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SCIENCE REPORTER

CONTENTS

Eosinophilia and leukaemia

1. How can the increased eosinophil content in the blood be decreased?
2. What is the recently known medicine for leukaemia?

BHABANI PRASAD SAHOO
Calcutta

1. Eosinophils constitute 2-4% of the white blood cell counts. They increase in number in certain diseases such as allergy (asthma), and in certain infections by animal parasites. Drugs which specifically cure parasitic infections and conditions which eliminate onset of allergy are likely to decrease eventually the increased eosinophil content of blood in man. Eosinophils decrease in number in blood following the administration of adenocorticotropic hormone (ACTH) or cortisone.

2. Depending on the type of leukaemia concerned and the response obtained antimetabolites, alkylating agents or corticosteroids are used to destroy abnormal leukocytes and to suppress abnormal leucocyte proliferation. Of the recent effective drugs, prednisolone, 6-mercaptopurine, methotrexate, chlorambucil, cyclophosphamide and busulphan are used alone or in combination for the treatment of leukaemia. Enzymic therapy using L-asparaginase has proved highly promising in certain types of leukaemia (*S.R.* 5, 409, 1968 ; *Indian Med. Gazette*, 7(9), 36, 1968).

BHAKTI DATTA
Beth Israel Medical
Centre, New York

Hirsutism

Please explain the causes and cure of the disease "Hirsutism" resulting as a side-effect in women using pills.
Shahdara, Delhi BRIJ LAL

Hirsutism is characterized by excessive growth of hair or the presence of hair in unusual places. A familial or racial origin is traced in a majority of hirsute persons (idiopathic hirsutism). By itself hirsutism is not a disease, but may be manifestation of some disease conditions involving endocrine system in women and children. Hirsutism is frequently associated with adrenal cortical tumours, basophilic adenoma of the pituitary and arrhenoblastoma of the ovary. It may arise from side-effect of adenocortical steroid therapy. Chronic irritation may be also a cause.

Treatment of the underlying endocrine disorders may eliminate hirsutic condition. Local treatment involving destruction of individual hair follicles by electrolysis, mechanical measures involving plucking, shaving and use of epilating wax, and chemical measures using depilatories and bleaches (if the hair are fine) may be helpful. In the case of idiopathic hirsutism, one may use female sex hormone estrogen cyclically, as it diminishes the diameter of the hair.

BHAKTI DATTA
Beth Israel Medical
Centre, New York

Leucorrhea

1. What is the cause of leucorrhea in females?
2. Is there any possibility of curing it permanently?

S.M. TOLLA
Peddakhojjiria

1. Leucorrhea, which is not in itself a disease but rather a symptom of some disorder in the genital tract or elsewhere in the body, is caused chiefly by infection of the vagina or cervix with bacteria, protozoa, or fungi. Infection with *Trichomonas* or *Monilia* (Candida) organisms is the most frequent direct cause of the discharge. Other causes may be pelvic congestion, foreign body, postmenopausal atrophy, endocrine disturbance, hypersecretion, unhealed lacerations, uncleanliness or chemical irritants.
2. If the cause of leucorrhea is known through investigation, the proper treatment is likely to cure it permanently.

BHAKTI DATTA
Beth Israel Medical
Center, New York

Bertrand Russell

I read with interest the obituary of Bertrand Russell by G.H. Keswani (*S.R.* 7, 3) and also the letter to this effect by Miss Gill Dammers (*S.R.* 7, 6). I fully agree with Miss Dammers that Russell had never been a 'professed Christian', as reported by Mr. Keswani in his otherwise delightful article. In fact, Russell was a severe critic of Chris-

tianity and religion in general, and he even wrote a book, *Why I am not a Christian*. He never believed that there is a Creator of the universe and that the universe has a divine purpose,—and he laughed at the idea of the immortality of the soul. However, all this does not mean that Russell was a 'professed atheist' as Miss Dammers holds. True, he did not aver, like true Christians, that he knew that there is a God, but he also never denied emphatically His existence. He simply suspended his judgement and said that there are no sufficient grounds either for affirmation or for denial. In short, Russell was neither a Christian nor an atheist, but he was an 'agnostic'. Russell's own words may be quoted to prove the point. In his autobiography, while describing his first prison life, he wrote thus: 'I was much cheered on my arrival by the warden at the gate, who had to take particulars about me. He asked my religion and I replied, "agnostic". He asked how to spell it, and remarked with a sigh, "Well, here are so many religions, but I suppose they all worship the same God." This remark kept me ammused for about a week'. (*Autobiography*, 2nd volume, Pp. 29-30)

S.N. BARNAN
Deptt. of Physics,
Arya Vidyapeeth College,
Gauhati

Anti-alcoholic drugs

The article 'Alcoholic drinks—kinds and effects' by Mr. V.K. Sharma, (*S.R.*, 7,6) is quite accurate and up-to-date. However, while advocating the medical approach to alcohol addiction the mention of anti-alcohol drugs would have made it more informative.

There are certain drugs the administration of which creates a repulsion against alcohol. Among these is "Apomorphine". During treatment the patient is allowed to drink as much as he likes and is then given injections of the drug which causes severe vomiting. The idea is that the unpleasant association between drinking and vomiting would dissuade him from further indulgence in alcohol. Another effective prescription is the Danish drug, 'Antabuse' or 'Disulfiram' (a sulphur compound) which when administered regularly makes the patient so ill after drinking due to severe vomiting and nausea, that it turns him against the habit.

RAJINDER KUMAR MAHINDROO
Srinagar

DNA

The answer to the query of Shri Rabindranath Padhy by Bhakti Datta and Tris Masterangelo (*S.R.*, 7,6) about the relative amount of DNA/cell of a particular organism and species difference, needs a little modification.

Each species of organism has a characteristic amount of DNA/haploid set of chromosomes. It should be noted that the amount of DNA/cell does not necessarily indicate its evolutionary position, even though in invertebrates DNA content/cell progressively increases with increasing degree of complexity. In vertebrates little relation is found between DNA content and phylogenetic relationship (Mirsky, 1950).

Reference

Cell Physiology, Third Edition, Arthur. C. Giese. page 154.

(MISS) JAYASHREE MITRA
Bilaspur (MP)

'Disease and Man'

Of the items in the Special Edition (*S.R.*, 7,5) the one "Advancing frontiers of the chemotherapy of mental diseases" by M.V. Varghese, R. Sitaram Iyer and K.V. Thomas impressed me very much. The manner in which the authors have correlated various data on the subject in the easily digestable manner deserves praise.

I would like to see an article on "Residue analysis in the study of peptides and proteins" which is indeed a highly evolved branch in biochemistry.

K. VENUGOPAL
Irinjalakuda
Kerala

I have read with great interest the recent Special Number on 'Disease and Man' (*S.R.* 7,5). One of the human diseases which do not easily yield to successful treatment and are almost incurable is 'Osteo-arthritis'. You may invite articles from eminent scientists and experts on this subject.

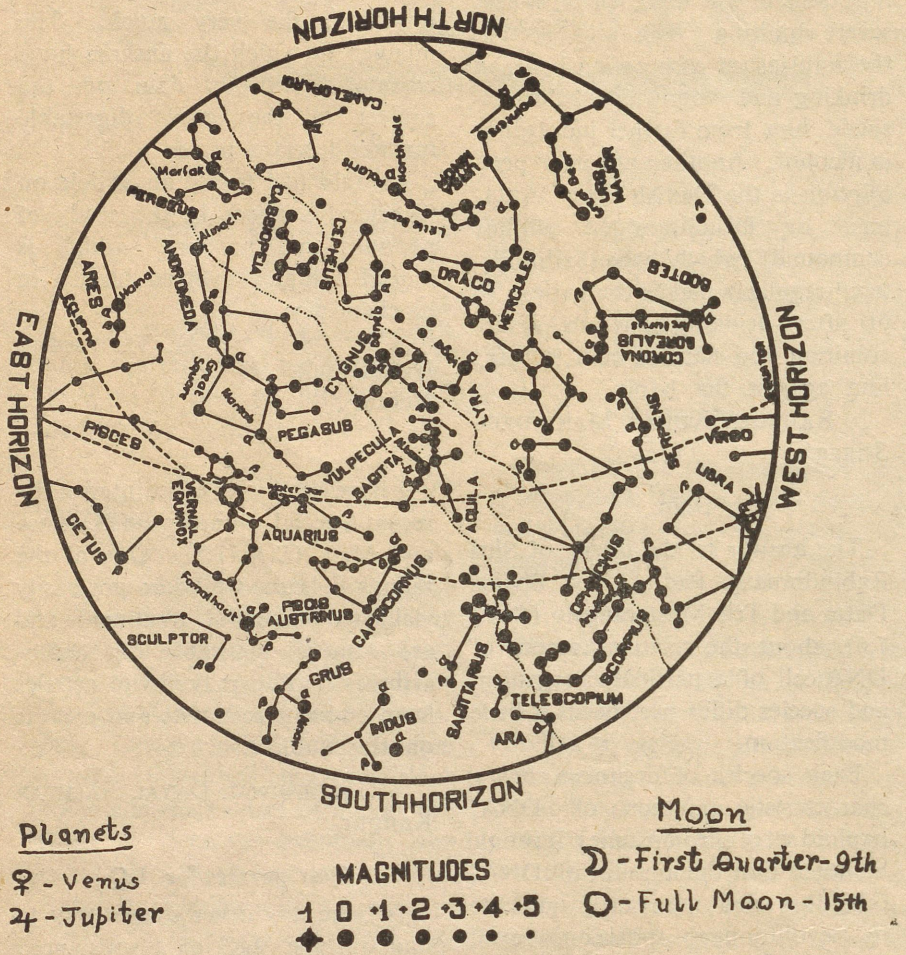
JAGESHWAR DAYAL NASHTAR
Kanpur

Test puzzles for I.Q.

Is there any other simple way to find out the 'age' of a substance? Please arrange to publish (1) Mathematical and logical puzzles, (2) Problems on Chess-game and a new column in which tit bits of scientific terms (as Molar constant, impedence, etc.), events, etc., may appear regularly. Please also publish objective test puzzles so that interested readers may check their I.Q.

PIJUSH BANDYOPADHYAYA
Calcutta

PLANETS AND THEIR POSITIONS—SEPTEMBER 1970



The Moon

NEW moon occurs on the 1st at 3-31 a.m. and again on the 30th at 8-02 p.m. and Full moon on the 15th at 4-40 p.m. I.S.T

The moon passes about two degrees south of Venus on the 5th and thereafter six degrees south of Jupiter in the evening of the same day, eight degrees north of Saturn in the night of the 19th, about three degrees south of both Mars and Mercury in the early hours of the 29th. The lunar crescent becomes first visible after the new moon day in the evening of the 2nd. The moon is at perigee or nearest to the earth on the 14th and at apogee or farthest from it on the 27th.

The sun is at the autumnal equinox on the 23rd.

There will be an annular eclipse of the sun on Aug. 31-Sept. 1, but it is not visible in India.

The planets

Mercury is too near the sun to be visible during the first three quarters of the month, being in inferior conjunction with the sun on the 12th. Thereafter, it reappears as a morning star and rises about an hour before sunrise. It becomes direct on the 22nd and is at the greatest western elongation of 18 degrees from the sun on the 28th. It approaches very close to Mars, being only half a degree east of it, in the early hours of the 26th. It moves form Virgo to Leo by retrograde motion. Its visual magnitude varies from +1.1 to −0.4.

Venus, an evening star, sets about two hours after sunset during the month. It is at the greatest eastern elongation of 46 degrees from the sun on the 1st. It passes five degrees south of Jupiter on the 14th. It is in Libra. Its visual magnitude is about − 4.1.

Mars is too near the sun to be visible during the first half of the month. Thereafter, it reappears in the morning sky and rises about an hour before sunrise. It is in Leo. Its visual magnitude is +2.0.

Jupiter, visible in the evening sky, sets about two and half hours after sunset during the first half of the month and about two hours after it during the second half. It is in Libra. Its visual magnitude is about −1.3.

Saturn rises about three and half hours after sunset during the first half of the month and about three hours after it during the second half. It becomes retrograde on the 4th. It is in Aries. Its visual magnitude is about +0.2.

(The report and the star chart are supplied by the Nautical Almanac Unit of the Meteorological Office, Alipore, Calcutta-27).

X RAYS *from the* SUN

Chintamani Mande

Introduction

The sun has caught attention of the human mind since antiquity. It occupies a proud place in ancient scriptures and mythology, oriental as well as western. Often affectionately called 'our star', it has been one of the most intensely pursued objects by astronomers and physicists. The importance of the sun needs no elaboration because it is too well known that the entire flora and fauna of the earth survive on the energy it generously showers on them. For the astrophysicist to-day, it is an incandescent hot, rotating, almost perfectly spherical mass of matter consisting of a core, a photosphere and a chromosphere surrounded by a corona (Fig. 1.). Each is characterized by different constitution and properties, giving out an enormous amount of radiation, losing about four million tons of its mass every second from times immemorial! Apparently the biggest brightest object in the sky, however it is known to be one of the smallest and least luminous of the stars in the universe around us.

X-ray astronomy has become today one of the most promising areas of research. Apart from the academic interest in the distribution of X-ray sources in outer space, such studies are of great value in space travel programme

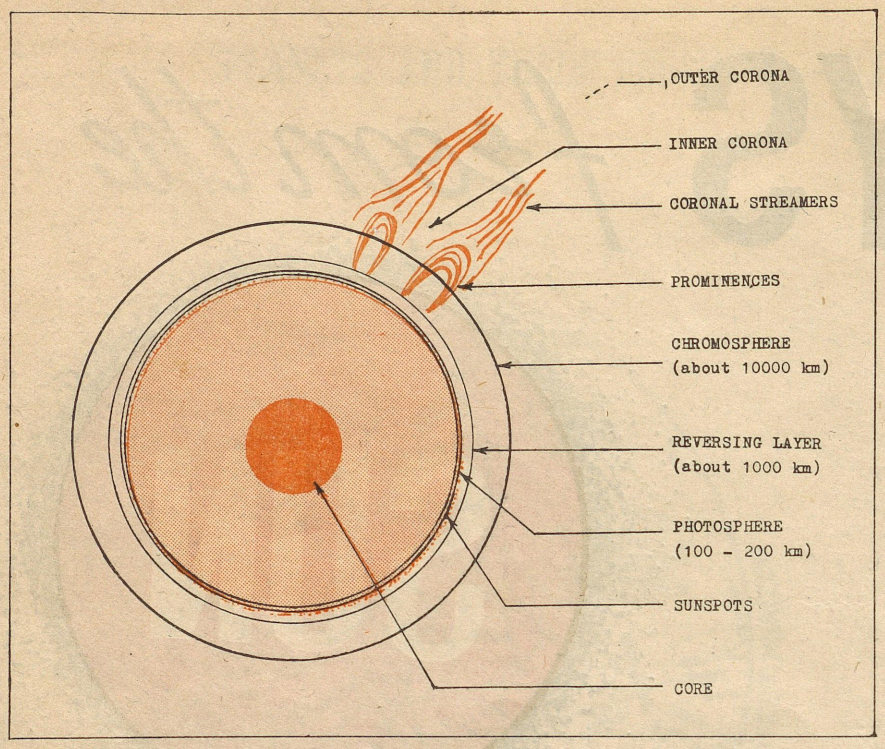


Fig. 1. The sun and its atmosphere (not to scale).

Radiations reaching the earth

The earth's atmosphere absorbs most of the electromagnetic radiation coming from celestial bodies. Thus radiation in only certain frequency regions reaches the earth's surface. Spectroscopic investigation of celestial bodies from the ground is thus severely limited. From the surface of the earth, therefore, observations can be carried out only in narrow regions, the radio and the optical windows producing at best a distorted and prejudiced picture of the universe. Even in these narrow regions, the background radiation resulting from the atmospheric scattering reduces the contrast and consequently the clarity of the images of the celestial bodies. The constant thermal wavering in the atmospheric fluid, the cause of the shimering of the stars also contributes to the blurring of the images. It may be remarked here that it is because of this scattered light in the lower atmosphere and air-glow in the upper atmosphere that we are unable to see the stars during the day.

A new dimension was added to the study of stellar radiations when certain properties of the ionosphere (Fig. 2) were discovered, the interpretation of which led to the discovery of x-rays in outer space. As is well known, between 70 and 330 kilometres above the earth's surface there exists a region of ionized gases which, in turn, consists of D, E and other layers with differing electronic densities. The peak daytime density of electrons in the E layer is of the order of 10^5 electrons per cm^3. To explain this high density, it is necessary to assume the existence of an ionizing agency such as radiation in the range of x-rays. It was in 1938 that Vegard and Hulburt independently suggested that the ionization in the earth's upper atmosphere could be attributed to x-rays from the sun. Spectroscopic investigations showed that the temperature of the solar corona was about 10^6 °K and from this, in 1945 Shklovsky showed that the electron density in the ionosphere can be attributed to the high energy radiation from the solar corona. Under the leadership of Richard Tousey, Burnight of the Naval Research Laboratory (N.R.L.) employed a V-2 rocket (obtained during World War II from the Germans) to haul some Schumann

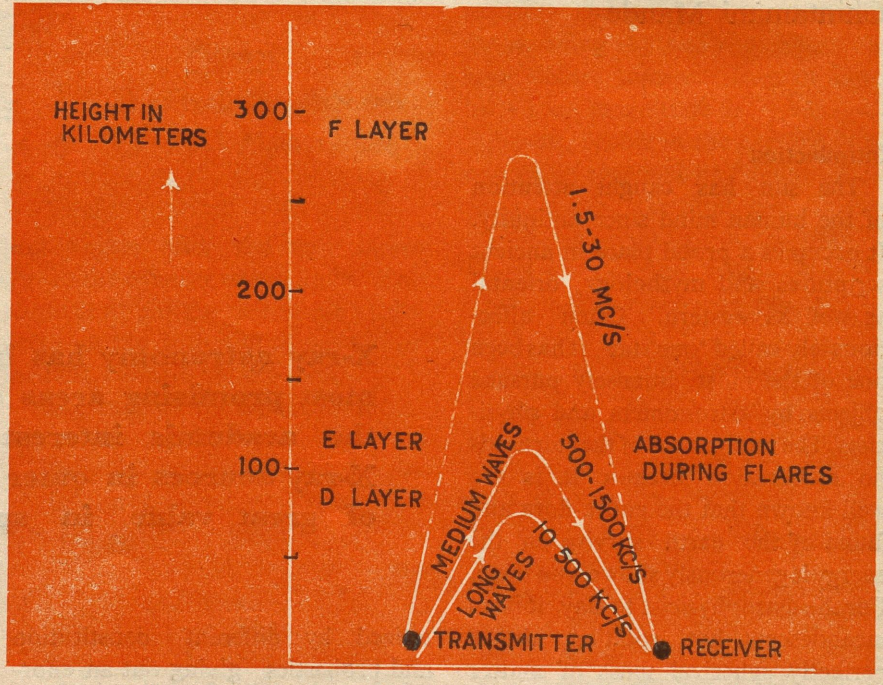


Fig. 2. The earth's atmosphere. During solar flares the short radio waves are absorbed in the D and F layers causing radio fadeouts.

photographic plates above the earth's atmosphere. These plates, specially made for ultra-violet and soft x-rays, were exposed through aluminium and beryllium windows which were opaque to visible radiation. On recovery and development, blackening of the plates was observed. The era of x-ray astronomy was born; since then, physicists all over the globe have been busy investigating solar x-radiation by means of balloon, rocket and satellite-borne equipments. The first x-ray photograph of the sun was obtained by the staff of the N.R.L. with the help of a pin-hole camera launched on an Aerobee Hi-rocket in 1960.

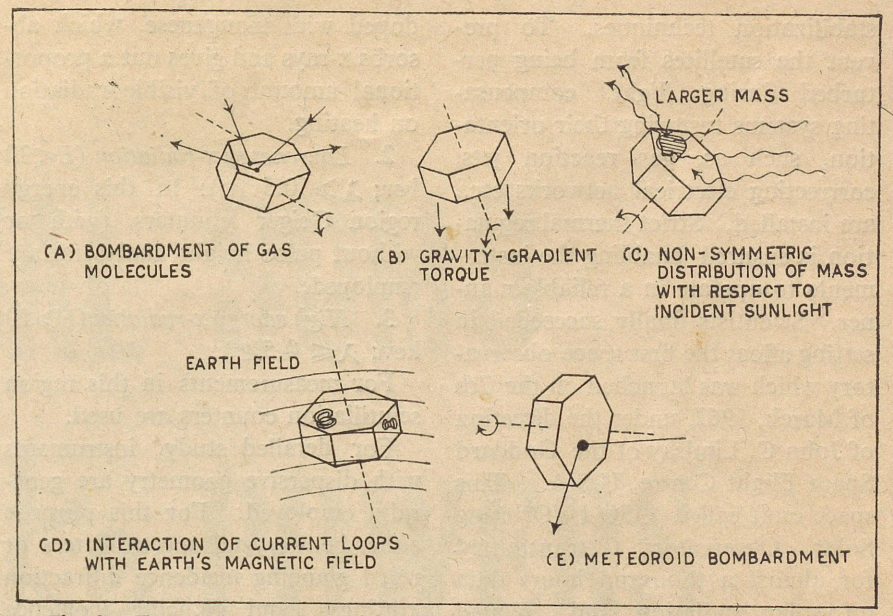


Fig. 3. The various factors tending to produce imbalance in the orbiting

Orbiting observatories

The limitations of earth-bound observatories have now been overcome with the rapid advances in space technology. The entire spectrum of electromagnetic radiation, from the radio-waves on the low energy side to the ultraviolet and x-rays on the high energy side, has now come within our reach because of the floating observatories. However, new technological problems arose posing several difficulties and challenges (Fig. 3). There exists an aerodynamic drag due to the motion of the observing system. The bombardment of gas molecules tends to produce imbalance. There exists a tidal effect, gravity-gradient torque, tending to rotate the system about its centre of mass. The non-symmetric distribution of mass of the orbiting system with respect to the incident solar radiation becomes significant, especially if solar panels are attached. The interaction of the earth's magnetic field with the various current loops in the electrical net work results into a magnetic torque tending to perturb the orbiting system. In addition to all these, meteoroid bombardment, cosmic radiation and extremes of temperature have posed serious problems which have to be solved to stabilize the orbiting systems.

Much experimentation has gone into the perfection of satellite orbit

Table 1. Showing the range of observation of equipment mounted on earth-bound, balloon-borne, rocket-borne and satellite-borne observatories

Observatory	Electromagnetic Radiation
(Effective time of observation)	radiowaves infrared ultraviolet γ-rays microwaves visible x-rays
Satellite-borne (indefinite)	entire electromagnetic spectrum
Rocket-borne (few minutes)	almost entire electromagnetic spectrum
Balloon-borne (few hours)	X-rays, γ rays and a portion of radiowaves are not accessible
Earth-bound (no limit)	radiation in the visible region (optical window) and a portion of radiation in the radio and infra-red region (radio and infra-red windows) reaches the earth
Wavelength in metres	10^2 1 10^{-2} 10^{-4} 10^{-6} 10^{-8} 10^{-10} 10^{-12}

stabilization techniques. To prevent the satellites from being perturbed during flight, compensating systems restoring their orientation, such as, gas reaction jets, corrrecting electrical networks etc., are installed. Strict thermal regulation is ensured enabling the instruments to operate in a reliable manner. Scientists finally succeeded in setting afloat the first space observatory which was launched on the 7th of March, 1962, under the direction of John C. Lindsay of the Goddard Space Flight Centre, U.S.A. This space craft called OSO I (Orbiting Solar Observatory I) transmitted for almost a thousand hours data on solar radiation and related phenomena. Since then, a large number of orbiting observatories have been scanning the sun's surface and other astral bodies over the entire frequency spectrum telemetering to earth-bound stations a rich store of data.

Instrumentation

Instrumentation for detecting and recording x-rays from the sun or any other source varies in principle and constructional features with the wavelength region. In the early stages, photographic plates in ordinary pinhole cameras covered with beryllium windows were used. For the last two decades or so, a wealth of information about the flux levels of x-rays in different energy regions is being obtained with the help of sensitive emulsions and photon counters in conjunction with filters transmitting known wavelength bands.

Instrumentation exployed for non-dispersive study of solar x-radiation can be generally classified into three types.

1. *Broad band observation:* A thermoluminescent photometer is used to observe the x-rays originating from the entire disc. This instrument contains a substance, such as calcium phosphate powder doped with manganese, which absorbs x-rays and gives out a proportional amount of visible radiation on heating.

2. *Low energy x-radiation* ($E \leqslant 20$ *kev*; $\lambda \geqslant 0.5$ *A*°): In this energy region Geiger counters (with or without pulse height analysers) are employed.

3. *High energy x-radiation*($E \geqslant 20$ kev; $\lambda \leqslant 0.5A$°):

For measurements in this region scintillation counters are used.

For detailed study, instruments with dispersive geometry are generally employed. For this purpose either bent crystal spectrometers or ruled glancing incidence diffraction gratings and glancing incidence telescopes are employed. The glancing incidence telescope, in which the property of total reflection from polished surfaces at grazing incidence is exploited, is a much faster instrument compared to the pinhole camera, requiring about 1/500th of the exposure time required for the latter. Reflecting x-ray telescopes, using crossed mirror systems in which chromatic aberrations and other defects are minimized, have been flown in orbits.

Observations and theories

Analysis of the enormous bulk of data collected hitherto has enabled scientists to distinguish between three components of the solar x-radiation;

(i) a quasi-constant component originating from the quiet solar corona.

(ii) a slowly varying component originating from the 'active' regions such as coronal condensations etc., and

(iii) a rapidly varying component, commonly called x-ray burst, associated with the transient disturbances in the solar atmosphere, such as flares etc.

The quiet and the slowly varying components in the x-ray emission from the sun can be attributed to the thermal character of the corona. These soft x-rays ($E \leqslant 20$ kev) originate from the quiet corona, the transition region between the corona and the chromosphere and the dense hot regions. The quiet corona, with an average kinetic temperature of 1.5×10°K can give rise to radiation with wavelength 10 A° whereas the active regions, with temperatures reaching at times, 10°K, can produce radiation of wavelength between 1A° and 20 A°.

It is interesting to mention that a very strong correlation exists between the solar x-rays and the radiowaves. A close correspondence between the x-ray flux in the region 50-400°A and 10.7 cm radiowaves, and between the x-ray flux of wavelength 10-30A° and centimeter waves has been observed.

The observation of high energy x-rays ($E \geqslant 20$ kev) is strongly correlated with the occurrence of solar flares and with the centimeter and meter wavelength radio emission, suggesting that the same electrons are responsible for both the radiations. Since ions able to emit radiation of higher energy ($E \geqslant 20$ kev) are not in sufficient abundance in the solar atmosphere and temperatures seldom exceed 10^7 °K in the corona, the possibility of attributing the high energy x-radiation to thermal *bremsstrahlung* is eliminated. According to one explanation, energetic electrons gain acceleration in the dense flare region, produce centimeter wave bursts by synchrotron radiation, and through collisions with neutral hydrogen atoms give rise to high energy x-rays (non-thermal bremsstrahlung). According to another explanation high energy x-rays are produced due to the acceleration of electrons by the catastrophic collapse of intense magnetic fields in the solar atmosphere.

The quiet and slowly varying components of the solar x-radiation cause heating, ionization and

(*Continued on page 451*)

EQUAL SUMS of like POWERS

Prasanta Choudhury

Diophantus—an Alexandrian mathematician of the 3rd century A.D.—was the first to determine possible cases in which a number or the power of a number could be broken up into equal sums of like powers. Further attemps in this direction are dealt with in this article

THERE is a well known story about Ramanujan related by the British mathematician C.H. Hardy which goes to illustrate the former's exceptional faculties for recollecting the peculiar properties of numbers. Hardy recounts—'I remember once going to him when he was lying ill at Putney, I had ridden in a taxi-cab No. 1729, and remarked that the number seemed to me rather a dull one. "No", he replied, "it is a very interesting number, it is the smallest number expressible as a sum of cubes in two different ways". I asked him naturally whether he knew the answer to the corresponding problem for fourth powers; and he replied after a moment's thought he could see no obvious example and thought that the first such number must be very large. It may be recalled in this connection that the 17th century French Mathematician Fermat (*S.R.* 5,4) posed the problem of two equal sums of two cubes to his British and Continental contemporaries Brouncker, Frenicle and Wallis. Frenicle gave the solutions; $9^3+10^3 = 1^3+12^3$, $9^3+15^3 = 2^3+16^3$,


Jana-gana-mana-adhinayaka Jaya he
Bharata-bhagya-vidhata !
Panjaba-Sindhu-Gujarata-Maratha
Dravida-Utkala-Banga
Vindhya-Himachala-Yamuna-Ganga-
Uchchala-jaladhi-taranga
Tava subha name jage,
Tava subha asisa mage,
Gahe tava jaya-gatha.
Jana-gana-mangala-dayaka, jaya he
Bharata-bhagya-vidhata
Jaya he, jaya he, jaya he,
Jaya jaya jaya, jaya he.
JOIN
THE CHORUS
and respect the flag,
-symbol of the motherland
davp 70/203

$15^3+33^3=2^3+34^3$, $16^3+33^3=9^3+34^3$, $19^3+24^3=10^3+27^3$, and Wallis gave 22 additional solutions.

It is easy to see that $9^3+10^3=1^3+12^3=1729$, which was characterised by Ramanujan as the smallest number which can be expressed as a sum of two cubes in two different ways. Hardy also noted that Euler gave the corresponding solution for fourth powers namely, $158^4+59^4=133^4+134^4$, quite a large number as Ramanujan envisaged offhand.

Definition

The class of problems such as the above in which one determines the possible cases in which a number or the power of a number can be broken up into two (or more) equal sums of like powers, or more generally indeterminate problems involving solution in rational numbers are known as Diophantine Problems after the Alexandrian Mathematician Diophantus (3rd century A.D.) who in his work *Arithmetics* deals with the topics in algebraic equations and more particularly with the solutions of certain problems in which it is required to find rational numbers satisfying prescribed conditions. Diophantus in essence opened up a major line of mathematical investigation which now forms a distinctive branch of Number Theory. It may be remarked here that in modern terminology the concept of Diophantine problem is usually narrowed down to refer to solutions in terms of integers, which in general, are more difficult than rational solutions as envisaged by Diophantus. It is worthwhile to point out that latter day Hindu Mathematicians such as Brahmagupta (7th Century A.D.) and Bhaskara (12th Century A.D.) were particularly at home with Diophantine problems and tackled the more difficult case of integral solution with facility. In this connection J.F. Scott notes in his *History of Mathematics*—'The six centuries period following Aryyabhatta, i.e., from A.D. 600-1200 was a mixture of the brilliant and barren. Its most enduring contribution was still to the study of indeterminate equations; this has always made a strong appeal to the Hindu mind....their works mark a distinct advance upon anything we find in Diophantus.' In passing we may note that Partition Theory (See *Ramanujan's contribution to Partition Theory*, *S.R.* 6,7) belongs also to the class of Diophantine problems.

Fermat got interested in Diophantine problems through a copy of Bachet's (another French Mathematician and Scholar who translated Diophantus's *Arithmetics* in 1621) translation of *Arithmetics*. He used the margin of his well-worn copy of Diophantus to jot down several of his most important results. His famous *Last Theorem* was noted down in the same copy in the following words :

"However, it is impossible to write a cube as the sum of two cubes, a fourth power as the sum of two fourth powers and in general any power beyond the second as the sum of two similar powers. For this I have discovered a truly wonderful proof, but the margin is too small to contain it."

In the present article we consider the class of Diophantine problems typified by the general equation,

$$(1)\quad x_1^k+x_2^k+\ldots+x_m^k=y_1^k+y_2^k+\ldots+y_n^k$$

With values of k not exceeding 5, and for a limited value of m and n, in particular for the cases $k=4$ and $k=5$ which are particularly interesting in a sense. Naturally our interest lies with primitive solutions, that is, with the sets of numbers for which there is common factor other than unity. For, it is clear that if the set of numbers in a solution are all multiplied by a constant the resulting numbers will also be a solution.

When we take $k=2$, we have (i) $x^2_1=y^2_1+y^2_2$ (ii) $x^2_1+x^2_2=y^2_1+y^2_2$. The equation (i) is the case of Pythagorean triangles for which a large number of solutions exist and the literature is quite large on this topic. Because it forms a much studied subject all by itself, we will pass it over and point out interesting cases in which one leg of the triangle differs by unity from another. They are (5,4,3), (13,12,5), (25,24,7), three of an infinitely many solutions obtained from the general solution $a=2n+1$, $b=2n^2+2n$, $c=2n^2+2n+1$, obtained by putting $n=1,2,3$ successively. For (ii) $x^2_1+x^2_2=y^2_1+y^2_2$ there is a well known general solution; we will not discuss it here.

The impossibility of solving $x^k_1=y^k_1+y^k_2$ for values of k equal to or greater than 3 is Fermat's *Last Theorem* which has been demonstrated to be true for values of k equal to or less than 25,000. We have already referred to some interesting cases for $k=3$, i.e., of $x^3_1+x^3_2=y^3_1+y^3_2$. For $x^3_1=y^3_1+y^3_2+y^3_3$ we have a most interesting case $6^3=5^3+4^3+3^3$

The problem for $k=4$ and $m=n=2$, i.e., the equation $x^4_1+x^4_2=y^4_1+y^4_2$ was studied by the Swiss Mathematician Euler in 1772. He gave the following solutions apart from the case $158^4+59^4=133^4+134^4$ noted already:

$2379^4+27^4=729^4+577^4$

$122231^4+2903^4=103814^4+102034^4$

$2219449^4+555617^4=1584749^4+2061283^4$

Desboves (1879) gave the solutions:

$1203^4+76^4=1176^4+653^4$

Werebrusow (1913) gave the solution

$239^4+7^4=227^4+157^4$, and a little latter

$292^4+193^4=256^4+257^4$

Euler stated that the sum of three fourth powers can never be a fourth power, i.e., the case $m=1$, $n=3$ on equation (1) and Aubrey (1912) proved that the fourth power of

integers equal to or less than 1040 is not a sum of three fourth powers.

For the sum of four or more fourth powers equalling a fourth power, i.e., case m = 1 and n equal to or greater than 4 we have the following result due to A. Martin (1873).

$15^4 = 14^4 + 9^4 + 8^4 + 6^4 + 4^4$

Hart (1896) gave the new solution following A. Martin

$65^4 = 64^4 + 32^4 + 12^4 + 8^4 + 1^4$

Norrie (1911) found

$353^4 = 315^4 + 272^4 + 120^4 + 30^4$

Martin (1896) tabulated various sets of results with small integers for cases m = 3, n = 3 and m = 4, n = 2 i.e., 1, 2, 9 and 3, 7, 8; 1, 9, 10 and 5, 6, 11; 1, 11, 12 and 4, 9, 13; 1, 5, 8, 10 and 3, 11.

Miot (1911) noted (case m = 2, n = 3) 37, 17 and 35, 26, 3. Birck (1912) noted (for the same case m = 2, n = 3) 7, 28 and 3, 20, 26 as also 51, 76 and 5, 42, 78, while Werebrusow (1913) gave the solution 37, 38 and 26, 42, 25 and eight more such sets.

All the aforesaid solutions were obtained in a period when mathematicians had none of the mechanical contrivances, not even desk calculators, a very common thing now-a-days in research laboratories or commercial firms. It is worthwhile noting that with the advent of high speed electronic computing devices researches in number theory have taken quite a new dimension.

In a paper by L.J. Lander, T.R. Parkin and J.L. Selfridge in the Journal '*Mathematics of Computation*' of July, 1967 the problem as stated in equation (i) has been studied in a systematic fashion and a series of searches for solutions by the electronic computer CDC 6600 was made. Some of their interesting findings and observations which summarise the previous results as also their own are described.

Euler's conjecture, which we referred to previously that the sum of three fourth powers can never equal another fourth power and which Aubrey proved for integers equal to or less than 1040, was shown by Ward (1948) to be valid for x, equal to or less than 10,000. Lander, Parkin and Selfridge extended the demonstration of the validity of this conjecture still further for range of values of x less than or equal to 220,000.

For fourth powers their findings may be summarised as follows:

For the case of the equation $x_1^4 = y_1^4 + y_2^4 + y_3^4$, non-availability of solution conjectured by Euler was extended by computer search for values of x_1^4 equal to or less than 2.34×10^{21}. For $x_1^4 = y_1^4 + y_2^4 + y_3^4 + y_4^4$, 23 solutions have been listed by them. The smallest solution due to Norrie has been noted already. For $x_1^4 = y_1^4 + y_2^4 + y_3^4 + y_4^4 + y_5^4$, there are many solutions, a particularly simple example is $5^4 = 2^4 + 2^4 + 3^4 + 4^4 + 4^4$.

For $x_1^4 + x_2^4 = y_1^4 + y_2^4$, they mention 46 solutions including the least solution $59^4 + 158^4 = 133^4 + 134^4$ due to Euler which we cited in the beginning. For $x_1^4 + x_2^4 = y_1^4 + y_2^4 + y_3^4$, there are many solutions. A particularly simple example is $7^4 + 7^4 = 3^4 + 5^4 + 8^4$. In the case of $x_1^4 + x_2^4 + x_3^4 = y_1^4 + y_2^4 + y_3^4$, there are many solutions, a particularly simple example is $2^4 + 4^4 + 7^4 = 3^4 + 6^4 + 6^4$

We now note some of the multiple coincidences of fourth powers before we proceed to consider the case of fifth powers,.

The least triple coincidence is $811538 = 29^4 + 17^4 + 12^4 = 28^4 + 21^4 + 7^4 = 27^4 + 4^4$ another triple coincidence is

$635{,}318{,}658 = 159^4 + 58^4 + 1^4 = 134^4 + 133^4 + 1^4 = 154^4 + 83^4 + 71^4$ which was discovered by Lander and Parkin (1966) by chance from the equation $159^4 + 58^4 = 134^4 + 133^4$ which we have already noted as being due to Euler.

The number 8,657, 437,698 was found by them to be expressible as sum of three biquadrates in five distinct ways namely:

$(296,157,139)^4 = (293,184,109)^4 = (292,193,1)^4 = (271, 239, 32)^4 = (257, 256, 1)^4$ where $(296, 157, 139)^4$ means $296^4 + 157^4 + 139^4$ and so on for the others.

For fifth powers a few of their interesting findings are reproduced below:

For the equation $x_1^5 = y_1^5 + y_2^5 + y_3^5$ no solutions are known.

The equation $x_1^5 = y_1^5 + y_2^5 + y_3^5 + y_4^5$ was conjectured by Euler to be insoluble in terms of integers. In fact, Euler stated:

"It has seemed to many Geometers that this theorem ($x^n + y^n \neq z^n$, n greater than 2) may be generalised. Just as there do not exist two cubes whose sum or difference is a cube, it is certain that it is impossible to exhibit three biquadrates whose sum is a biquadrate, but that at least four biquadrates are needed if their sum is to be a biquadrate..... In the same manner it would seem to be impossible to exhibit four fifth powers whose, sum, is a fifth power, and similarly for higher powers."

It may be pointed out here that if the general assertion contained in the last line of the aforesaid statement were correct then Fermat's *Last Theorem* ($x^n + y^n \neq z^n$, n greater than 2) would follow as a special case. However, Lander and Parkin (1967) found a counter-example thus disproving Euler's conjecture in so far as it relates to fifth powers. They found:

$144^5 = 27^5 + 84^5 + 110^5 + 133^5$

which disproves Euler's assertion that, 'it would seem to be impossible to exhibit four fifth powers whose sum is a fifth power' contained in the last sentence of the previous quotation.

For the equation $x_1^5 = y_1^5 + y_2^5 + y_3^5 + y_4^5 + y_5^5$, S. Sastry and S. Chowla obtained in 1934, $107^5 = 7^5 + 43^5 + 57^5 + 80^5 + 100^5$. Lander and

Parkin (1967) with the help of the electronic computer found, however, two smaller solutions. $72^5 = 19^5 + 43^5 + 46^5 + 47^5 + 67^5$ and $94^5 = 21^5 + 23^5 + 37^5 + 79^5 + 84^5$. For the equation, $x_1^5 = y_1^5 + y_2^5 + y_3^5 + y_4^5 + y_5^5 + y_6^5$ we have the smallest solution, $12^5 = 11^5 + 9^5 + 7^5 + 6^5 + 5^5 + 4^5$, due to A. Martin (1887).

For the equations $x_1^5 + x_2^5 = y_1^5 + y_2^5$ and $x_1^5 + x_2^5 = y_1^5 + y_2^5 + y_3^5$ no solutions are known. Lander and Parkin carried computer searches up to the range $(x_1^5 + x_2^5)$ equal to or less than 2.8×10^{14} for the former and 8×10^{12} for the latter equation without getting a solution. For $x_1^5 + x_2^5 = y_1^5 + y_2^5 + y_3^5 + y_4^5$ several solutions are known, the smallest is $3^5 + 29^5 = 4^5 + 10^5 + 20^5 + 28^5$ due to K. Subba Rao (1934). The equation $x_1^5 + x_2^5 = y_1^5 + y_2^5 + y_3^5 + y_4^5 + y_5^5$ has several solutions. A particularly simple one is $1^5 + 22^5 = 4^5 + 5^5 + 7^5 + 16^5 + 21^5$, due to Subba Rao (1934).

For the equation $x_1^5 + x_2^5 + x_3^5 = y_1^5 + y_2^5 + y_3^5$ there are many solutions, the smallest is $24^5 + 28^5 + 67^5 = 3^5 + 54^5 + 62^5$. For the equation $x_1^5 + x_2^5 + x_3^5 = y_1^5 + y_2^5 + y_3^5 + y_4^5$, there are several solutions. A simple example is $3^5 + 22^5 + 25^5 = 1^5 + 8^5 + 14^5 + 27^5$ due to Subba Rao (1934).

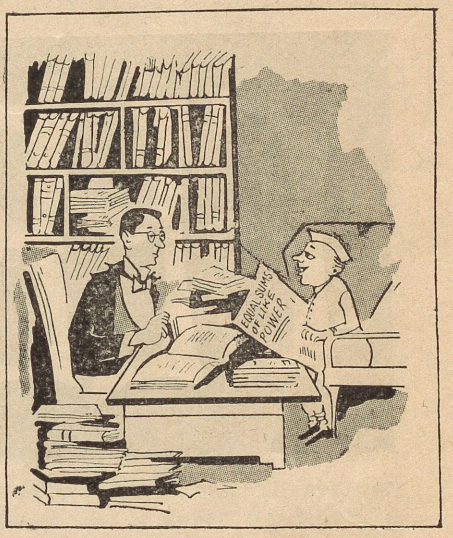
In the case of the equation $x_1^5 + x_2^5 + x_3^5 + x_4^5 = y_1^5 + y_2^5 + y_3^5 + y_4^5$, there are several solutions. A simple example is $5^5 + 6^5 + 6^5 + 8^5 = 4^5 + 7^5 + 7^5 + 7^5$, due to Subba Rao (1934).

We now conclude our account by noting the first triple coincidence of fifth powers. It is:

$$1479604544 = (3,48,52,61)^5 = (13,36,51,64)^5 = (18,36,44,66)^5$$

Further reading

1. L.E. Dickson, *History of the Theory of Numbers*, vol. II (Diophantine Analysis), 1952.
2. L.J. Lander and T.R. Parkin, *Equal Sums of Biquadrates* (Mathematics of Computation July, 1966).
3. L.J. Lander, T.R. Parkin, and J.L. Selfridge, *A Survey of Equal Sums of Like Powers* (Mathematics of Computation, July 1967).



"It's not so with us politicians. We spend equal sums but do not derive equal powers."

X-RAYS FROM THE SUN (*Continued from page 446*)

dissociation of the earth's upper atmosphere. During flares and and other spectacular eruptive disturbances on the sun's surface, there is a sudden increase of the solar x-ray flux and consequently an increase in the electron density in the ionospheric layers. The latter is responsible for severe disruption or attenuation of radio waves, commonly called 'fade-outs', in telecommunication. Existence of x-ray flux in the auroral zone is also a consequence of solar x-rays. Yet another interesting observation is that of x-ray fluorescence from the moon's surface under excitation of solar x-rays.

Conclusion

X-ray astronomy as a discipline involving the study of x-radiation from the sun and other celestial bodies has become today one of the most promising areas of research. Apart from the academic interest in the distribution and constitutions of the x-ray sources in outer space, such studies are of great importance in space travel programme.

Further reading

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The MAN made ELEMENTS

Biman Basu

Out of the 105 elements known today only 88 could be obtained naturally, the rest were created by alchemy of the modern laboratories using powerful particle accelerators

THE urge to take our material world apart and identify its ultimate units of construction is, at least as old as the early Greek philosophers. Aristotle believed that all matter on the earth were composed of only four ingredients—fire, water, earth and air—which he called the 'elements'. But, now we know that an element is more fundamental than that, and at the present moment the list of identified elements stand at 105. Out of these, only 88 could be isolated from natural sources, and the rest were created by alchemy of the modern laboratories.

Atomic structure

The chemical properties of an element are solely dependent on its atomic structure. The 1803 model of the Daltonian atom was an indivisible, impenetrable and indestructibly solid sphere. It served chemistry well for almost a hundred years, till a series of discoveries during the late nineteenth and early twentieth century exposed the hidden spring and complicated machinery of the not-so-simple atomic world. First, in 1897, an Englishman J.J. Thomson discovered the electron. Fourteen years later, one of Thomson's pupils—Ernest Rutherford demonstrated that the atom also contained another component, the proton. Then in 1932, James Chadwick picked out

still one more basic particle of the atom which was named the neutron. Innumerable and ingenious experiments coupled with clear and bold reasoning finally produced a blueprint of the new atomic architecture. Electrons, protons and neutrons were arranged in different patterns in each of the different elements. The dense nucleus inside the atom gave the element its mass or weight as well as its other physical characteristics. Outside the nucleus, at a relatively great distance from the centre and moving in concentric orbits, were all the electrons of the atom. The arrangement of these electrons in concentric shells around the nucleus determined all the chemical properties of the elements.

In order to have electrical neutrality, each atom has the same number of electrons as that of protons in the nucleus. The number of protons or electrons in an atom decides the position of the element in the periodic table. This number is called the atomic number. Apart from protons, the nucleus also contains the neutrons. The total number of protons and neutrons in the nucleus is known as the atomic weight. Two atoms having the same atomic number may have different atomic weights due to different number of neutrons in their nuclei. Such atoms are known as 'isotopes'. They behave identically in their chemical reactions but differ in physical properties.

The periodic table

When the Russian chemist Dmitri Ivanovitch Mendeleyev arranged the elements in his Periodic Table, he did so according to their atomic weights and concluded that the properties of the elements were the periodic function of their atomic weights. He was wrong however, because it is not the atomic weight but the atomic number which characterises a particular element. After the X-ray studies by H.G.J. Moseley of England, the periodic table was modified and the elements were rearranged according to their atomic numbers. But it was found that many members were missing from the family of 92 elements which were known at that time. A frantic search was made for the missing elements and by 1925 only four elements with atomic numbers 43, 61, 85 and 87 remained to be discovered.

Radioactivity discovered

We have known for a long time that during a chemical reaction only the outermost electrons take part and that the nucleus remains untouched even during the most violent chemical change such as the big chemical explosions. However, the nucleus also breaks down in a few instances and one element, changes into another. This change, called the 'transmutation' occurs spontaneously in nature. The first evidence of this fact turned up when Mme Curie and Pierre Curie discovered the element radium in December 1898. Scientists for the first time were presented with a most unusual spectacle, a perfectly pure and simple element throwing off rays and particles and finally disintegrating into a lighter element, lead. Two years before the discovery of radium, in 1896 Henri Becquerel had already discovered the phenomenon of radioactivity. Later it was found that the radiations coming from radium or other radioactive atoms consisted mainly of three kinds of rays : the alpha (α) rays consisting of positively charged helium nuclei, the beta (β) rays, which were nothing but high speed electrons, and the most penetrating electromagnetic radiations—the gamma (γ) rays.

Rutherford and Soddy gave the first correct explanation of the above phenomenon in 1902. They declared that the electrons and

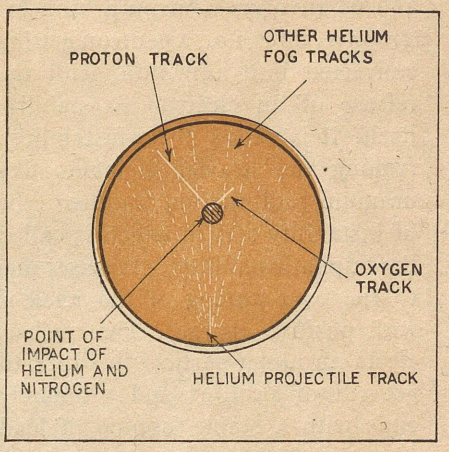


Fig. 1. Fog tracks in the discovery plate of Rutherford's historic artificial transmutation of nitrogen into oxygen in 1919

helium nuclei thrown off by radium came from the breaking up of a very unstable nucleus inside the radium atom. When an atom ejected an alpha-particle consisting of two protons and two neutrons, its atomic number decreased by two units while if a beta-particle was emitted its atomic number increased by one unit. This process of spontaneous disintegration cannot be controlled or accelerated.

Each radioactive isotope has a characteristic disintegration rate which is constant. The time it takes for half the number of atoms in a radioactive isotope to breakdown, is known as the 'half-life' of that isotope. The half-life varies from a few hundredths of a second to many millions of years. The elements with atomic numbers 43, 61, 85 and 87 are all radioactive and one of the longest lived isotopes among them has a half-life of only 100,000 years. Which means, that even if these elements were initially present in the earth's crust, during the billions of years that have passed since the earth was born, they have been transmuted into isotopes of the more stable elements.

Stability of the nucleus

The form of instability responsible for the absence of elements 43

and 61 involves neutron-proton interconversions, i.e., a neutron getting converted into a proton, with the release of an electron to stabilize itself. It is called 'beta-instability'. Among the heavier elements like uranium and radium another type of instability sets in which is called the 'alpha-instability'. It arises due to the over-stuffing of the nucleus with positive charge. The nucleus ejects an alpha-particle in order to get rid of protons and ultimately ends with a stable isotope of lead (At No. 82).

Artificial transmutation

When the process of radium disintegration was demonstrated to be nothing more than a change in the composition of an unstable nucleus, scientists began to wonder whether this process could be imitated by man in the case of elements with stable nuclei. Artificial transmutation, evidently could be brought about by so disturbing the nucleus as to force it to eject parts of itself or receive one or more additional protons. But then, how to get inside the nucleus? Firstly, its size is so small that an even tinier projectile would have to be used. Secondly, it has to be accelerated to a stupendous velocity to overcome the electrical defenses protecting the positively charged nucleus. Rutherford came up with a possible solution. It was known at that time that the alpha-particle emitted by radium had velocities greater than 10,000 miles per second. Could not these high velocity particles be used as projectiles? With the help of C.T.R. Wilson, one of his colleagues at the Cavendish Laboratories, who developed the cloud chamber for photographing the nuclear events, he went on with his effort to artificially transmute the atom.

Using a tiny speck of radium as a source of high speed alpha-particles, he hurled them at the atom of nitrogen gas contained in a flask. He did thousands of experiments and finally one day in 1919, he got the evidence he was waiting for. It was a broken line known as a fog track on the photographic plate, attached to the Wilson's cloud chamber, which told the story (Fig. 1). An alpha-particle had found its tiny target, ploughed its way into the nucleus of a nitrogen atom, ejected a proton and thereby changed nitrogen into a different element, oxygen. This nuclear change may be represented as follows:

$$_7N^{14} + _2He^4 \rightarrow {}_8O^{17} + {}_1p^1$$

Despite this historic achievement —the first artificial transmutation produced by man—the world of science was still not completely satisfied, after all Rutherford had used a natural source of radiation for his transmutation. They wanted nothing less than a man made projectile. To accomplish this, scientists would have to invent a machine that could accelerate an electron, a proton or an alpha-particle to velocities of the order of 10,000 miles per sec. and more. It was almost an impossible task.

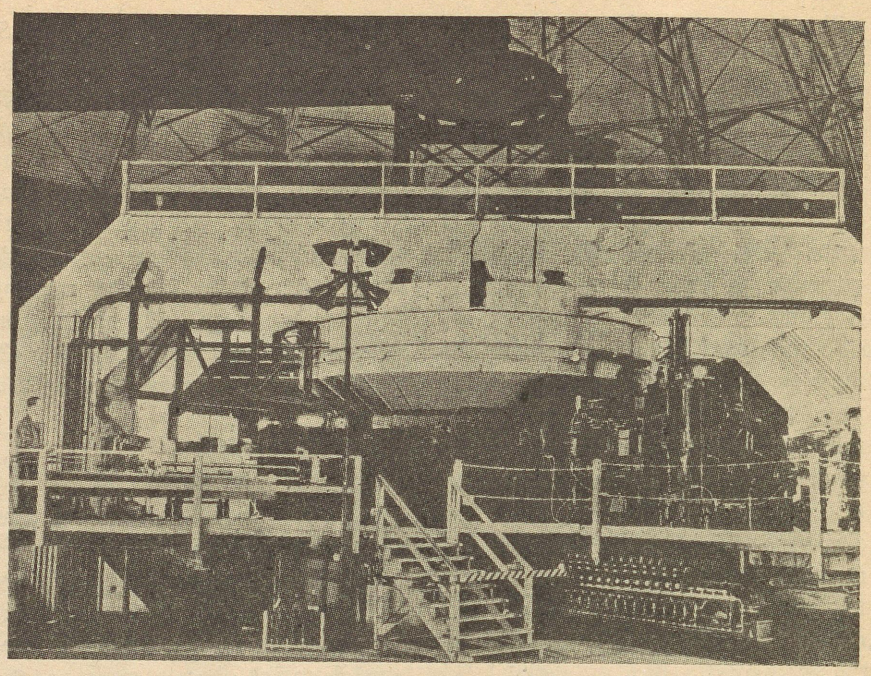


Fig. 2. The 184-inch cyclotron at the Radiation Laboratory, Berkeley, California

The first cyclotron

Nevertheless, a young scientist named Ernest Orlando Lawrence, working at the university of Berkeley, came up with a glass and sealing wax model of his 'accelerator' of tiny particles—the first cyclotron. Soon, another 11-inch model was built which could speed up hydrogen particle as they rushed around the circular track, by giving them ingeneously devised electrical 'kicks'. When the hydrogen ions were finally hurtled out of his cyclotron, as from a huge sling shot, they were moving at a velocity which gave them tremendous penetrating power. Meanwhile, in the Cavendish Laboratory in England, two of Rutherford's young lieutenants — J. D. Cockcroft and E.T.S. Walton, were also busy on the same problem. But they had used a somewhat different method. Instead of speeding up the hydrogen ions with small 'kicks', they accelerated them to high velocities by applying tremendously high voltages, of the order of 1,000,000 volts—across two electrodes (Fig. 3). The first artificial transmutation of an element using man-made projec-

tiles was done in 1932 by Cockcroft and Walton in the Cavendish Laboratory. A few weeks later, Lawrence with his baby cyclotron also succeeded in transmuting lithium atoms into helium particles:

$$_3Li^7 + _1H^1 \rightarrow 2\ _2He^4$$

Although scientists were at least able to transmute the atom, the quantity of the new element produced was vanishingly small. Hence special ultramicro-chemical methods were developed which permitted almost any type of chemical and physical measurements to be made on only a few microgram (10^{-6}g) of an element. The periodic table also was a boon to chemists because, from the expected position of a new element in the table, its physical and chemical properties could be quite accurately predicted. The separation of the minute traces of the elements produced was done by ion-exchange resin adsorption and elution techniques.

The first synthetic element

The first synthetic element to be created was technetium (Te), element 43, which filled the gap in the periodic table between molybdenum and ruthenium. In 1937 a sample of molybdenum that had been irradiated with deutrons in the University of California's 37-inch cyclotron, was sent to C. Perrier and E. Segre of Italy. They isolated the first isotope of the element-43 which had a half-life of 88 days.

$$_{42}Mo^{96} + _1H^2 \rightarrow _{43}Tc^{97} + _0n^1$$

Ten years later Segre suggested that it be named technetium derived from the Greek 'technikos', signifying the element's artificial or technical origin. A more stable isotope Te^{99} was produced by G.T. Seaborg and E. Segre in 1939, by the interaction of Mo^{98} with slow neutrons. It has a half-life of 5×10^5 years.

$$_{42}Mo^{98} + _0n^1 \rightarrow _{42}Mo^{99}$$

$$_{42}Mo^{99} \rightarrow _{43}Tc^{99} + e$$

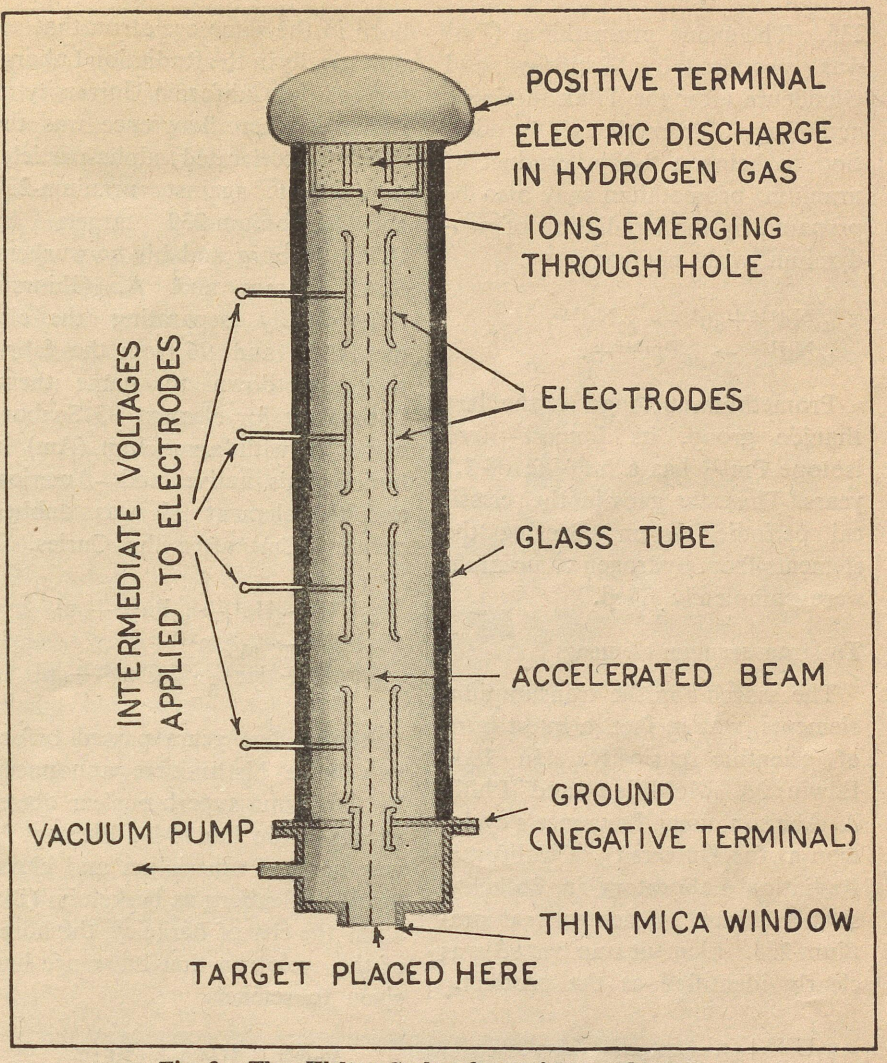


Fig. 3. The Walton-Cockcroft particle accelerator.

The next element to be discovered was francium (Fr), element 87. In 1914 Stefan Meyer, V.F. Hess and F.A. Paneth of Austria noted that an isotope of actinium Ac^{227}, which was known to be a beta-emitter, also decayed occasionally by alpha-emission. Since actinium is the element-89, its alpha decay product must be an isotope of element-87. It was not until 1939, however, that Mlle. M. Perey of France succeeded in isolating an isotope of this element, which she named in honour of her native land. It had a half-life of only 21 minutes.

$$_{89}Ac^{227} \rightarrow _{87}Fr^{223} + _2He^4$$

The synthesis of element 85 was done in 1940 in the University of California. This time D.R. Corson, K.R. Mackenzie and Segre irradiated bismuth with accelerated alpha-particles. They named it astatine (At) from the Greek word 'astatos' meaning unstable. The ine ending means that the element belongs to the halogen family. The longest lived isotope of this element At^{210} had a half-life of only 8.3 hours.

$$_{83}Bi^{209} + _2He^4 \rightarrow _{85}At^{211} + 2_0n^1$$

The first positive identification of the element 61 came in 1945 from the experiments of J.A. Marinsky, L.E. Glendenin and C.D. Coryell at the Oak Ridge National Laboratory in the U.S.A. This element appears in the fission products of uranium-

235. The name promethium (Pm) was proposed by Marinsky and Glendenin after the Titan in Greek mythology, Prometheus. In addition to being a fission product of uranium, promethium may also be prepared by the irradiation of neodymium with neutrons.

$$_{60}Nd^{144} + {}_{0}n^{1} \rightarrow {}_{60}Nd^{145}$$
$$_{60}Nd^{145} \rightarrow {}_{61}Pm^{145} + e$$

Promethium belongs to the lanthanide group, its longest lived isotope Pm^{147} has a half-life of 3.7 years. Thus, the gaps in the classical periodic system covering the elements from hydrogen to uranium were completely filled.

The transuranium elements

The search for the transuranium elements, was in fact, a quest born of scientific curiosity. In 1940 Edwin M. McMillan and Philip A. Abelson, using Lawrence's cyclotron at the University of California Radiation Laboratory in Berkeley, shot a stream of neutrons at uranium-238. Element number 93 was clearly identified as the product.

$$_{92}U^{238} + {}_{0}n^{1} \rightarrow {}_{92}U^{239}$$
$$_{92}U^{239} \rightarrow {}_{93}Np^{239} + e$$

McMillan christened it neptunium (Np) after the planet Neptune, which is just outside Uranus. The atom of neptunium is also a very jittery item, for half of it, unhappy with its lot, changes spontaneously into another element within less than $2\frac{1}{2}$ days. The new element 94 was manufactured and identified for the first time, late in 1940 by Glenn T. Seaborg and his associates. Following the system used in naming neptunium, element 94 was called plutonium (Pu), after the outermost planet of our solar system—Pluto.

$$_{93}Np^{239} \rightarrow {}_{94}Pu^{239} + e$$

In 1944, two new elements were born in the same cyclotron that sat majestically in the Radiation Laboratory of the California University at Berkeley where Lawrence was the chief. Accelerated alpha-particles were shot against uranium-238 and plutonium-239 targets by G.T. Seaborg and his co-workers, R.A. James and A. Ghiorso. After finally separating the elements 95 and 96 from the debris they sat down to name them. Ultimately for element 95 Seaborg came up with americium (Am) in honor of his native land—America, and the element 96 was dubbed curium (Cm) after the Curies.

$$_{92}U^{238} + {}_{2}He^{4} \rightarrow {}_{94}Pu^{241} + {}_{0}n^{1}$$
$$_{94}Pu^{241} \rightarrow {}_{95}Am^{241} + e$$
$$_{94}Pu^{239} + {}_{2}He^{4} \rightarrow {}_{96}Cm^{242} + {}_{0}n^{1}$$

Almost five years passed before two more births were announced by that same superb nuclear obstetrician in the late 1949. Element 97 was born of americium and christened by Seaborg as berkeluim (Bk) after the city of Berkeley, the home of the cyclotron that Lawrence had given to science.

$$_{95}Am^{241} + {}_{2}He^{4} \rightarrow {}_{97}Bk^{245}$$

The element 98 which was discovered in 1950, was named californium (Cf) by Seaborg and his co-workers in honor of the university and state where these deliveries were made. The new element was produced by bombarding microgram amounts of curium-242 with alpha-particles from the Berkeley cyclotron.

$$_{96}Cm^{242} + {}_{2}He^{4} \rightarrow {}_{98}Cf^{246}$$

Another two crowded years went by and in 1952 came the announcements of still two more new transuranium elements. Element 99 was prepared by A. Ghiorso, one of Seaborg's associates, by bombarding uranium-238 with accelerated nitrogen nuclei, and was named einsteinium (Es) after the great physicist Albert Einstein, who had just died. The isotope produced Es-247 had a half-life of only 7.3 minutes.

$$_{92}U^{238} + {}_{7}N^{14} \longrightarrow {}_{99}Es^{247} + 5\ {}_{0}n^{1}$$

A more stable isotope Es^{253}, with a half-life of 20 min. was later produced by means of neutron irradiation of plutonium-239.

The 100th element of the periodic table, together with the 99th was first accidentally discovered in the debris of a hydrogen bomb explosion set off in November 1952, in the Pacific. Samples of the dust were collected on large filter papers carried by planes through the radioactive clouds. Element 100 also turned out to be highly unstable with a half-life of 16 hours. It was named fermium (Fm) after Enrico Fermi, one of the greatest of the pioneers of the atomic age. A less stable isotope Fm^{252} which had a half-life of 30 min. was made by a swedish group of scientists at the Nobel Institute of Physics in Stockholm by bombarding uranium-238 with accelerated oxygen particles.

$$_{92}U^{238} + {}_{8}O^{16} \longrightarrow {}_{100}Fm^{252} + 2{}_{0}n^{1}$$

One hundred might have made a nice round number of elements to satisfy any chemist. But before the world of science could settle back, another blessed event occurred. The delivery was made in 1955 in the same 60-inch cyclotron at Berkeley, and the doctor again was Seaborg, aided by his four co-workers. Element 101, born of einsteinium was an extremely active one with a half-life of about an hour. It was named mendelivium (Mv) in memory of the man who had given science the first practical catalogue of the chemical elements.

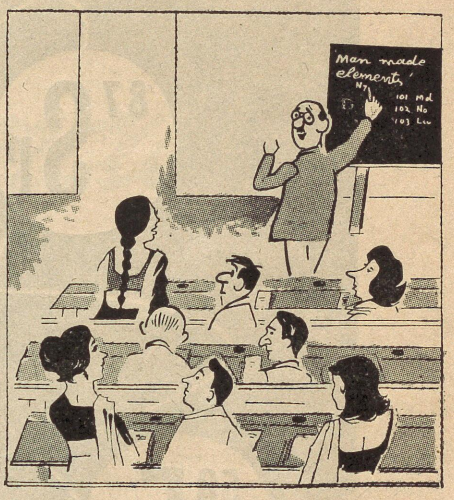
$$_{99}Es^{253} + {}_{2}He^{4} \longrightarrow {}_{101}Mv^{256} + {}_{0}n^{1}$$

Then came nobelium (No), element-102, created by an International team of American, British and Swedish scientists in Stockholm in March 1957. It was synthesised by bombarding a target containing curium-242 with 110-120 Mev ions of carbon-13

$$_{96}Cm^{242} + {}_{6}C^{13} \longrightarrow {}_{102}No^{253} + 2\ {}_{0}n^{1}.$$

The thirteenth of the series of elements called the actinides—element 103, was produced in 1961 in a powerful new particle accelerator called HILAC (Heavy Ion Linear Accelerator) which had been built at the University of California. A few atoms of the new element were produced by the bombardment of californium with nuclei of boron-10 having energies of 70-Mev. It had a half-life of 8 sec. and has been named lawrencium (Lw) after the inventor of the cyclotron. The 104th element was recently synthesised in the U.S.S.R. by Georgii Nickolaevich Flerov in collaboration with a team of scientists at the Laboratory of Nuclear Reactions in the Joint Institute for Nuclear Research at Dubna, by bombarding accelerated neon-22 nuclei on plutonium-242 target. It was named kurchatovium after the Soviet physicist Igor Kurchatov and had a half-life of approximately 0.3 sec. The latest addition to the family is the element-105, the formation of which was announced early this year by scientists at the Lawrence Radiation Laboratory Berkely, California.

We have thus come a long way from the Olympian world of four elements but still have not reached the end of the road. The Alchemists' dreams have come true and, as more and more powerful particle accelerators are being developed, we can hopefully look forward to more additions to the already big family of the chemical elements.



"Sir, when are they going to make gold in the lab?"

BLOOD FAT in Animal BODY

T. N. Murthi

In blood, cholesterol is distributed equally between plasma and the cells. It plays a vital role in the formation of bile acids and the sex hormones, and is a precursor to vitamin-D and cortical hormones

GENERALLY, cholesterol (a kind of fat in the blood) occurs in all animal cells and is a major constituent of the body. It is present in large amounts in several parts of the body like brain, spinal cord, adrenal, liver and kidney. Thus in a man weighing about 65 kg the total quantity of cholesterol will be approximately 210 gm or 0.3% of nett weight of the body. The largest amounts are present in skin (51 gm) and nervous tissue (31 gm). Though cholesterol is a common constituent of the animal body, its actual role in different tissues is not known clearly. It is likely that it may be involved in the organisation and permeability of cell membranes. Inspite of its importance in general physiology, it is however not an essential dietary constituent. It can be synthesized in the body from acetate compounds which are obtained by the animal from carbohydrates and proteins. Above all, it is the main part of the bile acids, sex hormones and a precursor to vitamin D and cortical hormones.

The structure of cholesterol molecule consists of a cyclopentaphenanthrene ring with a hydroxyl group.

The role of cholesterol in animal body can be explained better by studying its behaviour towards arteries, liver, brain, etc.

Cholesterol in blood

In blood, cholesterol is distributed equally between plasma and cells, as combination products with protein. Generally, the concentration of cholesterol in blood, i.e.,

serum cholesterol level, is fairly constant and it is completely independent of cholesterol intake. For instance, the serum cholesterol level in man is about 130-200 mg per cent and is not changed even after taking cholesterol upto 700 mg per day.

But the serum cholesterol level in animals can be increased or lowered by changing the amount of fat in diet. Thus blood cholesterol level is increased with increased dosage of fat in the diet. Moreover, unsaturated dietary fats increase the serum cholesterol level more than the saturated dietary fats. Thus butter diet causes significantly higher blood cholesterol than margarine containing large amounts of hydrogenated whale oil. This is partially due to the difference in chain length and unsaturation of fatty acids present in the products. The mechanism of fat diet in increasing the serum cholesterol level involves stimulation of the bile flow which provides fatty acids for esterification of cholesterol in the blood. This helps in retaining the cholesterol in blood, thereby increasing the serum cholesterol level. However, changing the fat diet from animal to vegetable origin lowers the serum cholesterol level and phospholipids. This effect is due to the presence of essential fatty acids.

The study of the distribution of cholesterol in blood and its change with fat diet might help in controlling the coronary heart diseases like atherosclerosis with which lipoproteins are associated. Hypercholesterolemia is induced in animals due to obstruction in the absorption of cholesterol by vegetable sterols. In the laboratory-adopted animals this can be induced by injecting carbon tetrachloride and can be suppressed by injecting the sodium salt of malonate, arsenite, vitamin 'C' and thyroid hormone.

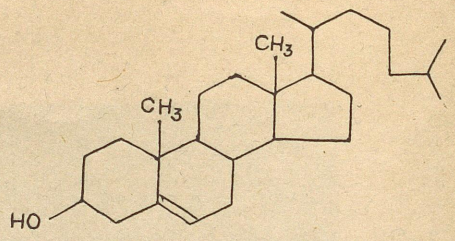
The serum cholesterol level also increases with age and sex. For example, females have higher free cholesterol level in blood than young men. Since a definite correlation has not been obtained between the increase of cholesterol level in blood and age, it may serve as a clue and not a definite factor in classifying blood with regard to age.

An increase in the blood cholesterol is also observed in case of pregnancy, alcoholism, icterius, nephritis and diabetes. Thus it may help in tracing the above stated symptoms in animals. Finally, though aorta appears to be less active than liver in cholesterol synthesis, it is an important factor in the development of atherosclerosis.

Cholesterol in pancreatic secretions, liver and brain tissue

The role of cholesterol in pancreatic secretions is understood by a study of its relationship with lipotropic substances and liver cholesterol and its behaviour towards the intestine. Some of the lipotropic substances are vitamins, hormones, enzymes, folic acid, estrogens and trypsin. These substances act as antifat liver substances and prevent the fatty infiltrations into the liver. Lack of the lipotropic substances in high fat diet does not increase liver cholesterol. Since pancreatic products contain the effective substance lipocaic, by and large this pancreatic factor only reduces the liver cholesterol which in turn controls the serum cholesterol levels. Pancreatic juice, liver cholesterol and serum cholesterol levels are thus interconnected.

The behaviour of cholesterol in pancreatic secretions was also studied with regard to the intestine. The removal of pancreatic juice from the intestine promotes the intestine to have the capacity for esterification of cholesterol and thus increase its absorption in the intestine. Mammals do not absorb sterol of vegetable origin as they do



Cholesterol

with cholesterol in the intestine. The non-absorption of vegetable sterols by the gastro-intestinal tract is really a physiological mystery. In the intestine, normally, micro-organisms destroy a major quantity of dietary cholesterol. But this capacity is inhibited when antibacterial drug, streptomycin is added to the diet. This suggests that micro-organisms of the intestine are mainly responsible for the destruction or modification of the consumed cholesterol. The conversion of cholesterol to vitamin D_3 takes place in the intestine walls. Modern studies have indicated that main catabolism of cholesterol takes place through oxidation to bile acids and it is as bile acids that cholesterol is eliminated in feces. Thyroid hormone also stimulates degradation of cholesterol and in particular in its conversion to acidic products. The concentration of cholesterol in the liver of mice fed with cholesterol in diet can be reduced by soybean oil which contains choline. Reduction of the liver function in the synthesis of cholesterol in dogs decreases the ability to catabolize and to synthesize phospholipids. This helps in controlling the excess deposition of fat in the liver of animals.

In brain, the nervous tissue contains high cholesterol content. The usually high cholesterol content may possibly function as insulator by virtue of its low conductivity. In brain tissue, the cholesterol is present in combination with brain proteins. In cattle brains, 24-27% cholesterol is present in the grey

matter of the brain, 6-8% in the white matter and 11 to 18% in the cerebellum.

In muscles, cholesterol has structural or metabolic activities. Hence, the muscles of young animals contain high cholesterol content.

Behaviour of cholesterol towards sex

The behaviour of cholesterol towards sex is a very interesting feature. It shows marked differences between male and female animals. In women the serum cholesterol level is higher than in man. In the age group 61–87 years the serum cholesterol level is 200 to 481 mg/100 ml in females, while in men the level is 176 to 409 mg/100 ml. It may be possible to classify blood with regard to sex by knowing the content of cholesterol in blood. In women, but not in men, there is a significant correlation between the dietary intake of fat and the serum cholesterol level, and also between the thickness of the abdominal skin fold and the serum cholesterol level. Similarly, in liver males have significantly small amounts of liver cholesterol when they are fed with extra egg albumin. Females too have consistently lower liver cholesterol than males but show no significant change with increased protein intake.

In female rats, esterifying activity of cholesterol in plasma was higher than in males when they were fed with diets free from fat but containing cholesterol. There was, however, no sex difference in the sexually immature young animals.

In some instances, cholesterol helps in recognising the sex. By looking at the hair we may not be able to judge to which sex it belongs, but it may be possible with cholesterol. It is because the hair fat from men contains cholesterol and other compounds, while the hair fat from women contains other compounds and no cholesterol. This helps in differentiating hair with regard to sex.

Cholesterol also plays an important role in other parts of the body like adrenal, kidney, etc., and also in the development of chick embryo. Cholesterol content of the blood, liver, spleen, and kidney of mice on fat-rich diets is considerably increased by feeding sodium, or potassium salts of organic acid or ammonium chloride.

Lastly, cholesterol protects the body against hemolytic action of bacterial toxins, snake venoms, phospholipids, soaps and salts.

SCIENCE IN INDUSTRY (*Continued from page 489*)

production of the chemical from toluene has been developed by the Central Fuel Research Institute (CFRI), Dhanbad. Toluene is at present available in the country as a surplus from the steel plants and coke ovens as a result of their increased coal carbonization capacity.

In the CFRI process toluene is reacted with ammonia in vapour phase in presence of air and a suitable catalyst. The new process dispenses with the use of expensive chemicals and yields a pure product on a continuous basis. The Institute has also developed a specific catalyst for the process.

A preheated mixture consisting of 2 parts of ammonia, 1 part of toluene and 75 parts of air is passed at 50°C over the catalyst. After the oxidative ammonolysis of toluene the reaction products are collected in three sets of condensers, the first cooled with air, the second, with circulating water at 10°C and the third, under crushed, ice. The major part of the nitrile (b.p.191°C) is trapped in the air condensers, the ice-cooled traps holding the residual nitrile along with traces of the unreacted toluene. Toluene is isolated from the outgoing stream by refrigeration, effecting near quantitative recovery. The yield of benzonitrile obtained (per pass) is 60 kg per 100 kg of toluene charge. With the recycling of the unreacted feedstock, the yield is higher.

Utilization OF HIGH INERT COALS

B. Acharjee

Potentialities and problems of steam raising by burning low-grade coals in fluidized bed are discussed

INDIA has a large reserve of coal; the total is estimated at about 200 thousand million tonnes. About 80% of this reserve is of low rank and its major industrial use is in steam generation—be it for power or process plants or in locomotives.

Majority of the Indian coals are, however, of inferior grade containing high proportion of inerts. Besides, there are non-coking slacks, washery middlings and rejects, and coke breeze which can be included in the category of low grade fuels. The term "low-grade" is used because efficient utilisation of these fuels needs specially designed firing equipments which are more expensive than those requiring low inert steam coals.

In fixed-bed firing, coals containing high proportion of fines and mineral matter present some difficulties. Fines tend to pass through

the grate in unburnt or partially burnt condition, thus decreasing the combustion efficiency. With increase in ash content there is the likelihood of increase in combustible loss in ash. However, these disadvantages are no longer considered serious problems, as there are firing equipment now available to deal with such low grade coals. Examples of suitable equipment are chain-grate, spreader and Martin stokers. Stoker firing is not usually applied to boilers with capacities exceeding 300,000 lb/h steam.

For boilers with high steaming rate and using low-grade fuels, pulverized coal (p.c.) firing and cyclone furnaces are commonly used. In cyclone firing, since the major part of the ash is discharged in slag form, low ash fluidity temperature is a must, even if it means doping with a suitable fluxing agent. In addition, high heat losses occur if the ash content of the coal is high. Most of the Indian coals have high ash content and are at the same time somewhat refractory in nature. Thus it is easy to see why cyclone firing has not got general acceptance in India. For the same reason, wet-bottom p.c. firing also is not practised in India.

With correct furnace design, dry-bottom p.c. furnaces do not seem to present any operational problem with Indian coals, but preparation of p.c. is an expensive operation, involving elaborate grinding and classification equipment and the associated wear problem. An added disadvantage in India is the replacement of the worn-out grinding parts—at present they are procured from abroad at the expense of our slender foreign exchange resources.

Search for a new technique that would reduce capital and operation costs of the generating station and at the same time have high adaptability, has brought the fluid-bed combustion technique into active consideration of the researchers.

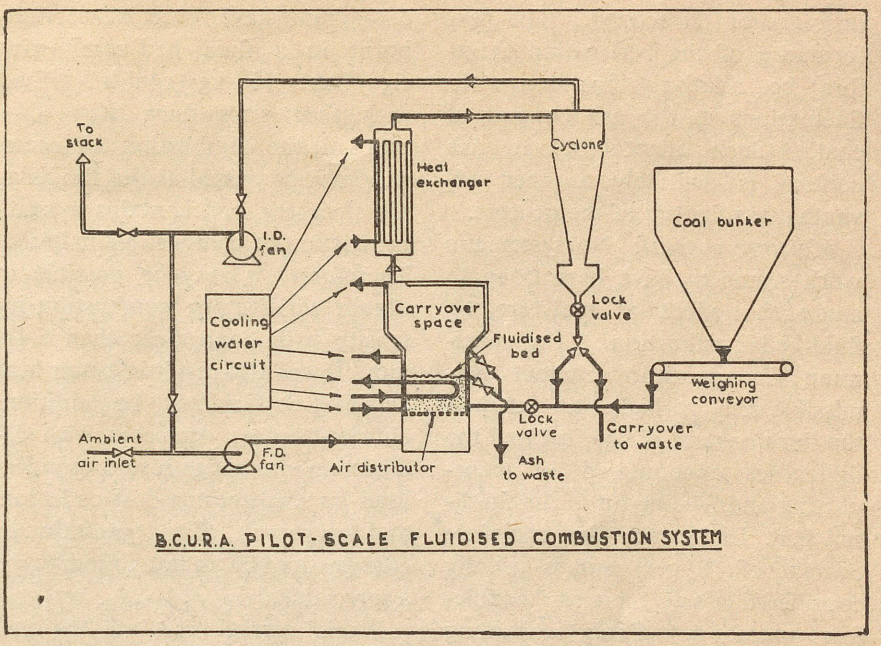


Figure 1

This article deals with the potentialities and problems of fluid-bed combustion utilizing low-grade coals.

Fluid-bed combustion

Fluidized beds are well-known for their rapid mixing and heat-transfer characteristics. Within the coal industry, fluidized-beds have been used for drying, gasification and carbonisation purposes. Combustion of solid fuels in fluidised bed, solely as a source of heat for external use was initiated a little over ten years ago. However, until recently this technique of combustion did not show signs of general acceptance, because most of the past work mainly aimed at utilising low grade fuels, and the heat transfer surfaces were placed above the bed as in a conventional boiler.

In a system developed by Friese to burn 10—0 mm oil shale in fluidized bed, the primary objective was to provide a carbon-free suitable for cement manufacture, and agglomeration had to be prevented by keeping the bed temperature below 820 °C. Cooling of the bed, when necessary, was effected by inserting water tubes in the bed. Under such conditions considerable amount of steam could be raised from a relatively small area of heat transfer surface immersed in the bed. Later, Central Electricity Generating Board, U.K. emphasised the importance of immersing boiler water tubes into the fluidised combustion bed to take full advantage of the good heat transfer properties. This technique of steam-raising seems to have great possibilities, as discussed below. Fig. 1. shows a typical test rig on fluid-bed combustion.

Fuel characteristics

Ash content: One of the main advantages of fluid-bed combustion is that the process can cope with coals having much higher ash content than is used in other types of firing. In fact, success has been reported in burning a coal with 84 per cent ash. In Britain, since coals are of relatively low ash, the practice has been to burn particulate coal in a fluidized bed of ash and/or refractory material. The carbon content of such burning beds lies below 10 per cent.

The fluidized combustion bed consists mainly of the inert material

(ash and/or refractory). The performance of the bed would therefore be relatively insensitive to fluctuations in the ash content of coal. Such adaptability to ash content is definitely another advantageous feature of the process.

Moisture content: No systematic work seems to have been done to study the effect of moisture on fluid-bed combustion. The maximum free moisture content permissible may perhaps be related to the fines content of the fuel and the difficulties encountered in transporting and feeding on to the fluidized bed. In practice, free moisture content of 10 per cent is usually considered a safe limit for trouble-free operation. Coals containing upto 30 per cent and lignites containing upto about 40 per cent total moisture have been successfully burnt in some existing fluid-bed combustion processes.

Sulphur content: Ash beds show a sulphur retention capacity. Since the fluid-bed would consist largely of coal ash, the process may accept coals with higher sulphur content than are used in conventional boiler, without causing excessive fouling problems.

The sulphur retention capacity of the ash bed may be enhanced by addition of limestone. About 80-98 per cent of the sulphur in coals could be retained in the bed by adding 10-12 per cent limestone to the coal feed. These results may have a bearing on the utilisation of high-sulphur Assam coals.

Ash fusion: The fluidized bed temperature is kept relatively low, about 800 °C. At such bed temperatures ash fusion would not be any problem, and a clinker-free form of combustion can be obtained.

Coal size: With decrease in particle size the heat transfer coefficient increases but the combustion intensity decreases since less air can be passed through the bed. Coals of 6.4-0 mm have been successfully burnt in a fluid bed combustion rig (Cap: 160 kg coal/h). Even with feed sizes finer than 6.4-0 mm, all the combustion air necessary may be passed as the fluidising air since the bed contains a small proportion of combustible material. Therefore, it may be possible to obtain satisfactory combustion intensity with coals finer than 6.4-0 mm. It will also result in better heat transfer coefficients. In addition, elutriation loss decreases with decrease in size range resulting in less load on the cyclone dust-collectors and less recycle. Size degradation of coal in the bed is not found to be appreciable.

Work carried out at National Coal Board and Central Electricity Generating Board of U.K. suggests that 1.6-0 mm would be the suitable feed size for fluid-bed combustion.

Effects of operating variables

Fluid velocity: The higher the fluid velocity, the greater is the carbon loss in ash when fines are not recycled. With fines recycle the fluid velocity has only very small influence on carbon loss. CO_2 concentration in the exit gas, however, tends to increase with increase in fluid velocity. Presumably, higher fluid velocity increases the carbon concentration over the bed, due to elutriation, and helps in the reduction of CO_2 to CO. The suggested suitable fluid velocity is 0.3-0.6 m/sec.

Bed temperature: Bed temperatures of around 800 °C are considered adequate for efficient combustion. At such temperatures and with fines recycle the total combustible loss (unburnt fuel + CO in exit gas) was found to be about 1 per cent. This compares favourably with p.c. combustion where the total combustible loss is often about 1.5 per cent. At 700 °C bed temperature the combustible loss amounted to as much as 3 per cent.

Fines recycle: It has two effects: on the one hand it reduces the fuel loss in ash, while on the other it tends to increase the concentration of CO in the exit gas, presumably due to increased carbon concentration over the bed, reducing the CO_2. However, the former effect is more pronounced than the latter, and overall effect is favourable, i.e., there is less total combustible loss with fines recycle than without it.

Excess air: With stoichiometric air appreciable loss of combustibles occurs, and bench-scale results indicate maximum combustion efficiency at about 5 per cent excess air.

Increase in excess air results in an increased stack loss. With excess air of upto about 30 per cent, the overall heat loss in the fluid-bed system would be less than that in a typical pulverised coal-fired boiler. This result is relevant to the problems of distributing coal and air to the fluidised bed in a large-scale plant, where the coal feed points per unit area are likely to be far fewer than in the experimental rig. Above the coal feed point the coal/oxygen ratio would be higher than that between the feed points. It would appear that the combustion efficiency would compare favourably with that achieved in a p.c. fired boiler if the overall proportion of excess air was below 30 per cent.

Bed height: Increase in bed height beyond 0.4 m seems to have little effect on combustion efficiency, but it increases the pumping cost. The suggested suitable bed height in a full-scale plant is 0.9-1.2 m.

Heat transfer

In conventional systems at temperatures about 800 °C radiative heat transfer usually plays a significant role. But in fluid-bed combustion operating at around 800 °C, radiation accounts for only 20-30

per cent of the total heat transfer. The major part of heat transfer takes place by convection caused by the fluidized mass.

The bed-tube and bed-wall heat transfer coefficients are about 200-285 w-m^2 deg C (35/50 Btu/ft^2 h deg F). The bed-tube coefficient is independent of tube position in the water-tube arrangement, and is uniform around the tube circumference and is not affected by the depth of the bed above the tubes.

The coefficient is influenced by fluidizing velocity and coal particle size. Increase in fluidizing velocity and decrease in coal size tend to increase the coefficient. After a certain fluid velocity, however, the coefficient remains almost constant, until elutriation of particles begins to reduce markedly the particle concentration in the bed, thus reducing the coefficient.

Economy factors

In conventional furnaces not more than 70 per cent of the boiler tubes is directly exposed to flame radiation, whereas in a fluid-bed boiler, almost the entire tube surface is available for heat transfer. In addition, the heat transfer rate in a fluidized bed is considerably higher than that in a conventional boiler. The estimated cost of water tubes in a fluid-bed boiler is about 1/3 to 1/4 of that in a p.c. fired boiler.

Another important feature of the fluid-bed boiler is its high volumetric heat release, which is about 10 times that of a p.c. fired unit and about 5 times that of a stocker-fired unit. The fluidized beds thus offer the potential advantage of a more compact combustion system, with possible savings in the cost of furnace construction.

Fluid-bed boilers show quick response to load changes. Hence less spinning reserve is required, resulting in a considerable economic saving.

The operating bed temperature is relatively low, and the devolatilisation of alkali and alkali-earth salts from the ash is expected to be small. This will lead to less deposit build-up and corrosion trouble resulting in less downtime and maintenance cost. Retention of sulphur in the ash bed may also reduce fouling and corrosion troubles. Other advantages of low operating temperature are clinker-free form of combustion and less auxiliary heat transfer surfaces required after the fluidized bed.

If the heat flux for a boiler tube exceeds a certain value (burnout heat flux), the inner wall of the tube may become locally dry and the heat transfer rate reduced; under these conditions the tube temperature may rise rapidly to the melting point. Burnout is usually caused by maldistribution of heat; this problem is less likely to occur in fluid-bed boilers because of lower and more uniform temperature of the heat transfer-medium.

Stable combustion conditions can be obtained in a fluid-bed combustor at temperatures as low as 450°C with bituminous coal. Hence the banking loss can be minimised by idling on very low feed rates.

Fluid-bed combustor would efficiently use washery rejects as fuel, and this fuel could be obtained free. In utilising the rejects, the transport cost of the inerts will, however, be involved. Due to intensive oxidation in the fluidized bed it may also be possible to utilise another industrial waste, coke breeze. In this context, it may be mentioned that the Ignifluid process can deal with coke breeze. High moisture lignites have also been burnt in fluid-bed systems without briquetting or pulverisation —both rather expensive fuel preparation techniques.

The elaborate grinding and classification units required for p.f. fired boilers are eliminated, since coarser particles are used in fluid-bed combustion. The combustion is substantially complete with only the fluidising air; this indicates the possibility of removing secondary air injection device. These result in considerable reduction of the capital and running costs.

Because of the lower bed temperature, the ash particles are not sintered, nor their surfaces appear to show any sign of vitrification. Such material may be of use in agriculture and in other industries.

Other important features of fluid-bed combustion include:

1. Ease with which bed temperatures can be controlled by the balance of heat release and heat transfer processes occurring within the bed.
2. Flexibility in fuel type;
3. No explosion risk during ignition as present in p.f. or oil-fired furnaces.

The British Coal Utilisation Research Association proposes to develop a fluid-bed combustion system under pressure, recovering the pressure energy in a gas turbine.

Operation under pressure would lead to an improvement in the quality of fluidization and it should be easier to maintain a uniform bed temperature and to achieve a high combustion efficiency. The heat release rate would also increase, thus promising further reduction in capital cost.

There are, however, several factors that tend to counteract the economic advantages mentioned above. These factors are:

1. Requirement of fairly elaborate coal and air distributors.
2. Collection of the relatively high grit burden in the flue gases, and their recirculation to the fluidized bed to minimize unburnt carbon loss.
3. Additional fan power to overcome the resistance of the air distributor and the fluidized-bed. Flue gas recirculation, useful for increasing the turn-

down ratio, will also require some fan power.

4. Possible erosion of the immersed tubes due to the impingement of their particles. The observations on the experimental rigs do not, however, indicate that erosion would be a serious problem; but these observations are not based on sufficiently long-term tests, and it is difficult to rely too much on them.
5. The overall size of the boiler also depends on the waterside conditions in that a certain minimum surface area of boiling water is required to avoid wet steam troubles. Thus, the boiler shell may have to be made larger than that dictated by the volume of heat transfer space.

In spite of these disadvantages, it would seem to be worth the effort to develop the fluid-bed combustion process, particularly because of the economic saving due to the high heat release and heat transfer rates. Moreover, reduction in tube corrosion would increase the life of the tubes and save foreign exchange.

However, a good deal of problems and uncertainties still exist in the areas of combustor design, coal/air distribution and boiler steam circuit design. The solution of these problems is the objective of most of the current research and development work on fluid-bed combustion abroad.

Conclusion

The important specific features of fluid-bed combustion are: non-selectivity and flexibility in fuel characteristics; use of a relatively coarse fuel bed; uniform temperature within the bed to concentrate the thermal gradient at the heat transfer surface; the high heat transfer coefficient; relatively low bed temperature and clinker-free combustion. These promise reduction in steam generation plant capitals, operation and maintenance costs mainly as a result of :

1. elimination of expensive grinding and classification circuits required in p.f. firing;
2. reduction in steam generation tubes and in furnace construction costs;
3. less fouling, corrosion and deposit build-up; and
4. increased plant adaptability.

Thus, while stoker, p.f.- and cyclone-fired boilers have some limitations in fuel and/or ash characteristics, the fluid-bed combustor is non-selective in both fuel and ash characteristics. At the same time the fluid-bed technique promises considerable reduction in steam generation costs. The process is therefore attractive from the points of view of both economy and the country's resources.

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BOOK REVIEWS (*Continued from page 491*)

accepted as the price of high thermal efficiency. After the second World War two things happened that led to complete change of outlook: (1) Supplies of good gas making coal were decreasing and market of coke decreased considerably. (2) Nationalization of gas industry opened up the opportunity of being able to link together the distribution system to form large grid networks. It was considered that such grid system would benefit enormously if gas could be made at high pressure. The British industry initiated an ambitious programme of research on its own research stations and by 1960 four new processes had been demonstrated on large pilot scale. One for production of gas from low grade coal and three for production from petroleum feedstocks.

The author has described these new gas making processes in detail in this booklet. From a gas industry based on coal carbonisation it has become a highly sophisticated chemical engineering industry. The author has shown the stepwise development of gas industry in England from oil and other liquid hydrocarbon feedstock to liquid natural gas from Algeria, and how the discovery of natural gas under the North sea is going to help the British gas industry. In connection with the United Kingdom-Algerian project, the author has described how natural gas has been liquified, how the liquid gas is transported over the ocean and how it is stored in frozen ground storage. In connection with the discovery of natural gas under the North sea, the author has discussed how seismic methods have proved to be most applicable and uniformly successful of all the geological methods for detailed survey. This book will be a great asset to the students of industrial chemistry and gas engineers.

R.C. BHATTACHARJEE

SCIENCE SPECTRUM

Nuclear magnetic resonance

NO other single technique has proved as useful to a large variety of sciences—physics, chemistry, biology, and medical science—as the nuclear magnetic resonance spectroscopy. The technique is based on the fact that nuclei of most of the elements behave like tiny spinning bar magnets. This can be easily visualized by considering a spinning hydrogen nucleus (proton). Since a spinning charged sphere is equivalent to a small current loop, it can be replaced by an equivalent magnetic shell of strength and magnetic moment by Ampere's law. Now, when a sample nucleus having this property is placed in a constant magnetic field (d.c.) and a radio-frequency magnetic field is applied at right angles to it, the sample gives a signal at a field value peculiar to itself, and can therefore be identified by the detection of this signal. The amount of substance required in this case is very small (of the order of a fraction of a gram) and the information can be obtained without, in anyway, destroying the sample. The technique was first given by two scientists, Bloch and Purcell, almost simultaneously but independently and has been put to innumerable uses by people working in various fields. So fruitful has been their invention that both of these scientists were rewarded with the Nobel Prize in the year 1952.

To understand what nuclear magnetic resonance is, consider a nucleus having a magnetic moment μ and picture it as a spinning sphere (Fig. 1). If this spinning sphere is placed in a strong uniform magnetic field H, the field will exert a torque on the nuclear magnetic moment and the nucleus tends to assume a definite orientation with regard to the external magnetic field. The net effect is a rotation of the nuclear axis, called the precession, around the direction of the external field. The rate at which the precession takes place, the precession frequency, is proportional to the magnetic field and is given by

$$w = rH \ldots\ldots\ldots (1)$$

where $w = 2\pi\nu$ (ν being the precession frequency) and r is a constant called the gyromagnetic ratio of the nucleus. It is equal to the ratio of the magnetic moment and the angular momentum of nucleus.

Now, according to quantum mechanics, only selected orientations of the nucleus are allowed corresponding to certain available energy levels. These orientations are characterized by the magnetic quantum number m, which can have any of the values lying between $-I$ and $+I$, and differing by unity, I being the spin value of the nucleus. Transitions can be caused between these magnetic energy levels by absorption of radio or microwave

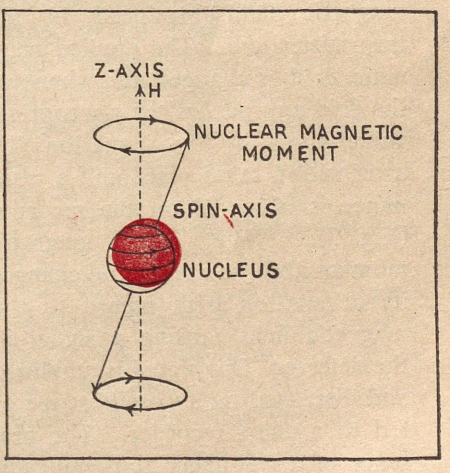


Figure 1

photons and give rise to the phenomenon of magnetic resonance.

The apparatus used for the detection of nuclear magnetic resonance is represented schematically in Fig. 2. The sample, say water, is placed in a small test tube located between the pole-pieces of a very strong magnet. At right angles to this magnetic field direction is placed a radio-frequency transmitter coil, excited by a radio-frequency transmitter. A receiver coil, at right angles to both the constant d.c. magnetic field and the r.f. transmitter coil is wound tightly around the sample tube. The radio-frequency receiver is tuned to the frequency of the transmitter. A radio frequency detector and a recorder for output display follow.

A sweep generator and sweep coils are used to produce a slowly changing magnetic field to modulate the main precession field H. If any recurring phenomenon is to be observed as a signal at the recorder, it will be dependent upon the value of the applied magnetic field. The latter is therefore periodically swept in the immediate vicinity of the constant magnetic field so that a dynamically recurring event can be recorded.

Transitions between the magnetic levels are induced by the oscillating magnetic field produced in the transmitter coil. The applied magnetic field is changed and whenever the field approaches the appropriate value given by the equation (1), a transition takes place and a resonance is observed on the recorder (Fig. 3). The spin magnetic moment absorbs energy and changes its orientation with regard to the magnetic field causing a signal in the detector. This signal is amplified and displayed on an oscilloscope or fed to a chart recorder. The presence of a resonance thus indicates the presence in the sample of a

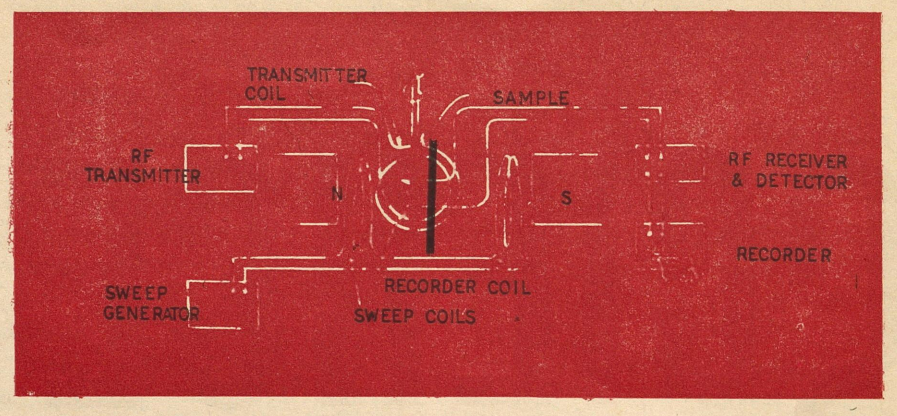


Figure 2

nucleus with a non-zero spin.

The resonance can be obtained either by varying ν or H. If the transmitter frequency is kept constant, the resonance will be obtained at a value of H given by the equation (1). On the other hand, H may be kept constant and the transmitter frequency varied till the resonance is obtained. In practice, however it is customary to keep H constant and vary ν. Thus

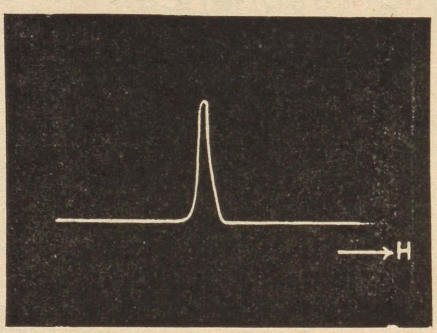


Figure 3

in the sample taken in the above experiment, namely water, if the magnetic field is set at an initial value of 10,000 gauss a resonance is obtained at a frequency 42.577×10^6 cycles per second. This corresponds to the precession frequency for hydrogen nuclei in water. Another resonance is obtained when the transmitter frequency is set at 5.772×10^6 cycles/sec, arising from the naturally occurring O^{17} in water and still another resonance can be obtained at the transmitter frequency 6.536×10^6 cycles/sec. This resonance corresponds to the rare but naturally occurring population of deutrons (H^2) in the water. No resonance is however obtained for the O present in water, because the spin of these nuclei is zero, although the amount of these nuclei is much more than that of O^{17} or H^2.

Such an experimental set up can thus serve as a spectrometer for nuclear isotopes, which can detect and distinguish all non-zero spin nuclei present in a given sample. The substance to be studied may be available in a very small amount; it can be tested without destroying the least part of it. It would however, not tell anything about the nuclei having a non-zero spin.

The nuclear isotope spectrometry is only one of the large majority of uses to which the N.M.R. technique can be put. Another important use of this technique is the precise measurement of magnetic field strengths. If the value of γ for a particular nuclei is determined beforehand (the value has been measured

for hydrogen nuclei to an accuracy of one part in 50,000) any large magnetic field can be measured accurately if the hydrogen nuclei are placed in this field and the precession frequency determined by making use of the equation (1). A modification of the above experiment has also been used by Russell, Varian and Packard to determine accurately the value of the Earth's magnetic field. This has been measured to an accuracy of one part in a million.

The nuclear magnetic resonance technique has proved to be a very useful technique to the chemist also. It has been found that the exact value of the magnetic field at which a given type of nuclei resonates at a given frequency depends slightly on the chemical compound containing the nuclei. Further, within one molecule, one type of nucleus may show different resonance peaks for chemically different positions it occupies. Three different resonance peaks are observed for ethyl alcohol, indicating that the protons are located at three different positions in the compound. The effect was first demonstrated by James Arnold and Martin Packard at Stanford University. These shifts in the magnetic fields (known as chemical shifts) arise because the nuclei in a magnetic field are partially shielded from the magnetic field by the molecular electrons. The resonance, therefore, occurs at a slightly larger magnetic field than that given by the equation (1). Further, since the integrated intensity of the resonance signal for two identical nuclei is the same, the approximate relative heights in the example considered above show that these peaks are respectively for the —OH, —CH_2, and CH_3 protons respectively.

The N.M.R. spectrum thus gives a fingerprint of the molecule which not only identifies it but also gives a lot more information about it. The technique has been used in various branches of chemistry, from finding the structures of different kinds of substances, studying soaps, oil and also complicated molecules of living matter. It is also being put to many other uses including those in the medical science.

B.L. ARORA

Further reading

1. *NMR and EPR spectroscopy* by STAFF OF VARIAN ASSOCIATES.
2. *Spectroscopy and structure* by Richard N. Dixon.

Beyond the speed of light

GREAT strides have been made in recent years to bring the planets and the stars closer to us. We can now fairly comfortably blast-off to our nearest neighbour, the moon, and be back on earth in a week's time. Yet how fast can we travel? 40,000 kilometres an hour (the speed of a space ship) seems quite a dizzy rate of travel when we talk of terrestrial distances, but serves no useful purpose if man is to step into space and ultimately explore the universe. The criterion is speed and man's ability to create such high speeds and to withstand them.

A popular limerick goes like this:

There was a young lady called Bright
Who could travel much faster than light,
She went out one day
The Einsteinian way
And returned on the previous night.

First of all, is it possible for Miss Bright to travel with a speed much faster than that of light?

Einstein in his famous theory of relativity, stated that it is not possible to travel faster than light. For more than half a century, this view has been accepted by scientists all over the world. The speed of light is indeed very great, difficult to imagine under usual conditions to which we are accustomed. Thus far we have attained speeds of about 40,000 kilometre per hour, that is to say, only about 11 kilometres a second. To reach the speed of light, which is 300,000 kilometres a second seems pure fiction. Nevertheless, with the rapid advancement of space travel in recent years, this no longer seems an impossibility. For, unless man is able to reach such high speeds in the future, space exploration of the galaxy in which he lives will come to a halt. Taking a concrete example, it would take 4½ years for *light* to travel to our *nearest* star, Centauri. So, if man were to travel at the speed of 300,000 kilometres a second, he would take 9 years to make the trip to Centauri and be back. What then about our galaxy? It is so huge that it would take 80,000 years to cross from one side to another if we were to travel at the speed of light!

Hence we arrive at the inescapable conclusion that we should step up our speed of travel enormously if we are to become future travellers in space.

The limerick stated above depicts the way in which Miss Bright travelled, viz., the Einsteinian way. What then, is this way of travel? It would be better if we study this first.

The theory of relativity was put forward by Einstein to explain the

difficulties arising from the Michelson-Morley experiment, which was designed to test whether the velocity of light depended on the velocity of its source. In other words, when a beam of light is shone in the direction of the earth's rotation, does it travel faster than when it is shone in the opposite direction to the earth's rotation? The experiments showed that there was no change in the velocity of light and it was always the same, independent of the speed of the source of light. It was here that an observer encountered enormous difficulties. For the addition law of velocities was apparently in a state of contradiction with the results of the Michelson-Morley experiment. Considering the example of a bullet fired from a moving train, the velocity of the bullet would be the sum of the individual velocities of the bullet and the train. But if we now replace the bullet by a beam of light, it is found that the addition law does not hold good, as shown by the results of the Michelson-Morley experiment.

It was upto Einstein to avoid this discrepancy. Explaining that space and time were inter-related, he showed that the inter-relation of space and time was different for observers moving with constant speed relative to each other. In other words, according to Einstein, a person moving away from a clock, would observe it to move slower than his own clock. Prior to Einstein, it was supposed that all clocks moved at the same speed; everyone thought of time as an absolute quantity. However, this is not true—time is relative, as space. There is a difference between the rates of clocks of two observers moving at constant speed relative to each other. And a new element was introduced to our original concepts of space and time.

Thus light always travels at the same speed irrespective of the speed of the observer. However, the addition law of velocities holds true for objects travelling at speeds much less than that of light, only breaking down when the object (the bullet in the last example) is of the same speed of light.

Another implication of Einstein's theory is that the mass of a moving body increases as the speed of the body increases, reaching infinite mass when the speed of light is reached. Hence the same impulse to the body will produce smaller changes of speed. An infinite amount of energy would be necessary to reach the speed of light, which is practically an impossibility.

Therefore a body cannot be made to reach the speed of light. It is like a 'Barrier', which cannot be crossed. Yet, truly speaking, is there no body, no particle which can move with a speed greater than that of light?

The sixties have ushered in a number of wonderful contributions to science. During this period, scientists in many parts of the world came out with postulates regarding particles which can travel faster than light. These particles are termed "tachyons" (from *tachys*, the Greek word for 'swift'). Now, *such a particle is always travelling faster than light;* it therefore does not have to cross the so-called light barrier, and so the problem of having infinite energy does not arise. Tachyons are created with speeds greater than that of light; they cannot be created with speeds less than that of light and ultimately be made to attain the speed of light.

A strange characteristic of the tachyon is that it loses energy when its speed increases and gains energy when its speed decreases. (On the other hand, particles moving with speeds slower than that of light lose energy when their speed decreases.) A tachyon finally reaches zero energy at infinite speed. When its energy increases enormously, its velocity approaches that of light. Thus the speed of light can never be reached by a tachyon as the speed of light can never be reached by an ordinary particle travelling with speeds slower than that of light. An interesting barrier—the speed of light, indeed!

But since a tachyon travels extraordinarily fast, one has to understand that it goes out before it comes in, or a tachyon moved backwards in time, satisfying the conditions attached to the limerick.

The question therefore arises: do tachyons exist? This presents a possibility which cannot be avoided. The search for such a particle is on, along with the magnetic pole and the boson. But plainly in order to find out the existence of tachyons, something is necessary in order to interact with them. Again the light-barrier presents a problem: are interactions possible between tachyons and other ordinary particles travelling at speeds slower than that of light?

Experiments are in progress with the use of light itself, since light is emitted or absorbed by charged particles and these particles may very well be tachyons. A recent study was undertaken by a group of American scientists to produce a pair of tachyons (charged oppositely) by shining light of high energy into lead. But results did not indicate the presence of such particles. Another recent theory predicts the existence of tachyons in matter only when it is subjected to conditions of intense pressure. Such conditions of matter under infinitely high pressure are said to exist in the interior of *quasars**; so it is possible that tachyons may

exist in the centres of quasars or pulsars. But it is well-nigh impossible to create such conditions in the laboratory.

Granting that tachyons do exist and can be isolated, we come to the most important question before us: can tachyons be used for fast space travel? Will it be possible for a space-ship to travel say, at a speed ten times that of light and proceed to the nearest star? No, since we can never cross the light barrier in the manner in which the sound barrier has been crossed (for reasons already dealt with beforehand).

However, tachyons can be used as a possible means of space communication, in the way electromagnetic waves (radio waves) are used for earth communications. The speed with which these waves travel is quite slow if one has to traverse even small distances in space. Tachyons would open up a faster mode of communicating between stellar bodies—new worlds, and perhaps new civilisations would come to light. But, a space-ship travelling with tachyon velocities, proceeding to stellar worlds other than our own—well, the answer is NO, at least in the present age in which we live.

**quasar:* a quasi-stellar radio source, situated at enormous distances—of the order of several thousand million light-years emitting wavelengths 2 or more times the wavelengths used for transmission.

JAYANTA MAHAPATRA

The plus and minus signs

We are all familiar with the symbols + and — which are respectively used to denote the operations addition and subtraction. We knew these symbols from our fathers and forefathers, they knew those from their fathers and forefathers. But who was or were the first to use the symbols ?—a question which can easily flash in our minds. To get a suitable answer to this question let us search all the old manuscripts on science, especially on mathematics.

The symbols of addition and subtraction were first found in Egyptian manuscripts. It was Ahmes (C. 1550 B.C.) who first used the symbols ρ and ч to denote respectively the operations addition and subtraction. In *Arithmetica*, Diophantus (c. 275) represented the addition by a simple juxtaposition as in $K^{Y}\bar{a}\Delta^{Y}iy$ for x^3+13x^2 and the subtraction by the symbol ↑.

The symbol + was first found in use in the works of Brahmagupta and Bhaskara. We now use this symbol to denote positive quantities but they used it in opposite sense, i.e., they denoted the negative quantity by + and placed the symbol after the number concerned thus:

13 6+
1 1

means 13–6, i.e., 7

The plus sign

How the symbol + came. There are a number of opinions about the birth of this symbol.

1. The Indian mathematicians generally used the first letter of the word to denote its meaning. It may be the case that they used the sanskrit letter ऋ which is the first letter of the word "Reena" (meaning loan) to denote subtraction and this was changed into +.

2. The letter ka (क) of the Ashoke script has a great resemblance with +. So it might have happened that this क, after a long practice, might have changed to +.

3. Both the words 'kaniyas' and 'nyun' mean diminished. The abbreviation 'ka' of the first or 'na' of the second would be a cross in the Brahmi script.

4. Diophantus used the letter ψ upside down (⅄) to denote a negative quantity. The symbol might have come from ⅄. Based on this argument Dr. Kaye concluded that Indian mathematics used the symbol following Greeks. Dr. Brij Mohan said it to be a clear injustice (Brij Mohan, *Ind. J. Hist. Sc.* 2, 47, 1967).

5. It is the slightly changed form of the letter 'ksh' abbreviated from the Sanskrit word 'kshaya' meaning decrease (B.B. Dutta, *B.C.M.S.*, **21**, 1, 1929).

Europeans first used the symbol P, P^1 or P^2 for plus. The Dutch mathematician Vander Hoecke used the cross sign for addition for the first time. Germans also used + for addition in sixteenth century. Grammateus used the sign in the Rule of False Position.

The minus sign

1. Fifteenth and sixteenth century mathematicians used $\bar{m}$ or $\tilde{m}$ to indicate subtraction. The bar over the letter possibly meant an omission. The sign '—' may be the abovesaid bar.

2. The symbol ÷ is commonly written for m in Uncial writing and ÷ in Visigothic writing. It may be the case that (—) would have been used for m dropping the dot above or below the dash.

S. KARANJAI

Falling meteorite photographed and retrieved

IT is a common sight to see an extra-terrestrial object such as a meteorite fall through the earth's atmosphere like a fire ball, but attempts to retrieve the same on ground are usually not successful. There are two reasons for this: the object usually gets burnt due to the heat generated by friction with the atmosphere during the descent; even if it survives the heat and falls on the ground, it is difficult to pinpoint the location of its impact for subsequent search and retrieval.

To enable quick recovery, photographing the falling meteorites has been tried but the number of corresponding cases of actual recovery are almost nil. A rare case of such a retrieval was recently reported by the Smithsonian Astrophysical Observatory, Cambridge, Massachusetts, from near Lost City, Oklahoma, U.S.A. (*New Scientist* Vol. 45, No. 687, 5th February, 1970, p. 249).

A network of automatic photographic stations spanning the midwest of U.S.A. has photographed many falling meteorites during the last five years, but this is the first time that an actual recovery has been made on the ground with its help. The Smithsonian Astrophysical Observatory set up the network composed of 16 automatic comera stations about 5 years ago with the object of evaluating the size, loss of mass and orbits of a meteorite during its journey through the earth's atmosphere. These details, it was thought, might also help in recovering the object photographed. The hope entertained has been realized in the case of the reported find.

The Smithsonian Astrophysical Observatory analysed the photographs of the fire ball supplied by the camera stations and delineated an area of about a square mile within which the impact was expected. The object fell on the 3rd January of this year within the prescribed area and the fall was accurately recorded by the cameras. The meteorite, a 22 lb bronzite chondrite belonging to the stony type of meteorites, was actually sighted on a road on the 9th January in the midst of snow. Soon after recovery, pieces of the meteorite were sent to laboratories to make analyses of the short-lived radioisotopes borne on its body. The quick retrieval enabled the possibility of carrying out such radioisotopic studies which are helpful in tracing the nature of the cosmic rays that bombarded the bronzite chondrite in space. Astrophysicists estimate that the stony meteorite weighed a ton before its entry into the earth's atmosphere. It is reported that the meteorite had an elliptical orbit and travelled into the group of asteroids which are pieces of rocks of various sizes orbiting between Mars and Jupiter and thought to be remnants of a broken planet. The photograhic records supplied by the camera stations trace the meteorite's path into the earth's atmosphere and throw light on its possible course in the Solar System.

C.R.S. RAO

Electrophotography

COPYING is involved in documentation of any kind. The time-honoured method has been manuscript-writing. A later development has been photostatic copying. Conventional photographic paper has been used for the purpose. But then the cost involved in doing photostatic copying has been rather high, so much so only for special purposes such silver halide photography is used.

Apart from silver halide photocopying, there are several other similar processes as for example thermography, plan copying better known as blue printing and ammonia printing, microfilming and electrostatic processes. Except for the electrostatic process others involve chemical changes. In this article we shall outline the electrostatic process.

There are two popular forms of electrophotography:

(1) Selenium based "Xerox" process

(2) Zinc oxide paper based "Electrofax" process.

Both work on the principle of photoconductance basically. In brief, a surface is electrically charged with a single charge in darkness on a special material. When a pattern of light and dark patches is made to fall on this charged surface, in places where light strikes the surface, the electrical single charge leaks away to the ground through the material and the supporting base. Thus a latent electrostatic image is recorded on the surface of the material. The next process is to fix this pattern permanently. The fact that the electrical charge remains intact where light has not acted has been made use of in fixing the image. A pigmented micronised powder is charged opposite to that remaining in the dark areas of the pattern and sprinkled on the pattern in a dark room. The powder being electrically charged, its particles cling to the regions on the material where the charge remains without leaking away. Thus the whole pattern is

developed. Now, to make it permanent a resin of rather low melting point is incorporated in the powder and the developed pattern is heated in a chamber with infra-red lamps. The resin softens and fixes the powder to the paper permanently. Thus the original is reproduced.

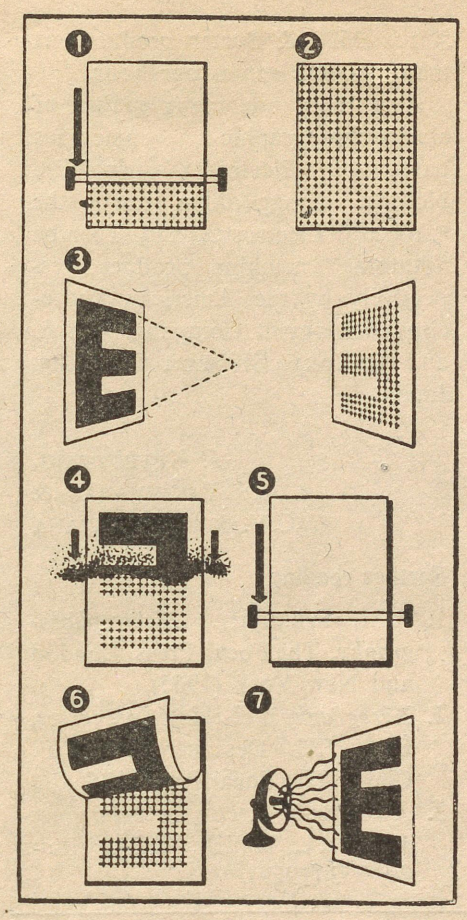
Now what is the essential difference between the selenium and the zinc oxide-based electrostatic processes?

The American patent attorney and engineer Chester F. Carlson invented the xerographic process. He made use of the purely physical phenomena of photoconductivity and electrostatics to develop the process. As mentioned previoulsy, the steps involved in the process are the following in the order given:

1. *Sensitisation:* The photosensitive layer, on an aluminium base, is charged uniformly by a corona discharge at potentials of 4000-9000 volts. Selenium is used as the photoconductive layer. It is coated by vaccum evaporation or with a lacquer dispersion to a thickeness of 20 to 100 microns. Selenium is a good insulator in the dark, so that the electrical charges are retained on its surface till exposure is effected. On exposure to illumination, the resistance is reduced sufficiently to enable surface charges to dissipate to the ground, through the conductive substrate, which is aluminium.

2. *Exposure:* A latent electrostatic image is formed by exposing the photoconductive surface to the subject to be copied. Electrical conductivity is produced in the areas where light impinges and charge dissipates to the ground in those areas. Electrical charges in the dark areas of the image are not affected.

3. *Development:* The image is made visible by development with triboelectric powders. This is a mixture of a pigmented micronised



How xerography works

resinous powder and a relatively large sized and granular carrier. The pigmented toner powder particles can vary in size between 0.1 to 20 microns and the size of the carriers can be about 300 microns. The carrier granules generate an electrostatic charge by triboelectrification on the toner particles and hence the latter stick to the coarser carrier granules. These fine charged powder particles are swept over the latent image surface during the developing process. The toner particles being oppositely charged to the image, cling to the charged areas and reproduce the image.

4. *Transfer:* The powder image on the photoconductive base is transferred on to a sheet of ordinary paper by the application of electrostatic charge (to the paper support kept in contact with the image) of an opposite sign to the charge on the powder. This causes the powder image to adhere to the paper.

5. *Fixing:* The image is fixed and made permanent by removing the paper and subjecting the image to heat. The low melting resin component of the micronised toner gets fused to the paper surface and thus the final print is obtained. The commercial selenium process is well known by the trade name "Xerox" process.

One of the main differences between the selenium process and the more recent "Electrofax" process, is that the latter is a direct one and no transfer step is involved. The photoconductive substance used here is a special grade of zinc oxide powder. The name "Electrofax" refers to the composition containing this photoconductive zinc oxide dispersed in a polymer resin. This composition is coated over a specially prepared conductive paper. This coated paper itself is the final copy. This coated paper is corona-charged in the dark, exposed to the subject to be copied and developed by means of a toner powder which sticks to places where charge has not leaked away. The powder image thus got is fused by heat on to the paper, making the final copy of the sensitive paper itself.

Though the basic principles of both the processes are the same, "Electrofax" process has several advantages over the selenium process. The foremost among them is the elimination of the transfer step which avoids any degradation of the image arising during the transfer. Also it lessens the registration problems in obtaining multicolour prints. The sensitive layer is flexible and hence the coating problems are less.

The development of the image is by a different method in the case of

the "Electrofax" process. While the developer is cascaded over the selenium plate in the "Xerox" process, a magnetic brush develops the image in the "Electrofax" process. For this, the machine contains an electromagnet which is activated after the exposure. The magnet picks up the developer powder (containing the toner powder mixed with iron fillings) and there is a brushing action as the magnet rocks to and fro in a direction perpendicular to the of motion of the "Electrofax" paper having the charge image. One contact with the charge image, the triboelectric powder clings to the image and thereby the image becomes visible. The fixing of the image is by heat as in the "Xerox" process.

Selenium based electrophotographic machines are manufactured by the Xerox Company, U.S.A. and The Rank-Xerox Ltd., U.K. They produce a range of fast copier-duplicators, one of which, the Rank-Xerox 3600 & Sorter produces as many as 3600 copies per hour.

Also there are many makes of electrophotographic machines based on "Electrofax" principles. Notable among them are the "Apeco" Electrostat and Toshiba "Autofax" machine produced respectively by the American Photocopy Equipment Company, U.S.A. and the Tokyo Shibaura Company, Japan.

J. KUPPUSWAMI,
A.S. LAKSHMANAN &
C.V. SURYANARAYANA

Further reading

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2. *Xerography and related processes*, Ed. J.H. Dessauer and H.E. Clark, The Focal Press (1965).
3. *A review of electrofax behaviour*, James A. Amick, RCA, Rev. 20, 753 (1959).

A new pesticide from garlic

CHEMICAL pesticides such as DDT have now been proved beyond doubt to have adverse effects on both humans and animals. Many countries have even taken steps to ban the use of chemical pesticides and insecticides to check environmental pollution. In their endeavour to find alternatives to chemical pesticides two entomologists, Dr. S.V.Amonkar and Dr. E.L. Reeves of the Division of Biological Control, University of California have found, of all things, garlic to be one of the promising candidates (*New Scientist*, 29 Jan. 1970)!

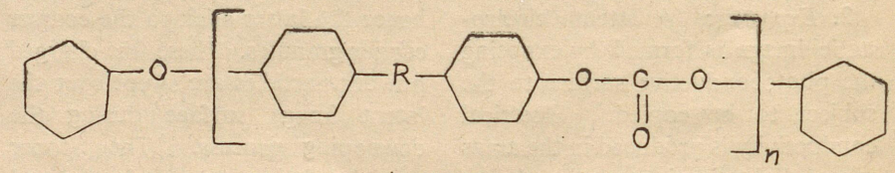
The odorous garlic (*Allium sativa*) has long been used as a spice for flavouring meat and curries, especially in India. It was also known from ancient times to cure a number of common ailments. Scientific studies have now confirmed the antibacterial and anti-protozoal properties of garlic. Allicin, the active principle of the plant, was shown to be active against a large number of human pathogens, including gram positive and gram negative bacilli and fungi.

Drs. Amonkar and Reeves prepared two extracts of garlic, one with methanol and the other, a more refined form, by steam distillation. These extracts were then tested against larvae of a number of species of mosquitoes. It was found that crude methanolic extract killed larvae at concentrations of 100-200 ppm, whereas the steam-distilled oil fraction of garlic was found to be effective at concentrations of only 20-30 ppm. The two workers believe that a chemically pure fraction of oil of garlic might possess still higher pesticidal activity. And when isolated, the fraction could be used in much the same manner as chemical pesticides. Of course, without the danger of pollution!

BIMAN BASU

New process for polycarbonates

POLYCARBONATES are new thermoplastics which may be regarded as polyesters of carbonic acid. They have the generic formula:



A polycarbonate

So far polycarbonate compounds where R is $>C(CH_3)_2$ have only been marketed, but a large number are likely to make their debut soon because of their unique versatility as industrial raw materials. Polycarbonates are characterised by high impact strength, good electrical properties, low water absorption, heat, shear, stain, and oil resistance, transparency, colourability, machinability, and maintenance of good properties over a wide temperature range from 100° to 280°F. They are utilized widely for such purposes as making parts for electronics, aircrafts, and communication equipments; for making lenses,

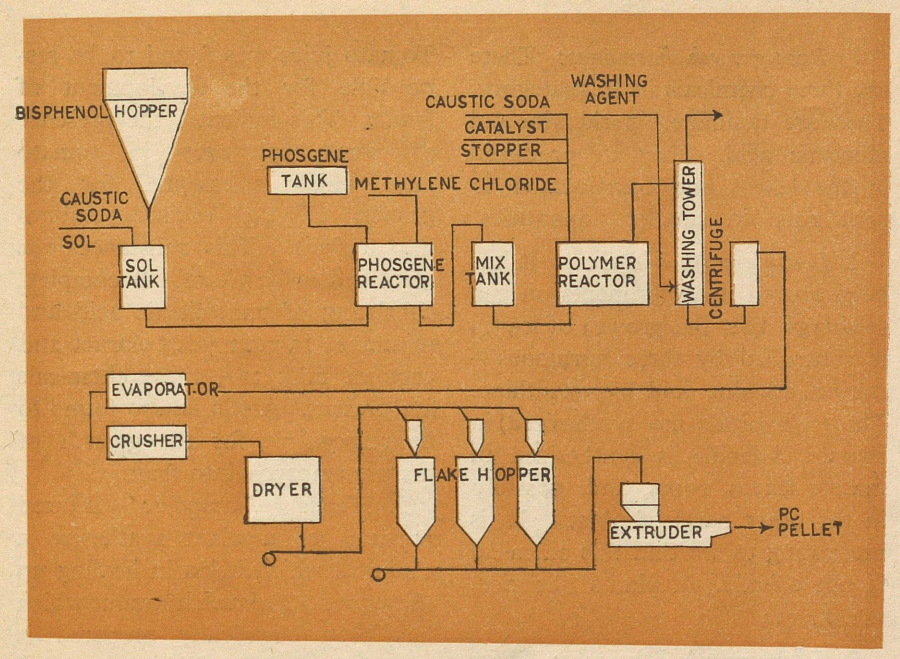


Figure 1

instrument covers, and lighting devises; for fabricating fasteners, terminal blocks, connectors, switch housings, and other electrical parts, Many die cast metal parts, especially of brass and zinc are being replaced by those of polycarbonates.

The usual method of production involves the combination of bisphenol A, a condensation product of phenol and acetone, with carbonyl chloride to give a linear polymer, consisting of bisphenol groups joined together by carbonate linkages. A number of polycarbonates can be made by using other phenols and ketones to modify the isopropylidene group, or by substitutions on benzene ring. In all the prevailing methods of manufacture the reaction is carried out on batch basis.

The process developed recently by *Idemitsu Petrochemicals*, a subsidiary of *Idemitsu Kosan* of Japan, has the distinction of being the first process for the continuous production of polycarbonate resins. Known as alkali-soda process, it is an improvement over other prevailing methods in that it economises in the consumption of raw-materials, other chemicals, and utilities. The production unit is compact and can be erected at a lower cost. The number of operations are also less and the end product has a uniform quality. The chemical reactions involved are same, and the range of molecular weight is greater than in other processes. *Idemitsu Petrochemicals* are installing 16,000 tons a year capacity for the production of polycarbonates using this method.

In this process the basic raw-material bisphenol is dissolved in an aqueous solution of caustic soda. As this solution gets oxidized on storage, a continuous dissolution is carried out in the continuous powder feeding unit. To carry out this operation with less change in concentration, a recently developed quantitative powder feeding unit has been combined with the continuous powder dissolution unit. The main reaction with phosgene is carried out in continuous phosgene blowing reactor (Fig. 1). This phase of reaction is the main and unique feature of the continuous reaction. The oligomer obtained has a low viscosity and better reactivity as a solution, but has less storage stability in comparison to the product obtained from batch system. The condensation of polycarbonates is an interfacial condensation polymerization and requires powerful agitation. This is done in a special reactor. For the refinement operation of the condensate, which acquires a high viscosity and is in the form of an emulsion, a combination of refining towers and supercentrifuge is used. In this method greater contact with the washing liquid is achieved. The pulverisation unit is unique in that it avoids the gel formation completely. The end-product which is in the form of powder has a bulk density as high as 0.5 and the grain size is uniform at 20-60 mesh. The dried powder has a volatile content of 0.1% or less. The product when marketed will be available in various grades that have been standardized during trial sales of products from the semicommercial polycarbonate plant.

DEVENDRA N. BHATNAGAR

Plant growth substances

IN the simplest plants, such as yeasts and bacteria, there is very little differentiation of structure. Hence, growth is undetectable in them. But in the multicellular plants there are distinct organs performing their special functions the control on the developement of which is vital for normal growth of the plant.

In animals the endocrine glands produce special organic chemicals, called hormones, to control the developmental activities. Hormones are released into the blood-stream in minor quantities and pass on to

the various parts of the body. The secretion of hormones is maintained by their parent glands.

In the green land plants also there are several naturally occurring hormones. There is in addition, a number of organic compounds which, when introduced into plants in small quantities, induce effects similar to those produced by naturally occurring hormones.

History

The factors underlying the development of plants have occupied the thoughts of several early naturalists. In the 17th century there was a concept that a 'sap' was always moving in the plant body which was responsible for the growth activities. However, only in the later half of the 19th century, a detailed study of the phenomena started. Sachs, the father of plant physiology, believed that there were organ-forming substances which were affected by external forces and had specific actions at different locations. But the original observations on the isolation of plant hormones were published in *The Power of Movement In Plants* by Charles Darwin. He observed in the coleoptile of canary grass that when this organ was illuminated from one side it bent over towards the source of illumination. The bending region was however, situated lower part of the organ. Darwin opined that some 'influence' must have been transmitted from the stimulated tip to the reacting zone. Boysen-Jensen (1911) suggested that a purely chemical mechanism was responsible for it. The exact nature of the chemical influence was studied by Paul in 1919 but this chemical was isolated in 1926 by Dr. F.W. Went.

Types

The plant hormones are of five types.

1. *Root growth hormones:* There are three chemicals in this category. These are thaimine, pyridoxine and nicotinic acid. They are produced in the leaves and translocated to root zone in smaller quantities.

2. *Leave growth hormones:* It has been proved by experiments on pea seedlings that the growth of leaves is controlled by three hormones—purine, adenine and hypoxanthine. These chemicals are synthesized in roots. Adenine is synthesized in mature leaves, roots, and possibly in the other parts of plants. It is interesting to see that this chemical is not effective in plants like rice, wheat, etc.

3. *Stem growth hormones:* These are synthesized in young leaves of the shoots and are translocated to the elongating zone of stem where they initiate cell elongation. In an experiment with pea seedlings in a medium containing sucrose there was no elongation. But when Indole-Acetic-Acid (IAA) was added, there was active growth.

There are several chemicals including IAAs which are stem growth substances and are collectively called auxins. They are responsible for integration of other processes as well.

4. *Fruit growth hormones:* It has been experimentally seen that a fertilized ovary can be excised and cultured in a suitable medium consisting of mineral nutrients, salt, sugar and juice of mature tomato fruits. Tomato juice was found to be responsible for the development of fruits. This indicates the presence of some substance in tomato juice which is essential for the growth of the excised embryo into a fruit. This substance was identified to be vitamin B complex, consisting of pantothenic acid and thiamine. In malt, yeast extract and coconut milk too, these chemicals are present. Auxin is also found to be responsible for the growth of mature embryos into fruit.

5. *Wound hormones:* Injured portions of a plant synthesize a chemical which helps in healing up the wound. One such hormone which has been chemically prepared is traumatic acid. This compound has been found in green beans but in other plants if was found to be ineffective, which indicates that different hormones are essential for different plants.

Haberlandt (1921) showed that if freshly cut plant tissue is immediately rinsed with water, very few cell divisions occur in the cells adjacent to the wound. However, if the wounded area is smeared with finely ground tissue of the same species, cell division takes place. This result led him to postulate the existence of substances which he called 'wound hormones' in injured tissues, which are required if cell division is to be resumed in the cells bordering a wound.

PANKAJ PRASOON

Chondroitin Sulphate—A and Antiatherosclerosis

IN atherosclerosis, there are localized accumulations of lipid-containing material (atheromas) within or beneath the intimal surfaces of blood vessels. It is thought to be due to a metabolic defect involving lipids or lipoproteins or cholesterol. It is one of the common

causes of acute cardiac episodes in patients with ischemic or coronary heart disease. During the recent annual convention of the American Medical Association held in New York, Dr. L.M. Morrison, director of the Institute for Arteriosclerosis Research, Loma Linda University reported the first clinical study using chondroitin sulphate A, an acid mucopolysaccharide, as an anti-atherosclerotic and anti-thrombogenic agent in a 30-month study of 120 patients, divided into comparable control and treated groups of 60 each (*Hosp. Tribune*, **3** (15) 3, 1969). In extensive animal studies, chondroitin sulphate A (CSA) was found to clear up induced atherosclerotic lesions in animals or prevented development of atherosclerosis. The 60 treated patients were 44 women and 16 men with an average age of 65 years. 40 of them suffered from angina and 13 had one or more myocardial infarctions. They were given oral tablets of CSA, the daily dose ranging from an initial 10 grams to the currently employed 3.0 to 1.5 grams. The 60 control patients were 35 women and 25 men with an average age of 66 years; among them 39 suffered from angina and 15 had one or more myocardial infarction. At the end of the $2\frac{1}{2}$ year period of observation, 20 patients in the control group suffered cardiac episodes or myocardial ischemia. On the other hand, in the CSA-treated, matched group of 60 patients, only one patient with myocardial ischemia terminated in fatal myocardial infarction. The investigator believes that the CSA is a promising and specific anti-atherosclerotic therapeutic agent under current clinical investigation in coronary heart disease. Further, according to the investigator, acid mucopolysaccharides including CSA arise in the connective tissue of the arterial wall as a part of the first line of defense against the invasion of foreign or any noxious substance which can be harmful or challenging to the integrity of the arterial wall.

R.K. DATTA

Hydroxycholecalciferol and calcium transport

ABOUT 3 years back a highly biologically active vitamin D metabolite was discovered and later identified as 25-hydroxycholecalciferol (HCC) (*J. Lipid Res.*, 7,739 1966). This compound is more potent than vitamin D in curing rickets which results from the deficiency of vitamin D. One of the functions of vitamin D in the body is to increase calcium transport from the intestine. Among other properties, this new compound HCC is said to possess *in vivo* stimulating activity in respect of intestinal calcium transport and the transport is more rapid than with an equivalent amount of vitamin D (*Proc. Natl. Acad. Scis.*, **61**, 717, 1968). Recently, further evidence has been obtained in this respect by Drs. E.B. Olson and H.F. DeLuca of the Department of Biochemistry, University of Wisconsin, Madison (*Science*, **165**,405, 1969). In their experiments, the perfused small intestine of a vitamin D deficient rat transported only one-half of calcium compared to the intestine from a rat fed with vitamin D. The investigators introduced 2.5 micrograms of HCC *via* the arterial blood to vitamin D deficient intestine and observed a significant rise in calcium transport through the intestine. On the other hand, 250 micrograms of vitamin D given by the same route failed to exert any appreciable effect on the calcium transport through the intestine. Further work is under way to test the hypothesis whether vitamin D changes to HCC before it exerts its calcium-mobilizing and intestinal transport effect.

R.K. DATTA

About anaesthetics

IN olden days a patient had to undergo intense pain in amputation of an injured limb or during any other surgical operation. Patients were used to be tied to the table and the operations were performed with greatest possible speed. At present, however, the situation has much improved. A number of chemicals like nitrous oxide, ether, chloroform, procaine, etc., are now available for inducing "anaesthesia" in patients. When a person is under the effect of an anaesthetic, there is either complete loss of consciousness or a particular portion of the body is made senseless.

The pain-deadening effect of opium was known to the Chinese about 3000 B.C., and the Greeks knew about it by 400 B.C. The Incas of Peru had the experience of numbness of the tongue caused by chewing cocoa leaves and ether was known at the time of Renaissance. Paracelsus had also made a mention of it. Nitrous oxide was prepared by Priestley in 1772 and its properties were studied by Humphry Davy in 1800. But the use of any substance as an anaesthetic in the modern sense was not made till the middle of nineteenth century.

Nitrous oxide was first used as an anaesthetic by an American dentist, Horace Wells. In 1845 he per-

formed a number of painless extractions of teeth using this gas. He invited a number of medical students for a demonstration of his method in Boston, which was at that time the centre of medical education in the U.S.A. In 1846 Dr. William Morton gave another demonstration at the same place using ether as an anaesthetic in removing a neck tumour from a young patient. When the incision was made in the neck, the patient under anaesthesia did not groan or cry. When the tumour had been removed and the patient recovered consciouness he maintained that he had felt no pain. In 1847 Sir James Simpson introduced the use of chloroform as an anaesthetic.

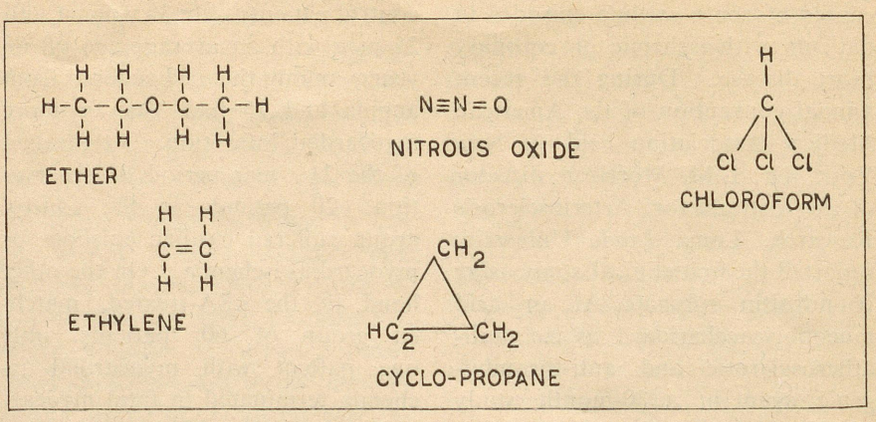
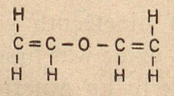


Figure 1

Earlier anaesthetics

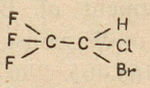
Anaesthetics manifest complete loss of consciousness by inhalation or injection. An ideal anaesthetic must be capable of producing deep anaesthesia, with no adverse effect on the body processes, and should be non-inflammable. If it is a liquid, it must be volatile. This means that its molecules must be relatively simple in structure. Some of the earlier volatile liquids and gaseous agents were in fact very simple (Fig. 1). However, these substances had many drawbacks as anaesthetics. A number of attempts were made to improve upon these by modifying their molecules. In 1930 Leake suggested combining the properties of ether and ethylene by forming an ether from ethylene. The result, divinyl ether, was found to have anaesthetic properties, but was inflammable.



DIVINYL ETHER

Another suggestion was to chlorinate ethylene and give it the properties of chloroform. The compound, trichloro ethylene was found to produce moderate anaesthesia. It was non-inflammable, but larger doses caused toxic effects. Thus, like chloroform, anaesthetics containing larger number of chlorine atoms were found to have toxic effects on the body. If, however, some chlorine atoms were replaced by fluorine, the compound became less toxic.

From ethane, a number of compounds were prepared containing chlorine, fluorine and bromine among which Halothane was shown to be a suitable anaesthetic. It caused deep anaesthesia, was non-toxic, non-inflammable, and volatile (B.P. 50°C).



HALOTHANE

Local anaesthetics

A substance which produces deadening effect on a selected part of the body is called a local anaesthetic. Cocaine is one of these substances, but is habit-forming. Attempts have been made to find substitutes which do not have this defect. Presently, some derivatives of para aminobenzoic acid (PABA) have replaced cocaine as a local anaesthetic (Fig 2). Of these, procaine is widely used, particularly in dentistry, mainly for its non-habit-forming property.

How do they work?

A number of theories have been put forward to explain the mechanism of anaesthetics. The first explanation was put forward by Overton in 1901 who suggested that for a substance to show anaesthetic activity it must be capable of dissolving in brain lipids. He found that as the ratio of solubility in oil: water increased, the anaesthetic activity of the substance also increased. This could, however, be only one of the various factors in action. In 1904 Traube suggested that the action of these substances may be due to surface-activity of some of the groups in these compounds.

The present views suggest that these substances interfere with the oxidation processes in the brain and with the transmission of impulses along the nerves. The normal functioning of the brain depends on the release of energy by the oxidation of glucose. If the

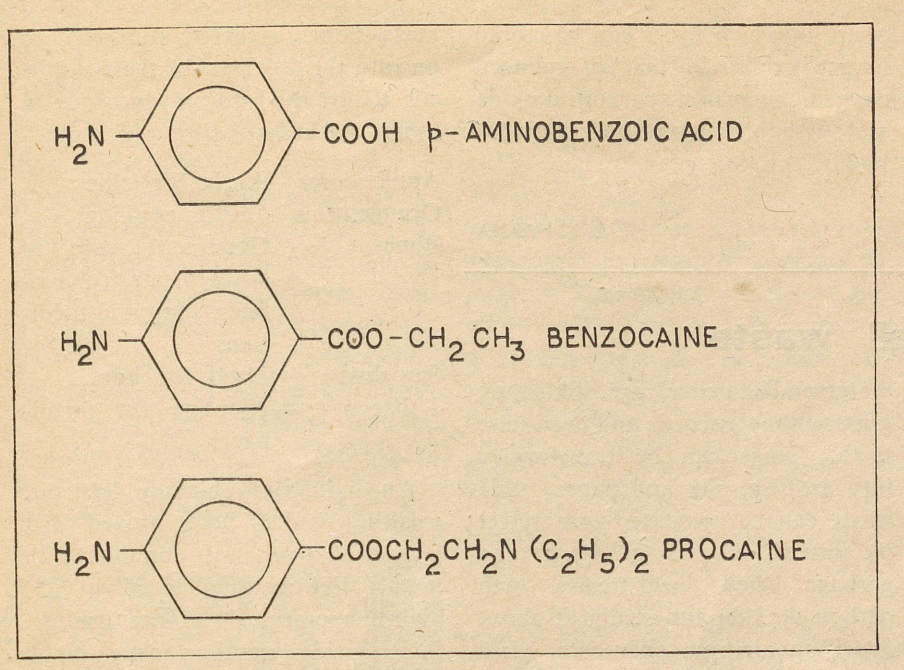


Figure 2

supply of oxygen or glucose is suddenly cut off, loss of consciousness results. The oxidation process, which takes place in a number of steps, involves a compound known as acetylcholine at one stage. It seems that many anaesthetics produce their effect by interfering with the action of this compound. This can be brought about either by preventing the formation of acetylcholine or by introducing a similar compound which would stop transmission of impulses along the nerves.

A.K. DHAR

Ethylene and fruit storage

SCIENTISTS F. Kid and C. West in 1933 while studying how unripened fruits ripe on storage in normal atmosphere, advanced the hypothesis that the 'ripening hormone' ethylene was responsible for this change. Later, with the advent of gas chromatographic technique it was established that ethylene was present in the intercellular spaces of fruit tissue. The presence of ethylene is, however, apparently detectable in some of the ripe fruits such as an apple. It is, in fact, a product and not a cause of the ripening process. The intercellular threshold concentration of ethylene in many fruits necessary to initiate ripening, has been observed to lie between .04-0.5 ppm.

The various factors constituting the complex process of ripening controlled by ethylene are: loss of chlorophyll, softening, colouring and sweetening. These changes are preceded by a rise in the rate of respiration (climacteric rise) which sets in a high metabolic activity in the fruit tissue. If somehow the climacteric and postclimacteric changes in the fruit could be delayed, it would be possible to extend their storage life.

Various theories and model systems have been advanced to explain the role of ethylene and other enzymes in ripening of fruits. According to one such model system (*Endeavour*, Jan., 1970) methionine, a precursor of ethylene, is found to be present in apple tissues along with copper salts and ascorbic acid. The other substrate noted to be present in tissues is linolenic acid. The former gives rise to ethylene alone, while the latter, to ethane and ethylene in equal quantites. Oxygen is necessary for these conversions to take place. Hydrogen peroxide is also formed when the cuprous ion, produced by reduction of cupric ion by ascorbate, is reoxidised by molecular oxygen. It is thus supposed that cuprous ion and hydrogen peroxide are the essential catalysts in the production of ethylene from methionine. The concentration of copper metal in the tissues is found to be of the order of 10^{-4} 10^{-5}M. This corresponds with the effective concentration of copper, required for ripening, in normal tissues.

Three enzymes, one of them transminase, are supposed to be involved in the conversion reaction. The transminase, which is found in mitochondria and microsomal parts of the cell, is believed to convert methionine to 4-methyl-mercapto-2-oxo butyric acid. This is reacted upon by glucoseoxidase which generates hydrogen peroxide and peroxidase, and utilizes hydrogen peroxide to produce ethylene from the oxo acid.

Now let us come to our problem. Can we delay ripening of fruits by control of ethylene formation? There is no doubt that the storage life of fruits can be extended if they are kept in an atmosphere of reduced oxygen; but in that case fruits are liable to be physiologically damaged. An atmosphere having

a higher ratio of carbon dioxide also retards ripening of fruits. It is presumed that carbon dioxide combines with those sites in the tissue which combine with ethylene for maturation. It can therefore be inferred that a suitable atmosphere in which fruits can be stored longer would be that of reduced oxygen, increased carbon dioxide and with a temperature range of 1°-25°C.

C.B. SHARMA

It is not all waste

MANY things, at one time regarded as complete waste, are now being used and turned into sources of useful materials. The words 'waste', 'rubbish' or 'junk' only mean useful matter in a place where it should not be. By this definition if we assume that everything that we throw away as 'waste' is useful, a situation might arise when we may run short of storing space and may have to dispense with really useful things in order to save the 'waste'.

Salvaging wealth from waste is a highly organised process. It is also technical to a large extent. For instance, separation of ferrous from non-ferrous material with the help of strong electromagnets can be quite complicated. The ferrous material separation process makes available, in the separator plants, articles like cans, knives, razor blades and other iron and steel bits thrown into the dustbin. They are then melted at very high temperatures and moulded anew into different shapes and useful items again. Similarly, removal of dust, dirt and light material with forced-draught method needs complicated ducting and control of draught speeds.

Processing of the garbage matter with forced-draught separates out materials like paper, rags, silk waste, gramophone records and even false teeth. Rags can be transformed into artificial silk and paper. Silk waste can be converted into velvet by suitable processing. Paper and garbage when heat-treated with carbon dioxide and steam at about 700°F in air-tight chambers, yield oil at the rate of one barrel per ton of garbage. This can then be converted into fuels and other valuable products.

If sewage is not to be regarded as a nuisance to the city dwellers it can be turned into a source of combustible gas, fit for domestic use. It will prove far more economical than any of the gases in use at present and yet will have the least offensive smell. This gas is basically methane. It is colourless, has a very hot flame, and can produce millions of calories of heat in one hour. This heat energy, if harnessed, can become a good source of electric power.

Dustbin garbage can yield synthetic materials costing thousands of rupees. One ton of garbage can produce twentyfive yards of heat-resistant weather-proof slab, as hard as a stone which can be used to layout road surfaces.

We, in everyday life throw away things like apple cores, orange peels, bones, cigarette stubs and so on into the dustbin. All these can be effectively used to produce useful things as the list below will show—

Apple cores—Pectin for jellies
Orange peels—Oil for cooking
Bones —Gelatine, used in sweet meats, chocolates, soap and medicines
Saw dust —Food for horses
Tobacco —Nicotine for fertilizers

An industrial chimney lets out wealth. It has been proved that industrial flue soot contains rare metals like gallium, used in TV high-temperature thermometers. Soot yields another costly metal called germanium. This is used in making transistors, and even medicines.

Coaltar is used to make dyes. For those who visit "Beauty parlours", it may come as a shock to know that most of the aids exhibited there are by-products of coaltar. For instance, perfumes like jasmine and orange blossom, are coaltar products.

Processing of waste oil, like spent engine oil and sedimentary sludge in tanks, has been done in India to give new usable oil again.

In the overall assessment nothing is a waste. How much of the so-called waste can be converted into useful matter depends on the ingenuity and resourcefulness of the technicians in a country. Let us hope that one day nothing will be thrown into a dustbin. The only industry to suffer then will be the garbage-dustbin industry!

PRAN NATH

Dr. Pauling receives Lenin peace prize

DR. Linus Carl Pauling, now Professor of Chemistry at Palo Alto's Stanford University, has been named to receive the Lenin Peace Prize for his outstanding contribution towards establishment of peace in the world. To the 69-year old much-crowned Dr. Pauling this is a laurel of different colour from the U.S.S.R. on the occasion of the birth centenary of Lenin. Previously, Dr. Pauling received the 1962 Nobel Prize for Peace. Prior to that he received the 1954 Nobel Prize in Chemistry. Besides Madam Curie, Dr. Pauling is the only scientist who received the Nobel Prize twice.

Dr. Pauling, who is also a Resident Professor at the Center of Democratic Institutes at Santa Barbara, California and is actively busy in fostering world peace, revealed the nature of chemical bonds that join atoms together to form both simple and complex molecules and provided precise quantitative information about the geometry of organic molecules and the structures of giant molecules of proteins. In recent years, Dr. Pauling has shifted his interest from physical chemistry to biochemistry and is making penetrating attack on the nature of life itself. He discovered that hereditary disease sickle cell anemia is due to abnormality in the molecular structure of hemoglobin.

Born on February 28, 1901 and the son of a druggist in Portland, Oregon, young Pauling became fascinated with the study of chemistry while he was still a boy. Entering college at the age of 16 he majored in chemistry and physics at Oregon State College. He did his research at California Institute of Technology (Ph.D. in 1925) and his post-doctoral studies in Munich, Zurich and Copenhagen. He was Professor of Chemistry at California Institute of Technology from 1931 to 1963.

R.K. DATTA

news & NOTES

Smoke density indicator

Indian Standard (IS: 4286-1967) states that there was a long standing need for a standard procedure by which domestic fuels could be tested to give a measure of their smoke emission characteristics. However, absence of any reliable method to measure smoke emission of domestic fuels created difficulties in declaring a fuel smokeless on a scientific basis.

At CFRI, a method as recently been developed which includes setting up of an apparatus for smoke emission measurement, arriving at an acceptable minimum level of smoke in a suitable scale, keeping in view of any future regulation on air pollution control, and a probe into the fundamental aspects of the chemical constitution of fuels and its relation to smoke emission.

The apparatus set-up recently at CFRI employs a technique of burning a few gms. of coal in a furnace and letting the smoke into a horizontal pipe through which a beam of light travels. At one end of this pipe is placed the source of light and on the other end, a photo-electric cell. Thus the smoke pipe serves as an absorption tube. Depending on the density of the smoke, intensity of the light beam varies and in turn falls on the light-sensitive surface of the photo-electric cell. This variation is indicated on a galvanometer scale calibrated from zero to 100. The zero reading corresponds to full light intensity (i.e. no smoke) and 100 reading to zero light intensity. By directly reading from the scale against time it is possible to calculate 'smokiness' of a fuel in terms of 'smoke index' numbers. The smoke index number of anthracite is taken as zero. On this scale the fuels having an index below 400 can be regarded as smokeless in a domestic oven.

Results from the burning performances of different fuels have shown that smoke index number decreases as the rank of the coal increases or the volatile matter decreases.

Dr. Handler receives scientific achievement award

DR. Philip Handler, a distinguished biochemist whose research has focussed on niacin and choline deficiency, renal mechanisms and hypertension, biological oxidations and the actions of enzymes, has recently received the American Medical Association's Scientific Achievement Award for 1969.

Dr. Handler, who recently became president of the U.S. National Academy of Sciences, the highest scientific body of the U.S.A. (since July 1, 1969) is the James B. Duke Professor of Biochemistry and Chairman of the Department of Biochemistry at Duke University, Durham, North Carolina, with which he has been associated for the last 30 years. He has been a chairman of the biochemistry study section of the National Institute of Health, an advisor to the National Science Foundation, a consultant to the Veteran Administration and a member of the President's Commission on heart disease, cancer and stroke.

Born on August 13, 1917 in New York City, Handler received his education at the City College of New York and at the University of Illinois. He worked as a chemist for the U.S. Department of Agriculture from 1937-1939 before going to Duke University as an instructor.

R.K. DATTA

Dr. Watson establishes Tumour virus research center

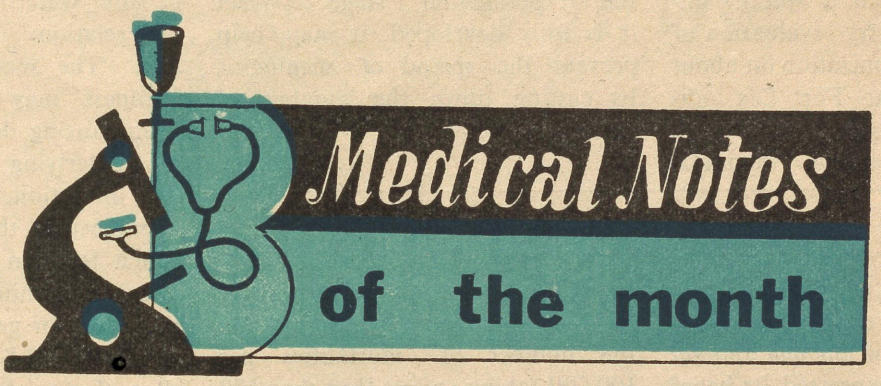
THE U.S. National Cancer Institute has recently made a 5-year $ 1.6 million grant to Nobel laureate Dr. James Dewey Watson towards the establishment of a tumour virus research center at Cold Spring Habour Laboratory of Quantitative Biology in Long Island, New York. Dr. Watson, who is the director of the Laboratory will initiate studies on genetic and biochemical aspects of tumour viruses SV-40 and polyoms, which contain DNA and cause tumours in animals, Synthesis of viral specific DNA, RNA and protein will be a subject of investigation there.

Dr. Watson, who elucidated (with Dr. F.C. Crick) the double helical structure of DNA and the role of RNA in protein synthesis, was born on April 6, 1928 and educated in the University of Chicago (1947). He received his Ph.D. degree from Indiana University in 1950. He carried out research at the University of Copenhagen (1950-51), in Cavendish Laboratory of Cambridge University (1951-53; later 1955-56) and in California Institute of Technology (1953-55). He joined the Faculty of Harvard University in 1956 and became its Professor of Biology in 1961. Since 1968 Dr. Watson is concurrently the Director of the Cold Spring Harbour Laboratory of Quantitative Biology of which he is a trustee since 1965. He received Lasker Prize (1960), Eli Pilly Award in Biochemistry (1959) and Nobel Prize in Medicine and Physiology (with Drs. Crick and Wilkins)(1962). He authored two books, *Molecular Biology of Genes* (1965) and *Double Helix* (1968). In the latter book Dr. Watson drew a candid self-portrait and wrote a fascinating story of events that led to the elucidation of the helical structure of DNA, one of the greatest biological discoveries of our time since Mendel's law of heredity.

R.K. DATTA

SPECIAL NUMBER

The September 1970 issue of SCIENCE REPORTER will be a special number on "Technology in the Seventies" incorporating the papers presented at a two-day symposium organised by the SCIENCE REPORTER FORUM of the CSIR recently. The papers, contributed by eminent scientists, technologists, industrialists and journalists bring out the problems, prospects and possibilities of Technology in the Seventies, with special reference to India.



Breast cancer and the atom bomb

Mrs. C.K. Wanebo, K.T. Johnson, K. Sato and T.W. Thoralund of the Atomic Bomb Casualty Commission, Hiroshima and Nagasaki, Japan, and the Department of Public Health, Cornell University Medical College, New York published information on breast cancer among survivors of the atomic bombings indicating a fairly defiite carcinogenic effect of exposure in these two cities (*New Eng. J. Med.*, 279, 668, 1968). According to their findings, in women exposed to 90 rads or more of radiation, breast cancer developoled at a rate two to four times the rates observed in the comparison group of the study sample. Moreover, the onset of breast cancer relatively early in life, before menopause, distinguished the exposed (irradiated) women from the control group. The study sample included 12003 female survivors and other carefully chosen from among residents of Hiroshima and Nagasaki in 1950 and they were periodically examined biennially by the physicians who were unaware of the subject's status regarding exposure to atomic radiation. The association between radiation exposure and breast tumours in women as revealed in the above study agrees well with Dr. I. Mackenzie's suggestion that the incidence of breast tumours was increased by extensive fluoroscopic examinations (*Brit. J. Cancer*, 19, 1, 1965). It may be mentioned in this connection that there are some cytogenetic changes due to maternal exposure in those who were in the second and third trimesters of gestation at the time of the bombings in Hiroshima and Nagasaki (*S.R.*, 6,7 375, 1969).

BHAKTI DATTA

Meningitis vaccine developed

THE U.S. Army finds about 300 to 500 cases of meningococcal meningitis per year with a mortality rate of about 10%. There are about 3000 cases each year among the U.S. civilian population, accompanied by a 25-30% mortality rate. In other countries the incidence and mortality rates are higher. Previously, sulfa drugs were highly effective in the treatment of meningococcal meningitis. Of late, the causative bacteria have become resistant to to sulfa drugs and the U.S. army researchers are now trying to develop a vaccine by isolating an antigenic component of the bacteria—their polysaccharide capsule. Dr. Emil C. Gotschlich used a detergent (Cetavlon) to precipitate the polysaccharide. Some 150 soldiers at Fort Dix were given the experimental vaccine and remainder 450 were observed as controls. Two

weeks later all but two in the vaccinated group had developed antibodies. By other tests over the next six weeks it was found that this vaccination induced a specific immunity. Preliminary evaluation of the results of immunization on about 600 volunteers at Fort Dix indicated that the vaccine nearly halved the carrier rate among immunized soldiers (*Med. World News*, May 23, 1969). Though the vaccine seems safe and seems to reduce the carrier rate, the vaccine is still in the experimental stage. When it is fully developed, it may help prevent the spread of meningitis by cutting down the number of carriers.

R.K. DATTA

Hardness of water and low death rate

A Toronto team of Medical Scientists in their report published recently in *The New England Journal of Medicine* has expressed its belief that ischemic or coronary heart disease may have a linear relation to the hardness, or softness of water consumed by the patients. On analysing 55,000 cases of people who died in the province of Ontario in 1967 and also the hardness of the local water supply, they observed that the number of mortalities per 100,000 taking softest (less than 100 ppm), medium hard (100-200 ppm) and hardest water (above 200 ppm) was 416, 310 and 365 respectively. Similarly, the death rate due to coronary diseases was higher in soft water-taking patients than in those taking medium-hard and hard water. The scientists are still not certain whether anything present in hard water or absent in soft water, is responsible for this relation. They, however, feel that "The main effect of water hardness may be on the mechanism causing death rather than on the underlying process of myocardial infraction." It has also been hypothesised that the soft water which is often slightly acidic may dissolve cadmium—an impurity in zinc used for galvanising pipes— in quantities 2-8 times the limit allowed for human consumption (i.e., about 10 micrograms per litre). Rats injected with this quantity of cadmium show hypertension.

C.B. SHARMA

science for the YOUNG

Science quiz

1. An artificial satellite is traversing a circular circumterrestrial orbit. Where would it go if it brisks up its pace to—,

   (a) 7 miles per second, or
   (b) 26 miles per second.
   (c) At what speed the satellite was travelling previously?

2. "The sun rises at dawn, reaches the zenith at midday and moving downwards eventually sets in the west". Do you think this statement is correct?

3. Which of the following shapes can be attributed to earth?

   (a) Sphere.
   (b) Spheroid.
   (c) Geoid.

4. Cyclotron, the device whereby particles with comparatively high speeds can be obtained, was invented by

   (a) Prof. W. Röntgen and Sir J.J. Thomson.
   (b) Bunsen and Kirchoff.
   (c) Lawrence and Livingston.

5. Total reserves of iron in the world are reckoned at

   (a) 3,000 million tonnes.
   (b) 129,000 million tonnes.
   (c) 32 million million tonnes.

6. A metal constitutes about 1/20th of the earth's crust in combination with the most abundant element present in the latter. The amount of the metal present in the human body exceeds that of others. An insufficient intake of it yields pronounced effects in children. The metal is present in adequate amounts in green leafy vegetables, cereals, milk, etc., and in minute quantities in rice. Can you name it?

7. The laws of heredity were propounded by

   (a) The reputed Dutch merchant, Leeuwenhoek.
   (b) The celebrated Austrian monk, Mendel.
   (c) None of the above persons.

8. Linnaeus is famous due to the fact, that

   (a) He bestowed us with a method of taxonomy.
   (b) Gave us the theory of organic evolution.
   (c) Performed outstanding research on microbes.

9. It takes approximately 4.3 years for light to reach the sun from the nearest star, *Alpha centauri*. How distant is the star from the sun in kilometres?

   (Time limit—30 secs.)

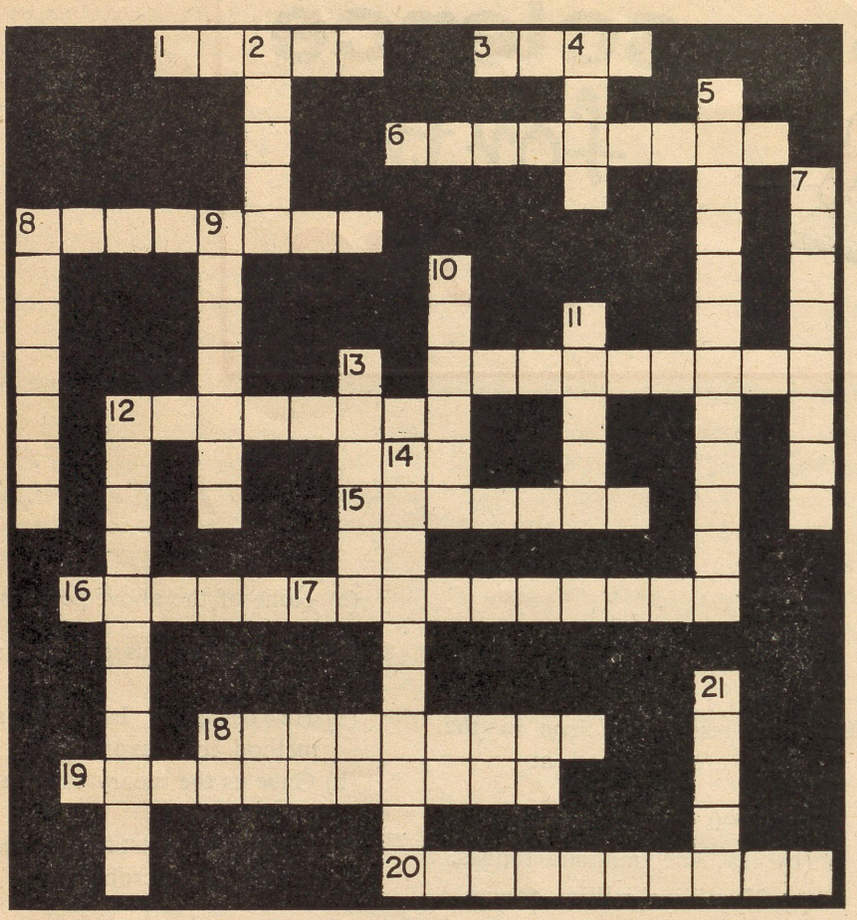
10. The old gentleman was very proud of his purse, but justful. He had a big bank balance of Rs. 462359876X (X representing a digit of the number). He divided this among 18 individuals so that each received an equal amount in rupees (no fraction was involved.) What was actually the sum he had? (division not allowed)

    (Time limit—30 seconds)

V.K. KHANNA

(*Answers in next regular issue*)

SCIENCE CROSSWORD PUZZLE (SCIENTISTS)



CLUES

Across

1. An internationally renowned Indian crystallographer who is at present director of one of the national laboratories.

3. The Indian botanist who first proved that plants have life.

6. A famous organic chemist who is also a Fellow of the Royal Society of London.

8. The Indian born American scientist who won the Nobel Prize for medicine in 1968.

12. Indian scientist who is at present the Chairman of the Atomic Energy Commission of India.

15. A great ancient Indian algebraist.

16. A renowned Indian scientist who pioneered ionospheric research.

17. An ancient Indian who is considered an authority on alchemy.

18. An internationally famous Indian mathematician who was a Fellow of the Royal Society of London.

19. The ancient physician who was believed to possess the power of curing all types of illnesses.

20. An internationally famous Indian botanist who died a few years back. He was recipient of the Birbal Sahni Memorial Medal presented by the Indian Botanical Society.

Down

2. The Indian physicist who has won a Nobel Prize in physics.

4. An Indian astrophysicist famous for his theory of ionisation of gases in space.

5. The Indian mathematician who gave 'Zero' its status.

8. A famous Indian astrophysicist who first proved that atoms can be ionised by the application of pressure alone.

9. A famous ceramic technologist, now Director General of a large research organization.

10. An ancient astronomer who is taken to be the propounder of the theory of creation of the universe.

11. An Indian who is said to be the enumerator of constellations.

12. Scientist, who is at present the Director of Indian Agricultural Research Institute.

13. The famous Indian nuclear physicist who died in an air crash in 1964.

14. The former scientific advisor to Ministry of Defence, Govt. of India.

21. An ancient Indian scientist considered to be an authority on ship-building.

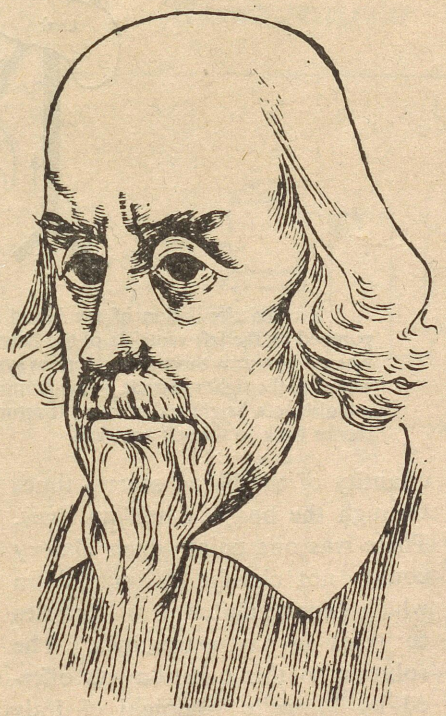
B.L. ARORA

William Harvey
(1578-1657)

WHEN a physician examines a patient the first thing he does is to feel the patient's pulse. An expert can diagnose diseases from minute variations in the pulse rate. Pulse is an echo of the heart-beat. This important diagnostic tool was made possible with the discovery of blood circulation by William Harvey in 1616.

Galenic theory

Notions about blood were formulated by Galen, a Greek physician, who lived more than twenty centuries ago. According to Galen's theory, food migrated from the stomach to the liver where it was converted to venous blood, wherefrom it was distributed throughout the body, including the heart. In other words, the role of heart was unknown. According to the Galenic scheme blood flowed through veins and arteries to different parts of the body and after supplying nourishment, it simply disappeared. There was absolutely no knowledge of the continuous blood circulation. These erroneous beliefs survived unchallenged for 15 centuries because physicians were not allowed to dissect cadavers, though the rulers of the day did not hesitate to throw gladiators to lions and burn people at the stake ! However, 14th century saw some relaxation and postmortems were allowed on bodies of criminals and paupers. As a result, the first challenge to the Galenic theory was made in 1555 by Vasalius and Febricius of Padua. They discovered that veins possessed valves, which they called "Little Doors" and that blood flowed from the right side of the heart through pulmonary artery to lungs and then back to the left



side of the heart through pulmonary vein.

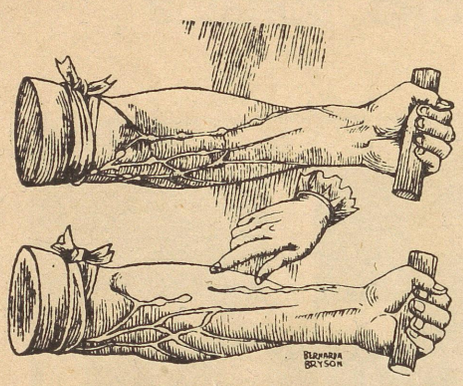
Early life

It was at this time that Harvey came into the picture. He was born in an yeoman family at Folkestone in 1578 during the reign of Elizebeth I. He was an eccentric; in young days he wore a dagger after the fashion of the day. He was wont to draw it on the slightest provocation. During the Civil War he was in charge of the young Prince of Wales. When the battle was raging, he sat under a hedge and read a book; but his precious collection of papers could not escape the ravages of the rioters. They destroyed all his manuscripts. No grief was greater to him than the loss of his papers.

He set up practice as a doctor in the year Spanish *Armada* marched against England. He was a contemporary of Shakespeare, Galileo, Kepler and Descartes. Not much is known about his private life except that he had married at the age of 26 and had no children. He graduated from the University of Cambridge in 1597 and took his medical degree from the University of Padua where Galileo had worked. Harvey returned from Padua to England in 1602. He must have been a popular doctor because the Royal College of Physicians offered him the post of Lumleian Lecturer. In 1616 he delivered his first lecture on the circulation of blood.

Theory of blood circulation

Following the trail of Fabricius' discovery of valves in veins (Fabricius was his teacher at Padua), Harvey felt strongly that the valves had been provided by nature for

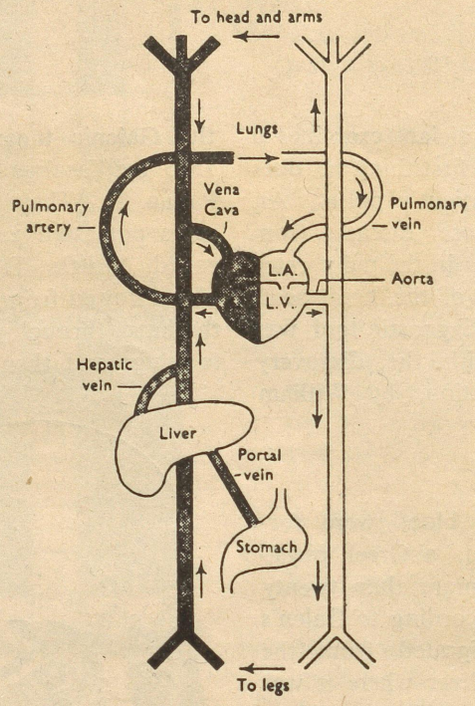


something. He was convinced that blood circulated through the body, and heart was its pumping motor. It is now realized that this tiny pump develops 1/2 horse power and continuously circulates 15 lbs of fluid through miles long blood vessels. No 1/2 horse power machine could do the job without the aid of unidirectional valves. Harvey experimentally proved that the "little doors" of Fabricius' were nature's aiding valves. Twelve years later, he published the *De Motu Cordis*, a small book of 17 chapters (72 pages) dealing with all aspects of circulation. It was written more with the hope of dispelling the ridicule hurled at him by his colleagues, the blind adherents of the Galenic system. The fact of his being physician to King Charles I and a great friend of the President of the Royal College did not save him from the ostracism of his colleagues in the medical faculty who treated him as a "quack".

The gist of his theory can be summarised as follows: (i) heart pumps blood from veins to arteries, all in a short time, (ii) the blood flowing to the extremities is much more in quantity than what is required for nutrition, and (iii) blood continously returns to the heart through the veins. Harvey was the first to carry out quantitative measurements of pumping rate of the heart and the total quantity of blood in circulation. It should be admitted that his results were absurd and wide of the mark. But faulty calculations did not hinder him from proving his main point, namely, that heart circulates the total quantity of the blood several times through the body in half an hour. There was one point which Harvey could not clarify: the manner in which blood shifted from arteries to veins in the extremities. The solution to this question was offered by Marcello Malpighi of Italy who discovered capillaries as the link between arteries and veins. Capillaries in one cubic inch of flesh, if placed end to end, would be enough to cover a distance of 2-3 miles. The phenomenon of circulation was completed by the discovery of capillaries.

Support from Descartes

When everyone was deriding Harvey as a quack, he received a strong support from the continent, from no less a person than the renowned mathematician Descartes. Though a man of different discipline, Descartes had personally studied physiology by visiting a butcher's shop and was convinced that blood *did* circulate.



The circulation of the blood as discovered by Harvey. The blood is pumped by the left ventricle of the heart through the arterial system (unshaded) whence it returns through the venous system (shaded) to the right auricle. It then passes to the right ventricle which pumps it to the lungs, where it is changed from a bluish to a bright red colour. It returns from the lungs to the left auricle and thence back to the left ventricle.

P. B. JANARDHAN

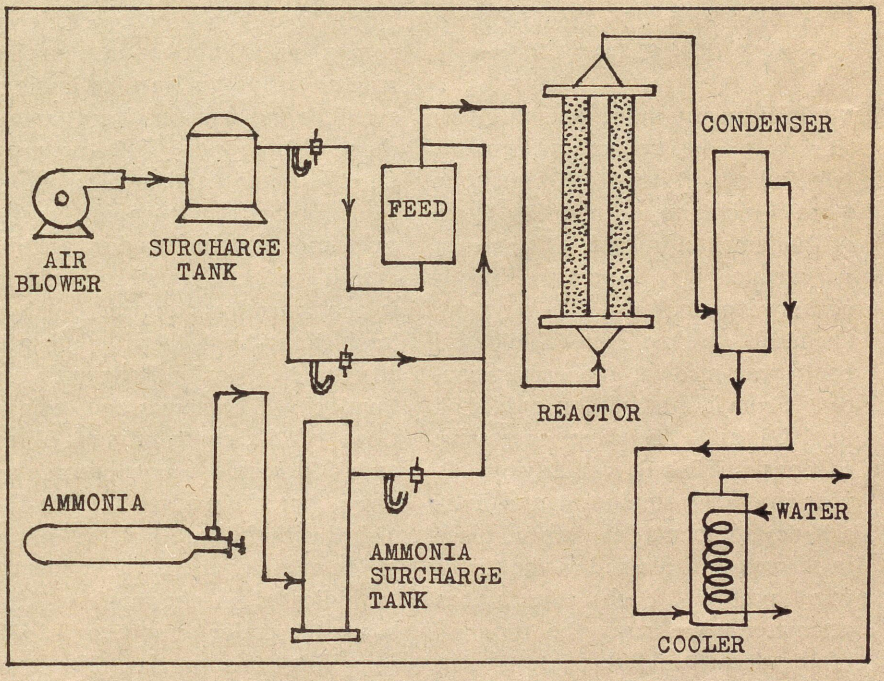
Biman Basu

PLASTICS, solvents and various resins form a sizable portion of the organic chemicals industry today. And as a raw material benzene and its derivatives play a major role. One such is benzonitrile or cyanobenzene.

Due to the presence of the cyano (CN) group benzonitrile can undergo a variety of addition and substitution reactions and thus is capable of yielding a host of organic compounds. Benzonitrile can be hydrolysed to benzoic acid or sodium benzoate, of which the former is in great demand in the pharmaceutical, plastics, dyestuff and other industries, while the latter finds use as a preservative for foodstuffs. The nitrile can also be converted into benzaldehyde required for cosmetics, perfumery and medicinal purposes.

Benzonitrile constitutes an important raw material in the production of benzoguanamine which is used in the manufacture of benzoguanamine resins. The resins find extensive use in the manufacture of laminates, moulded plasticware and hard, wear-resistant surface coatings. Benzoguanamine-formaldehyde resins have been found to possess better physical stability as compared to other similar products.

Benzonitrile from toluene



Flow diagram for the production of benzonitrile from toluene

Benzonitrile can be prepared by various processes, but most of them involve the use of expensive chemicals. Recently, a process for the

(*Continued on page 461*)

VAN NOSTRAND'S SCIENTIFIC ENCYCLOPAEDIA, *D. Van Nostrands Co.*, Princeton, New Jersey, USA, Pp. 2018, 22 x 31cm, Fourth Edition, £ 18 ($42.75)

THIS huge volume weighing well over 4 kg, defines and explains two-and-a-half million scientific words including over 16,500 terms of fundamental interest. The range is cornucopian, especially since it covers explanations in physical, chemical, technological, biological zoological, medical and earth sciences. From its first edition published in 1938 and the three successive editions published regularly at 10-year intervals, significant and massive developments have taken place in science as explained in the three-page preface. Each edition has attempted to portray the progress of the decade and this latest work indeed forms a cornerstone for enlightened readers, be they scientists or laymen.

In any encyclopaedia, certain limitations are bound to exist by virtue of its very nature of presentation of matter. Thus some articles are extensively dealt with and are well explained while others are very brief. Topics on atmospheric regions, boiler and boiler efficiency, computers, lubrication, nuclear reactor and nuclear technology, satellites and spacecraft are among those which receive full treatment. On the other hand nuclear explosions for peaceful purposes, cosmic rays and neutrino studies are discussed briefly. Very strangely, there is no mention anywhere about 'architecture', 'abacus', 'inflatable structures', 'wenkel engine', and 'nuplex'. The names and designations of 42 contributing editors and 6 deceased contributors are given, but the readers are not furnished with the names of the editors of the encyclopaedia who evidently, as indicated in the preface, have borne the major responsibilities in compiling this work. The only name mentioned is that of William R. Minrath who, now retired, acted as General Editor since the inception.

All items are well cross-linked and the definitions and explanations throughout are authoritative and up-to-date. The 16 full colour plates like those on blood cell grouping, liquid hydrogen bubble chamber, laser illumination of a hologram, the docking of Gemini 6, and a fantastic view of a 50 mw laser beam taken from a distance of 25 miles, vividly bring to the reader the achievements of modern science. In trying to cover all the sciences in one volume, the encyclopaedia has become physically and financially very heavy. At this rate it may become completely unwieldy with the next edition. This reviewer is of the opinion that the time has now come to publish the work in two volumes—one dealing with the physical sciences including engineering and technology, and the other with life sciences including medicine, zoology, biology and botany. This would reduce the weight of each volume and in turn the cost, and would enable more material to be packed in its pages. As it stands, the 4th Edition, except for some minor drawbacks is a very colossal work of scientific scholarship which should be in the hands of all scientists and engi-