



DREAM 2047

May 2001

Vol.3

No. 8

VP News

Uttaranchal Chief Minister Participates in VIPNET Workshop

Dehra Dun, capital of the newly-formed State of Uttaranchal, was the venue for a workshop of VIPNET Clubs of the region on 6-7 May 2001. Vigyan Prasasr has been contemplating to organize special programmes in the states which came into being recently - Uttaranchal, Jharkhand and Chhatisgarh - to create general awareness among the masses and activate science clubs to take up socially relevant projects. In this regard, the workshop at Dehra Dun assumed great significance so far as addressing to the local problems of this hill-state was concerned. Society of Pollution & Environmental Conservation Scientists (SPECS) and Students Awareness for Environment (SAFE), two prominent platforms of S & T activities in Dehra Dun, locally hosted the workshop on behalf of VP in the Press Club of Dehra Dun. Students and teachers from 35 schools of Dehra Dun, science communicators from a dozen NGOs, members of the regional and national press and electronic media, local academicians and scholars attended the event on both the days. The major activities centred around Food Adulteration Testing, Water Testing, Nature Study and Explanation of Science Behind Miracles. Prof. S. K. Kulshrestha, Head of Zoology in P.G.D.A.V. College; Dr. G. K. Sharma, Joint Director of IRDE; Dr. Brij Mohan Sharma, Coordinator of SPECS; Mrs. Geeta Srivastava, teacher in a local college; Dr. B. P. Bahuguna, Chief Medical Officer of Dehra Dun; Shri S. K. Dhar, Advocate in the High Court; Shri B. K. Tyagi, NCSTC, New Delhi; Shri Vivek Sudarshan, Secretary of SEARCH (Ghaziabad); and Smt. Anjula Tyagi, Convenor of SAFE conducted the various technical sessions and interacted with the students. VIPNET Coordinator Shri A. K. Misra introduced Vigyan Prasasr and VIPNET to the participants and the media in two separate sessions through a slide show. The workshop received a big boost when Shri Nityanand Swamy, the honorable Chief Minister of Uttaranchal, joined the participants on 07 May 2001, interacted with all of them in a very informal manner and assured VP of his full cooperation for similar programmes in other parts of the State.



Shri Nityanand Swamy, honorable Chief Minister of Uttaranchal, receiving a copy of "Where Gods Come Alive" from VP Fellow Shri Arup Kumar Misra.



A section of the participants of the Workshop seen engrossed in the proceedings.

(VP News conttd. on page... 23)

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

Inside

EDITORIAL

The Discovery
of the Electron



Making Women
Realise their
Scientific Potential



Intellectual
Property Rights
(Part-I : Patent System)

Quest for Self-Reliance

A feeling of despair swept across the nation when the launch of the Geosynchronous Satellite Launch Vehicle (GSLV) was aborted on March 28, 2001, just a second before it was to lift off, as one of the strap-on engines failed to derive the necessary thrust. However, the bright spot was that the safety mechanism worked well, and the launch vehicle was saved. April 18, 2001, barely three weeks later, highlighted the ability of nation's scientists to handle complex systems, when the GSLV blazed into the afternoon sky. Undoubtedly, they were the longest seventeen minutes for those who had contributed towards the fruition of a four-decade dream of Vikram Sarabhai. It was also a testimony to the ability of ISRO that it can quickly and accurately identify its mistakes and correct them. The Geosynchronous Satellite (GSAT-1) was injected into the Geotransfer Orbit as planned. But, soon after it was discovered that the farthest distance from the Earth after the launch was slightly less than 36,000 kms which should have been achieved. In addition, the orbital inclination, that is, the angle at which the satellite's orbit is inclined to the equator – was 19.2 degrees, compared to 19 degrees planned for. Compensating for these shortfalls required the use of on-board propellant which was meant for fine orbit trimming operations that need to be carried out throughout the life time of the Geosynchronous Satellite after it has reached its final home in orbit. As a result, the life of the satellite gets considerably reduced. Still, all seemed well. But, the on-board propellant soon got depleted due to the unequal consumption of fuels stored in two tanks. The result was a "drift" orbit, which led to GSAT-1 circling the Earth once in every 23 hours, drifting at the rate of 13 degrees a day instead of being in a geostationary orbit matching the Earth's rotation. Despite the fact that the satellite is in excellent condition, it would be visible only for 10 days in a month when the payloads, that is, the on-board equipment could be switched on for testing purposes. GSAT-1 was to be used for demonstrating digital audio broadcasts, internet services, compressed digital TV experiments and developmental communication.

Indeed, the first flight test of GSLV was intended to

validate the various systems of the vehicle in an actual flight. Though each of the subsystems had been tested on ground, it is only through a few developmental tests that the launch vehicle, as a whole, and all the associated ground systems could be validated. The project faced quite a few hurdles ranging from U.S. technology sanctions and cost overruns to supply (or non-supply!) of the appropriate cryogenic engine technology from Russia. In any case, the question still remains: what caused the underperformance of the GSLV? One reason could be the imported Russian cryogenic engine which was only ground-tested and had never before flown on any launch vehicle, could not impart the requisite velocity to GSAT-1. The other reason could be the rocket's guidance and navigation system that may need to be improved upon.

In any case, GSAT drift is only a temporary setback. We shall have to take it in its stride. One should look at it from the point of view that it has taken the country further from having had to abandon the GSLV flight earlier. If the drift has raised doubts about the satellite's usability, we shall have to resolutely move ahead in our pursuit for achieving perfection for GSAT to be completely error-proof. In addition, the success would give the Indian space establishment the confidence to proceed with its own development in cryogenic technology and indigenise it further. Today, we need engines that can lift much heavier satellites than GSAT-1. But, it has rarely happened that any country had a successful launch of a geosynchronous satellite at the first attempt. If they have become self-reliant in space technology today, it is through their own individual efforts. We, too, have no alternative.

But, the most important factor in the quest for self-reliance is attracting and retaining young and creative minds, and allowing them the freedom to tinker around. This process must begin at the school level. In this regard, it would be worth exposing school children to the exciting world of space science and its applications through activities like model rocketry, astronomy, amateur radio, and so on. Our quest for self-reliance could begin at school level. VIPNET clubs could play a significant role in accomplishing this goal.

□ Vinay B. Kamble

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The Discovery of the Electron

□ V.B. Kamble

As early as about 1830, electrical discharges in gases were intriguing a number of experimental physicists in Europe. In 1881, at the Cavendish Laboratory at the University of Cambridge, J.J. Thomson began experimenting with gaseous discharges, and continued to do so for the next 50 years. When Thomson started his research, cathode rays had already been known for about 50 years, but their nature was controversial. As Thomson later wrote in the paper reporting his discovery of the electron, "The most diverse opinions are held as to these rays; according to the almost unanimous opinion of German physicists they are due to some process in the ether to which, no phenomenon hitherto observed is analogous; another view of these rays is that, so far from being wholly ethereal, they are in fact wholly material, and that they mark the paths of particles of matter charged with negative electricity."

J.J. Thomson

Joseph John Thomson (1856-1940) was born on December 18, 1856 in Manchester. His father died when he was only 16. Young Thomson attended Owens College in Manchester, where his Professor of Mathematics encouraged him to apply for a scholarship at Trinity College, one of the most prestigious of the colleges at Cambridge University. Thomson finished second in his class in the graduation examination in mathematics in 1880 and won the scholarship. Trinity College gave him a fellowship where he stayed upon. He engaged himself in developing mathematical models that would reveal the nature of atoms and electromagnetic process.

The Cavendish Laboratory at Cambridge was founded in 1871 with James Clerk Maxwell (1831-1879) – who developed the basic equations of electromagnetism as the first Cavendish Professor. At 28, the young Thomson was chosen to be the third Cavendish Professor in 1884 following Maxwell and Lord Rayleigh (1842-1919). True, he was inexperienced in doing experiments, but he learned quickly. Supported by his administration and teaching, many important experiments on electromagnetism and atomic particles were performed. Many outstanding Physicists received their early training at the Cavendish, including 7 Nobel Prize winners and 27 Fellows of the Royal Society. Thomson took a keen interest in the work of all the young researchers, daily checking on their progress and making suggestions for improvement.

J.J. Thomson married Rose Paget on January 22, 1890. She was among the researchers at the Cavendish as one of

the first generation of women permitted into advanced university studies. She performed experiments on soap films in 1889 after attending some of Thomson's lectures. They had two children: George Paget Thomson who flourished into a prominent Physicist himself and won Nobel Prize for discovery of the diffraction of electron by crystals in 1937. Their daughter Joan Paget Thomson often accompanied his father in his travels.

In the paper published in *Philosophical Magazine* 104 years ago in October 1897, Thomson reported that cathode rays were charged particles, which he called "corpuscles". **It is hard to recall any discovery since then that has had more impact on not only physics but science, technology and our daily lives.** We shall briefly follow the course of history in this article that made it possible.

Cathode Rays

Indeed, as far back as 1705, it had been noticed that sparks from an electrical machine would jump further in rarified air than in air at normal pressures. Watson in 1748 observed an aurora borealis like "arch of lambent (i.e. glowing) flame" in a glass tube of rarified air 32 inches long. In 1838 Michael Faraday (1791-1867) sent a current from an electrostatic machine through a glass tube containing air at low pressure and observed a purple glow extending from the positive electrode, or anode, at one end, almost to the negative electrode, or cathode, at the other. The cathode was covered with a glow, and there was a dark space between this glow and the purple column. The dark space has since been called the "Faraday Dark Space." (The colour of the internal glow of such tubes depends on the kind of gas present in the tube. Neon, at pressures approximately one hundredth that of atmospheric pressure, glows with a bright orange colour when current passes through it; helium, a pinkish white; mercury vapour, a light greenish blue.)

Although Faraday observed a number of interesting phenomena, he was limited by the fact that the suction pumps available at the time for reducing the gas pressure were not too efficient. A great step forward was made, about 1854, when H. Geissler, a German glass blower of exceptional skill, not only developed an improved vacuum suction pump, but succeeded in sealing into glass tubes wires attached to metal electrodes. The evacuated Geissler tubes which he made were particularly suitable for the study of the passage of electricity through gases at low pressure, and with them J. Plucker, in Germany, made numerous experiments between the years 1858 and 1862.



Sir Joseph John Thomson



Hendrik Antoon Lorentz



Pieter Zeeman

Among other things, he observed that the tube in the vicinity of the *cathode*, i.e. the electrode attached to the negative side of the source of potential, emitted a green glow or luminescence. The position of the glow could be changed by bringing a magnet up to the tube.

The studies of electrical discharge through gases were continued in Germany by Plucker's pupil, W.Hittorf (1869), and by E.Goldstein (1876). From their observations they concluded that the luminescent glow on the tube was caused by "rays" originating at the cathode, which Goldstein consequently called *cathode rays*. The rays could be deflected by a magnet and were also able to cast a shadow of an obstacle placed in their path, showing that they traveled in straight lines.

Between the years 1879 and 1885 the English scientist William Crookes, who designed improved vacuum discharge tubes, made a very comprehensive series of investigations of the electrical discharge. From these he concluded that the cathode rays actually consisted of a stream of negatively charged particles, which were expelled from the cathode — the negative electrode — with extremely high velocities. This view of the nature of cathode rays supported a suggestion made in 1872 by C.F.Varley, but it was opposed by many European physicists, including such eminent men as E.Wiedemann (1880), H.Hertz (1883) the discoverer of radio waves, and P.Lenard (1894). The latter group thought the cathode rays were an electromagnetic wave motion or vibration, analogous to light waves but of shorter wave length. If the rays are really a stream of charged particles then they should be deflected by passage through an electric field, as well as by a magnetic field, although Goldstein, in spite of several trials, had failed to observe any such effect. But the deflection of cathode rays in the field of magnet was an accepted fact, and this could



James Franck



Gustav Ludwig Hertz



Jean Baptiste Perrin

not be explained if the rays were similar to light waves.

In an apparently decisive experiment, performed by J. Perrin (1870-1942) in France in 1895, the cathode rays were allowed to fall on a device known as a Faraday cylinder, connected to an electrometer by means of which the sign and magnitude of electric charge could be determined. It was found that a negative charge collected in the

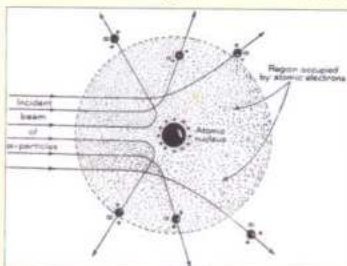
cylinder, and so it was argued that the rays were made up of negative particles. Objection was taken to this conclusion on the grounds that negatively charged particles might well be ejected from the cathode, but there was no proof that they are identical with the cathode rays.

The required proof was provided in 1897 by J.J. Thomson,

whose work has had a profound effect, both direct and indirect, on the study of atomic structure. In the first place, he repeated Perrin's experiment and confirmed that charged particles are emitted by the cathode. But, in addition, he showed that when the cathode rays are deflected by a magnetic field, as indicated by the change in position of the luminescence they produce, the negatively charged particles are correspondingly deflected. Further, Thomson succeeded, where Goldstein and others had failed, in deflecting the path of the cathode rays by means of an electric field. Previous failures had been due to excessive ionization of the gas still present in the discharge tube, thus offsetting the effect of the electric field. By working at very low pressures Thomson minimized the influence of this ionization and then he was able to observe the anticipated deflection. We shall trace his efforts that established that the cathode rays are actually a stream of particles carrying negative electrical charges. Indeed, this was the result of a number of converging studies by several prominent physicists, which we shall briefly consider.

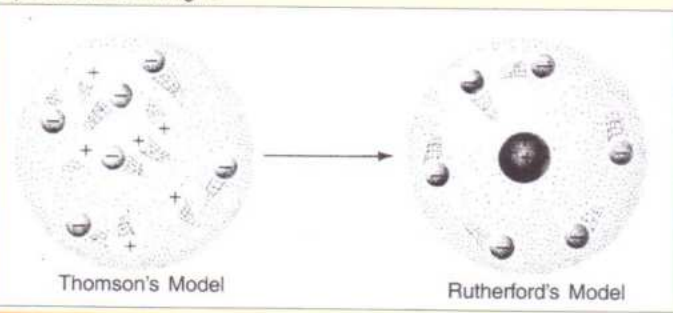
Atomic Models

On the basis of his experiments, J.J. Thomson proposed a model of internal atomic structure according to which atoms consisted of a positively charged substance (positive electric fluid) distributed uniformly over the entire body of the atom, with negative electrons embedded in this continuous positive charge like seeds in a watermelon, or raisins in pudding. Since electrons repel each other but are, on the other hand, attracted to the centre of the positive charge, they were supposed to assume certain stable positions inside the body of the atom. Ernest Rutherford (1871-1937) and Hans Geiger together bombarded thin pieces of gold with alpha particles. Most of the alpha particles passed right through the foil, and the result was exactly what the experimenters expected based on Thomson's model of the atom. But some of alpha particles struck the gold foil and were deflected at a sharp angle often 90° or more. This amazed Rutherford, who remarked "It was as though you have fired a 15-inch shell at a piece of tissue paper and it came back and hit you". Early in 1911 Rutherford exclaimed to Geiger, "I know what the atoms looks like!". Rutherford put



together a new idea of the atom: what if all the positively charged particles in the atom were not spread like a fluid throughout the atom as Thomson had thought but were lumped together in the centre in one tiny area, or "nucleus"? Most of the atom's mass would be contained in the nucleus, and an equal number of negatively charged electrons would be found

in motion somewhere outside the nucleus. Undoubtedly, it was a compelling idea — a sort of tiny planetary system that resembled the larger solar system we are living in.



The Experiments

First, in a variation of an

1895 experiment by Jean Perrin, Thomson built a cathode ray tube ending in a pair of metal cylinders with a slit in them (Figure 1). These cylinders were in turn connected to an electrometer, a device for catching and measuring electrical charge. Perrin had found that cathode rays deposited an electric charge. Thomson wanted to see if, by bending the rays with a magnet, he could separate the charge from the rays. He found that when the rays entered the slit in the cylinders, the electrometer measured a large amount of negative charge. The electrometer did not register much electric charge if the rays were bent so they would not enter the slit. As Thomson saw it, the negative charge and the cathode rays must somehow be stuck together: **you cannot separate the charge from the rays.**

All attempts had failed when physicists tried to bend cathode rays with an electric field. Now Thomson thought of a new approach. A charged particle will normally curve as it moves through an electric field, but not if it is surrounded by a conductor, say, a sheath of copper. Thomson suspected that the traces of gas remaining in the tube were being turned into an electrical conductor by the cathode rays themselves. To test this idea, he took great pains to extract nearly all of the gas from a tube, and found that now the cathode rays did bend in an electric field after all (Fig-2).

Thomson concluded from these two experiments, "I can see no escape from the conclusion that [cathode rays] are charges of negative electricity carried by particles of matter". But, he continued, "What are these particles? are they atoms, or molecules, or matter in a still finer state of subdivision?". This is the famous "duck argument". **If it looks like a duck, quacks like a duck and waddles like a duck, then we have good reason to believe it is a duck!**

Thomson's third experiment sought to determine the basic properties of the particles. Although he couldn't

Electron As A Particle

In 1899, Thomson set out to resolve the doubt concerning the significance of the e/m values of the "corpuscles" by determining directly their charge as well as the charge to mass ratio. Unfortunately, this could not be done with the cathode-ray particles, and so he turned to another source. It was well-known towards the end of the 19th century that ultra-violet light falling on certain metals, particularly zinc, was associated with the emission of negatively charged particles, a phenomena known as the photoelectric effect. Thomson determined the e/n ratio for these particles by means of electric and magnetic fields and found it to be virtually the same as for the cathode ray corpuscles. Charged particles emitted by an incandescent filament, i.e. by the thermionic effect, also had a similar e/m value. His estimate of the electronic charge of the photoelectric particles turned out to be similar to the unit electronic charge. In view of the consistency of the e/m for the negatively charged particles produced in different ways, it was reasonable to conclude that the particles were identical.

In the words of Thomson: "The experiments just described, taken in conjunction with previous ones on cathode rays, show that in gases at low pressures negative electrification, though it may be produced by very different means, is made up of units each having a charge of electricity of a definite size; the magnitude of this negative charge is equal to the positive charge carried by the hydrogen atom (ion) in the electrolysis of solutions".

Because the charge on the particles present in the cathode rays, and associated with the thermionic and photoelectric effect, was identical with the elementary electric charge, the name electron originally intended by G. Johnstone Stoney for magnitude of the charge, soon became associated with the actual particles themselves.

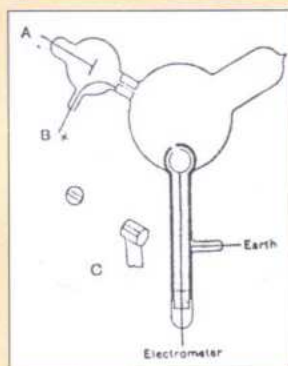


Fig-1 : J.J. Thomson's apparatus for demonstrating that cathode rays have negative electric charge. The slits in the cylinders are shown.



Fig-2 : Thomson's Tube for demonstrating that cathode rays are deflected by an electric field. It was also used to measure e/m .

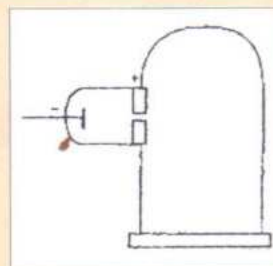


Fig-3 : Apparatus used by Thomson to measure the ratio of the mass of the particle to its electric charge.

shield.)

Further, if each particle is collected it will relinquish its kinetic energy to the collector, and this energy will be evident in the form of heat:

$$H = n(\frac{1}{2}mv^2) \quad (2)$$

Dividing Equation (1) by Equation (2) one finds

$$q/m = 2Qv^2H \quad (3)$$

It is hence necessary to measure velocity v .

Now, in a magnetic field oriented so as to be perpendicular to the original path of the rays, the resulting path is observed to be part of a circle. The magnetic field,

measure directly the mass or the electric charge of such a particle, he could measure how much the rays were bent by a magnetic field, and how much energy they carried. From this data he could calculate the *ratio* of the mass of a particle to its electric charge (m/e). He collected data using a variety of tubes and using different gases. The method essentially involved sending the beam into an electrically shielded collector, as in the Perrin's experiment, but in this case making the collector physically small. The beam gave up its charge to the collector and also heated it by mechanical impact (Fig-3). The quantity of heat energy, H , given to the collector in a given interval of time T could be determined from its mass, specific heat, and temperature rise. This charge in temperature could be measured by means of a very light thermocouple attached to the collector. The total charge, Q delivered to the collector could be measured by a sensitive electrometer.

Assuming that n particles each of mass m and velocity v hit the collector in time T , and that each particle carries a charge q , then $Q = nq$ (1)

provided each particle "sticks" to the collector, and hence deposits its charge to be measured, and does not cause any secondary emission of charged particles. Thomson tried to ensure that these conditions would be met by grounding his shielding electrode. (Even so, if the collector acquires a negative potential from the incoming beam, then it is possible that some of the beam may bounce away from it and be collected by the

then, must be exerting a centripetal force upon the ray particles. Assuming that each of the particles has a mass m , a velocity v , and charge q , and that they move in a magnetic field of intensity B in a path of radius of curvature R , one can write the following equations:

Magnetic force on particle = Centripetal force for circular motion

$$Bqv = mv^2/R \quad (4)$$

Which can be rearranged to give

$$q/m = v/BR \quad (5)$$

Hence, combined with magnetic field deflections, the relations (3) and (5) would give values for both q/m and v . Using this method, Thomson found values of v of the order of 2.4×10^7 to 3.2×10^7 meters per second (about one tenth the velocity of light), and from 1.0 to 1.4×10^{11} coulombs / kilogram for the ratio of charge to mass for cathode ray particles.

In the same paper that described the method described above, Thomson reported a different method for getting the needed second relationship between q/m and v . In this second method he used a tube popularly known as the Thomson tube. The schematic diagram for determination of q/m is shown in Figure-4. The cathode ray beam could be sent through an electric field produced by the plates A and B in which region there could also be a magnetic field perpendicular to the paper established by external coils. Any deflection of the beam could be measured by the scale S at the end of the tube.

With no electrical field applied, the magnetic field can deflect the beam upward or downward as shown, for example, by the dotted path in the figure. The beam travels in a straight line except in the region of the magnetic field, where its path is an arc of a circle of radius R , as in Equation 5. Neglecting the fringe effects, it is fairly easy to calculate R from the measured deflection of the beam and the geometrical constants of the tube. Thus this tube may be used, as other tubes had been, for measurements with



Albert Einstein



Niels Henrik David Bohr



Robert Andrews Millikan

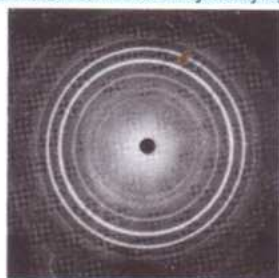
Electron As A Wave

The diffraction and interference properties of radiation necessitate a wave structure, but photoelectric phenomena and the Compton effect imply that radiation consists of particles rather than waves. In Compton effect, an instant X-ray is scattered by a free electron just like in a collision between two rigid spheres. In other words, radiation may be regarded as exhibiting a dual wave - particle behaviour; some of the properties of the radiation may be wave properties where as others are particle properties. By means of Planck's Quantum Theory equation and the mass energy relationship of Einstein, Prince Louis-Victor Pierre Raymond de Broglie (1892-1987) deduced that a particle mass m moving with a velocity v should be associated with waves of length λ , given by

$$\lambda = h / mv$$

where h is the Planck's constant. It was calculated that with a moderately high velocity such as could be obtained by passage of an electron through a potential of about 100 to 1000 volts, the de Broglie waves should have a wavelength of the order of 10^{-8} cms. If this were the case, then crystals should be capable of producing diffraction effects with electrons.

The first definite proof that electrons can be diffracted and consequently exhibit wave, as well as the familiar particle, properties was obtained in the Bell Telephone Laboratories in New York by C.J. Davisson and L.H. Germer in 1927. By studying



Left : Scattering of electrons by gold crystals Right : Scattering of X-rays by zirconium oxide crystals

(From U. Fano and L. Fano, *Basic Physics of Atoms and Molecules*, John Wiley and sons, New York 1959)

the reflection and scattering by a nickel crystal, of a beam of electrons, given a specific velocity by passage through a known potential difference, it was found that the electrons behaved like waves rather than particles. Using electrons which had been accelerated by a potential of 54 volts, the experimental results were found to be equivalent to those expected from radiation of wavelength 1.65 \AA , in remarkably good agreement with the value of 1.67 \AA calculated by means of the de Broglie equation.

Further, evidence for the existence of electron waves was obtained independently in 1927, by George Paget Thomson (1892-1975), son of J.J. Thomson. He passed a stream of fast moving electrons through a very thin sheet of metal and then allowed the resulting beam to fall on a photographic plate. Upon development, the plate showed a diffraction pattern consisting of a series of concentric circles, just as might have been produced by X-rays, indicating that the electrons were manifesting wave properties.

the magnetic field alone, and under these circumstances Equation 5 would apply.

But suppose that while the magnetic field is present, a potential difference V is applied to the two deflecting plates. If the plates are a distance D apart, then the resulting electric field strength between the plates will be

$$E = V/D \quad (6)$$

(If V is measured in volts and D is measured in meters,

then E will be found in newtons per coulomb). A charge q in this field experiences a force Eq , up or down depending on the sign of q and the direction of the field E . If we arrange the applied potential difference to have a value such that the force Eq is numerically equal, but opposite in direction, to the force on the particles due to the magnetic field (which is $F_{\text{mag}} = Bqv$, in which v is the velocity of the particles), we would then have

$$F_{\text{elec}} = F_{\text{mag}} \quad (7)$$

$$\text{or } Eq = Bqv \text{ and hence}$$

$$v = E/B \quad (8)$$

(It is easy to show that if E is measured in newtons / coulomb, and B in webers per square meter, then v is in meters per second). In practice, the potential V is varied until the beam is observed to be at a position of no net deflection. Zero deflection implies that the electric and magnetic forces are equal. V is then measured with a voltmeter, and B is determined by use of a search coil and ballistic galvanometer.

One can then put the numerical value of v thus found back into Equation 5 to determine the value of q/m . Thomson found, in a series of experiments, values for q/m which, when averaged, came to 0.77×10^{11} coulombs / kilogram. This value disagreed with the one he published from his heating effect experiments, a disagreement he attributed primarily to possible systematic errors in the latter experiments. In his writings for the next few years he usually gave the value of q/m as "approximately 10^{11} coulombs / kilogram".

Thomson boldly announced



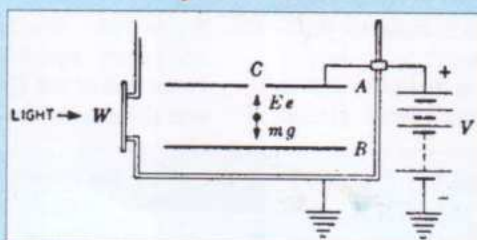
Philipp Eduard Anton von Lenard

the hypothesis that "we have in the cathode rays matter in a new state, a state in which the subdivision of matter is carried very much further than in the ordinary gaseous state: a state in which all matter ... is of one and the same kind; this matter being the substance from which all the chemical elements are built up". Thomson remarked that this surprising result might be due to the smallness of m or to the bigness of e . He argued that m was small, citing Philipp Lenard, who had shown that the range of cathode rays in air (half a centimeter) was far larger than the mean free path of molecules (10^{-5} cm). Lenard was awarded the Nobel Prize in Physics in 1905 for studying the cathode rays. If the cathode ray travels so much farther than a molecule before colliding with an air molecule, it must be very much smaller than a molecule. Thomson concluded that these negatively charged particles were also constituents of atoms.

From 1897 onward, thanks largely to the experiments of Perrin and Thomson, the corpuscular model for cathode rays received general consent. Thomson's view that the cathode ray particles were the fundamental building block, or even a fundamental building block of atoms was not, however, received with much enthusiasm. Several other lines of research, notably in the fields of analysis of spectra and of radioactive phenomena, had to converge before the real role of Thomson's corpuscles within the atom could be understood and generally accepted.

Thomson's achievements were honoured in numerous ways, and mark him as among the most

"e" by Millikan's method



Millikan's apparatus consisted of two horizontal metal plates about 22 cm diameter and 1.6 cm apart as indicated by A and B. The plates were supported in a closed vessel containing air at low pressure, and were connected to the poles of a high voltage (10,000 volts) battery, V. In the upper plate, there were a number of small holes as represented by C. By means of an atomizer, a fine spray of a non-volatile oil was introduced into the vessel. As a result of friction in the atomizer, the droplets of oil so obtained were electrically charged. From time to time, one of these droplets would pass through the hole C, and then it could be observed by means of a telescope (not shown in the figure). By using the illumination of a powerful beam of light, entering the window W (at left), the droplet appeared as a bright star on a dark background.

With the battery V disconnected, the droplet fell slowly under the influence of gravity, and the rate of fall was measured. This rate (or velocity) represented by v_1 is dependent on the mass m of the droplet and is given by the equation $v_1 = kmg$ where g is the gravitational acceleration (981 cm/sec^2) and k is a proportionality constant which is related to the viscosity of the air and the size of the oil droplet. The high voltage battery was then switched on, thus producing the electric field, the direction being such as to make the charged droplet move upward, against the force of gravity. If E is the strength of the electric field, i.e., the voltage of the battery divided by the distance between the plates, then the upward force acting on the droplet is Ee_n , where e_n is the charge carried by the droplet. Since this is opposed by the gravitational force mg , the net upward force is $Ee_n - mg$. The upward velocity v_2 of the oil droplet which is measured, is then represented by

$$v_2 = k(Ee_n - mg)$$

The proportionality constant k has the same significance as in the previous equation.

From the above two equations, it is easy to show that

$$e_n = mg(v_1 + v_2) / Ev_1$$

Since the quantities v_1 , v_2 , g are available, it is possible to calculate the charge e_n carried by the oil drop if the mass m were known. Using Stokes Law, applicable to small spherical drops falling under the influence of gravity, it could be shown that

$$v_1 = 2gr^2d / 9\eta$$

Where η is the Coefficient of Viscosity of air.

Here d is the density of the oil of which the drops are made. Since v_1 has been determined, as described above and g , h and d may be regarded as known the radius r of the drop could be determined from the above equation. It is now easy to determine the mass of the oil drop which is given by $m = 4\pi r^3d / 3$, inserting this result into the equation for e_n , together with the measured velocity, v_1 and v_2 , the magnitude of the charge e_n carried by the oil droplet can now be determined.

As a result of a large number of measurements, Millikan found that the charge e_n was always an integral i.e. a whole number, multiple of a definite elementary charge, which was presumably the electronic charge. After applying numerous corrections to the foregoing equations, Millikan concluded in 1917 that the most reliable value of the unit charge was 4.774×10^{-10} esu which is very close to the modern value 4.803207×10^{-10} esu.



Johannes Stark

accomplished physicists of his era. In 1906 he was awarded the Nobel prize in physics for his researches into the discharge of electricity in gases. In 1918 he was chosen Master of his old college, Trinity, and the next year he resigned the Cavendish Professorship. He guided Trinity with his usual common sense and benevolence until shortly before his death in August 30, 1940.

Millikan And His Oil Drops

Robert Andrews Millikan (1868-1953) was the son of Silas Franklin Millikan a congregational preacher, and Mary James Andrews, a graduate of Oberlin who had been Dean of Women at a small college in Michigan. Raised in Maquoketa, Iowa, where his family moved in 1875, young Millikan enjoyed a story book, Midwestern American boyhood, fishing, farming, fooling and learning next to nothing about science. In 1886, he enrolled in the preparatory department of Oberlin College and in 1887, in the classical course of the college itself. At the end of his sophomore year, he was asked to teach an introductory physics class. Millikan plunged into the subject, liked it and soon decided to make it his career.

Millikan graduated from Oberlin in 1891 and continued to teach physics to the preparatory students. He was awarded an M.A. for his achievement of successfully pursuing a course of instruction in Dynamic Electric Machinery in 1893. Millikan entered Columbia University on a fellowship as the sole graduate student in physics. He was impressed by the experimental deftness of Michelson, under whom he studied at the University of



Arthur Holly Compton

1947) at Berlin, and did research with Walther Hermann Nernst (1864-1941) at Göttingen. In 1896, the excitement of the discovery of X-ray still fresh in his mind. Millikan joined the faculty of the University of Chicago as an assistant in physics. This is where he met Greta Irwin Blanchard, the daughter of a successful manufacturer from Illinois whom he married in 1902. He spend a large fraction of his energies into the development of the physics curriculum, especially in introductory courses and wrote/co-authored a variety of text books which quickly became standards and sold in large numbers. Mainly because of his outstanding pedagogical achievements, Millikan was promoted to an Associate Professorship.

By 1909 Millikan was deeply involved in an attempt to measure the electronic charge. No one had yet obtained a reliable value for this fundamental constant, and some insisted that it was not the constant of a unique particle but a statistical average of a diverse electrical energy. His famous experiment of determination of the electronic charge is described elsewhere in the article. Off and on all the while Millikan had continued his exploration of the photoelectric effect and by 1950 had confirmed the validity of the Einstein's equation of photoelectric effect in every detail.

Millikan held many

Chicago in the summer of 1894. After receiving his Ph.D. in 1895, Millikan went to Europe for post-graduate study. He heard Poincaré lecture at Paris, took a course from Max Planck (1858-

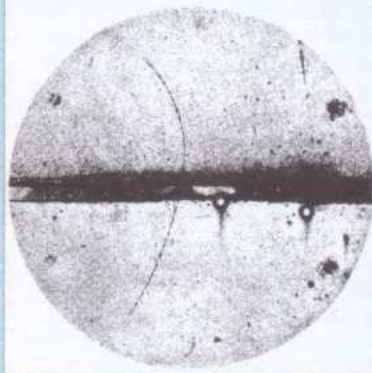
important posts and membership of several eminent Academies and Societies. In 1921, Millikan accepted appointment as the Chairman of the Executive Council and Director of the Norman Bridge



Charles Thomson Rees Wilson

How the "Positive Electron" or the "Positron" was Discovered

The English mathematical physicist P.A.M. Dirac (1902-1984) in 1928 presented theoretical arguments indicating that a particle similar in mass to the electron but carrying a positive charge may exist. His discussion based on relativistic wave mechanics was of a highly abstruse character. However, the proof of the existence of the long-sought positive electron was obtained by C.D. Anderson (1905-1991) at the California Institute of Technology in 1932. In order to study the so-called cosmic rays, which appears to come from outer space, Anderson in conjunction with R.A. Millikan, had constructed an apparatus known as a cloud chamber which was placed in a very strong magnetic field. In this cloud chamber, the path of an electrically charged particle could be rendered visible and also photographed. A cloud chamber is based on the fact that whenever an electrically charged fast-moving particle passes through the air (or any other gas), it produces ionization along its tract. If the air through which these particles pass is saturated with water vapour, the ions serve as the centres of condensation for tiny water droplets, and we see long thin tracks of fog stretching along the particle's trajectories. The intensity of the track provided information concerning the mass of the particle, and the direction in which it was bent in the magnetic field indicated whether the charge was positive or negative. Numerous tracks were observed due to charged particles resulting from the impact on matter of the very highly energetic cosmic rays. A lead plate of 6 mm thickness was placed across the chamber with the object of depriving the particles of some of their energies. Anderson stated in one of his lectures: "The degree of curvature in the magnetic field shows a difference depending on the amount of energy lost in the plate. Measurements made on the track of a particle before and after it has passed through the plate, together with observations of the density of the track itself, give definite information about the mass of the particle and the magnitude of the electric charge it carries". The photograph shows one of the numerous photographs obtained in this



manner – a photograph of historical significance, for its interpretation by Anderson lead to the discovery of the positive electron. Since the curvature of the track is less below the plate than above, the energy of the particle is greater below the plate. Hence the particle must have been moving upward. Knowing the direction of the magnetic field and the direction of the motion of the particle, the curvature of the track to the left immediately showed that the particle must be positively charged. The density of the track was less than would be expected for a proton, but its length was greater. "Photographs of these positively charged particles could be understood only if the particles were assumed to have a mass approximately equal to that of the ordinary electron of negative electric charge, and thus the first evidence for the existence of the positive electron was obtained", Anderson said.

Other cloud chamber photograph examined in the light of new discoveries provided further proof that positive electron were produced by the action of cosmic rays. Some photographs showed charged particles to fall into two groups, one being deflected in one direction and the other in the opposite direction by the magnetic field, representing negative electrons and the positive electrons respectively. Anderson suggested the name "Positron" for the positive electron, and this immediately became into general use.

Laboratory at the California Institute of Technology. Employing the photonic interpretation of cosmic rays, Millikan developed a theory of their origin in 1928. To find a measure of cosmic ray energies, he put Carl Anderson, a young research fellow at Caltech to work with a cloud chamber set in powerful magnetic field which ultimately lead to which detection of the negative electron – also called Positron, in 1932.

Millikan was an able science populariser and lecturer and after he won the Nobel Prize in 1923, he became perhaps the most famous American scientist of his days. He was an outspoken and a religious modernist. Even after his retirement from his professorship in 1946, he remained active as a public lecturer and spoken frequently on the subjects of science and religion. By the time of his death, he had been awarded numerous medals even from honorary degrees and professorship of 21 foreign scientific Societies, including the Royal Society of London and Institut de France.

Thomson did not use the term "electron" to refer to his negatively charged particles; he preferred the term "corpuscle". "Electron" had been introduced by the Irish physicist G. Johnstone Stoney in 1891, as the name

of the "natural unit of electricity", the amount of electricity that must pass through a solution to liberate one atom of hydrogen. Stoney did not associate the electron with a material particle, and physicists at the time questioned whether or not electricity might be a continuous homogeneous fluid.

The early determinations of the charge of the electron had not established that there was a fundamental unit of electricity. That was because the experiments measured the total charge of a cloud of droplets, without showing that the value obtained was anything other than a statistical average. The same was true for Thomson's measurement of e/m for a beam of cathode rays.

It was the experimental work of Robert Millikan at the University of Chicago, beginning in 1909, that provided the next step in establishing the electron as a fundamental particle. Millikan not only demonstrated that there was a fundamental unit of electrical charge; he also measured it accurately.

Millikan's experimental apparatus and the method he used for the determination of the electronic charge is described in a box. He allowed single oil drops to fall a known distance in air, and measured the duration of the fall. He then turned on an electric field and measured the time it took for each drop to travel the same distance upward. (The oil drops were travelling at constant terminal velocity). These two time measurements let him determine both the mass of the drop and its total charge.

The charge on the oil drop sometimes changed spontaneously, by ionization or absorption of charge from the air. Millikan also induced such changes with either a radioactive source or x-radiation. One could calculate the change in the charge on a drop and the changes in that charge were small integral multiples of e , a fundamental unit of charge.

Millikan wrote, "The total number of changes which we have observed would be between one and two thousand, and in not one single instance has there been any change which did not represent the advent upon the drop of one definite, invariable quantity of electricity or a very small multiple of that quantity". Millikan's final value for e was $(4.774 \pm 0.009) \times 10^{-10}$ esu. (The modern value is 4.803×10^{-10} esu).

Millikan associated his measured e both with the charge on Thomson's corpuscles and the charge on the hydrogen ion in electrolysis. He combined his value for e with contemporary measurements of e/m by electrolytic and cathode ray

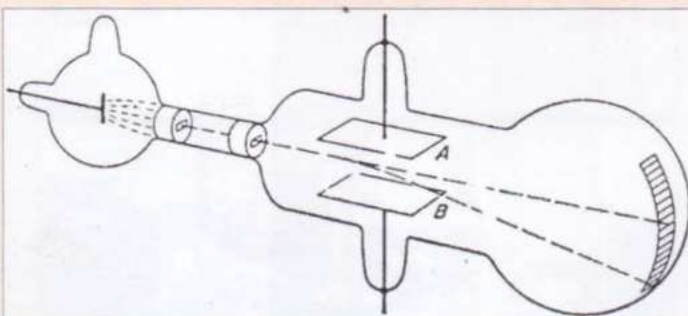


Fig-4 : Thomson's apparatus for determining q/m by magnetic and electric deflection of cathode rays. The magnetic field parallel to plates A and B, produced by external magnets or coils, is not shown.

techniques to determine that the mass of Thomson's corpuscle was $1/1845$ that of the hydrogen atom — surprisingly close to $1/1837.15$, the modern value. Now one had both a definite mass and a definite charge for this would be fundamental particle, and it behaved exactly as one would expect a negatively charged particle to behave. There was now good evidence for believing that it was a constituent of atoms — in other words, the

electron. He was awarded the Nobel Prize for his work in 1923.

Electron gets established

1. The Zeeman Effect : After Hertz had shown experimentally that electromagnetic waves are, in fact, produced by oscillating electric charges as predicted by Maxwell's equations, it became commonly agreed that light waves were

electromagnetic waves and that they were due to some sort of oscillation of charged particles within, or associated with, molecules or atoms. In 1896 a Dutch physicist, Pieter Zeeman (1865-1943) tried to see whether an external magnetic field would affect the wavelength of the light given out by these hypothetical oscillators. His apparatus was, in principle, quite simple: a light source (for example, sodium vapour in a gas flame) was placed between the pole faces of an

electromagnet, and the light from the source was sent through a spectroscope. In his attempts Zeeman found that the spectral lines were not changed or shifted when he switched on the magnet. He gave up the experiment, but then happened to read Faraday's accounts of his final experiments some forty years before. He found that Faraday had tried essentially the same experiment. Zeeman's admiration for his predecessor was so great that he decided that if Faraday had thought the experiment worth doing, then he, Zeeman, ought to be willing to put in a little extra effort to repeat it.

With a somewhat stronger magnetic field he found that the spectral lines (he was using the well known "D lines" of sodium vapour) were slightly broadened. The broadening was of the order of one fortieth of the separation between the two lines, or about 0.15 Angstrom Unit (Angstrom unit = 10^{-10} metre).

A few years later, it turned out that if one assumes that the emission of light takes place from small charged particles revolving in orbits in the atoms, then one can predict a slight contraction or expansion of the orbits when an external magnetic field is applied. The expansion or contraction of the orbits would result in a slight



Owen Willans Richardson



Prince Louis-Victor Pierre

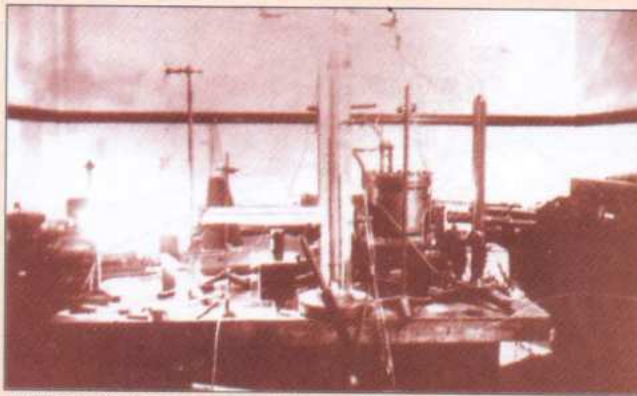


Erwin Schrodinger



Paul Adrien Maurice Dirac

shift in the wavelength of the emitted electromagnetic radiation. The actual amount of the shift can be predicted if one knows the ratio of q to m for the orbiting particles and the strength of the magnetic field. Lorentz and Zeeman were thus able to postulate the presence within the atom of small charged particles, and to estimate from the line broadening that the ratio of q to m for these particles would have to be about 10^7 emu per gram. This was, as they were quick to point out, the same ratio that Thomson had found for his cathode ray particles. Lorentz and Zeeman were jointly awarded the Nobel Prize in 1902 for their work.



Millikan's Oil Drop Apparatus for measuring the charge on the electron.

2. The Photoelectric Effect : Hertz in his famous 1887 experiments with electromagnetic radiation had made what seemed like an incidental or an accidental discovery, which was that ultraviolet light falling on certain metals caused them to emit negatively charged particles, or what is known as the photoelectric effect.



Victor Franz Hess

The discovery of the electron at once suggested the hypothesis that the photoelectric effect is due to the liberation from the illuminated metal plate of electron which under the influence of the electric field pass from cathode to anode, thereby causing photoelectric current. This hypothesis was confirmed by Lenard who showed that the photoelectric discharge is deflected in a magnetic field exactly as are cathode rays. By measuring the deflection of the "photoelectric rays" in a known magnetic field, he found a value of e/m about 1.2×10^7 in qualitative agreement with Thomson's value of e/m for electrons.

In 1899 Thomson applied the technique that he had used with photoelectrically emitted particles to a determination of q/m for the negatively charged particles that, as Edison (the same Thomas Alva Edison) had discovered, are emitted by white hot metals. Thomson found q/m for these particles to be 0.87×10^{11} coulombs per kilogram, again in satisfactory agreement with his value for cathode ray particles. In the next few years Owen in England and Wehnelt in Germany found similar values for particles emitted by certain metallic oxides heated to a red heat.



Clinton Joseph Davison

Lenard found out in 1902 that there was no relationship between the intensity of the light and the energy of the electrons emitted. And a brighter light might cause more electrons to be emitted, but they would not be any more energetic than those released by a dim light. Classical physics could offer no explanation.

By the turn of the century it was known that certain

radioactive materials emitted negatively charged particles that had come to be called "beta rays".

In 1900 Becquerel sent a beam of such particles through electric and magnetic fields to determine their velocity and their ratio of charge to mass. He found the then rather astonishing velocity of approximately $2/3$ that of light, and a ratio of charge to mass of about 10^{11} coulombs per kilogram. Kaufmann, in 1901 and 1902, determined q/m for beta rays more precisely, finding it to

be 1.77×10^{11} coulombs per kilogram. That's where Einstein stepped in, breaking out Planck's quantum theory, which had been gathering dust for a couple of years without too much attention. Planck had pointed out that light emits distinct "packets"; Einstein added that light also travels in packets. Einstein pointed out that a particular wavelength of light is made up of quanta of fixed energy content, according to quantum theory. When a quantum of energy bombards an atom of a metal, the atom releases an electron of fixed energy content and no other. A brighter light would contain more quanta, still always of fixed energy content, causing the emission of more electrons, also still all of the same energy content. The shorter the light's wavelength (and the higher the frequency), the more energy contained

in the quanta and the more energetic the electrons released. Very long wavelengths (of lower frequency) would be made up of quanta having much smaller energy content, in some cases too small to cause any electrons to be released. And this threshold would vary depending on the metal.

This was the first use of Planck's theory since its invention to explain the blackbody problem – and once again it succeeded in explaining a physical phenomenon where classical physics could not. For this work, Einstein received the 1921 Nobel Prize in Physics. It was the first major step in establishing what would become known as quantum mechanics, the recognition of the discrete and discontinuous nature of all matter, especially noticeable on the scale of the very small.



George Paget Thomson

All paths lead to Rome

Thus within four or five years of Thomson's 1897 investigations, he and others were able to show that electrons, as they were then commonly called, with essentially the same properties are emitted from all sorts of materials by

several different mechanisms:

- (a) By strong electric fields, or by bombardment of the cathode by positive ions, as in the classical cathode ray tube.

- (b) As a result of absorption of ultra-violet light by atoms.
- (c) By thermal agitation of atoms in white hot metals or oxides.
- (d) By some spontaneous process within radioactive atoms.

In addition, the Zeeman effect could best be interpreted as showing that precisely similar particles exist *within* atoms. (This is of

some significance, because it is not logically necessary for an atom to "contain" some particle that it is later observed to emit. Modern physics abounds with examples of emitted particles that are *produced*, as it were, on the occasion of their emission).

Thus by 1900 the electron was well established as a constituent of atoms. Already physicists were working toward a better knowledge of the electron's inherent characteristics, its charge, mass, and size, and toward an understanding of its role in an astonishingly wide array of chemical and physical phenomena. But follow the story further we must.

Electron through the 20th Century

In 1913, not long after Millikan's oil drop results, Niels Bohr constructed a theory whose confirmations provided support for the view that the electron was both a fundamental particle and a constituent of atoms. Bohr developed his theory based on Rutherford's nuclear model of the atom put forward in 1911 (in contrast to his mentor Thomson's idea that the positively charged particles in the atom were spread like a fluid throughout the atom — a sort of plum pudding!). Rutherford's model of the atom had a small, massive positively charged nucleus orbited by electron of mass m and charge $-e$. A decade later, Bohr's theory was superseded by the Quantum Mechanics of Erwin Schrödinger and Werner Heisenberg which also assumed an electron with charge e and mass m and it gives exactly the some predictions as the Bohr theory for the Balmer series in the Hydrogen atom.

In the 1920, the experiments of Otto Stern and Walther Gerlach established the existence of the spatial quantizations which provided the evidence for an intrinsic spin of the electron, that is, it behaves as though like a tiny spinning top and a magnet of certain strength.

The electron itself has turned out to be not quite the creature that J.J. Thomson thought it was. According to the quantum mechanics it is a mistake to think that electrons must be either particles or waves but not both. Under some conditions electrons act like particles; under other conditions they act like waves. (The wave character of electrons was in fact experimentally indicated by J.J. Thomson's own son, G.P. Thomson, who as a result shared the Nobel Prize in 1937). Physicists have also found that electrons are only the most common members of a whole "family" of related fundamental



Linus Carl Pauling



Pavel Alekseyevich Cherenkov



Brian David Josephson

particles — all of them infinitesimal points carrying charge, mass, and something called "spin". Why the particles have these properties remains a mystery, a grand challenge for the next century of research.

The knowledge we have gained has made key modern technologies possible. When you are sitting in front of a computer

monitor or watching television, you are probably looking at a direct descendent of the cathode ray tube that Thomson used in his 1897 experiments. Other solid state devices also descend almost as directly from the discoveries of Thomson and his colleagues. Indeed most of our civilization's computation, communications, entertainment and much else rely on technical calculations that would have been impossible without knowledge of the electron and its properties.

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Aaron Klug



Ernst Ruska

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"Nobel Prizes awarded for work with the electron"

The discovery of the electron brought about a revolution in conceptual understanding of the matter and found applications in various fields of human activity. Computers, control systems radio, television, telephones, space flights, ECG, Ultrasonography, Neon displays and what not! Think of anything – almost, and you have electrons there!

1902	Hendrik Antoon Lorentz	the Netherlands	in Physics for the extraordinary service he rendered by his researches into the influence of magnetism upon radiation phenomena.
	Pieter Zeeman	the Netherlands	-do-
1905	Philipp Eduard Anton von Lenard	Germany	in Physics for his work on cathode rays.
1906	Sir Joseph John Thomson	Great Britain	in Physics for the great merits of his theoretical and experimental investigations on the conduction of electricity by gases.
1918	Max Karl Ernst Ludwig Planck	Germany	in Physics for the services he rendered to the advancement of Physics by his discovery of energy quanta.
1919	Johannes Stark	Germany	in Physics for his discovery of the Doppler effect in canal rays and the splitting of spectral lines in electric fields.
1921	Albert Einstein	Germany	in Physics for his services to Theoretical Physics, and especially for his discovery of the law of the photoelectric effect.
1922	Niels Henrik David Bohr	Denmark	in Physics for his services in the investigation of the structure of atoms and of the radiation emanating from them.
1923	Robert Andrews Millikan	USA	in Physics for his work on the elementary charge of electricity and on the photoelectric effect.
1925	James Franck	Germany	in Physics for his discovery of the laws governing the impact of an electron upon an atom.
	Gustav Ludwig Hertz	Germany	-do-
1926	Jean Baptiste Perrin	France	in Physics for his work on the discontinuous structure of matter, and especially for his discovery of sedimentation equilibrium.
1927	Arthur Holly Compton	USA	in Physics for his discovery of the effect named after him.
	Charles Thomson Rees Wilson	Great Britain	in Physics for his method of making the paths of electrically charged particles visible by condensation of vapour.
1928	Owen Willans Richardson	Great Britain	in Physics for his work on the thermionic phenomenon and especially for the discovery of the law named after him.
1929	Prince Louis-Victor Pierre Raymond de Broglie	France	in Physics for his discovery of the wave nature of electrons.
1930	Sir Chandrasekhara Venkata Raman	India	in Physics for his work on the scattering of light and for the discovery of the effect named after him.
1933	Erwin Schrödinger	Austria	in Physics for the discovery of new productive forms of atomic theory.
	Paul Adrien Maurice Dirac	Great Britain	-do-
1936	Victor Franz Hess	Austria	in Physics for his discovery of cosmic radiation.
	Carl David Anderson	USA	in Physics for his discovery of the positron.
1937	Clinton Joseph Davisson	USA	in Physics for his experimental discovery of the diffraction of electrons by crystals.
	George Paget Thomson	Great Britain	-do-
1948	Patrick Maynard Stuart Blackett	Great Britain	in Physics for his development of the Wilson cloud chamber method, and his discoveries therewith in the fields of nuclear physics and cosmic radiation.
1954	Linus Carl Pauling	USA	in Chemistry for his research into the nature of the chemical bond and its application to the elucidation of the structure of complex substances.
1955	Willis Eugene Lamb	USA	in Physics for his discoveries concerning the fine structure of the hydrogen spectrum.
	Polykarp Kusch	USA	-do-
1958	Pavel Alekseyevich Cherenkov	USSR	in Physics for his precision determination of the magnetic moment of the electron.
	Il'ja Mikhailovich Frank	USSR	-do-
	Igor Yergenyevich Tamm	USSR	-do-
1960	Donald Arthur Glaser	USA	in Physics for the invention of the bubble chamber.
1964	Charles Hard Townes	USA	in Physics for fundamental work in the field of quantum electronics, which has led to the construction of oscillators and amplifiers based on the maser-laser principle.
	Nicolay Gennadiyevich Basov	USSR	-do-
	Aleksandr Michailovich Prokhorov	USSR	-do-
1973	Leo Esaki	Japan	in Physics for his experimental discoveries regarding tunneling phenomena in semiconductors and superconductors, respectively.
	Ivar Giaever	USA	-do-
	Brian David Josephson	Great Britain	in Physics for his theoretical predictions of the properties of a supercurrent through a tunnel barrier, in particular those phenomena which are generally known as the Josephson effects.
1977	Philip Warren Anderson	USA	in Physics for his fundamental theoretical investigations of the electronic structure of magnetic and disordered systems.
	Sir Nevill Francis Mott	Great Britain	-do-
	John Hasbrouck van Vleck	USA	-do-
1982	Aaron Klug	Great Britain	in Chemistry for his development of crystallographic electron microscopy and his structural elucidation of biologically important nuclei acid-protein complexes.
1983	Henry Taube	USA	in Chemistry for his work on the mechanisms of electron transfer reactions, especially in metal complexes.
1986	Ernst Ruska	FR of Germany	in Physics for his fundamental work in electron optics, and for the design of the first electron microscope.
	Gerd Binnig	FR of Germany	in Physics for his design of the scanning tunneling microscope.
	Heinrich Rohrer	Switzerland	-do-
1990	Jerome I. Friedman	USA	in Physics for his pioneering investigations concerning deep inelastic scattering of electrons on protons and bound neutrons, which have been of essential importance for the development of the quark model in particle physics.
	Henry W. Kendall	USA	-do-
	Richard E. Taylor	Canada	-do-
1991	Richard R. Ernst	Switzerland	in Chemistry for his contributions to the development of the methodology of high resolution nuclear magnetic resonance (NMR) spectroscopy.
1992	Rudolph A. Marcus	USA	in Chemistry for his contributions to the theory of electron transfer reactions in chemical systems

The Discovery Of The Electron: Glossary

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

- Anode** : The positive terminal of a primary cell or of a storage battery. The collector of electrons in an electron tube. Also known as plate; positive electrode. The positive terminal of an electrolytic cell.
- Anode rays** : Positive ions coming from the anode of an electron tube; generally due to impurities in the metal of the anode.
- Balmer lines** : Lines in the hydrogen spectrum, produced by transitions between $n=2$ and $n>2$ levels either in emission or absorption; here n is the principal quantum number.
- Balmer series** : The set of Balmer lines.
- Cathode** : The primary source of electrons in an electron tube; in directly heated tubes the filament is the cathode, and in indirectly heated tubes a coated metal cathode surrounds a heater. Designated K.
- Cathode dark space** : The relatively nonluminous region between the cathode glow and the negative glow in a glow-discharge cold-cathode tube. Also known as Crookes dark space; Hittorf dark space.
- Cathode emission** : A process whereby electrons are emitted from the cathode structure.
- Cathode glow** : The luminous glow that covers all or part of the cathode in a glow-discharge cold-cathode tube.
- Cathode ray** : A stream of electrons, such as that emitted by a heated filament in a tube, or that emitted by the cathode of a gas-discharge tube when the cathode is bombarded by positive ions.
- Cathode-ray oscillograph** : A cathode-ray oscilloscope in which a photographic or other permanent record is produced by the electron beam of the cathode-ray tube.
- Cathode-ray oscilloscope** : A test instrument that uses a cathode-ray tube to make visible on a fluorescent screen the instantaneous values and waveforms of electrical quantities that are rapidly varying as a function of time or another quantity. Abbreviated CRO. Also known as oscilloscope; scope.
- Cathode-ray tube** : An electron tube in which a beam of electrons can be focused to a small area and varied in position and intensity on a surface. Abbreviated CRT. Originally known as Braun tube; also known as electron-ray tube.
- Cathodoluminescence** : Luminescence produced when high-velocity electrons bombard a metal in vacuum, thus vaporizing small amounts of the metal in an excited state, which amounts emit radiation characteristic of the metal. Also known as electroluminescence.
- coulomb** : A unit of electric charge, defined as the amount of electric charge that crosses a surface in 1 second when a steady current of 1 absolute ampere is flowing across the surface: this is the absolute coulomb and has been the legal standard of quantity of electricity since 1950; the previous standard was the international coulomb, equal to 0.999835 absolute coulomb. Abbreviated coul.
- D line** : The yellow line that is the first line of the major series of the sodium spectrum; the doublet in the Fraunhofer lines whose almost equal components have wave-lengths of 5895.93 and 5889.96 angstroms respectively.
- Electric field** : One of the fundamental fields in nature, causing a charged body to be attracted to or repelled by other charged bodies; associated with an electromagnetic wave or a changing magnetic field.
- Electricity** : Physical phenomenon involving electric charges and their effects when at rest and when in motion.
- Electromagnetic cathode-ray tube** : A cathode-ray tube in which electromagnetic deflection is used on the electron beam.
- Electromagnetic deflection** : Deflection of an electron stream by means of a magnetic field.
- Electromagnetic field** : An electric or magnetic field, or a combination of the two, as in an electromagnetic wave.
- 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.
- Electrometer** : An instrument for measuring voltage without drawing appreciable current.
- Electron** : A stable elementary particle which is the negatively charged constituent of ordinary matter, having a mass of about 9.11×10^{-28} g (equivalent to 0.511 MeV), a charge of about -1.602×10^{-19} coulomb, and a spin of $\frac{1}{2}$. Also known as negative electron; negatron.
- Electron accelerator** : A device which accelerates electrons to high energies.
- Electron beam** : A narrow stream of electrons moving in the same direction, all having about the same velocity.
- Electron diffraction** : The phenomenon associated with the interference processes which occur when electrons are scattered by atoms in crystals to form diffraction patterns.
- Electron diffraction analysis** : Examination of solid surfaces by observing the diffraction of a stream of electrons by the surface.
- Electron emission** : The liberation of electrons from an electrode into the surrounding space, usually under the influence of heat, light, or a high electric field.
- Electron emitter** : The electrode from which electrons are emitted.
- Electron energy level** : A quantum-mechanical concept for energy levels of electrons about the nucleus; electron energies are functions of each particular atomic species.
- Electron gun** : An electrode structure that produces and may control, focus, deflect, and converge one or more electron beams in an electron tube.
- Electronic band spectrum** : Band of spectral lines associated with a change of electronic state of a molecule; each band corresponds to certain vibrational energies in the initial and final states and consists of numerous rotational lines.
- Electronics** : Study, control, and application of the conduction of electricity through gases or vacuum or through semiconducting or conducting materials.
- Electronic scanning** : Scanning in which an electron beam, controlled by electric or magnetic fields, is swept over the area under examination, in contrast to mechanical or electromechanical scanning. Also known as electronic-raster scanning.
- Electronic state** : The physical state of electrons of a system, as specified, for example, by a Schrödinger-Pauli wave function of the positions and spin orientations of all the electrons.
- Electronic structure** : The arrangement of electrons in an atom, molecule, or solid, specified by their wave functions, energy levels, or quantum numbers.
- Electron lens** : An electric or magnetic field, or a combination thereof, which acts upon an electron beam in a manner analogous to that in which an optical lens acts upon a light beam. Also known as lens.
- Electron linear accelerator** : A linear accelerator used to accelerate electrons in a straight line, usually by means of radio-frequency fields which are produced in a loaded waveguide and travel with the electrons.
- Electron mass** : The mass of an electron, equal to about 9.11×10^{-28} g, equivalent to 0.511 MeV. Also known as electron rest mass.
- Electron microscope** : A device for forming greatly magnified images of objects by means of electrons, usually focussed by electron lenses.
- Electron number** : The number of electrons in an ion or atom.
- Electroluminescence** : Luminescence produced when high-velocity electrons bombard a metal in vacuum, thus vaporizing small amounts of the metal in an excited state, which amounts emit radiation characteristic of the metal. Also known as cathodoluminescence.
- Electron optics** : The study of the motion of free electrons under the influence of electric and magnetic fields.
- Electron orbit** : The path described by an electron.
- Electron shell** : The collection of all the electron states in an atom which have a given principal quantum number.
- Electron spectroscopy** : A technique for a study of atomic, molecular, and solid-state structure based on x-ray-induced electron emission from substances.
- Electron spectrum** : Visual display, photograph, or graphical plot of the intensity of electrons emitted from a substance bombarded by x-rays or other radiation as a function of the kinetic energy of the electrons.
- Electron spin** : The property of an electron which gives rise to its angular momentum about an axis within the electron.
- Electron synchrotron** : A circular electron accelerator in which the frequency of the accelerating system is constant, the strength of the magnetic guide field increases, and the electrons move in orbits of nearly constant radius.
- Electron tube** : 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 (British usage).

Electron-volt (eV) : A unit of energy equal to the energy acquired by an electron when it passes through a potential difference of 1 volt in a vacuum; it is equal to 1.602×10^{-19} joule; larger units are keV (kilo-electron volt 1 keV = 1000 eV) and MeV (million-electron volt 1 MeV = 1,000,000 eV)

Electron wavelength : The de Broglie wavelength of an electron, given by Planck's constant divided by the momentum.

Faraday dark space : The relatively nonluminous region that separates the negative glow from the positive column in a cold-cathode glow-discharge tube.

Gas discharge : Conduction of electricity in a gas, due to movements of ions produced by collisions between electrons and gas molecules.

Geissler tube : An experimental discharge tube with two electrodes at opposite ends, used to demonstrate and study the luminous effects of electric discharges through various gases at low pressures.

Magnetic field : One of the elementary fields in nature; it is found in the vicinity of a magnetic body on current-carrying medium and, along with electric field in a light wave; charges moving through a magnetic field experience the Lorentz force.

Photocell : A solid-state photosensitive electron device whose current-voltage characteristic is a function of incident radiation. Also known as electric eye; photoelectric cell.

Photoelectric cell : A solid-state photosensitive electron device whose current-voltage characteristic is a function of incident radiation. Also known as photocell.

Photoelectric effect : The liberation of electrons by electromagnetic radiation incident on a substance; includes photoemission, photoionization, photoconduction, the photovoltaic effect, and the Auger effect (an internal photoelectric process). Also known as photoelectric effect; photoelectric process.

Photoelectricity : The liberation of electrons by electromagnetic radiation incident on a substance; includes photoemission, photoionization, photoconduction, the photovoltaic effect, and the Auger effect (an internal photoelectric process). Also known as photoelectric effect; photoelectric process.

*substance; includes photoemission, photoionization, photoconduction, the photovoltaic effect, and the Auger effect (an internal photoelectric process). Also known as Photoelectric effect.

Quantum : For certain physical quantities, a unit such that the values of the quantity are restricted to integral multiples of this unit; for example, the quantum of angular momentum is Planck's constant divided by 2π .

Quantum hypothesis : A hypothesis that some physical quantity can assume only a certain discrete set of values; examples are Planck's law, and the condition in the Bohr-Sommerfeld theory that the action integral of a system must be an integral multiple of Planck's constant.

Quantum mechanics : The modern theory of matter, of electromagnetic radiation, and the interaction between matter and radiation; it differs from classical physics, which it generalizes and supersedes, mainly in the realm of atomic and subatomic phenomena. Also known as quantum theory.

Quantum theory : The modern theory of matter, of electromagnetic radiation, and the interaction between matter and radiation; it differs from classical physics, which it generalizes and supersedes, mainly in the realm of atomic and subatomic phenomena. Also known as quantum mechanics.

Shell : A set of orbital electron states that have the same principal quantum number and, therefore, have approximately the same energy level and average distance from the nucleus.

Thermionic emission : The outflow of electrons into vacuum from a heated electric conductor. Also known as Edison effect; more broadly, the liberation of electrons or ions from a substance as a result of heat.

Thermionic Tube : An electron tube that relies upon thermally emitted electrons from a heated cathode for tube current.

Zeeman effect : A splitting of spectral lines in the radiation emitted by atoms or molecules in a static magnetic field.

(VP News contd.)

Ham Meet in Delhi

A get-together of amateur radio operators in Delhi was organized by Vigyan Prasar on 29th April, 2001. 30 radio amateurs (hams) participated in this get-together and exchanged their views about various aspects of amateur radio activity with emphasis on Delhi. The meeting was presided over by Dr. V.B. Kamble, Acting Director, Vigyan Prasar-also the founder member of Club station VU2NCT of National Council for Science & Technology Communication.

Shri Ved Prakash Sandlas, VU2VP, spoke on the need to prevent interferences on amateur radio bands. Shri Sanath, VU2YI, highlighted the need to stop the illegal use of mobile telephones and other wireless devices causing interference to amateur radio transmissions. Shri Sandlas, suggested that Vigyan Prasar can initiate a project to survey the unauthorized transmissions interfering with amateur operations. Regarding the use of wireless devices, used by illegal operators, which cause interference to the amateur radio bands, Shri Sahrudin, VU2SDN expressed his view that, the most important task is to educate these users who are unknowingly interfering with the amateur radio transmissions. He suggested that WPC might be requested to release a press note about the illegal use of the radio frequencies, especially in the range 130-330 MHz. It was also suggested that if possible, VU2NCT or any other agency could release a press note to make the public aware about the 144-146 MHz amateur band, in which cordless telephones have been causing nuisance. The radio amateurs active on the 2m VHF desired that a daily 2m net for hams in Delhi could be started. Shri Surinder Kumar, VU2SUU, brought out the need of one more VHF repeater in Delhi.

Shri Sahrudin, VU2SDN, President, Amateur Radio Society of India, apprised the participants of the licencing scenario in

India. He stated that more than 1,500 aspirants, who had passed the amateur radio licencing examination in 1991 are still awaiting their amateur licences.

There was a discussion about the problem of non-availability of low cost ham radio equipment. An old timer from Delhi, Shri Rahul Kapoor, VU2YK requested VP to take initiative in making available workshop/lab facility to amateurs. There was a suggestion from Shri Atanu Dasgupta, VU2ATN, that VP could establish a library exclusively meant for the radio amateurs. Many of the radio amateurs also expressed their concern at the non-availability of a reliable call-book providing updated addresses of the radio amateurs.

Shri Sandeep Baruah, VU2MUE, spoke on the need for the improvement of the Indian Wireless (Amateur Service) Rules. He apprised the participants of the on-line opinion poll conducted by VU2NCT, in which, nearly 108 amateur radio operators from across the country had participated. He informed the participants about the suggestions sent to the WPC by VU2NCT.

The meeting concluded with a discussion on the difficulty in promoting ham radio among the new generation. Shri Ved Prakash Sandlas, was of the view that the hobby of ham radio demands dedication and perseverance, which might be lacking in the younger generation. Ham radio operators belong to a restricted group who feel the thrill of talking to a distant person just at the press of a button and that, ham radio is a completely independent radio network that operates even in the event of a disaster. A few participants suggested that a debate could be organized on the topic-"Internet versus Amateur Radio".

It was agreed that there should be at least one get-together of radio amateurs of Delhi every month.

Indian Women Association of India

□ Dilip M. Salwi*

"The world cannot afford the loss of the talents of half of people if we are to solve the many problems which beset us," said the eminent American scientist and Nobel Laureate Rosalyn Yalow. Obviously, she was referring to the women who form half — if not the better half — the population of the world. In fact, in recent years, all the major world organisations like WHO, UNESCO, UNICEF, etc. have recognised the vital role that a woman plays in not only educating the entire family but also in maintaining its health and fuel needs in a developing country. But much before this recognition dawned upon these organisations, a group of twelve Indian women scientists gathered and formed an association called "Indian Women Scientists' Association" (IWSA) more than 26 years ago in Vashi, near Mumbai, with almost similar objectives.

What initially began as an association to fight for the rights of women scientists in a male-dominated scientific community has today culminated in an organisation that has the lofty goal of making women realise their scientific potential because science is a major component in all the daily activities of a woman. "Every woman, whether trained in the modern scientific discipline, or any other discipline, or not trained at all, is also a silent potential scientist," claims an IWSA brochure. From the problems related to science and technology that a woman faces today in daily life to science education, science popularisation and laboratory politics, the association tries to tackle all.

"Often, women who undergo higher education don't sacrifice their families for professional satisfaction," said Dr. Sudha Padhye, the past President of IWSA and a college physics teacher. "But when they are free from family responsibilities, they yearn to take up scientific activities. IWSA provides them a forum for channelling their scientific knowledge for the benefit of women". Their knowledge is utilised for training young girls in various scientific vocations, including manufacture of consumer goods, in career counselling for girls, in science popularisation among children, in medical care and even in conducting surveys on woman-related issues. Some of these job-oriented courses have also been formally recognised by the S.N.D.T. University.

Today, IWSA has its own building complex spread over an acre of land in Vashi, containing a 140 room working women hostel, a laboratory and computer facility for science teachers and school students, a library, a day care centre, a medical

dispensary, and a newly built auditorium. 1,400 women scientists from different parts of the country are its members, with eleven active branches in cities like Delhi, Pune, Bhopal, Roorkee, Hyderabad, Lucknow, Kalpakkam, etc. Regularly meetings, conferences and seminars that highlight issues that affect woman scientists as well as scientific issues that affect women are organised not only in the headquarters at Vashi but also in other branches.

Over the years, IWSA has organised several national and international conferences touching issues such as 'Specific Problems of Professional Women Scientists', 'Science Teaching, Nutrition, Family Planning, Indian Medicine, Health and Science Communication', 'Women and Environment', 'Role of Women in Science and Society Interaction', etc. During the IWSA Silver Jubilee International Conference on 'Expanding Frontiers of Science and

Technology' held in 1998, two Noble Laureates Dr Rosalyn Yalow and Dr Dorothy Hodgkin also attended the conference.

IWSA membership is open to science and engineering graduates and technical diploma holders, and Associate membership is open to any woman interested in science. In close touch with several woman bodies all over the world, IWSA also advises the Government and State Governments on various

emerging woman issues. Of course, it has not ignored the underprivileged Indian woman living in rural areas. Under the guidance of the eminent scientist Dr Kamal Ranadive, several projects to acquaint the rural as well as tribal women with medical care and



IWSA Nursery School.



IWSA's "School Education Committee with Balvadi Training Course Students at Teaching aid's exhibition



IWSA Building Complex at Vashi

health awareness as well as safe womanhood have been taken up in the neighbouring Rajur Village and some villages in Ahmednagar, Maharashtra. Several municipal schools in and outside Mumbai have been adopted for improvement in science teaching.

To encourage women scientists as well as inspire girls and women to take up science careers, IWSA also gives awards, honours, and scholarships to deserving candidates every year. Among the several publications brought out from time to time are *Down the Memory Lane*, a collection of reminiscences of pioneering Indian women scientists, a directory of Indian women in science and technology. Besides, a newsletter on the IWSA activities is regularly brought out. "We've now the necessary infrastructure," said Padhye proudly. "It is now upto the woman scientists to make best use of it for furthering their own - and society's - interests".

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Intellectual Property Rights

(Part-I : Patent System)

□ Subodh Mahanti

A patent system, like other kinds of intellectual and industrial property, is one of a variety of incentive devices used by governments to correct the situation in sectors of economy where there is judged to be a tendency towards undercommitment of resources to knowledge protection and innovation. The above was stated by the Economic Council of Canada in its Report in 1971 on Intellectual and Industrial Property.

Intellectual property will no longer be seen as distinct or self-contained domain, but rather as an important and effective policy instrument that would be relevant to a wide range of socio-economic, technological and political concerns. The development of skills and competence to manage IPR and leverage its influence will need increasing focus; in particular, among the developing countries...One of the concerns of the developing world is that the process of globalisation is threatening the appropriation of elements of this collective knowledge of societies into proprietary knowledge for the commercial profit of a few. An urgent action is needed to protect these fragile knowledge systems through national policies and international understanding linked to IPR, while providing its development and proper use for the benefit of its holders.

R.A. Mashelkar, Director General, CSIR, in his preface to the book, *Intellectual Property Rights : Unleashing the Knowledge Economy* by Prabuddha Ganguly (2001)

Following the emergence of strong global and national intellectual property regimes, the subject of intellectual property rights (IPRs) and their protection has become a central issue in economic development, scientific and technological development, protection of traditional knowledge and scientific and economic cooperation between industrialised and developing countries. There is a strong opposition or apprehension particularly in developing countries to the very idea of the necessity of strong intellectual property regimes. It is believed that only the developed countries will profit from it. But then, on the other side, it is believed that 'establishing ownership of intellectual assets, arriving at acceptable frameworks for fair and equitable sharing of benefits for social good and providing harmonised legal structures to encourage continuous flow of innovation are bare necessities to fuel a vibrant global economy.'* The subject of intellectual property rights is rather complex. Our intention is not to go into the merits and demerits of the evolving global economic intellectual property regimes. Here we intend to describe briefly the basic aspects of intellectual property rights. The present article will be concluded in four parts:

- Part I : A brief description of the general aspects of intellectual property rights and discussion on the patent system.
- Part II : Copyrights, Trademarks and Industrial Designs
- Part III : World Intellectual Property Organisation (WIPO); Trade Related Intellectual Property Rights (TRIPS) and other international agreements on intellectual property rights.
- Part IV : IPR related technical terms and relevant sources.

Intellectual property essentially includes the products or creations of the mind, and intellectual property laws aim at 'safeguarding creators and other producers of intellectual goods and services by granting them certain time-limited rights (intellectual property rights) to control the use made of those productions.' Traditionally intellectual property is divided into two groups:

Group I: Industrial Property

Industrial property includes inventions (process, products apparatus); Industrial designs (shapes and ornamentation); and Marks and Tradenames to distinguish goods. Recently the scope of industrial property has been expanded to include 'among others, the protection of distinctive geographical indications (in particular, appellations of origin), plant varieties, and the layout designs (topographies) of integrated circuits, as well as the repression of unfair competition, including the protection of trade secrets.'

* *Intellectual Property Rights : Unleashing the Knowledge Economy* by Prabuddha Ganguly, Tata McGraw-Hill Publishing Co. Ltd. New Delhi, 2001.

Group II: Copyrights

Copyrights broadly include : Literary works; Musical works, including any accompanying words; Dramatic works, including any accompanying music; Pantomimes and choreographic works; Pictorial, graphic, and sculptural works; Motion picture and other audiovisual works; Sound recordings; and Architectural works.

Recently an expression called 'neighbouring rights' has been added to the concept of copyrights. The expression "neighbouring rights" is the abbreviated form of "rights neighbouring on copyright". The following three types of rights are covered by the concept of neighbouring rights :

- The rights of performing artists in their performance.
- The rights of producers of phonograms in their phonograms.
- The rights of broadcasting organisations in their radio and television broadcasts.

The convention establishing the World Intellectual Property Organization (WIPO) concluded in Stockholm on July 14, 1967 (Article 2 viii) provide that "Intellectual property" shall include rights relating to :

1. Literary, artistic and scientific works
2. Performances of performing artists, phonograms and broadcasts
3. Inventions in all fields of human endeavour
4. Scientific discoveries
5. Industrial designs
6. Trademarks, service marks, and commercial names and designations.
7. Protection against unfair competition and all other rights resulting from intellectual activity in the industrial, scientific, literary or artistic fields."

Intellectual property like any other form of conventional forms of property is an asset. Just like real and personal property the intellectual property can also be bought, sold, licensed, exchanged or gratuitously given away. Intellectual property owner has also the right to prevent the unauthorised use or sale of the property. The most striking difference between intellectual property and other form of property is that it is intangible, that it cannot be defined or identified by its own physical parameters. So intellectual property must be expressed in some discernible way for enabling it to be protected. Unlike a physical object, an intellectual property like an idea for invention, a piece of music or a trademark cannot be protected against other person's use of them by simply possessing the object. Hence the necessity of enacting intellectual property laws distinct from conventional laws protecting personal property.

The practice of defining intellectual property started in the Italian City States. It has been reported that the first patent was granted to Filippo Brunelleschi in the Republic of Florence in

Box-I : Acts/Laws and Their Ammendments Related to IPR Enacted by India

- 1856 The Act on Protection of Invention based on the British Patent Act of 1852.
- 1859 The Act modified as Act XV; patent monopolies called exclusive priviledges (making, selling and using invention in India and authorising others to do so for 14 years from date of filing specification.
- 1872 The Patents and Designs Protection Act
- 1883 The protection of Inventions Act
- 1888 Consolidated as the Inventions and Designs Act.
- 1911 The Indian Patents & Designs Act (Under the mangement of the Controller of Patents & Designs). This came into force from 15 August 1947.
- 1914 Copy of the British Copyright Act of 1911 with suitable modification for British India.
- 1940 11 March 1940 legislation for protection of the Trade mark Act, brought into force from 1 June, 1942.
- 1957 Adopted many principles of the British copyright Act of 1956 This came into force to cope with new problems in the law of copyright created by technological advances in the fields of communication, broadcasting, microfilming, photolithography, movies cinemas and talkies.
- 1959 On 25 November 1959 the Act trade mark of 1940 ammended as the Indian Trade & Merchandise Marks Act, 1958.
- 1967 The patent Bill introduced in Parliament.
- 1970 The Indian patents Act, 1970. The Design Act of 1911 retained without changes.
- 1972 The Patents Act (Act 39 of 1970) came into force on 20 April 1972.
- 1983 Ammendments to availing the benefits arising from the revision of the Berne Convention and the Universal Copyright Convention to which India adheres.
- 1984 Ammendments to discourage and prevent piracy prevailing in the video film and records.
- 1992 Ammendment to increase protection time to Author's lifetime +60 years.
- 1992 Ammendment proposed for a "New Act" in line with internationally accepted norms. Debates continuing.
- 1994 On 31 December, 1994, Ordinance framed to amend the Patents Act, 1970, and the concept of exclusive marketing rights introduced as pipeline protection.
- 1994 Ammendment to give effect to the obligation arising from the GATT. Copyright protection extended to new areas of creative work, including the computer industry. Special rights introduced to cover the performing arts.

For more details see :*The Gearing uo for Patents : The Indian Senerio by Prabuddha Ganguly.*

1421. Brunelleschi was given a three year monopoly for his invention concerning special hoisting gear used on barges. An ordinance relating to patents was first enacted in a Venetian law of 1474. From the Italian City States the practice spread to other Western European countries. In England, during the reign of Elizabeth I (1533-1603), her minister, Lord Burghley (1520-98), granted a series of patents with a view to encouraging foreign inventors to import their inventions and work on them in England. It was also intended to stimulate inventions by domestic producers. In India the basic elements of intellectual property rights were first introduced by enacting the Act on Protection of Inventions in 1856. This Act, which was based on the British Patent Law of 1852, was the origin of patent legislation in India. A chronological perspective of the development of Indian IPR is given in Box-I. A list of international and regional agreements and treaties is given in Box-II.

Most of the countries give legal protection to inventions

Box-II : List of International and Regional Agreements/Treaties in Intellectual Property Rights

- 1883 Paris Convention for the Protection of Industrial Property
- 1886 Berne convention for the Protection of Literary and Artistic Works
- 1891 Madrid Agreement for the Repression of False or Deceptive Indications of Source of Goods .
- 1891 Madrid Agreement Concerning the International Registration of Marks
- 1925 Hague Agreement concerning the International Deposit of Industrial Designs
- 1957 Nice Agreement Concerning the International Classification of Goods and Services for the Purpose of the Registration of Marks
- 1958 Lisbon Agreement for the Protection of Appellations of Origin and their International Registration
- 1961 Rome Convention for the Protection of Performers, Producers of Phonograms and Broadcasting Organisations
- 1968 Locarno Agreement Establishing an International Classification for Industrial Designs
- 1970 Patent Cooperation Treaty ("PCT")
- 1971 Strasbourg Agreement Concerning the International Patent Classification
- 1971 Geneva Convention for the Protection of Producers of Phanograms Against Unauthorised Duplication of Their Phonograms
- 1973 Vienna Agreement Establishing an International Classification of the Figurative Elements of Marks
- 1974 Brussels Convention Relating to the Distribution of Programme-Carrying Signals Transmitted by Satellite
- 1977 Budapest Treaty on the International Recognition of the Deposit of Microorganisms for the Purpose of Patent procedure
- 1981 Nairobi Treaty on the Protection of the Olympic Symbol
- 1989 Washington Treaty on Intellectual Property in Respect of Integrated Circuits
- 1989 Protocol Relating to the Madrid Agreement Concerning the International Registration of Marks
- 1994 Trademark Law Treaty ("TLT")
- 1994 Trade Related Intellectual Property Rights ("TRIPs")
- 1996 Community Trademarks
- 1996 Documents of the Diplomatic Conference on Certain Copyright and Neighbouring Rights Questions (Geneva, December 2-20,)
- 1996 WIPO Copyright Treaty (WCT)
- 1996 WIPO Performance and Phonograms Treaty (WPPT)

through patents. However, in a few countries the protection to inventions may also be given by means of other than patents. A patent is a property right granted by the State to a patentee, excluding others, for a limited period, from using the patented invention without the proper authorisation of the owner of the patented invention. An invention without a patent is not necessarily a property right. After the expiry of the term of the patent, the invention passes into the public domain. The purpose of a patent is to provide an incentive to the inventor/investor so as to promote inventive activity and commercialisation of invention. Another purpose is to encourage the disclosure of the invention.

An invention may be defined as the idea of making a new and useful article, method or substance. The WIPO Model Law for Developing Countries on Inventions (1979) defines invention 'as an idea of an inventor which permits in practice the solution of a specific problem in a field of technology.' The basic root of

Box-III : What is non-patentable in India

- * Frivolous claims contrary to well-established natural laws.
- * Anything contrary to law or morality, or injurious to public health.
- * Mere arrangement or rearrangement or duplication of known devices, each functioning independently of one another in a known way.
- * A method or process of testing applicable during the process of manufacture for rendering the machine, apparatus or other equipment more efficient or for the improvement or restoration of the existing machine, apparatus or other equipment or for the improvement or control of manufacture.
- * A method of agriculture or horticulture.
- * Inventions related to atomic energy.
- * Computer software
- * Aesthetic creations
- * Discoveries, scientific theories, mathematical methods.
- * Schemes, rules or methods for performing mental acts playing games or doing business.
- * Presentation of information
- * Methods of treating humans or animals through surgery, or therapeutical diagnostics.
- * Animals and plants, and biological methods for rearing/growing them (however, microorganism is patentable in India.
- * Products made by chemical synthesis—foods, medicines.

Source: *Gearing up for Patents: The Indian Scenario* by Prabuddha Ganguli, Universities Press (India) Limited, 1998.

the word 'invention' comes from the Latin word '*invenire*' which means 'to come upon'. With most inventions there is a sense of surprise. There may be many reasons for making invention. The most obvious ones are:

- * For personal satisfaction.
- * For solving a problem faced in everyday life.
- * For being recognised by others.
- * For the desire to take up a challenging/interesting task.
- * For the desire to make money.

In industry the demand for the development of new technology, that is the demand for 'inventive activity' is generally influenced by the expected rates of returns to that activity compared with rates of return that can be achieved by investing in non-inventive activity including the adoption of alternative existing technologies.

Normally a distinction is made between inventions that concern with products and inventions that concern with processes. For example, an invention that consists of a new drug is a product invention, but an invention that consists of a new method or process of making a known or new drug is a process invention. The corresponding patents are usually called a 'product patent' and a 'process patent' respectively.

Not all inventions are patentable. The basic criteria for an invention to be patentable (as required by the patent laws of almost all the countries) are: **it must be novel, it must involve an inventive step (or it must be non-obvious), and it must have some industrial application.** But then, even if the invention is new it may not be patentable as according to the patent laws of certain countries certain articles, processes or ideas, just cannot be protected even if they are new. Things which are non-patentable in India is given in Box-III

For every invention there should be a separate patent application. However, if a group of inventions are so-linked that they form a single general inventive concept one application will suffice. The language in which a patent application is to be filed is also fixed. It cannot be written in any language. In India a patent application must be drafted in English. The complete specification of a patent application should include the following :

Box-IV : In India, the Controller General of Patents, Designs and Trademarks (CGPDT) functioning under the Department of Industrial Development control the granting of patents, designs and trademarks. The Ministry of Human Resources is in charge of the Copyright Board.

Address of Patent Offices in India

1. Office of the Controller General of Patents, Designs & Trademarks 101, Maharishi Karve Road Mumbai - 400 020	Lower Parel (W) Mumbai - 400 013
2. The Controller of Patents The Patent Office (Head office) "Nizam Palace" 2nd M.S.O. Bldg 5th, 6th, 7th Floor, 243/4 Acharya Jagdish Bose Road Calcutta - 700 020	4. The Controller of Patents The Patents Office, Branch Unit No. 401 to 405, III Floor Municipal Market Building Saraswathi Marg, Karol Bagh New Delhi - 110 005
3. The Controller of Patents The Patents Office Branch Todi Estates, III Floor	5. The Controller of Patents The Patents Office, Branch 61, Wallajah Road Chennai - 600 002
	6. Patents Information System 3rd Floor, Block- C CGO Complex, Seminary Hills Nagpur - 400 006

- * The object or title of the invention.
- * Prior art or cross-references to related applications, if any.
- * Brief summary of the invention.
- * Brief description of several views of the drawing, if there are drawings.
- * Detailed description of the invention.
- * Claim or claims.
- * Abstract of the disclosure.

The title of the invention should be as short and specific as possible. The specification must bring out the precise invention.

A patent application or patent document is a technical literature and it must be formulated in such a way that it conforms to the requirements of patent law of the country in which the patent application is filed. The conventions are more or less similar in all the countries. Only a skilled person familiar with patent law will be able to draft a patent claim. It is a normal practice to engage the services of a patent agent/patent attorney when seeking to make an application for obtaining a patent. The patent agent's skill and experience play a crucial role in drafting the claims. The drafting should cover the invention in the broadest possible way so that the inventor's rights are properly protected. It is the patent agent who advises whether an invention is patentable or not.

The concept of the right conferred by a patent right is often misunderstood. The grant of a patent carries with it no positive right. This is contrary to our common experience of ownership in case of most personal property where one enjoys a positive right. The right of ownership in a patent is a negative right - the negative right to exclude others from making, using or selling the patented invention. The mere granting of a patent does not ensure that it would enable the inventor to make, use or sell the invention. Thus, while the owner of a patent is not given a statutory right to practice his/her invention, he/she is given a statutory right to exclude others from practicing their patented invention. **The exclusionary privilege given to the owner of a patent is a negative right.** In fact, in making, using or selling his or her own invention, the inventor may find that he or she infringes the patent right of others. Only in those cases when the invention is very basic to art, does the grant of a patent take on the characteristics of a positive right. A patent is the monopoly granted by the State to an inventor for a fixed period in exchange for the disclosure of the invention so that others may profit from the invention. **The disclosure of an invention is considered of vital importance in any patent granting procedure.**
