecule or the separation of a colloidal aggregate.

Pauling explained the specificity of the antibody-antigen interaction by the formation of certain number of weak bonds, formed between atoms situated close together, in particular, hydrogen bonds between the antigen and the antibody. The complementary structure of antigen and antibody was evident from the existence of a large number of weak bonds.

What can we learn from Pauling's biography? Greatness can be achieved even through tremendous hardship. In fact many a great people had to struggle in the early years even for their bare survival. What is important is to have determination —determination to achieve something. But one needs to prepare for it. Self-teaching is very important. But then it has its own limitations. Proper training is important. Pauling could get opportunity to work with some of the best minds of his time. So it is also important to go where something is really happening, to get first hand experience and to be a part of it. Teachers can play a great role in shaping the careers of their students. This we see very often when we go through the biographies of great scientists. Unfortunately in India today teachers are hardly playing this role. Certainly there are exceptions. But the general trend is that by taking the name of 'professionalism' people are becoming more and more self-centered, often akin to being selfish. One cannot sustain an idea in vacuum. It needs a proper environment. In any case to achieve something one should, like Pauling, have enormous self-confidence and an urge to live a happy, useful and a satisfying life and help others to achieve the same. To quote Pauling : " The evidence of my senses tells me that I am a man like other men. When I cut myself, I am hurt, I suffer. I cry out. I see that that when someone else cuts himself, he cries out. I conclude from his behaviour that he is suffering in the same way that I was...I am led to believe that I am a

Electronegativity

Electronegativity denotes the easiness with which an atom can attract electrons to itself. Electronegative elements attract electrons, so forming negative ions. The halogens are typical electronegative elements. Pauling devised an electronegativity scale to indicate the relative power of attraction of elements for electron. Fluorine, the most non-metallic element has a value of 4.0 on this scale. Some other values on this scale are : boron(B) 2.0, carbon(C) 2.5, nitrogen (N) 3.0, oxygen (O) 3.5, silicon (Si) 1.8, phosphorus(P) 2.1, sulphur (S) 2.5, chlorine (Cl) 3.0, and bromine (Br) 2.8. In a covalent bond between two atoms of different electronegativities, the bonding electrons will be located close to the more electronegative atom, creating a dipole. Electronegativity values can be used to show why certain substances, such as hydrochloric acid, are acid, whereas others such as sodium hydroxide, are alkaline.

chemist, his early work involved mathematics and physics to a great extent. His research did not fit into any conventional definition of chemical studies. Once Pauling wrote : "Some people seem to think that work such as mine, dealing with the properties of atoms and molecules, should be classed with physics but I, as I have said before, feel that the study of chemical substances remains chemistry even though it reaches the state in which it requires the use of considerable mathematics." Pauling applied physical methods like X-ray diffraction, electron diffraction, and magnetic effects to determine molecular structures.

Pauling's interest in complex molecular structures led him to work in biology and medicine. He had a strong belief that all biological phenomena must have a molecular origin. He studied the properties of haemoglobin using magnetic measurements. This work led on to extensive studies of the nature and structure of proteins. Pauling jointly with Robert B. Corey showed that the amino acid chain in certain proteins can have helical structure. Pauling's work provided a powerful impact to F.H.C. Crick and J.D. Watson in their search for the structure of DNA.

Pauling made significant contributions to applying quantum mechanics to the bonding of chemical compounds. He developed almost all of the most fundamental principles

The Chemical Bond

The chemical bond is the force that holds atoms together in a molecule or a mechanism by which atoms combine to form molecules. We will say that there is a chemical bond between two atoms or groups of atoms only when the forces acting between them are strong enough to form an aggregate of the atoms involved with sufficient stability to be regarded as an independent species.

The amount of energy required to break a bond and produce neutral atoms is known as bond energy. Atoms combine with each other because of their tendency of acquiring stable electronic configurations. Atoms with full outer shells, of electrons are more stable than those with partially filled outer shells. The noble gases or inert gases have full outer shells and are very stable. Other atoms can acquire stable electronic configuration by combining with other atoms to form chemical bonds. The principal types of chemical bonds are the ionic, covalent, metallic and hydrogen bonds. There are other types also. The ideal cases are ionic and covalent bonds and the remaining ones are of an intermediate type.

The Ionic Bond : results from the attraction of oppositely charged ions. Ionic bonds are formed by the transfer of electrons from a metallic element to a non-metallic element. The atoms of metallic elements lose their electrons to form positive ions while the atom of non-metals gain electrons to form negative ions. The resulting highly stable ions retain their individual structures, as they approach one another to form stable molecule or crystal. An ionic crystal like sodium chloride is composed of independent sodium ion (Na^+) and chlorine ion (Cl^-). No discrete diatomic molecule exists and the entire crystal is a single giant molecule.

Covalent Bond : When a non-metal combines with another non-metal, they tend to share electrons so that the partner atoms each have a share in enough electrons to complete their outer

shells. A single covalent bond is formed when two atoms share a pair of electrons. Unlike in ionic bond, in the formation of covalent bond there is no electron transfer. The attractive force is produced by interaction of the electron pair with the nuclei of both atoms. Double and triple bonds are formed when the atoms share more than two electrons. Generally in covalent bonding each atom contributes to the shared pair. Covalent bonds are of particular importance in organic chemistry because of the ability of the carbon atom to form four covalent bonds. But there are cases when both electrons come from the same atom. In such case the resulting bond has a partly ionic character and is called a co-ordinated link.

Metallic Bond : Metallic elements are held together by metallic bonding. The metallic bond is responsible for crystalline structure of pure metal. Metallic bond is not ionic because all the atoms are identical. It is also not covalent in the ordinary sense as the valency electrons are shared collectively by all the atoms in the crystal. Metal atoms are packed together where each atom loses its outer electrons into a 'sea' of free electrons or mobile electrons. These free electrons are delocalised, that is, not restricted to orbiting individual positive ions. The mobile electrons form a kind of electrostatic 'glue' holding the structure together.

Hydrogen Bond : Hydrogen bonding is a strong electrostatic attraction between two independent molecules in which the electric charges are unevenly distributed. Such molecules are called polar molecules and usually contain nitrogen, oxygen and fluorine. These elements have a strong tendency to draw electrons towards them. The hydrogen atom acts as bridge between them. Hydrogen bond is much weaker compared to ionic or covalent bonds. However, this plays an important role in molecular biology.

man like other men.

I want to be free of suffering to the greatest extent possible. I should like to live a happy, useful life, a satisfying life. I want other people to help keep my suffering to a minimum. It is my duty, accordingly, to help them, to strive to prevent suffering for other people".

For Further Reading

1. Serafini, Antony, *Linus Pauling : A Man and His Science*, New York : Paragon House, 1989
2. White, Florence Meiman, *Linus Pauling : Scientist and Crusador*, New York: Walker & Co. 1980
3. Newton, David E. *Linus Pauling : Scientist and Advocate*, Hyderabad : Universities Press (India) Ltd., 1999.

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Attention

NCSTC is compiling a National Directory of Organizations/Institutions active in the field of S&T Communication/Popularization. This comprehensive collection properly cross-indexed, will be valuable source of reference to activists, academics and planners. For free registration please send a request to :

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This is a time bound project and may not be possible to include entries received after 15th December 2001.

SCIENCE EXHIBITION AT INDORE, MADHYA PRADESH

The National Children's Science Exhibition was held at Indore during 19-20 October 2001. The event was jointly organised by the Indore Chapter of VIPNET (Vigyan Prasar NETWORK of Science Clubs) and the Science Aur Kainat Society of India and the venue was Devi Ahilya Bai University campus. The primary objective of the exhibition was to spark the curiosity of the children and developing it into a well defined base for scientific knowledge and scientific temperament. The focus also was on indigenous scientific knowledge. The sub topics were Agriculture, Health, Nutrition & Sanitation, Energy etc.

The three day event was inaugurated by Md. Suleiman, IAS, District Magistrate, Indore and Shri Sanjau Shukla, IAS, Municipal Commissioner, Indore in the presence of a large gathering of students, teachers etc., in the auditorium



Young scientists explaining their exhibits

of the Institute of Management Sciences. Among the dignitaries present on the occasion were Shri S. Mandloi; Incharge of AVRC (CEC) Indore, Dr. Prabhakar Singh; S. P. of Indore, and Shri B. S. Negi. A host of prominent citizens from the academic life and social organisations also attended the session. Shri Arup Kumar Misra, Coordinator, VIPNET, represented VP and while addressing the gathering emphasised the need to encourage children to ask more questions in the classroom.

Among the major attractions of the Exhibition were efforts to educate people about water conservation. Children seemed keen to know more about how to overcome water crisis. There were exhibits which showed how ground water could be recharged and technology could be used to overcome water crisis. There were educative demonstrations on how to save water and conserve it from being misused. There were about 95 exhibits in all, of which Indore had the lion's share. There were models showing use of renewable sources of energy. There were demonstration on how to purify water using basil plant (Tulsi) and clove, and on how to use waste paper as fuel and of growing plants without soil i.e. Hydroponics. An interesting insight was provided into how the colour of the walls could be used to make maximum use of light from the conventional electricity bulb. Debates on various aspects of scientific understanding and how it could help society overcome some superstitious beliefs were also organised.

The closing ceremony was held on 21st October 2001. Dr. Vinita Manocha, Director, Valley Public School, presided over the impressive function.

VP News Contd.....

radio amateurs at Noida on October 14, 2001, which was attended by 35 radio amateurs. Various problems related to ham radio popularization were discussed in this meeting. The major attraction of this meet was the display of commercial as well as homemade radio communication equipment belonging to Shri Rahul Kapoor (VU2YK) and Shri Rakesh Kapoor (VU2RAK). The get-together on November 11, 2001 was hosted by the National Bal Bhawan Ham Radio Club. In this meet, one minute silence was observed by the radio amateurs of Delhi in memory of late Saad Ali (VU2ST), an energetic promoter of ham radio in India, who passed away recently at Mumbai. In this ham meet, Shri Ashok Kumar Sapra (VU3AKW) delivered a talk on "General circuits & components used in Amateur Radio".



A section of audience at Bal Bharti Public School during the lecture and demonstration on ham radio