

BARC

NEWSLETTER

From the Director



Dear colleagues,

We are now nearing the end of IX Plan period. We should, therefore, take stock of our programme and brainstorm on our next steps with a view to be able to shape the X Plan.

We have made good progress towards our goal of thorium utilisation, in the back end of the nuclear fuel cycle, in other energy and radiation technology applications particularly in processing of food items and in our programmes on industrial electron accelerators and their applications. IX Plan was also significant in terms of success realised in coordinated working for implementing our R&D programmes. We should now move further in this direction. Our programmes should be structured more on the basis of objectives with greater possibilities of multi-centric working and less along the lines of organisational structure. Best experts, regardless of their affiliation and location, should be involved with well defined linkages between them. As a part of this strategy, discussions have begun in Trombay Scientific Committee, which in turn, are based on the discussions within the Divisions and Groups.

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We should complete this round of discussions by sometime around April next year. The formal exercise of defining the plan projects through Divisions, Groups, Group Boards and Trombay Council could then start on the basis of collective ideas so generated involving the partners identified during discussions. We should leave enough scope for involvement of Universities and Research Laboratories in the country as well as for accommodating newer ideas that may come up as we go along.

While the next Plan should certainly involve further detailing of the thrust areas of our programme dedicated to thorium utilisation and our thrusts in enhancing the beneficial applications of our programme to society, we should leave enough scope for new technology development. In fact, we should have an ambition of being a global technology leader at least in some areas. At BARC, we have an excellent opportunity of realising this ambition through further strengthening of synergy between our research and technology work. While thorium utilisation is certainly one area, we also have the possibility of quick translation of excellent work of some of our researchers in basic sciences into new innovative technologies.

In my view, while excellence in basic research is judged by the assessment of peer group at the highest international level, excellence in applied work should be judged on the basis of benefit of our research and development to the down-stream partner. Such a partner could be the technology developer, the industrial user or a societal entity. Search for excellence should be our motto and in this endeavour, even the best can be bettered. Of course, our work should primarily have atomic energy in focus.

At this point, I would also like to dwell a little further on the value system in our work. While the excellence has necessarily to be foremost in our mind, continuity of our knowledge base should be another important attribute. I have been highlighting this point time and again. I think it is important that we make conscious efforts to guide and train our newer colleagues and in fact have the ambition of seeing them at a level of capability higher than our own. Our several programmes involve progressive development of a series of technologies spanning over decades. Thorium utilisation programme is an important example. The relevant knowledge base has thus to be built over generations. The third attribute of our value system should be an environment where we create opportunities for every one to excel. While in our drive to take organisational excellence to the highest level, we have to pick and push the best talent to lead, we cannot afford to ignore others. After all, each one of us have some strengths and it should be our endeavour to explore these strengths and create opportunities for every one to enthusiastically participate and contribute to organisational objectives. This of course needs a right attitude on part of all concerned. I must also stress that in this process, everyone has a role and we must all play our role.

I have always felt that BARC is a gold mine of talent and technologies. It is our duty to reach the benefits of this resource to our people and at the same time further enrich this gold mine through our human resource development programmes.

(Anil Kakodkar)
Director

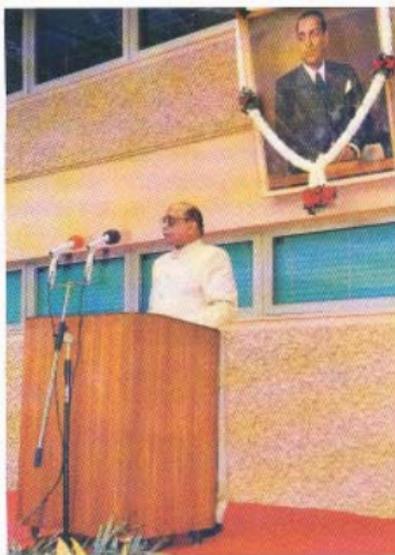
BARC OBSERVES FOUNDER'S DAY

(Monday, October 30, 2000 was a day of special significance for the staff of BARC and other units of the Department of Atomic Energy (DAE). It was the birth anniversary of Dr Homi Jehangir Bhabha, the founder and architect of India's atomic energy programme. On this day, which is observed as Founder's Day every year, the staff of DAE gathered in the open area behind the Central Complex building in BARC and listened to the addresses of Dr R. Chidambaram, Chairman, Atomic Energy Commission, and Dr Anil Kakodkar, Director, BARC, who narrated the milestones covered and outstanding achievements made during the past year in the various units of DAE. Later, they moved into the adjoining auditorium to witness the presentation of DAE awards for scientific and technical excellence and the prizes for the Essay Contest by Dr R. Chidambaram, Chairman, AEC.

This year, the Founder's Day Lecture was delivered by the Former Director of BARC, Dr A.N. Prasad, who spoke on the Nuclear Fuel Cycle.

The texts of addresses on the Founder's Day by Dr R. Chidambaram, Chairman, AEC, and Dr Anil Kakodkar, Director, BARC, are reproduced below.)

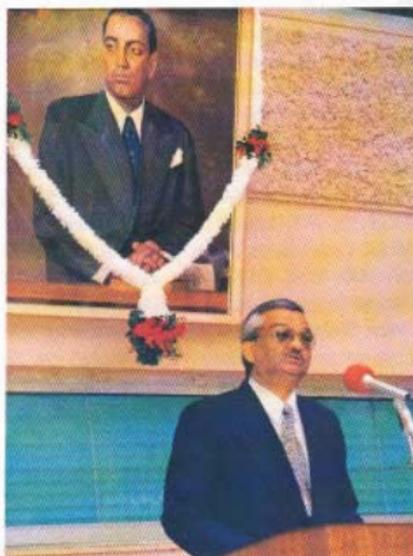
Address by Dr R. Chidambaram, Chairman, Atomic Energy Commission & Secretary, Department of Atomic Energy



Dr Kakodkar, Distinguished Colleagues and Friends,

As we celebrate the 91st birthday of our Founder, we can confidently say that Homi Bhabha's vision has come true. We are totally self-reliant in the design and construction of Pressurised Heavy Water Reactors. The average Plant Load Factor (PLF) of our Nuclear Power Plants was 80% last year and
(Chairman's address continued on page 4...)

Address by Dr Anil Kakodkar, Director, BARC



Dr.Chidambaram and Friends,

This year has been yet another very successful year in our march to make India technologically strong through our own research and development efforts in nuclear science, technology and engineering. Our research reactors, Dhruva and Apsara, have been the efficiently utilised in support of our

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

(Chairman's speech continued from page 3...)

this has been maintained for the first six months of the current year. These PLFs are good by international standards. Since September 1999, three new reactors have been connected to the grid. The second unit at Kaiga was connected to the grid earlier this month in a record time of 16 days after criticality. This record may be bettered when RAPP-4 achieves criticality in the next few days. The en-masse coolant channel replacement of RAPS-2 was carried out in record time at a fraction of the cost which Canadians incurred for a similar exercise.

After successful operation of the Fast Breeder Test Reactor, the technology development for the indigenously-designed 500 MWe Prototype Fast Breeder Reactor is in full swing in India's major industrial companies like BHEL. In the last couple of weeks, on behalf of the Indira Gandhi Centre for Atomic Research, I have accepted two excellently fabricated major prototype components - the steam generator reheater from Larsen & Toubro Ltd. and the Safety and Control Rod Drive Mechanism from MTAR Technologies, Hyderabad. The work on the twin 500 MWe PHWR units is in full swing at Tarapur for the last two years. The Advanced Heavy Water Reactor - designed by BARC and which uses both plutonium and thorium - has moved into the technology development phase. The preparation of the Detailed Project Report of the two Advanced Light Water Reactors VVER-1000, being built at Kudankulam with Russian technical cooperation, is in progress and construction should start in a year or so. We aim to indigenise LWR technology in the future as we have done in the case of PHWR technology.

The Central Government - which is strongly supporting the nuclear programme - has recently decided to give "mega project" status for projects in the nuclear power sector, starting from 440 MWe, which will bring down the capital cost of all our nuclear power projects. NPCIL is also trying to bring down the gestation period of construction of Nuclear Power Plants. The Nuclear Fuel Complex exceeded

its target last year for the production of fuel and structural components, while reducing the energy consumption per kilogramme of fuel fabrication. A couple of months back it reached a major milestone by manufacturing the 2,00,000th bundle of PHWR fuel. The Heavy Water Board has, by streamlining its manufacturing processes, ensured lower production costs while enhancing quality and productivity at the same time.

All these will have a major impact on the unit cost of nuclear electricity and this is good as we move into the future where nuclear energy will be the inevitable option to satisfy our energy needs. This is true not only for India but for all countries. Even in countries which are currently seeing a slowdown in their nuclear power development programme, it is likely that a reversal would occur due to two factors - firstly, due to a substantial increase in oil prices as is happening now and, secondly, due to the possibility of the global warming phenomenon caused by greenhouse gases becoming more serious. We are aiming for a nuclear installed capacity of 20,000 MWe by 2020; this is an achievable target with a mix of PHWRs, FBRs and LWRs and reflects a doubling time of about 7 years.



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

Our technology strength derives from the strong foundation of Research and Development which we have laid over the years. This goes beyond our Nuclear Power Programme. It goes beyond our Research Reactor Programme - which also gives us a hundred varieties of isotopes used extensively in medicine, industry and agriculture. It has enabled us to design and build accelerators both for basic

research and for applications. Currently we are building at CAT, Indore, the second Synchrotron Radiation Source INDUS-2, which will be a 2500 Million Electron-Volt electron storage ring giving hard X-ray radiation, after completing the first Source INDUS-1; we are building a superconducting magnet cyclotron at VECC, Calcutta. We are also building smaller electron accelerators which can be used for food preservation and for industrial and scientific applications. The Institute of Plasma Research - a DAE-aided institution - is designing and building a Steady-State Tokamak for thermonuclear fusion research. CAT, Indore, is building a variety of powerful laser systems for various scientific, medical and industrial applications. In developing all these systems, the DAE programme has also acted as a catalyst for other High Technology developments in the country.

Prime Minister Atal Bihari Vajpayee declared more than two years back that India is now a Nuclear Weapon State. The five carefully-planned and completely successful nuclear weapon tests we carried out in Pokhran in May 1998 and the confirmation of the design yields by seismic, radiochemical and other studies carried out by BARC gave us the capability to design and fabricate nuclear weapons of yields from low-yields upto around 200 kilotons. That was in May 1998 and a great deal of scientific and technological development has taken place since then. Nuclear Weapon technology is not one technology, but is a mixture of many scientific disciplines and technologies and we have some of the world's leading experts in each of these, thanks to the vast multi-disciplinary capabilities which DAE has built up deliberately and with forethought over the years.

This has happened not just in the nuclear weapon area. I had talked earlier about nuclear power, research reactor applications, accelerators and lasers. In all these areas or take at random any other field - materials science or mathematics, molecular biology or gamma-ray astronomy, superconductivity or parallel computing, radiation safety or nuclear agriculture, robotics or nuclear waste immobilisation, or - going in some detail -

gene therapy in cancer or string theory in high energy physics, density functional methods in condensed matter physics or solvent extraction methods in chemical engineering, we have some of the world's leading experts

And this is recognised world-wide. In the nuclear field, we are considered internationally a "developed" rather than a "developing" country. India is a founder-Member of the International Atomic Energy Agency where we are now a technical assistance - giver, not a taker. A large number of scientists from developing countries are trained in DAE every year. We are cooperating with Russia in peaceful applications of nuclear energy. President Putin's visit to BARC earlier this month is indicative both of the rapidly increasing momentum in our nuclear power sector and of our growing cooperation with Russia in this area. We are contributing some hi-tech components to the Large Hadron Collider - which will be the most powerful accelerator in the world - being built in the European Centre for Nuclear Research (CERN) in Geneva. Today's India should go for international cooperation in high-technology areas on an 'equal-partner' basis, as in the CERN project. I define Self-Reliance today not as self-sufficiency but as immunity against technology denial. We must also increase our Synergy with the University System and with the rest of the S&T System in the country and make careers in Science and Technology attractive to young people.

In conclusion, let me say that Indians in India and Indians abroad look at the work done by the Department of Atomic Energy with pride. DAE is, however, not just Research and Projects. DAE is people - scientists, technologists, technical staff, administrators, supporting staff, even those who have left DAE because as I say: "Once a DAE person, always a DAE person". We all have the responsibility of preserving the nuclear heritage that has been built up over the years and to enlarge it in the future. That would be the homage we pay to Homi Bhabha.

Thank you, Jai Hind.

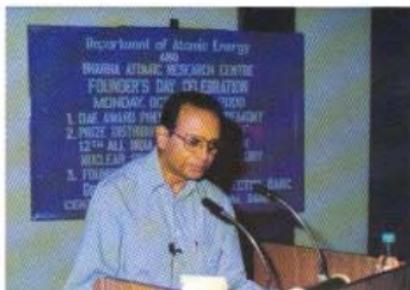
(Director's address continued from page 3...)

programmes. One noteworthy example has been conduct of shielding experiments for shielding of intermediate sodium heat exchanger of PFBR, which not only would give design data for PFBR shielding but would also provide a useful benchmark for validating shielding codes being used by various groups in DAE. Pneumatic Carrier Facility in Dhruva reactor was also commissioned during the year. Refurbishment of CIRUS is progressing well and we hope to bring CIRUS on line soon. All Reprocessing Plants are working well. Waste Immobilisation Plant at Trombay is about to be commissioned. Transportable system to clean liquid waste and reduce liquid waste inventory has been commissioned and is operating very satisfactorily.

R&D on power reactor front further progressed towards greater deployment and further development of coolant channel life management and repair technologies. All the BARCIS systems have been handed over to NPCIL. A total of 100 operators from various Power Plant sites have been trained and qualified for operation and maintenance of these systems. Advances have been made in terms of precision measurement of diameter to assess diametral creep as well as development of radiation resistant camera for in-channel visual inspection. Garter springs were re-located in 28 coolant channels of MAPS-2, enhancing their life. Work to support leak before break assurance in Primary Heat Transport piping has led to considerable augmentation of our data base at full size component level. In fact, this has led to some very useful international cooperative research programmes with complimentary benefits. Chemical decontamination of clean up system of the Unit-2 of Tarapur Atomic Power Station was carried out successfully for the first time.

Thorium utilisation has been the most important long term objective of our programme. In addition to its importance in realising a vast energy resource that we so desperately need, I also strongly feel that thorium has the potential to offer a very satisfactory

solution to global questions on sustainable development. Our work in the area of reactor and fuel cycle development centering around thorium has, therefore, evoked widespread interest. While detailed design and development of Advanced Heavy Water Reactor is making rapid progress and facility for separation of U^{233} from irradiated thorium is under commissioning trials, work on critical facility for AHWR has picked up and possibilities of regular irradiation of thorium fuel bundles in power reactors are being explored with NPCIL. Ideas for reprocessing and refabrication of AHWR fuel are about to be frozen and a road map for development of accelerator driven systems, a technology of importance to long term thorium utilisation in our context is being prepared by a specialist group specifically working for this purpose. Several innovative ideas are being deliberated upon and there seems to be a good possibility of a variant AHWR core being found attractive as thermal part of one way coupled fast thermal hybrid sub-critical blanket for such a system. As a part of support to data generation activities, good progress was made to prospect protoactinium-231 in small quantities.



Dr. A.N. Prasad, former Director, BARC delivering the Founder's Day lecture on Nuclear Fuel Cycle at the Central Complex auditorium, BARC.

While mixed carbide UC-PuC fuel developed for FBTR has continued to perform well exceeding the 50,000 Mwd/Te mark, some mixed oxide UO_2 - PuO_2 fuel bundles loaded in TAPS have completed their threeb irradiation cycle satisfactorily. MOX programme is progressing well. Two more MOX fuel bundles were delivered to TAPS recently.

In addition to electricity generation, we should also explore other applications of nuclear power at BARC. In fact, we should look upon ourselves as a major energy technologies development centre. In this context, the nuclear desalination demonstration project at Kalpakkam, which is making rapid progress, as also preliminary work on compact high temperature reactor, are important. We have to also accelerate our work on adding capacities in the back end of our fuel cycle.

Post test investigations following May '98 nuclear tests are now nearly complete. As you know, these have confirmed that all objectives of the tests have been fully met.

Work on setting up of POTON, a facility for radiation processing of onions and other food products, is progressing rapidly and the facility is likely to be commissioned early next year. POTON, along with Spice Irradiator, recently commissioned by BRIT at Vashi, Navi Mumbai, would provide demonstration over a full range of dose levels for various food processing applications on an industrial scale, hopefully evoking interest on part of industry to set up additional food processing capacity required to boost in export, prevention of food spoilage and price stability.

Industrial Electron Accelerators are gaining importance for a variety of industrial processing applications. Very soon, we will be in a position to offer the 500 kV and 2 MV accelerators for industrial demonstration runs at Vashi. Simultaneously, work on development of 3 MV and 10 MV accelerators along with setting up of Eb Centre at Kharghar, Navi Mumbai, jointly with SAMEER, where similar industrial demonstration runs can be offered with these bigger accelerators, is making rapid progress. While we pursue development of accelerators and process development using these accelerators, we are also encouraging and supporting Indian industry to set up their own facilities for large scale use of this technology. I am happy to note that two such facilities are likely to come up soon and would provide significant cable processing capacity. Some interesting new developments using this technology

are bio-degradable polyethylene-agrowaste composites and radiation grafted formulations which can concentrate uranium from sea water.

On the nuclear agriculture front, research efforts have led to a new black gram variety TU-94-2 with 35% more yield and resistance to yellow mosaic virus, as well as a high yielding soyabean variety TAMS-38. Both these varieties have been released recently. I wish to recognise at this stage our extensive collaborative research efforts with several Agricultural Universities in the country. In fact, we have given considerable boost to such collaborative programmes in recent years.

The activity of trouble shooting on various types of process columns using gamma ray transmission technique is becoming increasingly popular. These columns have a range in diameter from 2.5 m to 11 m and in height from 25 m to 45 m. We are exploring augmentation of technology by adoption of three dimensional computed tomographic imaging technique. Field trials were successfully carried out at New Mangalore as well as Mumbai ports on a prototype nucleonic suspended sediment concentration gauge which facilitates dredging operations in ports. Tracking of 10" diameter underground pipeline of Hindustan Petroleum Corporation which supplies aviation turbine fuel from the Mahul Refinery to Santacruz Airport was successfully carried out, using isotope tagged pipe inspection gauge.

On the health front, we now have the FDA approval for use of BARC developed radiation processed hydro-gel for human burn injury treatment. This hydro-gel has shown excellent results at 3 hospitals in Mumbai. Trials on ³²P coated stents now encompass 70 patients with encouraging results. Samarium-153 phosphonate complex for pain palliation in terminal cancer patients has been tried in 25 patients in two hospitals. Holmium-166 hydroxy appetite particles have been developed for treating arthritis and tried in 25 patients in one hospital. High purity cerium chloride was supplied to Davos Corporation of USA for pharmaceutical applications for the first time. A new Plant for

processing of ¹⁸⁶Re has been commissioned to handle upto 5 Ci activity. A Sr-Y generator has been developed and tested with excellent results.

On the technology front, together with Advanced Propulsion Facilities Division of the Vikram Sarabhai Space Centre, an indigenously developed 250 kW Constricted Arc Plasma Generator was qualified for testing strategic thermal protection systems for rocket motors and re-entry simulator devices. ANUPAM series Parallel Processing Systems have now reached a large number of institutions such as the National Centre for Medium Range Weather Forecasting, Delhi; Aeronautical Development Agency, Bangalore; Vikram Sarabhai Space Centre, Thiruvananthapuram; Indian Institute of Technology, Mumbai and Kanpur; The Institute of Physics, Bhubaneswar and Nuclear Power Corporation. Development of a 64 node system, which is expected to deliver about 25 Giga Flop performance, is now under way.

To support basic research activities, an indigenously built Folded Tandem Ion Accelerator (FOTIA) capable of delivering heavy ion beams upto A~40 and beam energy upto 66 MeV with a maximum terminal voltage of 6 MV has been successfully commissioned. The TACTIC (Tev Atmospheric Cerenkov Telescope with Imaging Camera) array installed at Mt.Abu in Rajasthan will be fully ready for sustained observations in a few months. Synergy between basic research and technology development has been the hallmark of activities of BARC. We now have a number of Task Forces with well defined objectives which are active. I expect such interactive working across the disciplines would further boost this synergy and result in rich dividends in years to come.

All the 9th Plan projects are progressing well and we now have a system of coordinated follow up involving interactive working of a large number of individuals. This approach has contributed to more efficient project implementation and I do hope that we will achieve our 9th Plan goals successfully. We have also begun brain storming discussions on our future activities which would take our scientific and

technological achievements to a much greater height. After all, it is clear that most of the new thrusts in our future programme have to be indigenously conceived to address our own specific national problems. On the basis of strength that we have built up over the years, I have no doubt that all of us would succeed in our missions through our interactive support to each other's activities.

CHAIRMAN PRESENTS DAE AWARDS TO STAFF

The Department of Atomic Energy (DAE) instituted an Award Scheme in the year 1993 for Scientific and Technical Excellence to recognise exceptional accomplishments and meritorious achievements, 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.



Mr A.K. Anand, Director, Reactor Projects Group and Technical Coordination & International Relations Group, BARC announcing the names of the DAE award winners for the year 1999.

The names and achievements of the various award winners for 1999 were read out by Mr A.K. Anand, Director, Reactor Projects Group and Technical Coordination & International Relations Group, BARC, and the awards were distributed by Dr R. Chidambaram, Chairman, AEC, on the Founder's Day.

The Award Scheme consists of three categories of Awards.

- (A) Homi Bhabha Science & Technology Award
- (B) Technical Excellence Award
- (C) Meritorious Service Award

These awards are given annually.

(A) **Homi Bhabha Science & Technology Award** is the highest among the three awards. It consists of: (a) a citation, (b) a medal, and (c) a cash award of Rs. 50,000/-

This award is given to an Engineer/Scientist who has made outstanding contributions towards the advancement of science and/or 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/international standards. This year the award was given to :

Dr T. Jayakumar of Non-destructive Testing and Evaluation Section, Metallurgy and Materials Group, Indira Gandhi Centre for Atomic Research, Kalpakkam.



Dr R. Chidambaram, Chairman, AEC, presenting the Homi Bhabha Science & Technology Award, 1999, to Dr T. Jayakumar

Dr T. Jayakumar was conferred the **Homi Bhabha Science & Technology Award** for the year 1999 for his outstanding contributions to the development of nondestructive testing and evaluation (NDT&E) methodologies and their applications.

Dr T. Jayakumar's work has encompassed a number of areas of which special mention may be made of the development and application of advanced nondestructive testing techniques and procedures for the characterisation of micro-structures, residual stresses, tensile deformation and fracture process, creep and fatigue damage and phase transformations in several important structural materials.

The special accomplishments of Dr Jayakumar in the area of NDT&E include integrity assessment of the ring beam of the dome of the Kaiga power plant, examination of steam turbine components, residual stress measurements and failure studies of the turbine blades, qualification of FBTR cladding tubes, assessment of the integrity of heavy water plant components and application of micro-focal X-radiography for defect detection in tube-to-tube sheet weld joints of steamed generators of Prototype Fast Breeder Reactor (PFBR).

The R&D efforts of Dr Jayakumar have led to the development of intelligent processing based methodologies for quality assessment of end cap, spacer pad and bearing pad welds of PHWR fuel sub assemblies, of a laser based non-contact etching technique for uranium dioxide and other fuel materials and of a focused eddy current probe assembly for the detection of scratches on the inner surfaces of the calandria tubes of PHWRs.

(B) The second category of the awards is the **Technical Excellence Award**. This award is conferred on an Engineer/Scientist who has made outstanding contributions and/or ideas, or made special efforts towards :

- (a) Development of a new or improved equipment, machine, materials, process of device with proven results meeting the immediate user requirements or futuristic needs or bringing credit to the respective Unit and/or leads to import substitution, technology transfer, etc.
- (b) Practical constructive ideas/suggestions leading to better utilisation of human resources, materials, processes, devices, etc. resulting in higher efficiency and significant financial saving to the Government; and/or
- (c) Handling of

emergency or crisis situations, exhibiting rare alertness and skill thereby averting accident/serious plant situation; and/or (d) Highly efficient planning and execution of important assignment in multidisciplinary/multiorganisational time bound projects of vital interest to the nation, and excellence in trouble shooting for expeditious implementation of ongoing projects.

The Award consists of : (a) a citation, (b) a medal, and (c) a cash award of Rs. 20,000/-

This year the award was given to :

- (i) **Mr Y.S. Mayya**
Head, Distributed Automation & Control Section,
Control Instrumentation Division,
E&I Group, BARC.
- (ii) **Dr Praveen Choudhary**
Industrial CO Laser Section,
Centre for Advanced Technology,
Indore.

(i) Mr Y.S. Mayya was conferred the **Technical Excellence Award** for the year 1999 for his meritorious contributions to the area of automation and control systems.



Mr Y.S. Mayya receiving the Technical Excellence Award from R. Chidambaram, Chairman, AEC

Mr Y.S. Mayya has been very successfully involved in the innovations of digitally controlled and networking systems and has pioneered developmental activities pertaining to large size automation control systems for important national facilities such as Earth Station, Dehradun, Master Control Facility, Hassan, and Giant Metre-wave

Radio Telescope (GMRT), Pune. He has shown commendable initiative in starting digital networking, monitoring and control systems architecture for their use in DAE plants. He has significantly contributed to technology development for defence applications and, in this context, mention may be made of Antenna Control Systems for the FALCON and PTA projects, Stabilisation and Tracking System for AD Project, Antenna Platform Unit for Multi-mode Radar of LCA and Fibre-Optic Gyro based Land Navigation System for battle tanks. The work carried out by him with regard to GMRT Antenna Control Systems, Token Bus networks for Nuclear Power Plants and Micro-processor based Traction Control System for Thyristorised AC Locomotives have also been of an exemplary standard. All these activities have resulted in the creation and consolidation of expertise in areas such as digital/analog hardware design, real time software modelling and design using object modelling techniques, establishment of software engineering practices with adequate documentation, development of real time kernels, modelling and simulation of dynamic systems, antenna and motion control systems, inertial navigation, computer networks, etc. and have constituted important inputs to the development of indigenous technology.

(ii) Dr Praveen Choudhary was conferred the **Technical Excellence Award** for the year 1999 for his very significant innovative contributions to frontline laser technology.



Dr Praveen Choudhary receiving the Technical Excellence Award from R. Chidambaram, Chairman, AEC

In the context of Dr. Choudhary's commendable work, a special mention may be made of his

involvement with high power carbon dioxide lasers, pulse power technology, power electronics, and gas discharges.

Dr Choudhary has been associated with the development of various types of electrical power supplies for high power continuous wave (CW) and pulsed carbon dioxide laser and also for the excitation, power control and protection systems necessary for their efficient and safe functioning. He has been instrumental in providing extremely useful electrical development support for a number of types of lasers such as multi-kilowatt CW-CO lasers, TEA-CO laser and RF-excited fast-axial-flow (FAF) CW-CO lasers. For CW-CO lasers pre-ionisation, he has developed all solid state magnetic pulse compression based pulser circuits replacing thyatron, and switched mode power supplies (SMPS) of 2 kV, 25 and 35 kW ratings for pulsed operation and power modulation of these lasers. This development of magnetic pulse compression to eliminate the need of thyatron is one of the premier examples of his important contributions having considerable impacts. For FAF-CO laser, he has developed 7.5 kW, 6.5 MHz RF power source and matching network for coupling the RF power to six discharge limbs of this laser. The impressive listing of his achievements extends to such specific examples as to the development of a trigger unit for 1 kW average power Nd : YAG laser and to the development of a 25 kHz induction heating unit for a vacuum furnace used in chemical vapor deposition application. All in all Dr. Choudhary has several firsts to his credit and they are remarkable technically.

(C) The third category of the award is the **Meritorious Service Award**. This award is conferred on an employee with a minimum continuous service of 20 years or more who has 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) a citation, (b) a medal, and (c) a cash award of Rs. 10,000/-.

This year the award was given to :

- (i) **Mr Ashok R.Kamath**,
Environmental Assessment Division, BARC
- (ii) **Mr S.R. Kumbhare**,
Plasma Radiation Section, CAT, Indore
- (iii) **Mr. J. R. Mishra**,
TSD, Engg. Services Group, BARC
- (iv) **Mr A.M. Muneer**,
Central Workshops, IGCAR, Kalpakkam
- (v) **Ms M. Radhika**,
Physical Metallurgy Section,
Materials Characterisation Section,
IGCAR, Kalpakkam

(i) Mr Ashok R. Kamath was conferred the **Meritorious Service Award** for the year 1999 for his sustained contributions to the field of thermoluminescence dosimetry.



Dr R. Chidambaram, Chairman, AEC, presenting the Meritorious Service Award to Mr Ashok R. Kamath

During the tenure of over three decades of service, Mr Ashok R. Kamath has involved himself with a number of programmes. He was an important contributor to the monazite survey programme. He has also been involved with the country - wide radiation (background) survey and, more recently, with the environmental radiation monitoring being carried out using TLDs at different nuclear installations. To quantify his impressive contributions it may be added that he undertakes the fabrication of about 500 TLDs on a quarterly basis and subsequently records the TL glow curves of the exposed ones coming back from different stations.

His confident disposition has always stood him in good stead.

(ii) Mr Sudhakar R. Kumbhare was conferred the **Meritorious Service Award** for the year 1999 for his meritorious contributions to some specific areas in the fields of high power Nd : glass lasers systems and X-ray diagnostic systems for measurements in laser produced plasmas.



Mr Sudhakar R. Kumbhare receiving the Meritorious Service Award from Dr R. Chidambaram, Chairman, AEC

During the last two decades, Mr Sudhakar R. Kumbhare has been very competently working on laser plasma interaction. He is one of the members involved with the development of the 1000 gigawatt, 25 psec laser system where contributions pertain mainly to the design and development of laser amplifiers, spatial filters and isolators. He is extremely knowledgeable about high power laser systems and amply processes the technical expertise required for setting up these systems. The list of his contributions is enriched by his independent involvement with the setting up of some laser plasma diagnostics.

(iii) Mr J.R. Mishra was conferred the **Meritorious Service Award** for the year 1999 for his meritorious contributions in activities pertaining to the maintenance of electrical equipment.

In the span of about 35 years, Mr J.R. Mishra has acquired commendable skills in maintenance of electrical sub-station facilities, especially power transformers, switchgears, cables, transmission lines and switch yard facilities. To specifically and representatively name some of his involvements,



Mr J.R. Mishra receiving the Meritorious Service Award from Dr R. Chidambaram, Chairman, AEC

mention may be made of the installation and commissioning of 1250 kVA, 22 kV/433V transformers and the LCLP substation at Vashi of 11 kV load break switch and associated cabling at Trombay Hill, and of 22 kV switchgears and overhauling/lifting of OLTC diverter switches of 110 KV/22 kV/11 kV, 50 MVA transformers. He has, besides, earned a reputation for himself for his disposition towards competent handling of electrical breakdowns and his proficiency in fault rectifications.

(iv) Mr A. Mohamed Muneer was conferred the **Meritorious Service Award** for the year 1999 for his significant contributions to the field of welding.



Mr A. Mohamed Muneer receiving the Meritorious Service Award from Dr R. Chidambaram, Chairman, AEC

Since 1974, Mr A. Mohamed Muneer has been intensely involved with the art of welding of a variety of materials under diverse situations. A special mention may be made of some representative jobs undertaken by him pertaining to reactor components, structures, pressure vessels, heat

exchanges and storage tanks, involving stainless steels, carbon steels, low alloy steels and a host of non-ferrous metals and alloys. He has earned the reputation of being one of the most accomplished welders who can successfully handle specialised jobs, however difficult, with confidence and expertise. Besides welding, he has also mastered other metal joining processes and has undertaken important and special brazing jobs. He is the role model and a source of inspiration for his colleagues. For his commendable contributions, he has been awarded the Best Craftsman in Welding Award (1969), Best Technical Paper Award (1998) and Meritorious Employee Group Award (1999).

(v) Ms M. Radhika was conferred the **Meritorious Service Award** for the year 1999 for her excellent work output pertaining to the applications of scanning electron microscopy in the study of materials.



Ms M. Radhika receiving the Meritorious Service Award from Dr R. Chidambaram, Chairman, AEC

During the tenure of nearly 23 years of service since 1977, Ms M. Radhika has had an extensive involvement with the use of scanning electron microscopy in alloy development, failure analysis and materials characterisation. The excellent micrographs obtained by her, have been crucially important in a number of critical investigations involving a variety of materials. She has also been associated with other physical metallurgy activities such as heat treatments and metallography. Ms Radhika has applied herself very creditably in relation to many R&D programmes having a direct bearing on nuclear power production. In addition,

her work related to failure analysis has been very useful to a number of other industries.

XIITH ALL INDIA ESSAY CONTEST IN NUCLEAR SCIENCE AND TECHNOLOGY

The DAE All India Essay Contest in Nuclear Science & Technology for students studying for graduation was started in 1989 and thereafter it has become an annual feature. This year's contest was 12th in the series. The students were required to write essays on one of the two topics that were specified for the contest. The topics for this year's contest were :

- (A) "Role of Nuclear Power in India's Long Term Energy Needs"
- (B) "Non-Power Applications of Nuclear Energy"

A total of 477 essays consisting of 254 essays on first topic and 223 on the second one were received. A total of 131 essays were written in various languages other than English.

The written essays were evaluated by 7 to 8 groups of evaluators from BARC, NPCIL and BRIT. The thirty finalists were invited to come to BARC for giving oral presentation of their essays.

In the oral presentation, a panel of judges for each topic evaluated the performance based on the presentation and the question-answer session that followed. Prize winners were decided on the basis of total marks obtained both in written essays and in the oral presentation.

The popularity of the essay contest amongst university students could be judged from the fact that in the last 12 years, over a thousand essays have been received. Essays could be written in any official Indian language or English. It was interesting to note that about 40% of the contestants have been girl students.

Dr Chidambaram, Chairman, AEC, gave away the prizes to the winners of the essay contest on the BARC Founder's Day, October 30, 2000.



Dr R. Chidambaram, Chairman, AEC, with winners of the All India Essay Contest in Nuclear Science & Technology

Prize Winners :

Topic A : "Role of Nuclear Power in India's Long Term Energy Needs"

First Prize : Prasant Das (Ist year Computer Engg., Bidar)

Second Prize : R.D. Mistry (Ist year Mech. Engg. Solapur)

Third Prize : G.B. Swamy (Ist year B.Sc., Shimoga)

Topic B : "Non-Power Applications of Nuclear Energy"

First Prize : R.S. Chauhan (IIIrd year B.Sc., Jodhpur)

Second Prize : Ms Gauri Jha (IInd year B.Sc., Patna)

Third Prize : K.G. Dinkar (IIIrd year B.Sc., Tiruchendur)

MICROCOMPUTER BOARDS FOR SAFETY CRITICAL SYSTEMS OF NUCLEAR POWER PLANTS AND OTHER HIGH RELIABILITY INDUSTRIAL APPLICATIONS

Shantanu Das, M.B. Patil, D.A. Roy, C.K. Pithawa and B.B. Biswas
Reactor Control Division

B. Ganaraj
Fuel Handling Control Section

Umesh Chandra
Assoc. Director, Automation & Manufacturing Group
and

P. Sudhakar
Electronics Corporation of India Limited

Introduction

Microcomputers found wide application in many embedded Control and Instrumentation (C&I) systems starting in early eighties. However, its use in safety critical systems of Indian Nuclear Power Plants (NPP) was restricted till last few years, one of the main reasons being non-availability of robust designs with built-in fault diagnostic and safety features. Internationally available microcomputer

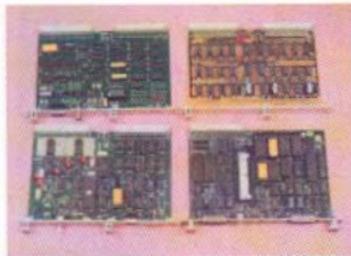
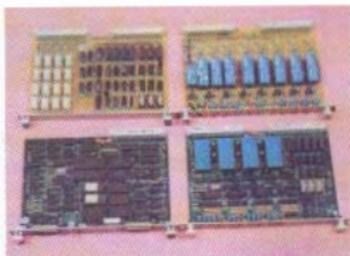
boards did not have these desirable features. Hence, a family of (Intel/Motel based) microcomputer boards on a proprietary bus called 'EURO bus', along with signal conditioning and power supply boards was developed in Reactor Control Division. These development efforts ensured self-reliance on delivering reliable computer based safety critical systems of NPP and other high reliability industrial systems.

These boards have been used in safety critical systems like Programmable Digital Comparator System (PDCS), Reactor Regulating System (RRS) and Process Control System (PCS) in KAIGA-1,2 and RAPP-3,4. In Fuel Handling Control System (FHCS) of Kaiga-1,2 and RAPP-3,4, X-ray diffractometer system, TG vibration monitoring system and Laser tuning system, boards from this family have been used. These boards have also replaced foreign designs in some C&I systems at NFC. Recently, a prototype multi-nodal RRS for 500 MWe has been integrated using these boards. Upgradation of some C&I systems of Dhruva and Apsara is planned using these boards. PDCS, RRS, PCS and FHCS of KAIGA-3,4 will also be made using these boards. These microcomputer boards have been used in above systems in different configurations like single computer, Dual processor hot standby, Triple modular redundancy and Multi-processor. More than 3500 boards of this family are already in use in various C&I systems.

This board family has about 40 different types of boards needed for various C&I applications. The board designs are NPC QA qualified. The boards have double EURO format (233.34 mm x 160 mm). These boards have been manufactured and supplied by ECIL for the above listed applications and are available from them as standard products.

List of main function modules

1. Main processor module with maths co-processor
2. Expandable memory module
3. Isolated digital input module with finite impulse testing
4. Isolated digital output module with read back
5. Relay output module with read back
6. Multi-channel 12 bit ADC module with on board calibration and MUX fault detection
7. Multi-channel 16 bit ADC module with on board calibration and MUX fault detection
8. Isolated 4-20 mA current output module with facility to read back
9. 2 wire, 3 wire signal conditioning modules with isolation for mV, RTD and current inputs
10. Supply monitoring, NMI manager and battery backed RAM module
11. Watch dog timer module
12. Intelligent communication module with isolated MODEM, DMA and DPRAM
13. Expandable serial communication interface module
14. Redundant network interface & controller module
15. Dual processor arbitrator module
16. Bus extender master module
17. Bus extender slave module
18. Multi-channel DMA interface module
19. Expandable interrupt controller module
20. Parallel processing DSP module
21. Software task monitor module
22. Floppy disk interface module
23. IDE interface module
24. Alpha Numeric Key board interface module
25. Alpha Numeric Display controller module & Display module
26. Low and High inertial mini micro stepper modules
27. Pulse width discriminator isolator with pulse counter module



Some main boards of Euro-Bus microcomputer board family

28. Proportional controller module for stepper motor
29. Servo amplifier for valve solenoid controller module
30. Various digital and analog back plane modules

Micro-processor, coprocessors & support chips

The processor architecture and timings are important issues while selecting a microprocessor. Familiarity and easy availability of microprocessor is also an important consideration. For real-time systems, assembly language know-how is essential to get optimized and reliable software code and hence the instruction code of microprocessor should be simple.

System bandwidths required for various C&I applications were studied and 2 to 4 Mbits/sec data BW was found to be more than sufficient. Higher end microprocessors like 80286, 80386, 80486 were also considered but were found to be overkill. For C&I applications, 16 bit data bus and 20 bit address bus was found to be sufficient. Intel 8086 microprocessor was therefore chosen with its powerful co-processor set and support chips for its familiarity simplicity and availability. Thus the designs of these boards are based on Intel series and few motel series chips. Choosing a simple microprocessor (8086) and distributing the peripheral jobs to specialized co-processors (8088, 80186, 8751 8087, 82586, ADSP2100) and support chips gave elegant, reliable and robust design with desired throughput for various C&I systems of NPP. Moreover these Intel series ICs are generic in nature and are available from multiple sources.

Euro Bus: with 8086 natural signals

An extension of natural signals of chosen microprocessor in desired form factor gives a reliable bus. The designers of reliable embedded systems like Siemens, ABB and Triconix also follow this criterion. System designers who have selected Signetics 2670 or Texas TMS 32XX micro-processors have used natural signals of their selected microprocessor and thus have their own

proprietary bus with proper form factor. This practice also saves component counts and reduces timing errors thus giving elegant, simple and reliable design.

Having chosen the main microprocessor and powerful co-processor/slave processor, next step was to design boards on a suitable bus. Proprietary bus signals were selected with 96 pin Euro connector. Rows A and C were dedicated for basic maximum-mode 8086 signals, along with power inputs. Row B was used for serial and parallel arbitration signals, for multi-master expansion. This allocation of signals resulted in design of most of the boards in double layer instead of multi-layer thus saving bare PCB cost. The 'EURO bus' thus has following bus signals: address signals A0-A19, data signals D0-D15, control signals INT1-INT4, INTA, HOLD, HLDA, SYSALIVE, LOCK, BHE, NMI, MEMRD, MEMWR, IORD, IOWR, RESET, CLK, XACK, in A and C rows of EURO connector and multi-master signals ARB CLK, BPRN (1-4), BPRO (1-4) in B row of EURO connector. A single bus structure was chosen for all the boards including I/O boards.

Features of EURO bus :

- Full capability of 8086 and other co-processors utilized.
- All Intel/Motel processors and co-processors interfaced directly.
- Single type bus structure to enhance reliability.
- Swappability of any board anywhere in a bin or any other extended bus bin.
- Expansion of bus DMA for multiple DMA channels
- Expansion of bus interrupts upto 32.
- Any board can be configured in memory or I/O map with all memory & I/O address available without gaps.
- Board absence detection facility.
- Power fail management to gracefully shutdown the node.
- Detection of absence of board (s) can be used to reconfigure the system.
- Multi-master expansion up to four processors.

- On bus failure, or any software or hardware failure, the outputs can be taken to desired safe state.

Microcomputer boards

- Board designs are based on generic components. Long term availability of components is thus assured from multiple sources.
- Generic component pin compatibility gives flexibility to use MIL or commercial components in same layout.
- All components are de-rated to 50%.
- The logic design is open and not programmed or hidden into PAL, EPLD and FPGA. Due to this bit flow and signals can be easily traced for verification. Servicing and repairing with generic components is easy and does not require any programming by site staff.
- On-line fault detection in hardware is possible to a large extent.
- Boards removal and insertion while system is running can be detected. Depending on application, the system can be reconfigured or can be gracefully shut down.
- Bus extension to other bins up to 10 feet distance is possible for large I/O applications.

- Fail-safe features are provided either to freeze or force the outputs to any desired value.
- The field connections are provided through IDC connectors on back-plane, which is a desirable feature for easy maintenance.
- All boards conform to PP-E-1443 of NPCIL.

Power supply boards

For safety critical systems, reliable power supplies are needed. Power supply boards were designed in Reactor Control Division to get reliable and robust power supplies with hot plugging and load sharing features. These power supply boards are based on current mode controllers and have desired controller stability margins. These power supplies have been used in various C&I systems of Kaiga-1,2 and RAPP-3,4 and are now available from ECIL as standard products.

Conclusions

A family of microcomputer boards with high reliability and on-line diagnostic features has been developed. The family of boards covers all possible functions needed in a C&I system. These boards have found wide use in NPP and other critical jobs.

DEVELOPMENT OF IN-SERVICE INSPECTION (ISI) SYSTEM FOR CALANDRIA TUBES OF CIRUS REACTOR

A calandria tube inspection system based on measurement by eddy current method has been recently developed by In-service Inspection Section of Research Reactor Services Division. The need for inspection of calandria tubes was strongly felt because, in the year 1971, the first calandria tube developed leakage and had to be remotely plugged. Soon after 1971, arrangements were made for measurement of thickness of the calandria tubes using absolute coil eddy current technique backed up by borescopic visual inspection. In the year 1994, the leakage in second calandria tube was detected.



Fig. 1 ECTprobe

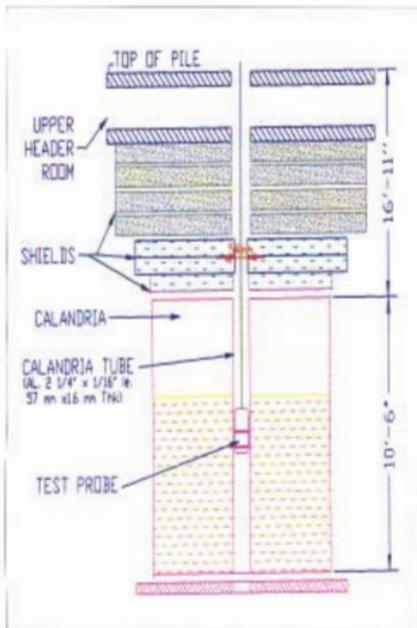


Fig. 2 ECT probe inserted inside the calandria tube

In view of the leakages detected in two calandria tubes, it was decided to inspect all the calandria tubes to study any ageing effect since Cirus reactor was in operation for nearly 40 years. This decision called for development of an accurate and reliable system for inspection of calandria tubes.

The ISI system for Cirus calandria tubes had to be tailor made incorporating special features due to the following reasons:

- The top of calandria which is the starting point for calandria tube inspection is about 17' vertically below the operating floor (Top of pile). The eddy current probe had to negotiate through various shields on top of calandria before entering into calandria tube.
- The probe was expected to encounter a radiation field of the order of 10^6 R/Hr during inspection.

- The main constraint in designing and developing the eddy current probe was the smaller size hole (2 1/8" dia i.e. 54 mm) in 2 nos. of top steel thermal shields through which the probe has to pass in order to reach the calandria tube which is of larger size 2 1/4" ID (57 mm).

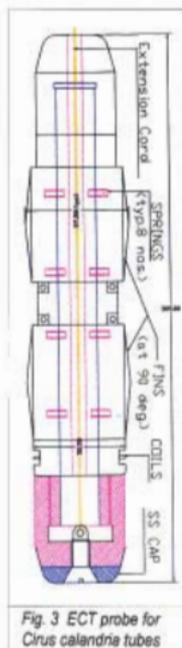


Fig. 3 ECT probe for Cirus calandria tubes

Accordingly, an eddy current test probe was designed, developed and fabricated to fulfill the above requirements for in-service inspection of 2 1/4" ID x 1/16" thick Aluminium calandria tubes (Fig.1). The eddy current probe consists of 8 nos. of spring loaded nylon fins positioned in two layers. The fins get compressed/expanded while passing through the vertical holes in the top shielding and in calandria tube. The spring loaded fins keep the eddy current differential coil concentric with the calandria tube and greatly reduce the distortion signal due to wobbling. The differential coil of the probe is connected to a dual frequency eddy current tester.

The probe can identify short discontinuities such as cracks, pits or other localised defects in calandria tubes. The defect signal can be recorded in magnetic tape recorder. Laboratory and out of pile trials of the probe were carried out on specially made defect reference standards fabricated at Cirus and Atomic Fuels Division. Initially, 13 nos. of calandria tubes have been successfully inspected on trial basis (Fig.2 & 3). This system is fully deployed and inspection of 140 nos of calandria tubes have already been completed.

IAEA/RCA REGIONAL TRAINING WORKSHOP

An IAEA/RCA Regional Training Workshop on "Electron Beam Processing of Paper Pulp for Viscose Rayon Industry" was organised by Radiation Technology Development Section at Hotel Days Inn, Mumbai, during October 23-27, 2000.



Participants of the IAEA/RCA Regional Training Workshop on "Electron Beam Processing of Paper Pulp for Viscose Rayon Industry". Also seen in the picture are Dr J.P. Mittal, Director, Chemistry & Isotope Group, BARC (8th from right), and Mr A.K. Anand, Director, TC&IR Group, BARC (6th from right)

The viscose rayon industry utilises toxic chemicals such as carbon disulphide for dissolving the pulp and is facing stiff regulations from the environmental agencies as hazardous gases like H₂S are emitted in the atmosphere. The use of electron beam treated pulp significantly reduces the quantity of toxic chemicals required for dissolving the pulp and hence significantly reduces the pollution levels associated with the process. As a majority of the viscose rayon plants now are located in the south-east Asia region, India being one of the major producers, the viscose industry in the region has shown keen interest in utilisation of EB technology. The training workshop was aimed at bringing together the personnel from viscose rayon industry and radiation processing institutes in the region together so that this technology can be suitably adapted in the industry.

The workshop was attended by 15 participants from RCA countries - China, Indonesia, Korea, Thailand, Vietnam and India. The participants were from the

rayon industry, cotton research institutes and from the atomic energy institutes. The workshop was inaugurated by Mr A.K. Anand, Director, Technical Coordination & International Relations Group, BARC, and the keynote address was delivered by Dr J.P. Mittal, Director, Chemistry & Isotope Group, BARC. Mr Anand, in his inaugural address, highlighted the key role being played by India in the RCA activities, while Dr Mittal, in the key note address, emphasised the application of radiation technology to develop environment friendly processes that minimize the emission of toxic effluents and pollutants. The training course consisted of class room lectures on topics such as electron beam technology, radiation effects on cellulosic materials, technical and economic benefits of EB technology in the viscose process and radiation dosimetry for the process control. The participants also visited the various radiation processing facilities at BARC and Century Rayon factory at Shahad. The faculty consisted of Dr Terry Stepanik, IAEA expert, technologists from the Indian rayon industry and scientists from various Divisions of BARC.

BARC TRANSFERS MEDICAL TECHNOLOGIES TO L & T LTD.

BARC has transferred to M/s Larsen & Toubro Limited, Mysore, two technologies viz., (i) Impedance Cardio-Vasograph, and (ii) Cardiac Output Monitor on August 9, 2000. Both the technologies are based on the principle of Impedance Plethysmography and are non-invasive in nature.

Impedance Cardio-vasograph is a medical instrument used to assess the central and peripheral blood flow in human body. Current is passed through the extreme ends of the body with the help of two surface electrodes and voltage developed across any two points on the body is measured with

the help of another pair of electrodes. This voltage signal is processed to derive the blood flow information in the body. Due to its non-invasive mode of working, the instrument can be repeatedly used in patients for the diagnosis of peripheral vascular occlusive diseases, monitoring of coronary artery diseases, for post therapeutic assessment of venous disorders, cardiac disorders and fluid retention. User friendly software has been developed under Windows 98 using lab Windows CVI/NI.



Mr A.K. Anand, Director, Technical Coordination & International Relations Group and Reactor Projects Group, handing over the Technology Transfer document to General Manager, L & T Limited, Mysore

Cardiac Output Monitor provides cardiac output signal which can be displayed on standard oscilloscope/PC monitor. It reveals pump performance of the heart. It will form front end module to patient monitoring system useful for monitoring of stroke volume and cardiac output in patients in Intensive Care Units and Intensive Cardiac Care Units, except in patients with shunts and valvular regurgitation.

Both the technologies were developed by Electronics Division, BARC. Technology transfer activities were coordinated by Technology Transfer & Collaboration Division, BARC.

BARC SCIENTISTS HONOURED

◆ The Asia Pacific Academy of Materials (ASAM) has elected Dr S.K. Sikka, Director, Solid State & Spectroscopy Group, BARC, as its member for the year 2000. His field of specialisation is High Pressure & Shock Wave Physics, besides Neutron and X-ray Crystallography.



◆ Dr Dipak Palit of Radiation Chemistry & Chemical Dynamics Division, BARC, has been selected to receive the Rev. Fr. L.M. Yeddanapalli Memorial Award of the Indian Chemical Society for the year 1999 for his outstanding research contribution in the field of ultrafast chemistry. The award consists of a medal and a citation, to be given away during the Annual Convention of Chemists, 2000, to be held at Gurukula Kangri University, Haridwar, in November, 2000.



◆ Mr T.K. Saha of Laser & Plasma Technology Division, BARC, was awarded the KCP best paper award on January 20, 2000, during the Symposium on "Joining of Materials", held at Tiruchirapalli. The award was for his paper, "Electron Beam Welding of Copper to AISI-304 SS" by T.K. Saha, A.K. Ray, B.K. Shah, K. Bhanumurthy and G.B. Kale presented at International Welding Conference on Welding & Allied Technology, organized by the Indian Institute of Welding in association with Confederation of Indian Industry at New Delhi during February 15-17, 1999.



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