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Summaries of Sectional Presidential Addresses

Engineering Sciences

Water resources management—Its needs and means

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The need for maximising the utilisation of water is gaining momentum with the ever increasing demand for an improvement in the standard of living. The following information may be interesting in respect of water availability. In the global context only 3% of the total available water belongs to the fresh category, the balance forming the oceans. Again 75% of the fresh water is permanently trapped in the glaciers and ice sheets. This means that hardly 1% of this resource is available for its innumerable uses.

Engineers have been engrossed in the fascinating task of harnessing water resources for the benefit of the mankind. The success and failure in the sphere of water resources management largely determine the economic progress and well being of any community. It is unfortunate that in our country the management of this resource has not come up to the expectation.

Water resources management problem has become very complex. Achievements brought about in the field of storage technology have helped in lessening the problems of maldistribution of useable water resources.

In our country, the prevalence of monsoon climate over the major parts of its territories, causes concentrated precipitation during only a few months of the year. The temporal and spatial distribution of precipitation have added to the complexities of the problem of management. Because of the unpredictability in the advent, duration and intensity of rainfall there is a continuing problem of adjusting the agricultural system with the monsoon. Notwithstanding, a colossal investment on major, medium and minor irrigation projects, there has been a gap between expectation and achievements. This is evident from the fact that the average national paddy yield in China has exceeded 3 tonnes per hectare as against the Indian average of 1.7 tonnes. Recent studies by the centre for science and environment, New Delhi, show that the Indian target could be about 5 tonnes per hectare. As against this low yield, the amount of water utilised is exceedingly high. Of the total quantity of water released from the reservoir, only about 70% reaches the field. Even this quantity is not always utilised efficiently.

The objective of water resources management is to match the temporal and spatial distribution of supplies and demands by increasing the supplies or minimising the demands or by both. The system approach to the management problem with the help of computer analysis can be of immense help in this regard. Further, data base generated by 'remote sensing' technique can play a very important role. The above technique however may not be effective without participation of the consumer at the level of decision making. The experience of South East Asia and China, as well as of some other countries clearly indicates the great difference that the associations of beneficiaries and communers have been able to make in the realm of productivity. All the important users of water are to be identified and their interlinking due to interdependence of withdrawals is to be considered in the management. The water management plan should take into consideration the effects of water on land. The relationship between water and land is like that of flesh and blood. Unfortunately, most often than not management of water resources in our country has been divorced from the land factor.

During the course of last few decades the requirements for fresh water have increased manifold and in many cases the surface water supply can hardly meet the demand. Of the other alternative sources, ground water can serve as a major source. Ground water provides a replenishable reserve and should be used in conjunction with surface water.

A water resource belongs to some natural echo system which includes a set of links. Water resources development projects tend to disturb the links as they existed previously. If the disturbances exceed certain limits, the system stability disintegrates. So water resource projects should not only be technically and economically sound but should also be environmentally acceptable.

Water management system embraces almost the entire spectrum of human life and activities. Therefore, it should be the duty of the engineers and scientists engaged in water resource management system to consider all the relevant parameters by exposing them to various disciplines of science.

Physics

Physics and Microwaves by Prof. G. P. Srivastava, *Former Head of the Department of Physics & Astrophysics, University of Delhi, Delhi 110 007.*

To a common man the word 'Microwaves' is synonymous to Radar. Though it is the most important application, it is not the only application which has made impact in Science. Of course the development of Radar during the second world war was the main incentive for development of 'microwave-technique'. On technical side the applications are in Radio Navigation, relay links, multichannel transmission of telephones, telegraph and television signals. From the point of view of radio communication great advantage of microwaves is due to 'spaceousness' of useful frequencies. The microwave frequency space is about 100 times the combined frequency space of present day radio broadcasting communication and television.

Another advantage of microwave is due to its high directivity and resolving power. Antennas of physically convenient size can readily generate narrow microwave beams. Higher frequencies perhaps cannot be subjected to such manipulations as frequency modulation and electronic control.

The applications which I propose to emphasise lie in the field of basic fundamental research. Microwave spectroscopy has become an established branch of science. Besides its application to the determination of molecular structure, it has found application in the field of electron paramagnetic resonance; though nuclear magnetic resonance studies are not carried out at microwave frequencies, it may also be called an offshoot of microwave spectroscopy.

Microwave spectroscopy deals with detection and interpretation of rotational transitions occurring in the molecules in microwave and millimetre frequency regions. As mentioned above this information is used for very accurate structural determinations. The structure determined by this technique is at least ten times more accurate than the spectroscopic techniques though the microwave spectroscopy suffers from the drawback that it is essentially a gas phase spectroscopy and cannot be applied to studies of non-polar molecules. In the past few years it has received tremendous boost because of the availability of high frequency microwave source and also because of tremendous progress that has been made in microwave circuits. The sphere of microwave spectroscopy has been expanding steadily from the laboratory investigations to the exploration of interstellar space, indicating the diversity of microwave spectroscopy. The linewidth involved are very narrow limited by only doppler and saturation broadening. Besides the accurate determination of structure, it can also be used for the determination of dipole moment, barrier to internal rotations and rotational isomerism. Microwave spectroscopy provides the most accurate method by which one can detect unambiguously, the presence of rotational isomers. The effect of centrifugal distortion, which creates a major hinderance in the analysis of rotational spectra of molecules, can be anticipated and analysed. The centrifugal distortion analysis of nearly symmetric top molecules has evolved a tremendous amount of interest these days. In recent years low resolution microwave spectroscopy (LRMW) has proved to be an efficient tool for conformational studies. It gives direct evidence of different conformers present in molecules. The inter-molecular studies can be carried out by studying molecular vibrations. Proper interpretation of vibrational frequencies is also possible.

Microwave spectroscopy has been applied for studies of hydrogen-bonded molecules. To produce a pure rotational spectrum, a molecule must have dipole moment; therefore symmetrical dimers cannot be studied. The only possibility is an unsymmetrical dimer. The alternative is to combine two different molecules through H bonds to give a polar species. In such a system there is equilibrium mixture of mixed dimers, two dimers and monomer species. Both the dimers and bimolecules are formed by bimolecular reactions described by the equations:

$$A-H+B \quad A-H \text{ —— } B$$

$$K_{12}=\frac{[A-H \text{ —— } B]}{[A-H]\,[B]}$$

K_{12} is the association constant and the square brackets denote the pressure of the constituents with a stark effect spectrometer; operation is normally limited to pressure below 200/, because a very broad line makes it impossible to displace the stark lobes from the line to produce the stark modulation spectra. The concentration of these mixed dimers at low pressures is proportional to the square of pressure and the necessity of working at a relatively low pressure is of serious disadvantage.

When a static magnetic field is applied to ferromagnetic material the magnetisation vector begins to process around the direction of magnetic field. If it is subjected to r.f. field in the direction perpendicular to d.c. magnetic field, heavy absorption of microwaves

takes place if the frequency of applied r.f. field is equal to the larmar frequency. This phenomenon is called ferromagnetic resonance. Londau and Lifshitz had predicted such a type of resonance in Ni at microwave frequencies. The proper understanding of FMR began after Kittel's analysis of this phenomenon who demonstrated the role of demagnetising field in determining the resonance condition.

In recent years, a considerable attention has been paid to the problem of propagation of microwaves through semi-conductors subjected to an external steady magnetic field. The electro-magnetic field, propagating through semiconductor shows many interesting phenomena such as Faraday effect, Voigt effect, Magneto absorption effect and Magneto Kerr effect. These effects have been shown to the powerful tools for investigation of transport properties of semiconductors.

From physics point of view interesting investigations are being carried out on the studies of tropospheric microwave propagation from inhomogeneties in tropospheric refractive index. The scattering occurs mainly due to 'eddies' and 'blops' formed in the troposphere due to turbulance of the air. Lots of theoretical investigations have also been carried by Booker and Gordon.

Chemistry

Chelating agents by Prof. Samir K. Banerji, *Professor of Chemistry, Birla Institute of Technology & Science, Pilani 333031.*

Part I:

1) *Hydroxy anthraquinone dyes*, which have found wide application in inorganic analysis at colorimetric reagent. This has been represented by Alizarin, Quinalizarin and Quinalizarine sulphonates. These form a lake in alcoholic solution.

2) *Hydroxy triphenyl methano group* is the second group which are well known for their interesting property of forming coloured products, with inorganic ions. This property has been extensively used in the field of inorganic analysis.

3) *8-hydroxy quinolines*: This is the third group which has been studied 5-chloro, 7-chloro, 5-7-dichloro-8-quinolinol and similar derivatives has been synthesized. Those compounds were found to have a great ability to precipitate metal ions from aqueous solutions.

4) *Substituted 8-hydroxy quinolines*: Many of which have been fully investigated. The composition, stability and thermodynamic functions of several complexes with metals have been reported.

5) *Phenolic ligands*: Four of the important and more versatile phenolic ligands which have been studied extensively are, 1,8-dihydroxy naphthalono, 1-nitroso-2-naphthaol-3, 6-disulphonic acid, 1,8-dihydroxy naphthalene, 3,6-disulphenic acid and 8-naphthol-3, 6-disulphonic acid.

6) *Azo dyes*: The donar properties of this group of dyes are known to be weak. It has however been found that if there is a suitable group in the ortho position, the compound becomes favourable to chelate formation. Of these PAN has proved to be most versatile. The composition, stability, thermodynamic functions and structures of a large number of metal chelates have been studied and reported.

7) *Metallochromic indicators*: Methyl thymol blue, first prepared by Korbl and Pribil (1958) has since been very well investigated. The composition, stability and thermodynamic functions of a large number of metal ions have been reported.

8) *Substituted thioureas*: Amongst the various sulphur donar ligands, thioureas have possibly the greatest potential and have therefore been most extensively studied. The synthesis and physicochemical characteristics of a large number of *N*-2(5-chloro substituted pyridyl)-*N'*-substituted and their metal complexes have been reported. Considerable amount of work has been done and reported on the applications of substituted thioureas. Complexes of substituted thioureas have been used in the fabrication of thin film solar cells.

9) *Waste management*: Waste management encompases comprehensively aspects of waste treatment, disposal, recovery of valuables and pollution problems. Work has been going on the following lines: (a) Ion-exchange methods, (b) Complexation followed by precipitation, (c) Selective precipitation, (d) Solvent extraction processes, (e) Some unconventional methods.

Work is in progress, modifying, adapting and finalizing earlier work in terms of constant techno economic survey and industrial viability of processes found chemically viable.

Part II:
Crisis in Tertiary Education and Research in Chemistry. Frankly speaking it is felt by many that the educators do not appear to be enough concerned about this crisis. It is primarily, the universities that are engaged in the task of training scientific manpower for the nation, and how can we have quality science, when these are in doldrums. With parents financing the expenses of their wards at the universities, the input material of the universities is largely, not only "unmotivated" but "antimotivated". Thus the major component of higher education cannot produce quality.

The second component of education – the faculty – finding that good teaching and research seldom gets recognition at these centres of higher learning, join the band of "manipulators" and "teacher politicians" who rule the roost. Thus "studentship" of the faculty makes its exit and academics takes a back seat. Thus the two main components of higher education becomes "negatively" motivated.

We now examine, the third component—course material. Small tinkerings of the course material goes by the name of updating of courses. These coupled with the drab, meaningless and repetitive laboratory courses completely benumbs, whatever little interest and initiative, the student has. Nowhere, perhaps, the axiom—"Mediocrity feels secure only when it takes refuge in tradition", gets best illustrated, than this.

To make matters worse, the process of a final and irrevocable judgement on the basis of one end-of-the-term examination appears to have only promoted the development and ramification of the "technology of copying".

If we now look at research as it is practiced, it will be apparent that it is being persued with the only aim to producing a doctoral dissertation. It is more often than not, "wholly" unconnected with life's problems and is usually "repetitive" in nature—often an extrapolation of the guides work. I firmly believe that, in a poor country, like ours, we can ill-afford this luxury.

It has been more recently observed that there prevails a certain amount of pessimism amongst the chemists. Since the front edge of the amount of pessimism amongst the chemists. Since the front edge of the discipline—physical chemistry is full of operators who are physicists, by training, thinly disguised as chemists; the full back-organic chemistry is being increasingly pulled into biology and biochemistry and the thin wraith – inorganic chemistry – one does not know what it means today.

The cause for pessimism disappears if we change and extend our activities, particularly, research to Chemical Science, getting out of the rigid orthodoxies, which have little relevance today as life's problems are always multidisciplinary. It is time that the chemists did some hard thinking on these lines, to make chemistry a useful profession, commanding the respect of the nation.

Geology and Geography

Hard Rock Hydrogeology in Indian Scenario by Dr. P. G. Adyalkar, *Director, Central Groundwater Board, Calcutta 700 016.*

Groundwater is the subsurface manifestation of water with which it is interchangeable, and the study of it in all facets constitutes Hydrogeology. Alluvial Hydrogeology is the first thing that comes to our notice after seeing the alluvium in the rivers, lakes and reservoirs. Rocks with a hardness of over 4 are considered as Hard Rocks. Amongst them are included the following rock formations, occupying about 70 per cent of the area in India, namely, Micro-alluvial valleys, Laterites, Tertiary Formations, Gondwana Formations, Karsts, Deccan traps and Puranas and the Crystallines.

Groundwater is the discovery of our primitive man, who discovered a mobile elixir of life in a pit of his own making some 10 000 years before. That was the beginning of the present inter-glacial period in which we are living. Prehistoric man has progressed from Palaeolithic to Neolithic period. With the discovery of groundwater he developed a new culture called Agriculture, with almost simultaneous development of fire and discovery of metal.

Water that occurs in streams, rivers and reservoirs is called surface water. When surface water disappears in sinkholes it becomes groundwater, but when it reappears again on surface it once more becomes surface water. The trajectory of groundwater may be short or long, but with passage always changes in quality and quantity.

Micro-alluvial valleys are essentially tiny alluvial valleys, strewn in the midst of hard rocks with a limited extent of about 500 sq. km and a vertical extent of 20 m in non-arid regions. Large number of such micro-alluvial valleys can be located in the hard rock terrains of India, which in entirety may have a cumulative extent of about 1,00,000 sq. km. Groundwater occurs in them under water table or semi-confined condition.

They can be precisely identified on large-scale aerial photographs by identifying bogs, oozes, marshes and springs. In these valleys individual wells are capable of yielding 100–500 m^3/d for a drawdown of 3–10 m by adopting a spacing pattern of 150 m. This has been achieved in such valleys in the Wardha and Godavary basins of Maharashtra, Singhana valley of eastern Rajasthan and Chinnathadagam valley of western Tamil Nadu.

Laterite is the product of intensive sub-aerial weathering under tropical climatic condition with enrichment of aluminium and iron and reduction of silicon than that of the underlying parent rock. Sandy, aluminous, ferruginous, nickeliferous, manganiferous and phosphatic laterites are its different varieties. Its colour is often deceptive. It is soft or hard, and often crumbly, disintegrated, friable and sticky in consistency. They are cavernous, vesicular, porous, spongy or honey-combed with a porosity of 15–40%.

Tertiary group of rocks are spread extensively in the Himalayas and in western Rajasthan, coastal Gujarat, Kerala, Tamil Nadu, Andhra Pradesh and in Orissa-West Bengal, with their extension also underneath the Gangetic alluvium. Amongst them Siwaliks, Surmas and Tipams in the Himalayas and the Neyveli lignite field are of particular significance. Based on these studies, it can be inferred that the wells and tubewells in them are capable of yielding 400–1,000 m^3/d for a drawdown of 5–10 m, when a spacing pattern of 500 m is followed.

Gondwanas are the coal-bearing rocks deposited in riverine and lacustrine basins, and preserved in faulted troughs. They occupy the east-central parts of Narmada, Sone, Damodar, Mahanadi and Godavari valleys and some patches along the East Coast. Amongst them granular zones of Kamthi, Raniganj, Bagra, Athgarh and Jabalpur are noted for their potential, while the coal-bearing Barakars are relatively inferior.

Limestones and dolomites are carbonate rocks with similar karst morphology. In India, practically all the stratigraphical horizons starting from the oldest Bijawar limestones of Jabalpur to the Porbandar limestones of coastal Saurashtra are karstic; and Chhattisgarh basin serves as the type area with the field Museum of karst, and development of caves and caverns.

Dark greenish black trappean basalt of western India along with its outlying areas cover 5,00,000 sq. km. depending upon their morphological setting, intrusion of dykes in them, and occurrence of Aa and Pahoehoe types of flows and intertrappean beds 5-fold classification has been suggested.

Puranas are the oldest sedimentary rocks like quartzites, quartzite-conglomerates and slates, and the crystalline rocks encompass gneisses, granites, migmatites, charnockites, porphyries, pyroxenites and dunites. They are highly fractured and jointed with 4–6 sets of joints, often with one or more sets of master-joints. Fractured zone often extends in depth up to 30–60 m, covered with a weathered mantle not exceeding 30 m in depth with a thin or thick soil cover. In these formations it is advisable to follow the idea of 'hydraulic trough' in morphological depressions to achieve best results.

Anthropology and Archaeology

Indian Archaeology at Cross-roads—The Fugure of our past by Dr M. K. Dhavalikar, *Jt. Director, P.G. & Research Institute, Deccan College, Pune 411006.*

Although archaeology in India was securely organised in 1861, it was under John Marshall, who became the Director General of the Archaeological Survey of India in 1902, that excavation and exploration became a major responsibility of the Survey.

Wheeler infused a sense of discipline in archaeological research in the country and brought it on par technically on the international level. He trained a whole generation of Indians in field archaeology and encouraged universities and research institutions to take active part in archaeological research. One of his important contributions to Indian archaeology was that he made it problem oriented, and he proved the utility of his approach by his excavations at Taxila, Harappa, Arikamedu and Brahmagiri. He also introduced the principle of stratigraphy in excavation which is better observed in a vertical trench which is also known as 'Wheeler's trench' as it was his invention. But this method of excavation is not followed anywhere except in India.

Wheeler is generally credited with the introduction of science in archaeology in India. He emphasised the need for a multi-disciplinary approach which in the Archaeological Survey was confined to chemical conservation only. He failed to include such scientists as a zoologist, a palaeobotanist, a geologist, a physical anthropologist, etc in his excavations. Their importance was already recognised in Europe in the forties and even earlier because of their contribution to the reconstruction of past environment and economic

aspects of archaeology. Similarly, Wheeler made no attempt to introduce social archaeology in India although it was already done in Europe with considerable success. Even in England Gordon Childe was interpreting archaeological data for the reconstruction of past social organization. Grahame Clark too viewed archaeology as a process of deploying the techniques to increase knowledge of social life. Again, such approaches as settlement patterns and ethno-archaeology were ignored by Wheeler. India, with its numerous tribes in different technological levels, has tremendous wealth so far as ethno-archaeology is concerned.

After Wheeler's departure in 1948, his pupils have been at the helm of archaeological matters in the country, and the post-independence period is marked by an outburst of archaeological activity in the country. But all the excavations have been vertical digs and we are not yet out of the time-space systematics. As a result we are not aware of the revolutionary developments in archaeological method and theory in the west. The leaders of this new wave are Lewis Binford in USA and the late David Clarke in England. According to the proponents of this New Archaeology, culture is defined as "man's extrasomatic means of adaptive system that is employed in the integration of a society with its environment and with other socio-cultural systems" and that there are three aims of archaeology *viz* reconstruction of cultural history, reconstruction of past lifeways and the delineation of cultural process. Since the New Archaeology is interested more in the study of cultural process it is also known as 'Processual Archaeology'. Binford's two major contributions are nomothetics, that is, the formulation of the laws of human behaviour and the systems approach which is borrowed from biology.

The scientific paradigms which can be profitably employed in archaeology have not only been clearly set out by David Clarke, but he has also given excellent examples in several of his papers which are models of scientific archaeology. They are as follows: (1) Morphological paradigm, (2) Ecological paradigm, (3) Anthropological paradigm, (4) Geographical paradigm.

The morphological paradigm consists of a detailed study of artefact assemblages using computer techniques which Clarke applied to the study of Beaker pottery in England. He showed that 80% of the subsistence in the Mesolithic was based on plant foods, the balance being made up by hunting-fishing. His paper on "Spatial information in Archaeology" is a superb example of the geographical paradigm.

When the tenets of New Archaeology were first propounded in 1962 the adherents of the Binclarke school had to face severe criticism but their work during the last two decades has shown their utility. The debate, however, is not yet over and doubts are still being expressed about the new methodology. We on our part employed it in our large scale excavations at Inamgaon near Poona and we can now emphatically say that it is only the adoption of new methodology which can save Indian archaeology from the morass of time-space systematics.

Inamgaon is small village, 85 km SE of Poona on the right bank of the Ghod. The ancient settlement, occupied during c. 1600–700 B.C, is spready over an area of 5 ha. While excavating we adopted the conjunctive approach of Walter Taylor and recorded every artifact in its proper context, especially in relation to the houses. For studying the culture change we decided to confine our excavation to the main mound and expose every year one occupational level completely and study minute changes in the artefacts. The following is the brief summary of the results:

1. *Settlement pattern*: The early farming settlements in Maharashtra are heavily concentrated in the Tapi valley, less in the Pravara–Godavari and are sporadic in the Bhima valley, the reason being the availability of the black cotton soil. In each area there was a regional center; Prakash in the Tapi valley, Daimabad in the Godavari valley and Inamgaon in the Bhima valley. These large settlements were probably fortified as Inamgaon evidence would show.

The micro-settlement pattern could be properly studied because of the ethno-archaeological evidence. At Inamgaon over 130 houses belonging to different cultural periods were exposed. There were pit-dwellings, rectangular houses as also round huts, all of which have exact parallels today and we could study the method of construction of each type and the functional aspect of different areas. At Inamgaon, in the earlier periods, the settlement appears to have been planned properly as is done by the Kolams today.

2. *Subsistence strategies*: The mixed economy of these first farmers was based on agriculture, stock-raising and hunting-fishing. They cultivated four cereals and four pulses by the crop rotation method which could be possible because of the facility of artificial irrigation in the second cultural period (c. 1400–1000 B.C.). It has been argued that they could not have cultivated the black cotton soil in the absence of iron plough, and their agriculture was confined to alluvial patches, but we now have convincing evidence to show that they did cultivate the black soil which, it is said, ploughs itself.

There was drastic change in the climate around 1000 B.C. which caused large scale desertion of settlements in the Tapi and Godavari valleys, but people continued to survive in the Bhima valley. They became extremely poor as is evident from their small round huts and coarse pottery; agriculture is on the decline and the people gradually resort to sheep/goat pastoral nomadism.

3. *Socio-economic organization*: The conjunctive approach enabled us to study the socio-political organisation. We could identify the houses of different craftsmen such as potter, lapidary, lime-maker, goldsmith and so on as also the houses of the ruling elite on the basis of mortuary evidence. This indicates that it was a class-structured society. By the side of the house of the ruling chief was the granary of the community. It is well known that chiefdom comes into being with the introduction of irrigation, for a ruling chief is needed to control the distribution of water. It was therefore a chiefdom society.

The people had trading contacts not only with the neighbouring regions in Maharashtra, but also with Gujarat, Madhya Pradesh and Karnataka. From Gujarat came conch shell for bangles and amazonite for beads. Karnataka supplied ivory and gold. Copper may have come from Rajasthan through Madhya Pradesh. The traded goods may not have come directly but all these large centres such as Prakash, Daimabad and Inamgaon may have formed a network in the exchange system.

4. *Religious Beliefs*: The people worshipped a mother goddess who was associated with fertility; her figurines were found in silos. Similarly, there was a goddess without head who was probably connected with the welfare of children. Male figurines were worshipped for success in an undertaking. The burials suggest that the people believed in life after death. The adults were buried in pits and the children in two urns, placed mouth-to-mouth horizontally. The pattern is symbolic and can be explained by a vedic hymn, according to which the two urns are respectively father and mother who signify regeneration.

Thus we can draw far reaching conclusions by adopting the new methodology. If we do not do this now, the future of our glorious past is bleak. Whatever be the criticism against New Archaeology, there is little doubt that it has come to stay and it is high time that Indian archaeologists adopt new techniques and concepts or else India will be branded as 'the land of archaeological sin'.

Botany

Genetic engineering and biotechnology: retrospect and prospect by Professor Deepesh N. De, *Head of the Department of Agricultural Engineering, Indian Institute of Technology, Kharagpur 721 302.*

From time immemorial man has been consciously or unconsciously manipulating various plants and animals to serve his needs. The *selection* of the most useful type, and *artificial hybridization* to recombine desirable characters in the offsprings have been the major tools for improvement of crops and domesticated animals. To this has been added, in the early part of twentieth century, the induction of heritable variants of *mutation* by ionizing and nonionizing radiations or chemicals. The conjunctive use of classical and better planned selection methods, hybridization and polyploidization with a large stock of easily obtainable mutants is presently the principal method of improving living organisms, be it a crop or live stock or zoo specimens like Tigon or the baker's yeast. Nonetheless, these methods of genetic engineering are largely empirical without much precision and predictability.

The recognition of deoxyribonucleic acid (DNA) as the chemical basis of heredity and the coming of age of the molecular biology has led to what is called molecular genetic engineering which promises to change the hereditary make-up of any organism in a definite manner. The new method, also known as *recombinant DNA technology*, involves transfer of a gene in the form of pure DNA to a recepient cell or organism. In practice, the foreign DNA is at first linked or joined to a carrier DNA molecule in a test tube, devoid of any cell or 'living' component. The carrier DNA may be derived from a very obliging yet harmless virus or episomal DNA. The newly reconstructed or 'recombinant' DNA is made to enter, replicate and express itself in the host cell. The altered metabolism, due to the presence of the foreign DNA, can make the organism behave very differently. Thus the common enteric bacteria, *Escherichia coli* with a piece of human insulin DNA is making insulin in abundant quantity in fermentation vessels.

The foreign gene to be recombined and cloned may be obtained as pure DNA by (1) specific enzyme dissection of the donor genome, (2) the action of reverse transcriptase on isolated specific messenger ribonucleic acid molecule or (3) laboratory synthesis of a gene, A *vector* or carrier molecule of DNA to which the foreign DNA is to be attached or 'spliced' has to be

selected. The vector has to be chosen so that it can enter and replicate within a host organism, a bacterium or a cell, without hurting it too much. The plasmids which exist as free ring DNA molecules in the cytoplasm of bacteria and many other organisms are found to be suitable vectors. In addition, certain viruses are also excellent vectors. With the aid of specific enzymes known as restriction endonucleases, the ring DNA of vectors is cut at specific points. The cut-ends are spontaneously sticky or are made sticky and the foreign gene also with sticky ends are joined end-to-end and sealed to make a recombinant ring DNA. All this is done *in vitro*. The recombinant DNA with the foreign gene has to be introduced in the recepient cell as free DNA, or the entry has to be mediated by a virus housing the recombinant DNA. Subsequently, suitable screening method is to be adopted to find the desirable host cell which has been transformed by the foreign DNA. Once a host with the desirable metabolic property is screened, it can be propagated in a mass scale and the specific metabolic byproduct can be obtained in great quantity. Unprecedented success has been obtained in gene cloning in microorganisms, which has become routine in many cases. If the foreign gene can be isolated, cloning of the same is no problem. Thus highly useful genes have been cloned and bacteria have been engineered to produce human albumin, interferons, growth hormones, etc.

The extremely complex structure of genetic material and lack of comprehension of gene expression in the eucaryotes coupled with difficulty in specific identification of the desirable gene, have made the application of molecular methods highly formidable in higher organism. Nevertheless, to bring about specific and radical improvement in higher plants and animals, the recombinant DNA technology is being increasingly employed and promising results already have been obtained.

The molecular genetic manipulation of higher plants has been attempted by direct treatment of seeds or cells of plants by purified DNA. Similarly, liposomes which are artificially produced lipid vesicles, have been used to introduce foreign DNA into wall-less plant cells or 'protoplasts' which would eventually develop into adult plants. These methods produced inconclusive results. But the methods of transfection by plant virus as vector, show promising results. Purified cauliflower mosaic virus DNA can be used as the carrier of foreign genes. By this method isolated bacterial genes have been transferred to plant cells. On the otherhand, though the technique is a little more complicated, the use of tumor-inducing (TI) plasmid present in crown-gall bacteria is rather efficient in transformation of plant callus cultures. Using mobile genetic elements, called *transposon*, the TI can carry yeast genes and transform tobacco cells. Moreover, the transformed tobacco segments gave rise to adult plants and the engineered DNA was transmitted through gametes.

Capitalizing chiefly on the genetic engineering of microbes, plant cells in culture, etc a new front in industry known as biotechnology, has come into being. Biotechnology is the collection of industrial processes that involve the use of biological systems as the central component. A host of very speciality health care substances *e.g.* vaccines, monoclonal antibodies, interferons are under active industrial production. Such *health care biotechnology* will mass produce exceedingly expensive medicine for common man's use. Similarly *Single Cell Protein* industry already produces huge quantity of protein as animal feed. *Plant Cells* in continuous or batch culture can produce very rare secondary metabolites in great quantity. *Bioconversion*, including bomethanation, biodegradation, etc is an emerging technology for fuel production from virtually any organic waste. Bacteria would be used for enrichment of low grade metal ores, enhanced oil recovery from difficult wells, clean up of oilspills, etc.

Those who have realised the immense possibility and power of biotechnology, have already started pouring all resources for its development. As many as 150 new companies all over the world have been born recently and the best of them are already marketing bioproducts which were unimaginable a decade ago.

Should not we in India, put the biologists' brains and financier's money to bring about miracle?

Agricultural Sciences

Agriculture in India by Prof. Abrar M. Khan, *Department of Botany, Aligarh Muslim University, Aligarh 202 001.*

There has been continuous improvement in the methods of agriculture from the Indus Valley civilization upto the 19 century. However, the problems connecting with agriculture are old and were not tackled through scientific efforts. This character of the agriculture began to alter in the 19th century and gathered greater moment in the 20th century specially after the Indian Independence. Efforts to improve our scientific technique began in an organised way towards

the end of the 19th and the beginning of the present century, probably due to frequent famines in the country and agrarian revolution in Great Britain. The Imperial Agricultural Research Institute was established in 1905 followed by a Royal Commission on Agriculture and the ICAR in 1926. Simultaneously the establishment of Agricultural colleges was going on apace. Yet, by the time of the independence not only had these agencies become inadequate, but our problems had also aggravated manifold. The ICAR activities were expanded by collaboration with Rockfeller Foundation and our agricultural scientists made hectic efforts to meet the situation with the result that we have become self-sufficient in food; there has been agrarian revolution in the country with great improvement in yield and quality of many basic crops, although with a rapidly increasing population we are still faced with many difficult problems.

In recent years criticism in certain quarters both at home and abroad about the achievements of our indigenous scientists had been made by Prof. E. C. Stakman and more recently by Prof. Bidwai. In the sphere of agriculture our scientists are second to none; but the exigencies of our national situation are such that the normal sequence of scientific development that is basic research first before its application has had to be altered and often both have had to be borrowed from abroad. We doubt there had been deficiencies in our agricultural institutions and in the execution of our programmes. Many of the defects have since been rectified. But still much remains to be done. There is also the basic necessity of improving the quality of our scientific community. The remedies suggested are as follows:

The syllabi and the admission system in our agricultural institutions has to be rationalised in the light of Kothari Commission report of 1964–66. The existing communication gap between the farmers and our research has to be filled. This could be done through the establishment of Plant Health Polytechnics throughout the country and attention should also be given in our institutions to producing generalists rather specialists properly trained in agricultural techniques. The problem of producing better scientists in the country would require a radical reconstruction of our scientific education from the school upwards. It is suggested that a sub-committee with wide terms of reference be immediately set up to consider these matters and suggest measures in this regard.

Further, to solve the food problem in the country greater attention has to be paid to the unconventional sources of food supply and the research programmes have to be geared to this as in the scientifically advanced countries.

However, in the foreseeable future we have to depend on conventional agriculture as primary source of food. Japanese farmers on small holdings produce about 7000 kg. grain per hectare as against 2500 kg. per hectare in India. For this, advanced technology supplemented with incentives to our farmers would be necessary. However, further we have to put agriculture at par with other industries.

Zoology and Entomology Section

Neuroendocrine Organisation in Insects and Hormonal Control of Oocyte Maturation by Prof. S. B. Singh, *Head, P. G. Department of Zoology, Magadh University, Bodh Gaya 824 234.*

Neuroendocrine system (NES) is one of the most vital system in insects. A bulk of literature is available in this field and new information is pouring in. The NES represents a functional unit which controls several aspects of insect physiology. It appears that there is not even a single system in the insect body which is not influenced, either directly or indirectly by this system. The insect neuroendocrine system comprises of four main components—the neurosecretory cells (NSC), the Corpora cardiaca (CC), the Corpora allata (CA) and the prothoracic glands (PTG). The neurosecretory cells are found in different regions of the nervous system. The Corpora cardiaca are the principal neurohaemal organs. The neurohormones produced from the brain NSC are stored and released from these organs into the haemolymph. The corporus allantum which may be paired or unpaired are the seats of production of hormone controlling several physiological processes including egg development and maturation. The prothoracic glands produce hormone(s) which controls moulting and metamorphosis in insects. All these four components of the NES play a key role in the physiological activities of the insects.

Although quite a good number of research papers are available on the morphology, staining behaviour, topology and etc of NSC, yet a detailed information regarding the origin, course and fate of neurosecretory fibres is still needed and of course only a few detailed papers are available today[1–5]. The neurosecretory tracts in the ventral chain of ganglia are also to be worked out in detail. It would not be out of place to mention here that Mason's technique[4] of axonal

iontophoresis will be of much help in knowing the exact course of the neurosecretory tracts. Further most of the literature deals with the activity of the NSC of brain and in only a few insect species the secretory activity of the NSC of ventral chain of ganglia has been correlated with various physiological events going on within the insect body.

The CC besides containing brain neurosecretory axons, also contain their own intrinsic glandular cells which in some insect species form a separate part of these organs. The effects of the secretions of these cells are also to be worked out in detail in many cases.

Although much information is available on the effects of CA hormones on the various physiological activities of insects yet control of CA activity till today is only poorly understood. This has to be worked out in detail in different species of insects. The recent works of Adiyodi[6] and Raziuddin *et al*[5] in blattids and grass hoppers respectively call for great caution in interpreting the results involving sectioning of allatal nerves.

Till recently PTG was known to be the lone source of ecdysone which is essential for ecdysis. But why some insects can moult even in the absence of these glands? This indicates the likelyhood of certain other sources of ecdysone production in the insect body. Further, ecdysone produced by adults in certain species are utilized for egg maturation. What are the other sources of ecdysone? We do not have much information on this aspect too.

The reproductive periodicity in insects is in itself suggestive of endocrine regulation[7]. The process of egg maturation includes the formation of vitellogenins (extraovarial yolk proteins) and their incorporation into the growing oocytes. Both these processes have been found to be regulated by hormonal agents. Since insects are adapted to various modes of life, comparison and analogies with regard to this aspect sometimes may be misleading. The variations in the hormonal regulation of oocyte maturation may depend more upon the habit, habitat and mode of life than on the systematic position. That is why many important differences have been noticed even in closely related species[8]. On the whole four types of hormonal control mechanisms of ovarian development are found in the insects:

1. Insects in which ovarian development is governed exclusively by brain neurosecretion.
2. Insects in which ovarian development is controlled by hormone(s) from Corpora allata.
3. Insects in which ovarian development is influenced by the hormones from both brain neurosecretory cells and Corpora allata.
4. Insects in which only some indirect involvement (*via* metabolism) of neurohormones appears to be at work.

Furthermore, a few species of insects like mosquitoes have followed an entirely different path by not only synthesizing ecdysone in their ovaries but also utilizing this hormone for egg maturation[9-11]. The role of ecdysoids on ovarian development in most species of insects is still to be worked out in greater details.

Keeping in mind these lacunae in our knowledge, I have tried to correlate the neuroendocrine activities in relation to oocyte maturation in insects.

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Physiology

Muscle receptors and their functions by Prof. J. M. Senapati, *Head of the Department of Physiology, S.C.B. Medical College, Cuttack 753007.*

Receptors are specialised structures at the afferent nerve endings. Skeletal muscle is supplied by motor and sensory nerves. The large medullated sensory fibres (1–20μ) terminate almost exclusively in specialised end organs. The small medullated fibres and the non-medullated fibres terminate as free endings. The chief specialised receptors in the muscle are the muscle spindles and tendon organs which are present in roughly equal numbers and are connected to large

diameter fibres (12–20 μ). There are a few Paccinian corpuscles and the other receptors are present as free nerve endings which are connected to thin myelinated (1–4 μ) or non-myelinated fibres.

A stimulus excites the receptors which produce a nerve action potential or nerve impulse. It is propagated along the afferent nerve to reach various levels of the nervous systems to produce reflex effects and arouse conscious experience. The tendon organs were first described by Camillo Golgi in 1880 and in man they may be 1 mm long. The tendon organ is usually supplied by a single medullated large diameter fibre which are closely applied to the surface of the tendon fascicles. The tendon organs are stimulated by stretching or contraction of the muscle. They measure the tension of the muscle that is developed during contraction of the muscle.

The muscle spindles are very complicated and lie inside the muscle. They have two types of afferent endings–annulospiral and flowerspray ending and intrafusal fibres which are supplied by gamma motor fibres. The annulospiral endings are stimulated by muscle stretch or contraction of intranfusal fibres due to impulses coming along the gamma fibres from the higher parts of the brain. The spindle detects the relative muscle length and is also responsible for maintaining muscle tone.

There are certain other receptors in the muscle connected to thinly myelinated fibres (1–4 μ), which have been named by Prof. Paintal as pressure pain receptors. They signal muscle pain. They also have other important function in mediating circulatory and respiratory changes during muscular exercise. During exercise there is intense increase in respiration to supply extra oxygen to the working muscles. The mechanism by which this occurs has been the subject of study since 1838. Geppert and Zuntz first showed that this may be due to chemical and nervous factors. Later in 1944, Comroe; in 1950 Kao and in 1962 Dejours have studied this problem. It was first suggested that chemical changes in blood during exercise like lack of oxygen and excess of carbon dioxide produce increase in ventilation. Such changes could not be demonstrated. Next it was shown that during exercise when the muscle contracts, nerve impulses from the receptors in the muscle produce increase in respiration. This aspect was studied by Senapati, Panda and Parida by stimulating electrically the nerve to the muscle in the dog. It was shown that stimulation of all types of nerve and muscle receptors (*viz.* tendon organs, muscle spindle, pressure pain receptors) produce increase in respiration, of which the contribution of the pressure pain receptors is maximum. It has also been shown by Prof. Paintal that the pressure pain receptors in the muscle is stimulated by muscle contraction. So it is logical to believe that they are concerned in the increase of respiration in exercise. Thus the long controversial problem of muscle receptor concerned in increasing respiration in exercise has been settled. This will help us in better understanding of regulation of respiration.

Psychology and Educational Sciences

Culture, cultural behaviour and tourism—A case for Cultural psychology by Dr. J. M. Ojha, '*Manasayan*' *32 Netaji Subhash Marg, New Delhi 110 002.*

The author pleads for a distinct discipline of cultural psychology in view of the importance of such studies in understanding various aspects and processes of human behaviour. Though this overlaps with Cultural Anthropology, which has almost exclusively concerned itself with culture so far, and also some other disciplines such as Cultural Geography, the Cultural Psychology will emphasise a larger use of sophisticated methodology consisting of experimental, measurement and verification methods to observe, analyse and assess the impact of culture and cultural changes on behaviour and also to probably predict behaviour under several conditions. Cultural Psychology so far has been largely concerned with cross-cultural studies and studies of some specific groups and their behaviours where they also overlap with Cultural Anthropology.

To do this, the author stresses the importance of defining culture in more measurable and tangible terms which can be subjected to a scientific methodology. The most acceptable definition of culture so far has been given by the anthropologists Kroeber and Kluckhohn who define it in terms of behaviour-patterns and an element which conditions, covers and helps us to understand various group behaviours. Such wide definition obviously cannot be of much use and we may have to break the concept into some more manageable and concrete elements which can be subjected to empirical research.

For a more objective study of cultural behaviour, therefore, the author starts with a premise that culture consists of behaviours which are manifested in actions—both overt and covert—and by studying such actions we can study the culture component which

determines our actions. In this he is supported by Wojciechowski and also Boesch who refer to culture as 'Existential System of Man' and 'Biotop' respectively. While the former denotes a system evolved through time and is cumulative unlike the human evolution which is non-cumulative, and becomes a natural existential habitat of mankind, the latter refers to it as an apex system which gives significance and meaning to all actions covered by it.

On the face of it, these definitions seem to be in essence the same as those of Kroeber and Kluckhohn but what is significant is that those reflect some attempts to stress the behaviours rather than the culture—behaviours which can be observed and studied and which could lead us to a better understanding of the construct which the culture is—while for classical anthropologists the culture comes first. The behaviours are important to them because they reflect certain patterns of culture while the cultural psychologists, on the other hand, will be more concerned with behaviour itself as it leads to a better understanding of underlying processes.

What actually are the cultural activities? Are they those which form the content of cultural policies or which are generally understood as cultural activities such as art or aesthetic activities or is it something more? The author cites his own study wherein he showed that the cultural activities as understood by people are many more than just those covered by cultural institutions or the cultural policy and that there are different motivations for engagement in such activities.

Due to the vastness of this area of cultural behaviour, the author limits his discussion to four areas: (a) leisure, recreation and sports behaviour, (b) art and aesthetic behaviour, (c) religious behaviour, and (d) tourism. According to him these illustrate some areas which reflect the content of culture. Studies about them, especially in our country, are extremely scarce though these are becoming the subjects of extensive research abroad. He also stressed that some concepts especially that of leisure and recreation need to be redefined in our cultural perspective as the connotation differs in different cultures.

A special reference was made to tourism which offers an ample opportunity for understanding of and training in inter-cultural behaviour. Citing several studies, including his own, he showed that tourism be viewed from this perspective and that our policies be more aimed to give satisfaction, need-fulfillment and a sense of participation to a tourist in the cultural life of the host country. A satisfied tourist not only brings money but also becomes a helpful intermediary to propagate cultural transactions. In this connection, he also stressed the vast field of domestic tourism, which is though complex, is challenging and rewarding besides having an immense social utility.

He concluded by stating that the philosophy and religion are actively associated with our behaviour, at least in India, and they provide the roots which have determined our actions. A study of philosophy, therefore, not only stimulates our thoughts but also provides us an useful insight into some determinants of our behaviour.

Medical and Veterinary Sciences

Fertility awareness—means to an end with special reference to Natural Family Planning by Dr. Ajay K. Ghosh, *Head of the Department of Gynaecology and Obstetrics, National Medical College, Calcutta 700 019.*

Fertility awareness has in principle two prime objectives, the promotion of fertility for subfertility and inhibition of uncontrolled fertility. Fertility awareness enables the individual to understand the male and female physiology related to fertility. Although inhibition of uncontrolled fertility is desirable as national priority, the improvement of fertility in infertile couple is no less important, problematic and complex. The meaning of life is only in the living. The ever expanding population tends to deplete the world's constant vital resources and offset the quality of life. Needless to mention the maternal mortality and morbidity are very high in women giving birth to too many babies too frequently.

At this juncture it is worth examining the demographic situation in the world—*vis-a-vis* China because China is the only country in the world starting family planning much later than us, demonstrated the best performance, unparalleled by any country. By 1980 one child family norm has been established. The current growth of population is 18 per 1000 from 42 in 70's and by the turn of the century the projected population profile will be 0 growth rate. The remarkable success of Chinese is attributable to strong leadership, structural organization etc. In contrast to this the current birth rate in India is 38 per 1000, and the growth rate is 2.5. The desired target by the turn of century is 1.2. Surprisingly, the figures for the different states in India have wide divergence. In Kerala the

birth rate is 18 per 1000 which is proof sure enough of what fertility awareness and consciousness for small family norm could achieve. There are three methods of population control, namely, pregnancy prevention, pregnancy terminated for unplanned, undesired pregnancy and fertility termination by vasectomy in male or tubectomy in female.

The 'Natural Family Planning' (NFP) consists of a very vital educational component for the couple to generate the awareness of the fertile and infertile phase of the menstrual cycle by recording the simple bodily changes like basal body temperature, vulvo vaginal discharge etc.

The advantages of NFP are that it helps in developing fertility awareness, knowledge of human anatomy and physiology, recognition of fertile and infertile phase and planning pregnancy. It is a cost free method without medical intervention and once learnt it is self help method. However, the variable period of abstinence may pose problem for some. The author having had experience of NFP programme in India, particularly in Calcutta from his association with Mother Teresa's Missionary of Charity's work in Calcutta slums since early 70's and a collaborative project of the Indian Council of Medical Research on NFP in Calcutta slums for 3 years (1978–80) now propose to deal with the use-effectiveness of the method.

In conclusion it is evident that the NFP is a very good way of achieving or avoiding pregnancy by generating fertility awareness. The greatest asset of the method is harmlessness. The method is cost free, without any medicinal intervention. However, the use of effectiveness of the method is dependent on a number of variables, *e.g.* strong motivation of the couple, willingness to practice abstinence as and when necessary and their ability to interprete fertile from non-fertile phase.

Science and Social Relations

Social Ecology of Science in India by Dr. C. H. Pathak, *c/o Department of Botany, Faculty of Science, M.S. University of Baroda, Baroda 390 002.*

We in India often revel in saying that India has the third largest force of scientific manpower. Such statements do not mean much; on the contrary they may lead to complacency and may blunt our will to develop adequate human resources to keep pace with leaders in science to achieve a degree of self sufficiency.

What do we mean when we say we have the third largest force of scientific personnel? Do we mean the absolute number of such persons without any regard to the size of the total population of which such force forms a fraction? And what do we mean by scientific personnel? Is it not a semantic jugglary to call anyone who has a degree/diploma in science, pure or applied, a scientist?

We have, as we like to repeatedly state, a large force of scientific personnel, we have some of the most potential source of fresh water, a rich variation of topography, climate, soil and vegetation which makes our country an excellent laboratory to study nature and we are politically independent now for almost half a century. How, then, do we explain some unpleasant facts like the brain-drain, dependence on imports for vitally needed components in industry, export of precious raw materials at throw-away prices and import of finished products at exorbitant cost, and the gulf of administrative inaction separating the lab and the land?

A possible answer to explain the situation is that we lack the will and action necessary to produce quality science.

The Indian Science Congress Association Committees on Science and Social Relations and on Science and Economic Development discussed 'Role of universities in the pursuit of quality science', in a joint session. The meeting also conducted a discussion on 'Role of Social Institutions in achieving quality in science'.

Home Science and Nutrition

Scope and Status of Home Science by Dr. (Mrs.) Yogini Pathak, *Department of Child Development, Faculty of Home Science, M. S. University of Baroda, Baroda 390 002.*

Over the last couple of decades the scope and status of Home Science as an academic subject has changed a good deal. Once the scope was restricted to minding the kitchen efficiently, maintaining the house neatly and looking after the children; there was no emphasis or theory. Over the years Home Science has assumed a rather professional status. Thanks to the social and family welfare programmes, there is a demand for professional home scientists.

The four topics chosen for discussion at the Forum on Home Science and Nutrition at the 71st Indian Science Congress Association Session at Ranchi

aimed at streamlining Home Science curricula to fit the present requirements of society and to ensure quality in research and education and at evolving strategies for working women to ensure a healthy growth—physical, intellectual and emotional—of their children when they (the working mothers) have only a limited time at their disposal to devote to the children. As the rural sector forms the major chunk of our population, the forum aims at suggesting effective approaches in working with rural communities, especially with women and children.

Under the Focal Theme for the ISCA Session at Ranchi, the Forum held discussions on four topics: (1) Areas which need priority on Home Science research, (2) Need to establish standards in unconventional food stuffs, (3) Problems of working mothers with particular reference to behavioural patterns of children, and (4) Appropriate approaches in working with rural communities.

The first two topics are self explanatory. The discussion on the problems of working women included problems like balance between career and legitimate demands of children from mothers, what the children may legitimately expect from mothers, how fathers may take over certain functions traditionally assigned to mothers, and looking after the family as a full time job.

Inspite of the growing status of the working women, she, at least in our Indian social context, has to work under stress. Her employers expect from her the same degree of efficiency as her male counterparts; at home, the members of her family expect her to fulfill the traditional duties of an Indian middle class housewife with the same efficiency. Also a working woman has a dilemma: how not to neglect her children (or at least make them feel that they are not neglected) while satisfying the employers and her own ego if she is a career-minded woman.

ANNOUNCEMENT

PLASMA-FIRED CUPOLA TO RECYCLE MACHINING SCRAP

Westinghouse Electric Corporation will apply its electric arc plasma torch technology in a demonstration project to reduce foundry production costs by sharply increasing the use of low-cost machining scrap as charge material for cupolas.

Cooperating with Westinghouse is Modern Equipment Company, a Port Washington, Wisc., manufacturer of cupolas – furnaces used to remelt scrap metals in iron foundries. Modern Equipment will supply the project with an experimental, $2\frac{1}{2}$ ton per hour cupola which will be fired by a Westinghouse plasma torch system.

The plasma torch is a small device that generates extremely high temperatures – as high as 10,000 degrees F – by passing compressed gases through a high-powered, rotating electric arc.

"Standard cupolas can use only small amounts of loose scrap from machining operations; electrically powered plasma torches may increase this dramatically, permitting as much as 70% machining scrap charge and saving an estimated $20 to $35 per ton of metal produced" said Dr Shyam V. Dighe, project manager for applied plasma systems at Westinghouse.

Large manufacturers such as automakers and their suppliers cast engine blocks and other iron products and then machine them, generating huge quantities of metal scrap which can be recycled.

According to Dr Dighe the key advantage of the plasma torch in recycling this material is its ability to attain high temperatures efficiently without combustion. This allows controlled, low rates of gas flow through the furnace to ensure that the loose pieces of machining scrap are melted and not lost in air currents directed toward the top of a conventional cupola. It also substantially reduces the consumption of coke and silicon.

He said that the cost of modifying a typical existing 60-ton per hour cupola for plasma operation, including all the required electric power and control equipment, would be paid back in just over two years, according to present estimates.

Dr Dighe credited the company's new Plasma Centre with making possible recently expanded efforts to develop electric arc plasma torch technology for a variety of metals, chemical processing and other applications. (Westinghouse Electric Corporation, Westinghouse Building, Gateway Centre, Pittsburgh, Pennsylvania 15222).