

## BARC OBSERVES FOUNDER'S DAY

(On October 30, 2001, the scientists and other staff of BARC and other sister units of DAE observed the Founder's Day with warmth and fond remembrance of its illustrious Founder, Dr Homi Jehangir Bhabha. Dr Anil Kakodkar, Chairman, Atomic Energy Commission and Secretary to the Government of India, and Mr B. Bhattacharjee, Director, BARC, addressed the staff members at Trombay. Dr Anil Kakodkar distributed the Homi Bhabha Science & Technology Awards, Technical Excellence Awards and Meritorious Service Awards to the recipients of these awards at a well-attended function in the Central Complex Auditorium, BARC. He also gave away the prizes to the winners of the XIII<sup>th</sup> All India Essay Contest in Nuclear Science and Technology.

As a tribute to Dr Homi Bhabha, the Founder's Day lecture was delivered by Dr R.M. Iyer, former Director, Radiochemistry & Isotope Group & Chemistry Group, BARC and Former Director, Division of Physical & Chemical Sciences, IAEA, Vienna, Austria, on 'Research in Chemical Sciences and the Benefits thereof for Atomic Energy Development in India'.

The texts of Dr Anil Kakodkar's and Mr B. Bhattacharjee's speeches are reproduced below.)

### **Address by Dr Anil Kakodkar, Chairman, Atomic Energy Commission & Secretary, Department of Atomic Energy**

*Dear Colleagues,*

Every year, we meet on this day to take stock of our achievements and to rededicate ourselves to the ideals and goals set forth for us by our founder Dr. Homi Jehangir Bhabha. This year is particularly important since the IX Five Year Plan is coming to a close in a few months from now and the process of formulation of the X Five Year Plan is now under way. We have to build our further programmes on the basis of our achievements so far (which indeed have been very significant) and the expectations from us to fulfill national needs in the areas of our capabilities. Comprehensive discussions have taken place to define our vision for the future and the activities that

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*Dr Anil Kakodkar, Chairman, Atomic Energy Commission & Secretary, Department of Atomic Energy, addressing the staff on the Founder's Day*

should be taken up in the tenth plan period. To facilitate networking of activities of different groups engaged in similar or complementary areas, we have divided our activities into six major programmes with identified key drivers for each one of them. I would like to use this occasion to urge each one of you to consciously contribute to these objectives in the spirit of teamwork and maximisation of synergy in our scientific research as well as between research and technology development. In the Department of Atomic Energy, we have considerable experience in converting our research efforts into successful large scale deployment. We must take these capabilities and their applications to greater heights. We know we can do it. Also we know that the nation expects this from us.

Our commercial nuclear power programme has been doing extremely well. Nuclear Power

Corporation, which is responsible for this programme has demonstrated a very high level of excellence in the performance of operating power stations as well as construction projects. The high capacity factors, in excess of 80 percent annual average for all plants put together, and the power reactor construction programme getting implemented ahead of schedule have given us the confidence to enhance our competitive edge in the electricity market in the country. In addition to the ongoing construction of Tarapur units 3 and 4, each with 540 MWe capacity, we are also beginning construction activities for the 3rd and 4th units at Kaiga (each 220 MWe), the two 1000 MWe VVER units of advanced version at Kudankulam and two more 220 MWe units (units 5&6) at Rawatbhatta. This construction programme when completed would add roughly 4000 megawatts of nuclear power generation capacity in addition to existing capacity of 2720 megawatts. Speedy completion of this construction programme along with sustained excellence in safe and economical nuclear power generation is the most important challenge before us and I am sure, all of us together will work hard to meet this challenge. After all, in the context of our ambition to enhance the share of nuclear power in overall electricity generation capacity in the country, this is only a beginning. There would be many more challenges to be overcome as we go along in meeting our long-term objective.

While we move on the path of excellence in our operation and construction programme, we should also remember that technology never remains static. It needs continuous upgradation. This is important for ensuring protection of our assets for as long a time as economically and technically possible. This is also important to enhance our competitive edge in the market place. And, therefore, I am extremely pleased at the programmes that have been taken up by NPCIL for enhancing the rating of 500 MWe units significantly through the use of limited boiling in coolant channels along with the activities to uprate some of the operating units. At one point of time, we had planned to set up

## Address by Mr B. Bhattacharjee, Director, BARC

Dr Kakodkar and dear colleagues,



At the outset, let me extend on this auspicious morning a warm welcome to each one of you to celebrate the 92<sup>nd</sup> birth anniversary of Dr Homi J. Bhabha whom we are all proud of, and to celebrate the Founder's Day of BARC, the mother institute of nuclear science and technology in India. As a mark of our respect and gratitude to Dr Bhabha, one of the greatest sons India has ever produced, we celebrate his birthday by taking stock of our achievements during the last year and rededicating ourselves to develop nuclear science and technology for improving the quality of life of our people as a token of our contributions towards security for electricity, security for health care, agriculture, food preservation and industrial needs, and finally the security for the nation.

This year has been yet another very successful year in our development efforts to exploit nuclear science and technology as we march towards our cherished goals.

Our research reactors, Dhruva and Apsara, continued to have been efficiently utilised for basic and applied research, radioisotope production and human resource development.

For designing the in-core shielding for intermediate sodium heat exchangers of the 500 MWe Prototype Fast Breeder Reactor, Apsara was extensively used for conducting a series of intricate experiments for optimization studies and validation of computational codes available at IGCAR by incorporating a Converter Assembly (CA) made of depleted uranium, leading to the creation of a facility for shielding experiments for Fast Reactors for the first time in India. Similarly, as a part of our AHWR development work, special experimental facility has been set up at APSARA to study flow pattern transition instability under two phase conditions, using real time neutron radiography and conductance probes.



A section of the gathering of the staff at Trombay on Founder's Day

For enhancing the utilisation of Dhruva, the national facility for neutron beam research, a controlled temperature irradiation facility is being installed in one of the neutron beam holes of the reactor. In addition, multi-detector based profile analysis instrument for powder materials and high-Q diffractometer for glass and amorphous material are

*(Director's address continued on page 6....)*

10,000 MWe nuclear power capacity by the year 2000. Let us realise this target in the next 10 years and also achieve the objective of realising 20,000 MWe capacity by the year 2020.

The excellent performance in our power programme was matched by excellent performance in fuel manufacture and heavy water production. Our Heavy Water Plants registered a substantial reduction in energy consumption, resulting in reduced production costs while maintaining an excellent safety record; similarly, the Nuclear Fuel Complex exceeded its target production for the third successive year. Programmes are now well underway to demonstrate front-end technologies for our heavy water plants, which would enable them to be delinked from fertiliser plants, which themselves are undergoing a technology change.

At this stage, I must reiterate the very high importance that we all attach to health, safety and environment matters. And it should be our endeavour to continuously excel on this front alongside our search for excellence in technology application area. A multi-pronged approach is required to ensure safety. Primary among these is the fostering of a safety culture and development of technologies. Development of world-class plant simulators for improved operator training and the first of its kind that were recently installed at the Kaiga Atomic Power Station is an important step in this context.

Our own research on health effects in natural high radiation background areas as well as the work of other scientific institutions does not show any significant difference between the health of the population living in these areas and that of those living in normal radiation background areas. The radiation exposure in these natural high background areas is considerably higher than the permissible radiation level for members of public.

The Atomic Energy Regulatory Board (AERB) has reported near total compliance in the year 2000-

2001 with its reduced annual permissible limits (30 mSv) on radiation dose to workers in the radiation installations in the country. As part of the policy of assuring a sound environmental management system, power stations at Tarapur, Narora, Kakrapar and Kalpakkam and also the heavy water plant at Manuguru have obtained the ISO 14001 certification. Heavy Water Board has also developed a technology for reduction of fly ash emission through the stack of coal-fired boilers.

Development of fast breeder reactor technology is of crucial importance in our efforts to exploit full energy potential in our uranium and thorium resources. The indigenously developed uranium plutonium mixed-carbide fuel has shown excellent performance and is nearing three times the original design target. The work on design and development of 500 MWe Prototype Fast Breeder Reactor (PFBR) has reached the stage when we can take up its construction. PFBR would serve as a commercial demonstrator on the basis of which further construction programme has to follow. The work on fast reactor technology has to be matched with the development of appropriate fuel cycle technologies aimed at minimising out-of-pile inventory and realisation of short doubling time. From long-term perspective, it is also important that research in actinide partitioning and transmutation is also pursued with a view to gain further advantages in management of nuclear waste. I am happy that this area including development of necessary solvents is receiving attention of our scientific community. Structural materials development, both for fast reactors as well as for reprocessing plants, is another area of crucial importance to us. While sodium cooled systems would remain important, we should also devote some attention to Pb or Pb-Bi cooled systems for their possible role in future systems.

Consistent with our mission to develop technologies for thorium utilisation, the detailed design of Advanced Heavy Water Reactor (AHWR) is nearing completion at the Bhabha Atomic Research Centre

(BARC). A new critical facility is also being set up at BARC for validating the reactor physics aspect of the core design of AHWR. A technology road map on shaping the third stage of our power programme has been formulated and a document on this has been distributed widely. This programme involves a very large number of scientific disciplines and technologies and needs to be pursued as a national programme involving every possible contributor.

Applications of atomic energy in other areas of societal relevance have also received our sustained attention. Radiation processing of agro and other food products would soon become very important in view of the possibility of storage over longer duration without spoilage and better hygienic quality. This technology along with other complimentary technologies can certainly contribute to higher value addition activities and also improved price stability, a factor of considerable importance in strengthening the economy in rural India. The high dose spices processing plant of BRIT at Navi Mumbai and a plant nearing completion at Lasalgaon near Nasik for radiation processing of agro products requiring low doses would serve as demonstration facilities of this important technology. We now expect other user institutions and entrepreneurs to take initiative in further deployment of this technology. I am happy to note that the foundation stone of the first private sector commercial plant for radiation processing of food products and sterilisation of medical products was laid a few days back. We are in touch with other entrepreneurs and state government institutions to facilitate setting up of more such plants. Centre for Advanced Technology, Indore, is working on use of electron beams for food processing.

In the area of nuclear agriculture, our research has proved to be beneficial towards enhancing production of important pulses and oilseeds. We have a good network with several agricultural universities. We should now make the benefit of our R&D available to farmers and villagers living in the vicinity of our installations. This would serve the

twain objective of demonstration and larger breeder seed production. An institutional mechanism wherein this could be done on the basis of self help, with DAE and its scientists playing an interactive and catalytic role, needs to be developed.

A long felt need for indigenous formulation of kit for Tc-99m based myocardial perfusion agent has been successfully met by BRIT. The indigenous two component kit for the formulation of Tc-99m methoxy isobutyle isonitrile (MIBI) has been successfully developed and evaluated in multi-centric trials. Availability of this indigenous product marks an important milestone in the field of nuclear medicine procedures for studies in cardiac patients. The first indigenous blood irradiator has been in regular use at the Regional Centre for Radiopharmaceuticals, KMIO Campus, Bangalore. Two more such units are about to be installed in Mumbai and Ahmedabad. A programme for development of low cost medical technologies is soon to be launched with full participation of medical specialists, technologists and industry groups.

The Cancer Research Institute of Tata Memorial Centre has been actively involved in basic research and translational research related to cancer. A Western blot kit for the detection of HIV was formulated in the Institute and this is now ready for marketing in India. For the first time in India, transgenic mice have been developed and preclinical studies for the gene therapy of oral cancer have been completed. Several new areas of research in modern biology, such as brain research, were opened up at TIFR.

The ILU 6 industrial electron accelerator is now in regular operation at Vashi and is available for industry users. The electron beam Centre being set up at Kharghar as well as the developments at Centre for Advanced Technology, Indore, would support further development and deployment of this important technology for industry use. I am glad that, even in this area, facilities are already being set up by the industry. A facility to qualify certain reactor equipment under post-loss-of-coolant-

accident environment has been set up at Electrical Research and Development Association, Vadodara.

In the area of basic research, Indus-1, the first synchrotron radiation source is in regular operation with three of its five beam lines commissioned at CAT, Indore. The work on construction of INDUS-2 is progressing well. Construction of superconducting LINAC booster to enhance the energy of heavy ion beams is in progress at the BARC-TIFR Pelletron Accelerator. The expertise acquired by our scientists in the area of accelerator technology should now enable us to take on, in a step by step manner, more ambitious development of high-power LINAC which has an important role in accelerator driven systems, an important energy technology for the future, in addition to its use as basic research tool.

The Department of Atomic Energy is unique in its technological capabilities both for basic research as well as for application development. We must now synergise our research activities in nuclear sciences and explore possibilities of converting some of the promising developments into front-line technologies. The large number of basic research as well as technology institutions that exist within DAE provide us an unique opportunity for this purpose. Already our linkages with CERN have enabled development and supply of state-of-the-art equipment and components.

Nurturing of research and education linkage is another area needing our attention. We have already made a good beginning in parking some of the research infrastructure in academic institutions, thereby enabling students to carry out research in areas of interest of our programmes. Enhancing the number of students who engage themselves in research activities of interest to us should be an important objective for long-term sustenance of our programme. We are also spreading our induction training programmes to more academic institutions in addition to the new training schools set up at CAT, Indore, and NFC, Hyderabad.

Dear colleagues, I am aware of the impediments that you face in your research activities due to the new security environment. This is a new challenge before all of us. You will agree with me that the present day scenario warrants all of us to be vigilant to ensure that our assets and our achievements so far remain protected. Security is our collective responsibility. Our programmes, however, must be carried forward with even greater speed.

Today is the day for us to introspect and rededicate ourselves for the cause of nation building by implementing applications based on nuclear science and technology in all possible fields. We have to do this by in-house efforts and by involving others from academia and industry. It is only through cooperation of all that we will be able to achieve the vision of our Founder.

Thank you.

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*(Director's address continued from page 3...)*

being installed under the aegis of DAE-Inter University Consortium. One of the major achievements of neutron beam research during the year has been the production of monochromatic neutron beam (using germanium and silicon crystals cut at special planes in a high flux reactor in Berlin) that has produced the sharpest angular profile in the world.

Refurbishing of our 40 year-old reactor CIRUS is now in advanced stage of completion and this opportunity has been used for making several modifications leading to its enhanced safety. A small desalination unit, based on low temperature vacuum evaporation process, is also being integrated with CIRUS to demonstrate desalination using waste heat from a research reactor.

Construction of a Critical Facility for conducting reactor physics experiments for AHWR and 500 MWe PHWRs has commenced recently.

BARC continued its full support for meeting the R&D needs of our PHWR programme by developing Fuel Handling Control Training Simulator for Kaiga, handing over two FM Heads for Kaiga and RAPS 3&4, and developing a miniature underwater CCTV camera for visual inspection of pressure tubes. An MoU has been signed for design, development and technology transfer of Adjuster, Control and Shut-off Rods for TAPP 3&4. A large number of computer based C&I systems have been developed which were installed and commissioned at RAPP-4.

As a part of our continued R&D support to operating PHWRs' life management, a Sliver Sample Scraping Tool (SSST) was used at RAPS-1 and MAPS-1 (which is also to be followed in MAPS-2) for obtaining samples from pressure tubes of the coolant channels. These samples were subsequently analysed for hydrogen concentration. This tool was modified to enable its remotised operation employing fuelling machines.

Facility for Integral System Behaviour Experiments (FISBE) which was commissioned earlier is being operated for experimental simulation of accident scenarios and operational transients in PHWRs.

The sludge lancing equipment for KAPS type steam generators is being assembled at BARC for performance demonstration.

As you are aware, for a country like India with a large population, having a low per capita electricity consumption, the energy mix has ultimately to fall back on its own vast thorium resource in the long run for its energy security on sustainable basis. Towards realising this goal of thorium utilisation, the development of Advanced Heavy Water Reactor (AHWR) along with all the technologies involved in thorium fuel cycle has been our major thrust. The design of this reactor has made significant progress during the past year which includes optimisation of reactor physics parameters, thermal hydraulics, and completion of the design of reactor fuel, reactor components and major process systems including the distribution of the shut-off rods and adjuster rods.

Some of the experimental programmes, like flow distribution and stability behaviour under natural circulation, endurance tests of full size fuel assemblies, have already been carried out. Creation of several experimental facilities have been taken up for thermal hydraulic studies and testing of the remaining components and systems of AHWR.

Last year, significant progress has also been made towards finalising the technical details of the various sub-systems of Accelerator Driven Sub-critical System (ADSS) which has been added to our programme on long term utilisation of thorium as yet another concept of nuclear reactor. The road map for development of all the technologies involved in ADSS has also been finalised.

In this connection, the development of AHWR, along with all the technologies involved in thorium fuel cycle, assumes special significance because AHWR concept can also be conveniently adopted as the thermal core part of ADSS that has been worked out by us based on one way coupling between a fast booster core based on MOX fuel and a thermal core in the blanket region based on thorium fuel.

As part of this programme, a small quantity of Protactinium-231 was irradiated at Dhruva to produce U-232 for spectroscopic studies to generate the crucial data needed for design of clean up facility for Th-U-233 fuel.

While Mark-I core (made of UC-PuC) of FBTR has attained about 80,000 MWd/Te without failure, fabrication of Mark-II core is progressing well. Fabrication of specially designed experimental fuel pins of MOX fuel for PFBR-500 is nearing completion and these fuel pins could be subjected to irradiation trials in FBTR while the new facility for regular production of MOX fuel for PFBR-500 is being established.

To cater to the needs of fuel for critical facility of AHWR and the fuel for first unit of 220 MWe AHWR, development of new fabrication techniques for production of (Th-Pu) MOX and (Th-U-233) MOX

fuel which are amenable to high level of automation and remotization is under way.

All the three reprocessing plants, i.e., at Trombay, Tarapur and Kalpakkam, continued to operate satisfactorily and supplied plutonium to meet the needs of DAE programmes.

Process flow sheet for CMPO-based extraction of minor actinides from high level wastes obtained from reprocessing thermal reactor fuel was tested with satisfactory results. Granulated inorganic ion exchanger AMP developed in-house was tested for Cs removal in the acidic PUREX process streams. Engineering scale production of CMPO and AMP is in progress.

A compact joule heated ceramic melter for vitrification of high level liquid waste has been commissioned with inactive trials.

The emphasis on R&D in reprocessing and waste management is now gradually shifted to match the various needs of the Thorium Fuel Cycle. While the facility for Uranium-233 separation from thorium fuel irradiated at Dhruva/Cirus is in an advanced stage of inactive commissioning at Trombay, the necessary safety clearances for active commissioning is being obtained.

For application of nuclear science and technology in the areas of non-power generation, where we can create significant impact with high societal values, our progress has been equally encouraging. In this context, the construction of our 6300 m<sup>3</sup>/day Nuclear Desalination Plant based on hybrid technologies has advanced significantly and part of the project based on RO technology is scheduled to be commissioned by March, 2002.

On nuclear agriculture front, a new black gram variety of TU-94-2 with resistance to yellow mosaic virus and with about 30% more yield has been notified for south zone of India. This variety together with earlier released TAU-1 variety accounts for more than 50% of total black gram breeder seed indent of the Government of India.

Large seeded groundnuts with a maturity period of 120 days with higher seed weight (of 1.2 to 1.3 grams compared to 0.8 grams for each seed developed earlier) has been developed by combining several radiation induced mutants.

In order to provide a boost to our nuclear agriculture programme, the process of establishing an agricultural farm at Tarapur for the twin purposes of nuclear agriculture research as well as seeds production has been initiated. This will accelerate our evaluation trials of "advanced selections" of different crops in our own farm (instead of going through the Agricultural University/ICAR) which in turn will also accelerate the process of subsequent multiplication of nucleous and breeder seeds.

Further, this farm will also be equipped with an Information Kiosk for providing all the relevant information to the local agriculturists, thereby making Tarapur farm a model for other DAE units for utilising fallow land for agricultural purpose.

Coming to utilization of radiation technology in food processing not only to avoid food spoilage but also to boost our food exports along with providing price stability for the farmers, our 30 te/day Spice Irradiator at Vashi has been performing well. Construction work for 10 te/hr "POTON Irradiator" at Lasalgaon in Maharashtra is nearing completion and is expected to be commissioned by the end of this year.

Technology for making value added fishery products from trash fishes like shark etc., is being offered to the Integrated Fisheries Institute, Cochin. MoU has been signed with both the Central Institute of Fisheries Education (CIFE), Mumbai, and the Central Institute of Fresh Water Aquaculture, Bhubaneswar, for preservation/shelf life extension of fishes.

As signs of wider acceptance, some private industries have already received site clearance from AERB for location of radiation processing plants for food products at Haryana (for disinfection of rice) and Maharashtra (multi-product facility to treat both medical products as well as food products).



Two new radiopharmaceuticals, 166 Ho-Hydroxy apatite particles and 153 Sm-Hydroxy apatite particles for large and small joint radiation synovectomy, have been cleared for treatment of arthritis with clinical efficacy equivalent to radiopharmaceuticals based on imported radionuclides.

Primary reagents (which include antiserum and conjugates for immunisation) for RIA worth \$ 11,000 were supplied to Sri Lanka under IAEA scheme.

Realising the growing potential of industrial electron accelerators, our plan is to establish four such units by the end of next year covering the entire range of beam energy (from 500 keV / 10 kW to 10 MeV / 10 kW) that would be needed for various industrial applications.

Presently, both 2 MeV – 20 kW ILU-6 Electron Beam Accelerator which has been installed and commissioned in record time as well as the inhouse developed 500 keV – 10 kW Electron Beam Accelerator at Vashi, Navi Mumbai, have been extensively utilised for various industrial applications with a revenue generation of more than Rs.50 lakhs. Construction of the other two electron beam accelerators that are being developed at Kharghar, Navi Mumbai, in collaboration with SAMEER (3 MeV/30 kW DC Accelerator and 10 MeV/10 kW RF LINAC) is progressing well.

Gamma scanning was successfully employed for trouble shooting of one 9.5 m diameter column under vacuum for Mangalore Refinery & Petrochemicals Limited (MRPL), Mangalore, leading to avoiding of huge production losses due to reduced shutdown period.

On the front of technology development, our progress is very heartening.

ANUPAM Supercomputer using 84 Pentium PCs giving a sustained speed of 15 giga flops (which is about 500 times faster than the first computer built in BARC in 1991) has been developed which would be extremely useful for undertaking computational tasks hitherto not attempted. ANUPAM

supercomputers are now working at 15 organisations outside DAE.

BARC has achieved for the first time Laser Cooling of Cesium atoms to the micro kelvin range by dissipating the kinetic energy of moving atoms by the mechanical braking action of triaxial laser beams (at a wavelength close to the atomic resonance) in a magneto-optic trap. This has enabled to achieve high resolution spectroscopy with very clear and reproducible structures in the fluorescence.

Another important breakthrough in technology development has been the in-house development of ultra high speed helium turbo expanders which will enable us to establish helium-cryo technology hitherto not available in the country.

Instrumented PIG that has been developed for IOCL has reached another milestone by completing the field trial runs between Mughalsarai and Allahabad.

Capacity of the heavy water upgrading facility has been enhanced by more than 3 times along with increased isotopic purity by undertaking process optimisation studies.

The complete 4 element TACTIC gamma ray telescopic array along with 349 PMT based central element imaging camera, which is the first of its kind built in the country, was made operational at Mt.Abu observatory.

Angle resolved photo electron spectroscopy beam line (soft x-rays with  $\lambda = 40 - 1000 \text{ \AA}$ ) has been commissioned in Indus-1 synchrotron source at CAT, Indore. Photo physics beam line (U-UV Ray with  $\lambda = 300 - 2000 \text{ \AA}$ ) is in advanced stage of commissioning.

Precision optical components and multi layer thin film devices, such as cavity mirrors for Holmium doped glass laser being developed at CAT and Fabry-Perot Etalons needed for stabilization of dye-laser wave length for use in U-232 clean up facility, have been developed.

The first ASIC-ADAM chip for Dosimetry application (to be used with small area PIN-Diodes) has been

successfully developed in collaboration with ITI, Bangalore.

As a token of demonstration of our multidisciplinary strength in the international arena, the Vibration Diagnostic Device that has been developed using mechanical vibration signatures for root cause identification of premature failure of equipment has been provided to the German Railways, for root cause identification of equipment vibrations.

Similarly, BARC has also successfully developed large area Silicon Strip Detectors (to be used for Pre-Shower Detector system in CMS) and Quench Protection Power Supplies along with associated Breaker Electronic for CERN, Geneva.

As a part of our prime responsibility to protect the health of the people and the environment around them as we march forward in the fields of Nuclear Science & Technology, efforts to develop new sensors with better sensitivity and calibration services have been sustained.

A new TLD badge with machine-readable ID has been developed. Technology for Auto TLD Badge Reader developed by BARC has been transferred to a private manufacturer for large scale production.

The Co-60 Theratron 780E machine has been installed at BARC for providing vital calibration services of dosimeters used in the treatment of cancer patients in more than 200 therapy centres in India and neighbouring countries in collaboration with IAEA/WHO.

In order to detect and provide alarm against unauthorised movement of Special Nuclear Materials (SNMs), a Portal Monitor has been developed. The Monitor is highly sensitive and can detect the presence of milligram quantities of fissile material in unshielded position.

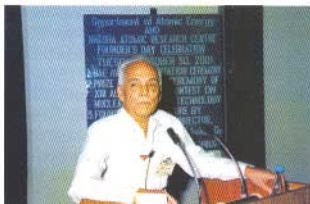
The actual list of achievements in BARC is too long to be covered in totality. However, before I conclude, I would like to take the opportunity to compliment all the members of BARC units under

DAE for assigning highest priority to safety while discharging their respective duties.

Friends, in the light of the above account of BARC's achievements during the year, you would undoubtedly agree that the basic strength of our success lies in our multidisciplinary structure and the tradition of exemplary work culture we have inherited as part of the legacy Dr. Bhabha has left behind. As a mark of the best possible way to pay our homage to this visionary, let us rededicate ourselves with a greater sense of pride and commitment for taking this great R&D institution created by him to a greater height of excellence and relevance to our national needs.

Thank you, JAI HIND.

## FOUNDER'S DAY LECTURE



*Dr R.M. Iyer, Former Director, Radiochemistry & Isotope Group & Chemistry Group, BARC and Former Director, Division of Physical & Chemical Sciences, IAEA, Vienna, Austria, delivering a lecture on the Founder's Day at Central Complex Auditorium*

Innovation in the face of difficulties has been the hallmark of human development. In this context, India's nuclear energy programme involving high technology development has benefitted in many ways from innovations in several disciplines. If one surveys the technology development scenario in this country, it becomes apparent that basic research inputs or involvement are absent, or marginal in technology related developments. BARC has addressed this vexing problem over the years and

today it stands as a shining star, being in the forefront of both high quality research and technology development.

This year's Founder's Day lecture was delivered by Dr R.M. Iyer, Former Director, Radiochemistry & Isotope Group & Chemistry Group, BARC and Former Director, Division of Physical & Chemical Sciences, IAEA, Vienna, Austria, on "Research in Chemical Sciences and the Benefits thereof for Atomic Energy Development in India".

The anchor role of basic research in technology development in BARC with specific reference to chemical sciences was highlighted in the lecture.



*Mr B. Bhattacharjee, Director, BARC, releases the Special Issue of "BARC Newsletter" on the Founder's Day.*

Prior to the Founder's Day lecture, Mr B. Bhattacharjee, Director, BARC, released the special issue of *BARC Newsletter* which was brought out as a homage to Dr Homi Bhabha and which contains some of the research papers that won various awards.

## CHAIRMAN PRESENTS DAE AWARDS TO STAFF

The Department of Atomic Energy instituted an Award Scheme in 1993 to recognise exceptional accomplishments and meritorious achievements in Science & Technology, and to create a congenial milieu for nurturing excellence and fostering creativity among the members of the DAE staff who are engaged in Research, Development and Engineering in the frontiers of Science and Technology dedicated to the development of the nation.

The Award Scheme consists of three categories of awards :

1. Homi Bhabha Science & Technology Award
2. Technical Excellence Award
3. Meritorious Service Award

These awards are given annually.

The **Homi Bhabha Science & Technology Award** is the highest award among them. It consists of a citation, a medal, and a cash award of Rs. 50,000/-.

This award is given to a maximum of two Engineers or Scientists who have made outstanding contributions towards the advancement of science and technology based on original research in the frontier areas of science or frontline development in engineering and technology, which would reflect excellence commensurate with national and international standards.

This year the award was given to **Dr Dhruba Jyoti Biswas** of Laser & Plasma Technology Division, BARC.

Dr. Biswas was conferred the Homi Bhabha Science and Technology Award for the year 2000 for his leading contributions to optical chaos, photo-refractive amplifiers, gas laser physics and technology, and optically pumped molecular lasers. The list is impressive. It is not only replete with new

results of considerable academic worth but also involves technological novelties.



Dr D.J. Biswas receiving the Homi Bhabha Science & Technology Award, 2000, from Dr Anil Kakodkar, Chairman, AEC

In the past, Dr. Biswas's research interest concentrated on optical chaos and photorefractive two wave mixing. In the former area, his work culminated in the finding of deterministic chaos in Raman lasers and; in addition, established that three frequency quasi-periodic state can precede chaos. He showed, for the first time, the coexistence of spatial and temporal chaos in an optical system by exploiting the transverse effect in the carbon dioxide laser operation. In the latter area, Dr. Biswas's ingenuity demonstrated the conclusive advantage of a Bessel beam over the normal Gaussian beam towards the exploitation of photorefractive effect in two wave mixing in a photorefractive crystal.

In recent years, Dr. Biswas's work principally revolved around the science and technology of gas and optically pumped molecular lasers. The demonstration of securing good quality glow discharge using unprofiled electrodes has greatly been instrumental to ease the construction of transversely-excited lasers. A very special mention, in this premise, must be made of the development of thyatron-less, repetitive, transversely-excited laser pulser having latch proof operation capability with command resonant charging. A number of innovative techniques have been demonstrated by Dr. Biswas for acquiring multiline emission from

carbon dioxide laser. The foremost among them goes to the use of a dual polarization resonator cavity.

His creative work unveiled the role of spatial burning on the emission spectrum of a laser. Dr. Biswas has been extremely successful in providing solutions to the problems of self focusing and saturation effects of pump pulse in the operation of an optically pumped molecular laser. This accomplishment pertains to exploitation of self focusing effect to an advantage and to also annul saturation effect. It has indeed been unique, judged in terms of sheer simplicity and newness. The validity of these methods has shown in the successful operation of ammonia lasers. An outstanding verified feature of such a laser is its application in the separation of strategic isotopes.

The second set of awards is the **Technical Excellence Award**. This award is conferred on a maximum of two Engineers or Scientists who have made outstanding contributions and special efforts towards :

- (a) Development of a new or improved equipment, machine, materials, process of device with proven results meeting the immediate use requirements of futuristic needs of bringing credit to the respective Unit or leads to import substitution, technology transfer, etc.; or
- (b) Practical constructive ideas and suggestions leading to better utilisation of human resources, materials, processes, devices, etc. resulting in higher efficiency and significant financial saving to the Government; or
- (c) Handling of emergency or crisis situations exhibiting rare alertness and skill thereby averting accident/serious plant situation; or
- (d) Highly efficient planning and execution of important assignment in multidisciplinary and multiorganisational time-bound projects of vital interest to the nation, and excellence in trouble shooting or overcoming or expeditious implementation of ongoing projects.

The Award consists of a citation, a medal, and a cash award of Rs. 20,000/-.

This year the award was given to :

- 1) Dr. Pitamber Singh, Head, FOTIA Section, Nuclear Physics Division, BARC, and
- 2) Mr D.N. Badodkar, Head, Control Mechanism Section, Division of Remote Handling & Robotics, BARC.

Dr Pitamber Singh was conferred the Technical Excellence Award for the year 2000 for his exemplary contributions to Accelerator Physics and Technology.



*Dr Pitamber Singh receiving the Technical Excellence Award for the year 2000 from Dr Anil Kakodkar, Chairman, AEC*

Dr. Pitamber Singh, during nearly 25 years of his distinguished professional career, has contributed greatly to the Accelerator Programme of BARC. The beginning phase of his career was replete with his accomplishments in the making of a 2 MV tandem accelerator. This was an eminent example of the first indigenously built tandem accelerator. It also provided significant evidence of the range and depth of understanding of accelerator technology of Dr Singh. No less important are his remarkable capabilities which are displayed in timely execution of project activity of great utility.

This early promise stood Dr Singh in good stead to later undertake a prestigious and impact bearing

work of the Centre, the development of a 6 MV Folded Tandem Ion Accelerator (FOTIA). It is a unique facility for multidisciplinary research and it is an accelerator of its own breed which can be counted amongst the extremely limited number available in the world. Its making involved development of state-of-the-art technologies of several important components like dipole magnets, high voltage generator, SF<sub>6</sub> gas handling system, vacuum systems, magnetic and electrostatic lenses, computer control systems and frontline electronics. This representative listing reflects the complexities and level of technologies involved, and the necessity of having intra- and inter-disciplinary participation. The progress that has been accomplished so far owes a great deal to Dr Singh who has taken the lead role in not only showing tremendous application himself but also gone ahead in establishing an excellent work culture in mobilising resources and expertise from within his team as well as from other Groups and Centres. Such special pursuits to put on stream a project of such magnitude, and advancing it to achieve end results are indeed impressive.

Mr D.N. Badodkar was conferred the Technical Excellence Award for the year 2000 for his highly commendable contributions to the design and development of special purpose drives and reactor control mechanisms.

The technical contributions of Mr D.N. Badodkar have been extremely useful in many ways in a number of specific applications in the different constituent units of the Department of Atomic Energy. They have been highly commendable. Among the many projects he has worked on, special mention may be made here of his contributions to the design and development of (i) drive mechanisms for adjuster, control and shut-off rods of TAPS 3&4; (ii) the canned motors for HWP's; (iii) drive motor for shut off rod drive mechanism of PHWR's; (iv) variable reluctance motor and regulating rod drive mechanism for PRP; and (v) two phase servo motor for servo manipulator application. These

representatively enumerated examples called for a significant amount of work, extensive testing, improvements on prototypes and extended cycle tests in order to certify field worthiness of the concerned components.



*Dr Anil Kakodkar, Chairman, AEC, giving away the Technical Excellence Award for the year 2000 to Mr D.N. Badodkar*

Mr Badodkar has consistently displayed excellent disposition in all his attainments. A number of instances may be cited for which either the information was not available or, if available, was too limited to be of any practical use. Mr Badodkar demonstrated exceptional capability and ingenuity in succeeding under these difficult circumstances. Mr Badodkar has registered a worthy service record which has indeed been very rewarding and satisfying. He has been thoroughly successful in setting a high standard of work, both in terms of quality and quantity.

The third set of the awards is the **Meritorious Service Award**. This award is conferred on a maximum of six employees with a minimum continuous service of 20 years of more, who have exhibited consistent improvement in skill, technology ability, including outstanding performance in the maintenance of equipment and facilities resulting in reduction in idle time and increase in effective utilisation. Emphasis is also on consistently high performance and achieving perfection in work.

The award consists of a citation, a medal and a cash award of Rs. 10,000/-.

This year the awards were given to :

- 1) Mr Ashok Sriram Kerkar, Applied Chemistry Division, BARC, and
- 2) Mr Ramanik Nanabhai Vaze, Technical Services Division, BARC.

Mr Ashok Sriram Kerkar was conferred the Meritorious Service Award for the year 2000 for his significant contributions to the specific area of Instrumentation bearing strong linkages with High Temperature Chemistry.



*Mr A.S. Kerkar receiving the Meritorious Service Award for the year 2000 from Dr Anil Kakodkar, Chairman, AEC*

Mr Kerkar has remained professionally focused on design, fabrication, repair and maintenance of multifarious instruments, which basically constitute the lifeline of thermochemical and thermophysical investigations. Mr Kerkar has acquitted himself very creditably in designing, developing and demonstrating the operation of a number of exceedingly well instrumented facilities. Besides providing years of service, these totally indigenously developed facilities still continue to be very much in use in the laboratory.

A worthy contribution from Mr Kerkar has been in the fabrication of a catalytic device for the mitigation of hydrogen in nuclear power reactors under severe accidental conditions. The present citation would remain incomplete if reference is not made to the participation of Mr Kerkar in a number of

thermochemical studies which have eventually culminated in the preparation of a number of research publications figuring in well reputed journals.

Ramanik Nanabhai Vaze was conferred the Meritorious Service Award for the year 2000 for the noteworthy contributions he has made to Air Conditioning and Refrigeration Systems.



Mr R.N. Vaze receiving the Meritorious Service Award from Dr Anil Kakodkar, Chairman, AEC.

During the span of well over three decades of service, Mr R.N. Vaze has remained engaged in a number of important assignments and, in all of them, he has conducted himself superbly. Notable was his involvement with the operation and maintenance of the central air conditioning plant at the Purnima reactor building. Going by the number of compressors, air handling units, pumps, chillers and condensers, exhaust and supply blowers and various other ancillaries, the utility assumes a substantial size. It is one to which Mr Vaze and his team have remained highly dedicated and rendered admirable service.

In addition to this singularly important assignment in BARC, Mr Vaze has stepped ahead and extended his specializations elsewhere. He has demonstrated excellent execution skill, experience and knowledge of his work at the Mumbai Municipal Corporation for

manning water pumping stations, at Gauribidanur for re-commissioning the air conditioning plant, and at Rajasthan Atomic Power Station for maintenance work on diesel generators and air conditioning plants.

## XIII<sup>TH</sup> ALL INDIA ESSAY CONTEST IN NUCLEAR SCIENCE AND TECHNOLOGY

The All India Essay Contest in Nuclear Science & Technology for regular full time students studying for graduation in any discipline was started by the Department of Atomic Energy in 1989 and has since been an annual feature. This year's contest is the 13<sup>th</sup> in the series. This year four topics for the essay contest under the major title 'Atomic Energy & Social Development in India' were :

- (A) Indian Nuclear Power Programme
- (B) Radiation & Radiation Technologies
- (C) Technology Development
- (D) Basic Research & Research-Education Linkage

The written essays were evaluated by 7 to 8 groups of evaluators from BARC, NPCIL and BRIT. Each group carried out evaluation of essays followed by a normalization process within the group and the best essays for further evaluation were short-listed. The short-listed essays from all the groups were then subjected to further assessment through inter-group evaluation and normalization of assessment. The contestants of final merit list so prepared were invited to come to BARC for giving oral presentation of their essays. Essays could be written in any official Indian language or English.

After evaluation, 14 contestants from topic (A) and 15 contestants from topics (B), (C) & (D) were qualified and invited to Mumbai to make oral

presentation of their essays in twenty minutes before a panel of ten judges comprising of senior scientists and engineers drawn from DAE organisations.



Dr Anil Kakodkar, Chairman, AEC, and Mr B. Bhattacharjee, Director, BARC, with winners of the XIII<sup>th</sup> All India Essay Contest in Nuclear Science & Technology.

For the topic on 'Indian Nuclear Power Programme', the presentations covered demand of electricity in India, various energy options and inevitability of nuclear power in terms of fuel resource position, environmental impact of different sources of energy, cost comparisons, etc., India's 3-stage nuclear power programme, heavy water production and waste management.

From the other 3 topics, the contestant had to choose any one of them. The subjects that were covered included Radiation & Radiation Technologies and their applications in health care, industry, agriculture and food preservation, technology development at DAE with specific reference to advanced technology like laser, plasma, accelerators, computers, robotics, bio-technology, etc., and basic research in the field of physical, chemical and life sciences

carried out at DAE laboratories, and support provided to other institutions and importance of research-education linkages with reference to DAE.

The top three prize winners were selected based on the combined performance in the written and oral versions.

On 30<sup>th</sup> October, 2001, Dr Anil Kakodkar, Chairman, AEC, distributed the prizes to the following contestants :

*Prize Winners : Topic A - "Indian Nuclear Power Programme"*

- First Prize* : Azad Singh, BA II  
(Rs. 5000/-) Bhivani, Hindi  
*Second Prize* : Ms Jyoti B. Sahu, BE IV  
(Rs. 3000/-) Khammam, English  
*Third Prize* : K. Pradeep, MBBS final  
(Rs. 2000/-) Coimbatore, English

*Prize Winners : Topic B - "Radiation & Radiation Technologies", Topic C - "Technology Development" & Topic D - "Basic Research & Research-Education Linkage"*

- First Prize* : Arvind Kedia, BE IV  
(Rs. 5,000/-) Dhenkanal, English  
*Second Prize* : Ms Bhawana Singh, B.Sc., B.Ed.  
(Rs. 3000/-) Bhuvaneshwar, English  
*Third Prize* : Ms Swapna S. Akhawe, B.Sc. II  
(Rs. 2000/-) Dapoli, English

In addition to the above prize-winners there were several consolation prize winners of Rs. 1000/-.

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