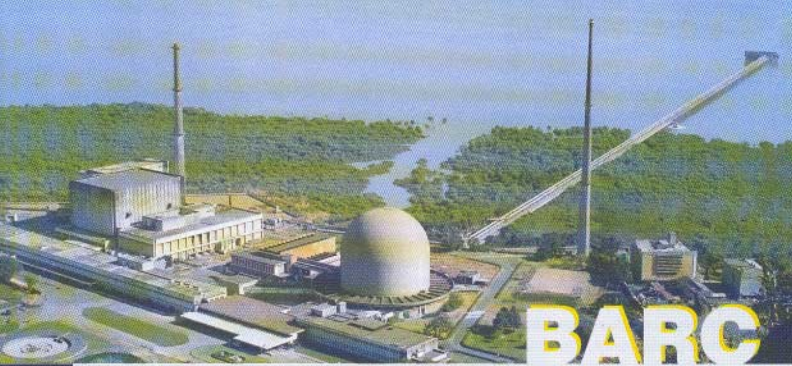

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Contents

HIGH POWER INDUSTRIAL RF ELECTRON LINACS: TECHNOLOGICAL CHALLENGES

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Introduction

The charged particle accelerators have played a key role in the field of basic sciences. Whether it is physics, chemistry, biology, medicine or material sciences, all of them have gone through radical transformations. All this has been possible because of the accelerator beams which have been used to unfold the secrets of nature[1]. Same is true in case of applied sciences too. In the field of medicine, the outdated methods of diagnosis are slowly getting replaced by accelerator-produced radioisotopes[2]. Treatment of malignant cells is another area where the accelerator's beams are being utilized[3]. Novel materials with special properties have been and are being produced through accelerator beams[4]. The production of energy, breeding of fissile materials and transmutation of nuclear wastes are the latest challenges being addressed through accelerators[5]. Inertial thermo-nuclear fusion, triggered by the high power heavy ion accelerator beams, is being contemplated as a possible future source of energy[6].

Industry also did not remain isolated from the big impact of the accelerators. It also went through a radical change for which the major credit goes to electron beams. Beams with varying energy and power have been extensively employed for this purpose[7]. Electrons up to an energy of 0.5 MeV and 10 kW are being used for curing of coatings, adhesives and paints on thin films, tapes, wooden panels, etc. These curing processes enhance the mechanical and thermal properties of the products. Similarly, heat shrink materials use electron beams in the range of 0.5 MeV to 2 MeV. To improve upon the lubrication property, Teflon is treated with beams of about 2 MeV and 10 kW. Diamonds with exotic colours are produced by using beams of 4-6 MeV and a power of 10 kW. Green strength of the rubber is enhanced by exposing it to electron beams of 2 MeV and 30 kW. Beams up to 10 MeV and 10 kW are used for cross linking of cables/wires, food preservation, medical sterilization, etc. The cross linking improves the tensile strength and fire resistance properties of the cables. Sterilization of the disposable medical products is done much more effectively and efficiently through electron beams. The irradiation of semiconductors has totally transformed the IC and microchip industry. Even the pathogenic germs of the sewage and sludge can be taken care of by the electron beams. For this purpose, 1 MeV beam with a power of about 100 kW are being utilised.

The field is growing and expanding at a fast pace with more and more avenues opening up daily. With time, the demand for the beam power is also going up. Today, for electron beam processing, accelerators up to a beam power of about 400 kW are being conceived.

However, it should be kept in mind that for industrial radiation processes, the energy has to be kept within 10 MeV. Beyond this, the nuclear reactions also become predominant and can render the radiated products as radioactive. Therefore, if the penetration depths are not met even by 10 MeV beams, two sided or double sided irradiations should be carried out. If this also does not suffice, the electrons should be converted into X rays which in turn can be used for radiation processing.

BARC had long back realised the enormous potential of the electron beams. That is why, way back in 1995, Accelerator & Pulse Power Division (APPD) of BARC was given the task of designing and developing a 500 keV, 10 kW DC accelerator. The accelerator is located at BRIT, Vashi, Navi Mumbai. It is operational at a power level of 3 kW and is in regular use for surface modification studies. Its power level will be raised to 10 kW as soon as the necessary operational requirements are met. Realising the need of variety in energy and power of electron beams, BARC has sanctioned two more electron accelerators. These are also being designed and developed by APPD. One is a 3 MeV, 30 kW DC and the other is a 10 MeV, 10 kW RF linac accelerator. Both of them will be housed at Electron Beam Centre (EBC), Kharghar, Navi Mumbai.

Choice of Accelerators for Industrial Applications

It is clear from the above facts that for the radiation processing, energy may vary anywhere from a few hundred keV to a tens of MeV and the power from a few kW to a few 100 kW. Therefore, it will not be possible for one accelerator or one type of accelerator to meet all the industrial needs. Apart from that, the type of accelerator used should exhibit highest possible efficiency. Otherwise, the radiation processing will never become a cost effective preposition.

Keeping in mind these constraints, both DC and RF accelerators have been employed. DC accelerators give high average beam power whereas the RF accelerators, generally operated in the pulsed mode, give low average power. On the other hand, DC accelerators have low energy gain per unit length as compared to the RF accelerators. In the case of electrons, this factor could be as high as 10 implying that the RF electron machines could be as much as ten times more compact as compared to the DC accelerators.

Therefore, if one is looking for large average power but low energy, DC accelerators are most suitable. Up to 3 or 4 MeV and 100 kW , DC accelerators are the best choice. For energies higher than that, they become bulky and less cost effective. Among the DC accelerators, Cockroft Waltons are used up to 0.7 MeV to 0.8 MeV and beyond that Dynamitrons or ELV type machines are employed[7].

For energies from 4 to 10 MeV, RF accelerators like RF Linacs, Microtron, Synchrotron, etc can be the possible choices. Since industrial applications require large beam current, the microtrons and synchrotrons will not be able to foot the bill. Hence, the RF Linacs become the best option and they are used up to a power level of 50 kW. Recently, however, in the RF category, a new type of accelerator has also appeared on the scene. This is developed by IBA, Belgium, and is named as RHODOTRON[8]. Energy up to 10 MeV and power up to 150 kW are being realized through this type of machine.

In this article, the emphasis will be on the RF Linacs and the associated technology, that too for the electron beams only.

RF Linacs for Industrial Applications

All types of linacs such as travelling wave, standing wave, constant geometry, constant field, side coupled, on axis coupled, etc. have been used to meet the specific needs[9]. Among them, the on axis coupled cavity, constant geometry, standing wave types operated in the $\Pi/2$ mode, have been more or less universally adopted for the industrial applications. A view of such a typical cavity is shown in Fig. 1. The electron beam entering into the Linac gets accelerated to the desired energy by traversing through various acceleration cells. Through the slots provided in the coupling cells, the RF power to all the accelerating cells is coupled. In the beginning of the Linac, a few buncher cells are provided for bunching the incoming beam. The electron Linacs are generally operated in the S band, the frequency of which lies somewhere between 2.5 GHz and 3.0 GHz. The main reason for this is the availability of klystron or magnetron which are built around this frequency range.

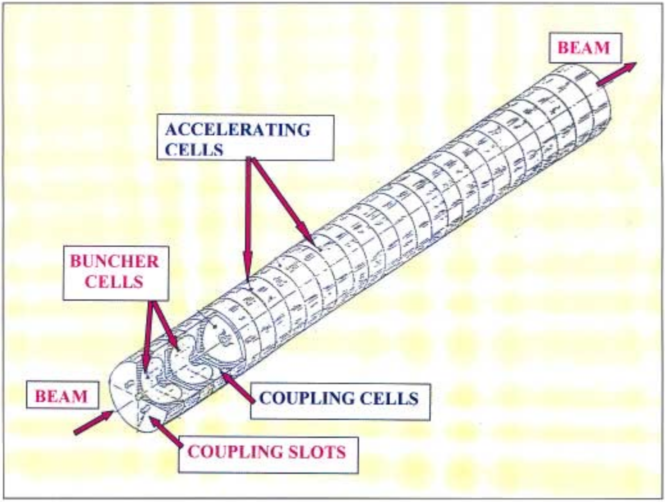


Fig.1 A typical configuration of an RF Linac

Compactness of Linacs brings in a lot of sophistications with it. Both physics and technology has to meet the high level of standards. Therefore, all the aspects connected with the design, fabrication, installation and testing, have to be tackled with utmost care. As far as the Linac design is concerned, primarily the RF cavity and the beam acceleration through it, are the two crucial issues. The cavity has to be designed for as high electric field as possible so that the length of the Linac could be reduced to the maximum extent. But at the same time, this field should not surpass the breakdown limit. Similarly, the designed cavity should exhibit highest possible Q value, shunt impedance, field uniformity and the transit time factor. On the beam acceleration side, all the efforts should lead to high beam transmission, low beam loss, desired beam size, intensity and energy distribution. The entire design is evolved by optimizing and balancing these facts.

On the technological front, particularly, the fabrication and braising techniques should match the required tight dimensional tolerances, surface finish and minimum deformation needs. Only then it will be possible to get the required frequency, the desired Q, shunt impedance and the dispersion properties of the cavity.

EBC Linac

As stated above, APPD has taken up the task of designing and developing a 10 MeV, 10 kW RF Linac, henceforth referred in the text as EBC Linac[10]. The layout of this facility is shown in Fig. 2 and the theoretically designed parameters are given in Table 1. 50 keV electron beam injected into the Linac is accelerated to the desired energy. The energy analysis is accomplished through the magnetic analyzer. The magnetic scanner is used to scan the beam on the products. Klystron-based RF source is used to generate the field in the cavity. The design has been conceived for a RF frequency of 2856 MHz. The configuration of the cavity cells is shown in Fig. 3 and its dimensions details are given in Table 2. The field distribution inside the cell for a Kilpatrick value of 1.4 is depicted in fig. 4. The computed beam energy & intensity distribution at the end of the Linac are shown in Fig. 5. The maximum beam size turns out to be 10 mm or less.

Table 1

Sl. No.	Sub system	Parameters
1.	Injector	Electron Gun, Triode type Output energy : 50 keV Beam current : 1.0 A (peak) Rep. rate : 400 Hz Pulse width : 10 μ sec.
2.	Accelerator	Length : 0.871 m Effective Shunt Impedance : 80 MΩ/m Max. Axial field : 18 MV/m No. of cells : 33 (coupling & acc. both) Transit time factor : 0.8
3.	RF Power Source	Power tube : Klystron Duty factor : 0.4 % Peak RF power : 6 MW Average power : 24 kW Macro pulse width : 10 μ sec. ß, 2.31
4.	Output Beam	Output average energy : 11.4 MeV Energy spread : 1 MeV Energy variability : 8-11 MeV Average beam power : 10.9 kW Beam transmission : 47 %

Technological Issues in RF Linacs

a) Geometrical features of the Cavity : The dimensional tolerances and the surface fnish play an important role. They have to be strictly controlled for obtaining the desired frequency and the other RF properties. For this, the deviations in the RF frequency should not be allowed to cross a factor of $\pm 10^{-4}$. In terms of frequency this works out to be about $\pm$ 300 kHz. Therefore, it becomes necessary

Table 2

Cavity Cell	Length L(cm)	Diameter D(cm)	Gap G(cm)	Outer Corner Radius R1(cm)	Inner Nose Radius R4(cm)	Thick T(cm)	Bore Diameter B(cm)
Buncher B1	4.5	8.343	1.322	1.600	0.100	0.300	1.000
Buncher B2	4.8	8.440	1.482	1.750	0.100	0.300	1.000
Buncher B3	5.0	8.580	1.604	1.950	0.100	0.300	1.000
Acc. A	5.2	8.350	1.559	1.900	0.100	0.300	1.000

Table 3

Sl. No.	Parameter	Change in Frequency kHz / μ
1.	D	-34 kHz
2.	B	-13
3.	L	-25
4.	T	+ 25
5.	G	+ 22
6.	R1	+ 24
7.	R2	+ 0.1
8.	R3	- 7
9.	R4	- 16

that the sensitivity of the various parameters vis-a-vis RF frequency be studied in details. The results pertaining to EBC Linac are given in Table 3. The minus sign indicates that the increase in the value of that parameter decreases the frequency. It is clearly evident from this table that the diameter of the cavity, its length, the thickness, the nose cone gap and the outer corner radius are more sensitivity to the dimensional variations as compared to the other parameters. Roughly the change in frequency is about 30 kHz per micron change. That means the maximum tolerance which can be allowed in a particular parameter is about ± 10 μ.

But luckily, the errors introduced are positive and as well as negative. Therefore, the situation does not become very alarming and can be controlled. In practice, at this frequency, if the geometrical errors are confined to a level of 10-20 μ, the cavities do exhibit proper RF behavior.

Similarly, to reduce the copper losses, the surface finish has to be at its best. At these frequencies, value should be preferably less than one micron.

These are certainly stringent requirements and can not be achieved with conventional machines and by following conventional practices. They demand highly accurate machines with lots of jigs and fixtures. Generally, as a first step, proto-type or test cavities are made. After attaining perfection in three or four trials, attempts are made to fabricate the actual cavities. This saves a lot of time and effort. Since EBC Linac is being made for the first time in the country, it was considered proper to go for proto-typing of the Linac cavity.

b) Proto-typing the Linac Cavity: For the EBC Linac, proto-type cavity was manufactured at CD & M, BARC, by using ETP copper. Minimum of five cell cavity is essential for performing the RF tests. But we started with a minimum of 9 cell configuration and subsequently went ahead with the fabrication of a 33 cell cavity. The initial measurements revealed deviations of about 50 μ in various parameters, which were gradually brought down to less than 20 μ. Similarly, the final surface finish achieved was as low as 0.2 μ. A full 33 cells Linac test cavity [11] has been made and is shown in Fig. 6. It has been characterized for the RF. The frequency is measured as 2855.759 MHz, which is only 0.241 MHz away from the design value. The Q value is measured as 10,000, the shunt impedance 70 MΩ/m and the stop band was found to be within ± 200 kHz. The first neighbour coupling coefficient was measured as 4.6% against

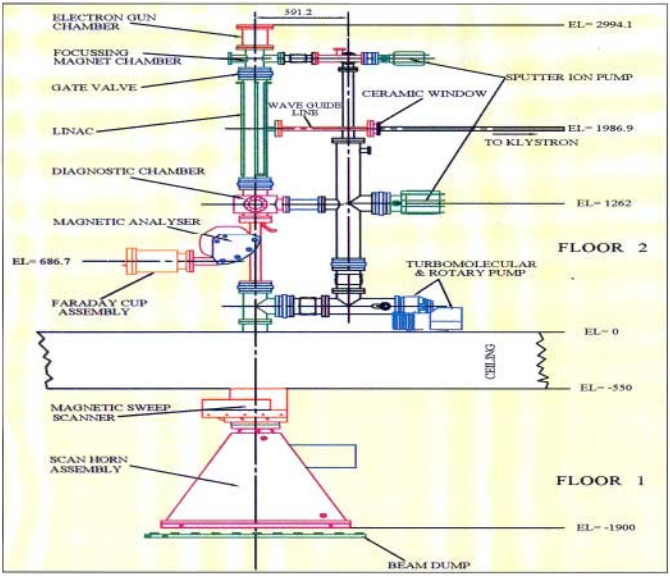


Fig.2 A layout of the EBC Linac

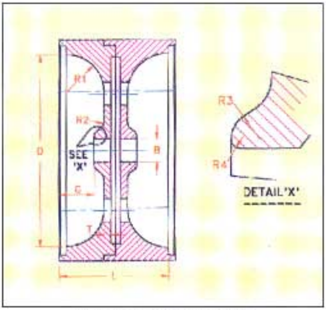


Fig.3 Details of a EBC Linac cavity

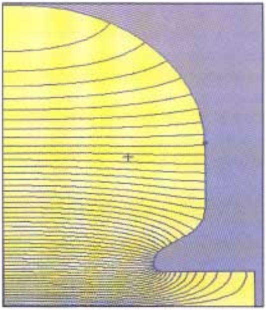


Fig. 4 Electric field distribution inside the cavity

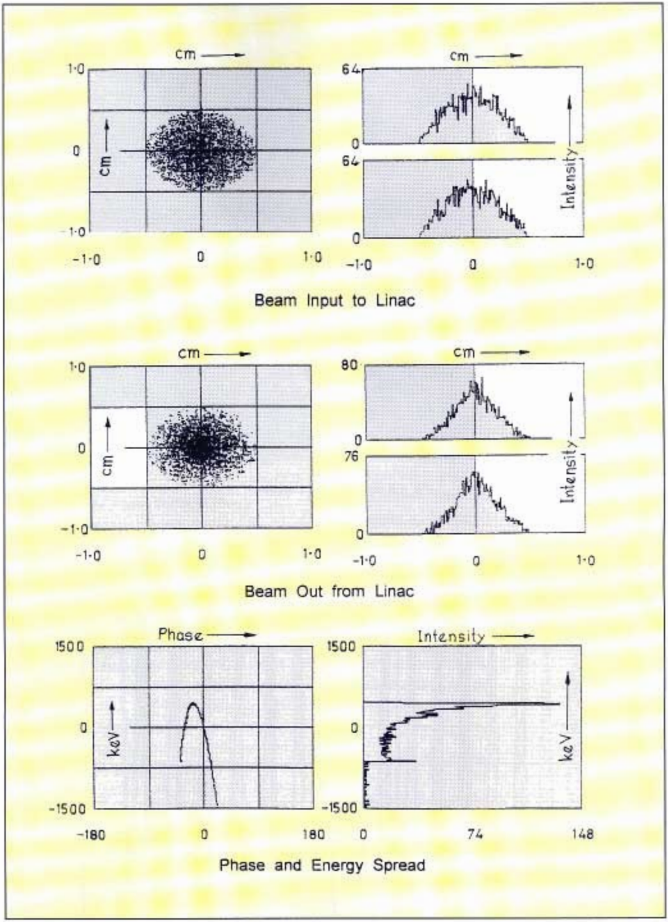


Fig.5 Beam behaviour of the EBC Linac

Fig. 6 A view of the EBC Linac cavity

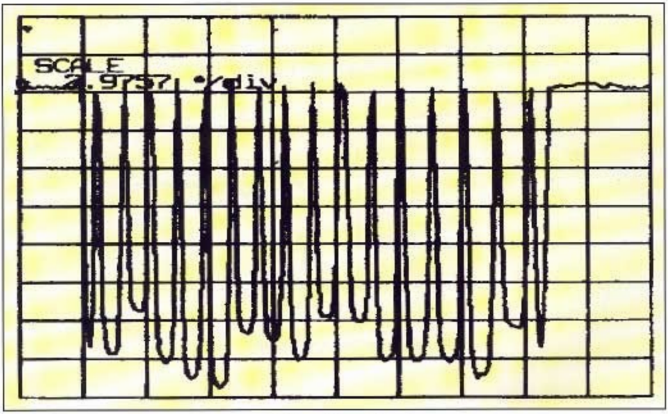


Fig.7 Measured field distribution

a theoretical value of 5%. The electric field distribution shown in Fig. 7 has a maximum variation of ± 6%. The beam dynamics recomputed by using this field as input did not show any adverse effect on the beam. The dispersion curve also does not show any distinguishable stop band features. This is evident from Fig. 8. Since all the RF properties have been attained more or less within the acceptable limits, the work on the fabrication of actual OFHC copper cavity has been initiated.

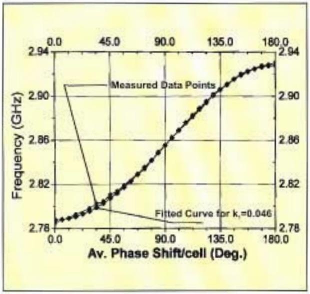


Fig.8 The dispersion curve

c) Braising of the Cavities : The conventional braising techniques are not of much use here. This is because of the following reasons:

Firstly, they produce large deformations in the job. Deformation of even 0.1mm will produce a frequency shift of ~ 3 MHz in the cavity. If the RF source and the cavity have different frequency of resonance, lot of power will get reflected and the power available to the cavity will get reduced. In the case of EBC Linac, it can go down to even half the value if the frequency shift is as large as 5 MHz.

Secondly, at an operational frequency of 2856 MHz, the skin depth is hardly a micron. Therefore, any oxidation of the surface even to a depth of 1 μ will be highly disastrous. It will enormously increase the surface resistance and hence the copper losses. To compensate that one will not only need more power to generate the required field but also will have to tackle extra heating problems of the cavity.

Thirdly, these cavities have to be operated in a vacuum of about 10^{-8} torr and therefore have to meet the stringent requirements of vacuum leak tightness.

To solve these problems, the braising of the cavities is performed in a furnace, that too in a reduced atmosphere of hydrogen. For the EBC Linac, the experiments have been conducted on a five cell cavity. After the braising, the difference in RF frequency was found to be within 0.8 MHz of the original value. The Q value is 12000 and the vacuum leak tightness was confirmed up to a level of $2*10^{-10}$ mbar-lit/sec. A few more trials are needed before the actual OFHC copper cavity is taken up for braising.

d) Fine tuning of the Cavity : Although the fabrication and the braising procedures adopted and explained above do give a cavity which is reasonably close to the desired frequency, sometimes there is a need to fine tune the frequency further. This tuning range is not very large and is confined within 100 Hz-200 kHz range only and is achieved through two techniques. One is by producing the symmetrical deformations on the diameters of the cells and the other is by working on the bore diameter of the cavity. The first one produces an increase in the frequency while the second one decreases it. These feats are achieved with the help of special devices which are being designed and built for EBC Linac too.

e) Power feed cell of the Cavity : Power to the linac is fed through an aperture in the central cell of the cavity, for which the proper value of the coupling factor ß has to be maintained. Larger the value of coupling, bigger is the size of this hole. On top of it, the coupling value is also not constant. It is a dynamic parameter and will vary from no load to the full load condition of the beam. For example, in the case of EBC Linac, it varies from 1 to 2.31. The variation in ß can be attained by coupling it to stubs. Sometimes a tapered wave guide in conjunction with stubs is also used. Moreover, the incorporation of the hole in the central cell will change its resonating frequency and the Q value. Hence the central cell has to be dealt separately and designed specially in such a way that it meets all the requisites. Detailed evaluation and experimentation has been done for the EBC Linac also. A maximum value of about 2.5 [12] has been achieved for an aperture of 31mm x 20 mm. One of the possible schemes which can also give variable coupling is shown in Fig. 9. The system is still being studied and more trials are needed to freeze the central cell.

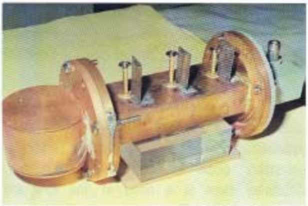


Fig. 9 Experimentation for power feed

f) Electron Gun and Modulator: The electron gun and the modulator is another area which also needs special care. These guns have to deliver a few amperes of peak current, at a suitable rep. rate, pulse width and the voltage. For the EBC Linac, the gun is to deliver a peak current of 1.0 A at the rate of 400 Hz with a pulse width of 10 μ sec. This current is to be achieved at a voltage of 50 kV with an emittance of about 100 mm.mrad. Such guns and the modulators have not been built so far. Hence prototyping in this area also became a must. APPD has now developed both the gun and the modulator[13,14]. The modulator is a five stage line type modulator triggered by a Thyratron HY11. The output is obtained through a 1:10 pulse transformer and fed to the gun. Maximum electron beam current of 1.2 A at a voltage of 50 kV was extracted through this proto-type set up. The gun has been tested in the triode configuration. The entire system is shown in Fig. 10. After satisfactorily testing all the features, the work on the actual gun and the modulator has now been started.

Fig. 10 Electron gun and the modulator for EBC Linac

Another important feature which asks for serious attention is the electron beam quality. The theoretical evaluation of the beam transmission through the linac is carried out for a known beam quality, viz, known emittance and configuration. If these are not ascertained, a lot of beam loss is expected to take place inside the cavity. This, in turn, will load the cavity and ask for much more power for generating the required field. Hence, a set up is essential for measuring the quality of the beam. For low power beams, the task is performed through the conventional technique of using a slit and multi-wire detector. For high power beams, this is replaced by a quadrupole magnet technique. A set up for EBC Linac is shown in Fig. 11 and is under fabrication at CD&M.

g) RF power source: To generate the electric field inside the cavity and to provide the required power to the beam, suitable RF sources have to be built. This is another vital area which needs special attention. These sources are built around high power klystrons which are fed by the high power pulse transformers. This technology is also relatively new to the country and is slowly being established through the RF Linac activity.

For EBC Linac, this responsibility has been taken up by SAMEER, Mumbai. They have some experience of designing and making such sources. The Linac needs to be fed with a peak power of 6 MW and an average power of 24 kW with a duty factor of 0.4 %. Klystrons with such large power are not made in India. For EBC Linac, it has been imported from Russia. A pulse transformer of 55 kV, 280 A and 10 μ sec., having a characteristic impedance of 12.5 ohms has been made to feed this klystron. A view of this transformer is shown in Fig. 12. A 10-stage, line type modulator, triggered by a thyratron at a peak voltage of 26 kV and a current of 1120 A, powers the pulse transformer.

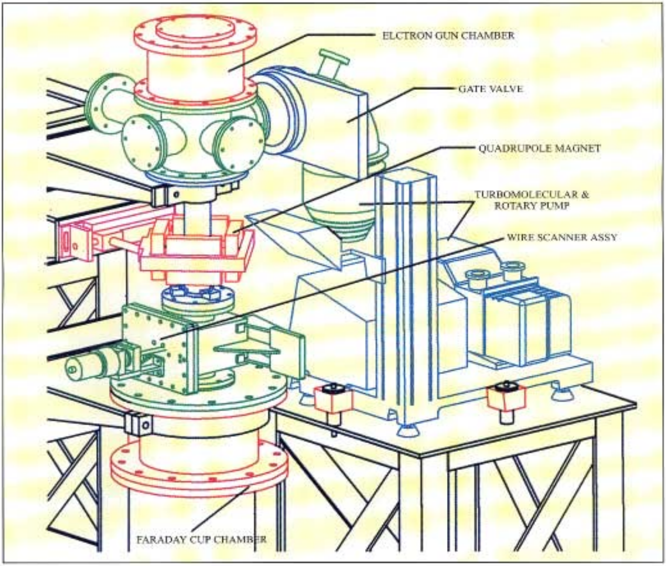


Fig. 11 Beam quality measurement set up

Fig. 12 Pulse transformer for EBC Linac

h) RF plumbing: The RF plumbing involves many components and devices, the major ones being the wave guides, bends, circulators, directional couplers and the high power RF loads. The power from the source to the Linac is fed via a wave guide. The ceramic window serves as the transition between the power feed cell of the Linac and the wave guide. Since high electric fields are generated inside the wave guide, it is generally pressurised at a suitable pressure. SF_6 is used for this purpose. The power being fed to the Linac is measured with the help of directional couplers. These couplers are used to measure both the forward and the reflected power. The circulators are employed to safeguard the klystron from the reflected power. They deviate the reflected power to the high power loads.

DAE-BRNS Role in Developing RF Linac Technology

As stated earlier, Klystrons and Magnetrons are not built in India. Similarly none of the RF devices used in the RF plumbing are produced in India. This is highly unfortunate. The Linac technology can never be on a firm footing until and unless these are developed indigenously.

Here DAE-BRNS has played a highly positive and an important role. It has funded many R&D projects in this direction. CEERI, Pilani[15], in collaboration with CAT (Indore), took up the task of developing a S band, 5 MW klystrons. This is designed for a frequency of 2856 MHz ± 5 MHz, for an output pulse width of 5 μ sec. The tube has been tested. The initial trials reveal a frequency of 2860 MHz ± 2 MHz with a pulse width of 4 μ sec. The efficiency of the tube is measured as 50%. This system is shown in Fig. 13. CEERI, Pilani, has also started a limited production of 2 MW, S band magnetron.

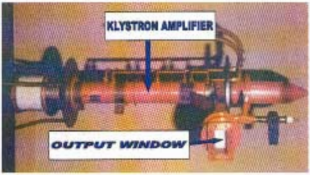


Fig. 13 Klystron amplifier built by CEERI, Pilani

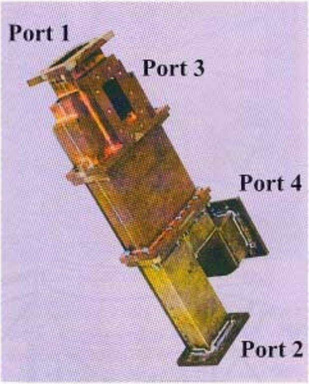


Fig. 14 Differential phase shift circulator

Fig. 15 Ceramic window

Similarly, DAE-BRNS has also funded the project for designing and developing RF devices like Circulator, Directional Coupler, Ceramic Window, Power Divider, RF Loads, etc. This project has been taken up by SAMEER, Mumbai, in collaboration with APPD. All these devices are designed for an RF frequency of 2856 MHz and average power of 25 kW. The proto-types of all of them have been built and tested at low power. The phase shift differential circulator , the ceramic window and the water load, built by SAMEER, are shown in Figs. 14 & 15. A view of the directional coupler built by APPD[16] is shown in Fig. 16. The ceramic window is made from 99.7 % alumina. It was tested to give a VSWR value of 1.06 and insertion loss as 0.3 dB. The measured values of the coupling factor, directivity, the insertion loss and the VSWR for the directional coupler are 55.3 dB, 24.1 dB, 0.1 dB and 1.05 respectively. Now, the work on the fabrication of actual pieces has been undertaken.

i) Magnetic Sweep Scanner, Scan Horn and Diagnostic Devices: The technology of all these sub systems is fairly understood because some of these devices were built for the 500 keV industrial accelerator. In fact, the scan horn for the EBC Linac has been built and is shown in Fig. 17.

ii) Similarly, the diagnostic devices and the sweep scanner also should not pose any difficulty.

Conclusions

A good beginning has been made by BARC to initiate the high power industrial RF Linac technology. CAT (Indore) has also initiated a programme on similar lines. All the efforts are being made to understand and perfect all the departments connected with the RF Linac technology. Most probably by the end of the Xth plan, BARC/DAE would have established a good base in this technology too.

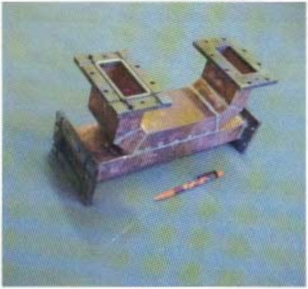


Fig. 16 Directional coupler

Fig. 17 The scan horn for EBC Linac

References

1. A.Zichichi, The ELOISATRON project, private communication
2. J.Sura, Proceedings of the 1986 International Conf. on Cyclotrons and their applications, Tokyo, Japan, p76.
3. Y.Jongen, Proceedings of the first European Particle Accelerator Conf., 1988, Rome (EPAC 88), p153.
4. K.Bethge, EPAC 88, p158.
5. R.A.Jameson, AIP Conf. Proceeding No. 253, p139. R.C.Sethi, Proceedings of 13 th National Symposium on Radiation Physics, Mangalore, Dec., 1999.
6. R.Bock, EPAC 88, p249
7. E.A. Abramyan, Industrial Electron Accelerators and Applications, Hemisphere Publishing Corp., New York, 1988.
8. IBA, E-BEAM Division, Louvain, la – Neuve, Belgium.
9. T.P. Wangler, Proceedings of the 1988 Linear Acc. Conf., Williamburg, V.A.
10. R.C.Sethi et al., Proceedings of the Ist Asian Particle Acc. Conf. KEK, Japan, 1998.
11. V.T.Nimje et al., Proceedings of the DAE Nuclear Physics Symposium, SINP, Kolkatta, Dec. 2001 (DAENPS-2001).
12. A.J.Dabeer et al., DAENPS-2001.
13. A.R.Chindarkar et al., International Symposium on Discharges & electrical Insulation in Vacuum. Tours, France, June 2002.
14. K.P.Dixit et al., Proceedings of the 12 th International symposium on High Voltage engg. IISc, Bangalore, Aug. 2001.
15. L.M.Joshi, CEERI Pilani, private communication.
16. V.Yadav et al., Proceedings of the International Symposium on Nuclear Physics, BARC, Mumbai, Dec. 2000.

IASTA WORKSHOP ON 'AEROSOL CHARACTERISATION TECHNIQUES FOR POLLUTION CONTROL APPLICATIONS'

In order to bring about an increased awareness on the use of current methodologies and the instrumentation used in the assessment of particulate pollution, Indian Aerosol Science and Technology Association (IASTA) conducted a two-day workshop on 'Aerosol Characterisation Techniques for Pollution Control Applications' during March 7-8, 2002, at BARC, Mumbai. The workshop catered to the beginners in the area of air pollution as well as those practitioners interested in familiarising themselves with the latest techniques. About 30 participants from industries and academic institutions attended the workshop.

The workshop was inaugurated at the AERB Auditorium by Dr V. Venkat Raj, Director, Health, Safety & Environment Group, BARC. In his inaugural address, Dr Venkat Raj dwelt at length upon the role of aerosol science in nuclear industry. He made a special mention of the nuclear aerosol studies being carried out in BARC in order to assess the environmental consequences in the event of reactor accidents. Dr U.C. Mishra, former President, IASTA, explained the role of the Association in disseminating information on the status of aerosol science and technology by way of conducting conferences and workshops of topical interest.

The inaugural session was followed by three invited lectures on the topics of relevance to particulate pollution studies. Dr T.N. Mahadevan, EAD, BARC, spoke on atmospheric aerosols, emphasising the measurement perspectives from the point of view of

Dr V. Venkat Raj, Director, Health, Safety & Environment Group, BARC, inaugurating the IASTA workshop

meeting the presently accepted international air quality standards and sampling conventions. Dr. Virendra Sethi, CESE, IIT, Mumbai, delivered a lecture on the optical characterisation of matter, in which he explained the use of light scattering principles and the recent ideas on using them for generating signatures of biological aerosols. Dr. R. B. Oza, EAD, BARC, presented the recent advances in the development of atmospheric dispersion models to characterise air pollutants in complex terrains.

Hands-on-training and demonstrations on the use of various instruments were given to the participants at the EAD laboratories housed at BARC Hospital. These included experiments concerned with the various aspects of aerosol sampling and characterisation (both physical and chemical) and the data analysis methodologies. The physical characterisation included aerosol mass distribution studies by impactors (Andersen Impactor and Quartz Crystal Microbalance Cascade Impactor), number size distribution by Single Particle Optical Counter and a novel technique of determining the density and fractal dimension using both the measurements simultaneously. The chemical characterisation experiments included processing of the samples for the chemical analysis and chemical identification using Atomic Absorption Spectrometry, Differential Pulse Anodic Stripping Voltammetry and Gas Chromatography-Mass Spectrometry technique. The programme concluded with a feed back session in which many participants expressed the opinion that such workshops need to be held more frequently in BARC which houses a near complete range of aerosol instrumentation for physical and chemical characterisation.

BARC TRANSFERS TECHNOLOGY OF SPECTROSCOPY AMPLIFIER

At the conclusion of the technology transfer agreement signing ceremony. Seen from (left to right) : Dr S.K.Kataria, Head, Electronics Division, Ms P. Sathish, Electronics Division, Mr P.K. Mukhopadhyaya, Electronics Division, Mr J.N. Reddy, Managing Director, M/s. Nucleonix, Mr G. Govindarajan, Director, A&M Group and E&I Group, BARC, Dr R.B. Grover, Associate Director, TC&IRG, Mr A.M. Patankar, Head, TT&CD, Mr R.P. Agarwal, TT&CD, Ms S.S. Mule, TT&CD

The technology of Spectroscopy Amplifier developed by Electronics Division has been transferred to M/s Nucleonix Systems Pvt. Ltd., Hyderabad, on April 29, 2002. Spectroscopy Amplifier A225 is a high performance amplifier ideally suited for use with detectors such as HPGe, silicon surface barrier and Si(Li) detectors. This is a single width NIM module with pile-up rejector (PUR), gated baseline restorer (BLR), auto threshold, unipolar and biopolar outputs, BUSY and Count-rate output, as some of the key features designed into it. The unipolar output is stabilised with gated baseline restorer. A pile up reject output is provided to facilitate experiments at high count rate. This amplifier performs quasi-gaussian or quasi-triangular pulse shaping with a choice of 6 shaping time constants. Spectroscopy Amplifier finds applications in nuclear pulse height spectroscopy, in nuclear timing spectroscopy and counting systems.

Technology Transfer and Collaboration Division co-ordinated all activities related to the transfer of this technology, i.e. preparation of leaflet and technical brochure, advertisement of the technology, technology transfer agreement preparation and the technology transfer agreement signing formalities.

FIRE SERVICE WEEK OBSERVED IN BARC

Every year, the fourteenth day of April is observed throughout the country as the National Fire Service Day. On this day, in the year 1944, the fire service personnel displayed exemplary courage and devotion to duty as they fought the huge fire that had erupted following an explosion on a ship S.S. FORT STICKEN berthed at the docks of Mumbai Port Trust. Many fire fighters lost their lives leaving behind their names etched in the minds of Mumbaites forever .

Inauguration ceremony of fund raising campaign held at Raj Bhavan. Among others, the occasion was graced by his Excellency, the Governor of Maharashtra, Dr P.C. Alexander and Hon. (Ms) Ackama Alexander

Several programmes were organised by Fire Services Section, BARC, during the Fire Service Week, April 14-20, 2002, to create fire safety awareness among the employees in BARC, Trombay, and Vikram Sarabhai Bhavan, Anushaktinagar .

Mr B. Bhattacharjee, Director, BARC, contributing to fire services personnel welfare fund

As an annual feature, the week began with the traditionally known "Commemoration Day". On behalf of BARC, Mr A.K. Tandle, Chief Fire Officer, placed wreaths at the memorials erected on the grounds of Mumbai Port Trust and at the Headquarters of Mumbai Fire Brigade, Byculla. He attended the inauguration ceremony of Fire Service Week at Raj Bhavan where His Excellency, the Governor of Maharashtra, Dr. P.C. Alexander and Hon. Ms Ackama Alexander also flagged off the Fire Services Personnel Welfare Fund campaign. On the next day, Dr. S. Banerjee, Director, Materials Group, BARC and Chairman, Conventional Fire Safety Review Committee, BARC and Mr D.S. Shukla, Associate Director, Chemical Engineering & Technology Group, BARC, were offered pin flags to start the fund raising campaign. Dr .S. Banerjee, emphasised the need for more fire safety awareness in organisations like BARC, and Mr D.S. Shukla highlighted the importance of fire prevention and fire protection in today's scenario of fire safety. Contributions to the fund amounted to Rs.13,220/- which was deposited with the Fire Advisor, Government of Maharashtra. On the same day, an exhibition on "Fire Safety Equipment" was inaugurated by Dr S. Sadasivan, Head, Environmental Assessment Division, BARC and Chairman, Modular Laboratories Safety Committee.

Fire fighting staff of Fire Services Section demonstrating their skills with special emphasis on rescue techniques held at Modular Laboratories, BARC

On April 16, 2002, two crews comprising of 7 fire fighting staff members from BARC participated for the first time in the Tactical Medley Drill and Individual Ladder Drill Competition which was held at Civil Defence Headquarters, Mumbai. Both crews were awarded a prize for their third and fourth positions respectively.

Fire fighting staff of Fire Services Section demonstrating their skills with special emphasis on rescue techniques using fireman lift at Vikram Sarabhai Bhavan, Anushaktinagar, Mumbai

Around 300 staff members witnessed a demonstration on use of Fire Safety Equipment and rescue methods near Modular Laboratories "C" Block. Fire Service Posters, Banners and National Safety Council Posters were displayed at all prominent locations all over BARC and other facilities of DAE in and around Mumbai.

Mr B. Bhattacharjee, Director, BARC, was offered a pin flag on April 19, 2002. In a brief address, he expressed concern regarding the Trombay Hill fire prevention requirements. He was apprised about the precautionary steps taken in preventing fire from spreading and the arrangements made for additional water on the hills during fire emergencies. Mr Bhattacharjee congratulated both the crew members who were awarded prizes in the competition.

A demonstration on fire safety was held which received overwhelming response from the staff members at Vikram Sarabhai Bhavan, Anushaktinagar, who witnessed the whole operation which laid special emphasis on high rise buildings. Around 3000 staff members witnessed the demonstration.

The Fire Service Week concluded with a ceremonial parade at Cross Maidan in which BARC's personnel participated alongwith the fire fighting appliances/ equipment.

TRAINING WORKSHOP ON RADIATION EMERGENCIES FOR MEDICAL OFFICERS

The 12th training workshop on 'Planning, Preparedness and Response to Radiation Emergencies' for Medical Officers was conducted during April 16-19, 2002 at AERB Auditorium, Anushaktinagar, Mumbai. Dr P.R. Bongirwar, M.O. I/C, Trombay Dispensary and the course coordinator, welcomed the guests and said that, although this is the 12th training workshop, this is for the first time that it is being hosted exclusively by Medical Division under the aegis of Local Working Committee for Radiation Emergency Medical Response (REMR) of BARC. He further mentioned that many senior specialists of different disciplines of medicine from major hospitals of Mumbai like KEM Hospital, Sion Hospital, Nair Hospital, Tata Memorial Hospital, Naval Hospital (ASVINI) and Directorate of Civil Defence along with Medical Officers of different DAE Units participated in this workshop.

Dr B.J. Shankar, Head, Medical Division and Chairman, Local Working Committee for Radiation Emergency Medical Response of BARC, emphasized the crucial need for imparting awareness among medical professionals about health effects of ionizing radiation and clinical approach to management of radiation injuries. He further said that cases of radiation burns seen by him were by and large from the field of Industrial Radiography in private sector and it was his experience over a period of time that there was lack of proper awareness among physicians about methodology of treating such cases.

Dr. (Ms) A.M. Samuel, Director, Bio-Medical Group, BARC and Chairperson, DAE Steering Committee for Radiation Emergency Medical Response System (REMRS), highlighted the need to have a proper protocol and action plan for medical management of radiation emergencies and said that with ever increasing use of ionizing radiation in diverse fields, the possibility of mishaps resulting in radiation emergencies including misuse of orphan radiation sources and threat of nuclear terrorism can not be ruled out. It is therefore of vital importance that networking of medical centres is established to address this emerging present day scenario.

Mr B. Bhattacharjee, Director, BARC, inaugurated the workshop and in his address explained the importance of establishing and further consolidating REMRS in different DAE Units as a measure of emergency preparedness at all times. He also highlighted the beneficial uses of atomic energy in various fields such as in the field of power generation, health care, food processing, agriculture, research and industry. He further gave an overview of nuclear and radiological accidents that have occurred globally and the lessons learnt there from. He later emphasized the need for augmentation of research in molecular biological aspects particularly with reference to use of DNA techniques to assess impact of ionizing radiation at cellular level.

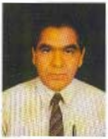
Mr B. Bhattacharjee, Director, BARC, inaugurating the workshop

The training course comprehensively covered various medical aspects of radiation injuries along with relevant health physics aspects involved in management of radiation emergencies. The faculty members for the training course were mainly from Medical Division along with members from RSSD of BARC, AERB and NPCIL.

Mr. A.R. Sundararajan, Head, Radiological Safety Division of AERB, said in his valedictory address that there was a long felt need to have a proper knowledge and practical awareness among physicians for assessment and management of radiation injuries. He later distributed certificates of participation to attending delegates.

Dr H.M. Haldavnekar and Dr S.S. Galinde proposed a vote of thanks for the inaugural and valedictory function, respectively.

भाभा परमाणु अनुसंधान केंद्र के वैज्ञानिकों को सम्मान



• डॉ. कौशल पी. मिश्र, अध्यक्ष, कोशिकीय एवं मुक्त मूलक विकिरण जैविकी अनुभाग, विकिरण जैविकी प्रभाग, भापअ केंद्र को कोबे विश्वविद्यालय, जापान में दिनांक 30 अक्टूबर, 2001 को आयोजित तीसरी एशिया पैसिफिक ईपीआर /ईएसआर समिति (ए पी ई एस) की आम बैठक में दो वर्ष 2001-2003 की अवधि हेतु एशिया पैसिफिक ईपीआर /ईएसआर समिति (ए पी ई एस) की परिषद के सदस्य चुने गए हैं । इस परिषद में एशिया पैसिफिक क्षेत्रों का प्रतिनिधित्व करने वाले कुल 11 सदस्य हैं जिसका केन्द्रीय कार्यालय हाँग काँग में है । ई एस आर वर्णक्रमदर्शिकी एवं मुक्त मूलक अनुसंधान के क्षेत्र में उनके योगदान को मान्यता देते हुए, परिषद के अध्यक्ष एवं सदस्यों ने डा. मिश्र से वर्ष 2003 में बेंगलूर, भारत में होने वाले प्रस्तावित चौथे एशिया पैसिफिक ई पी आर /ई एस आर वर्णक्रमदर्शिकी सम्मेलन के अवसर पर भा.प.अ. केंद्र , मुंबई में अंतर्राष्ट्रीय ईपीआर /ईएसआर वर्णक्रमदर्शिकी विद्यालय चलाने की जिम्मेदारी स्वीकार करने का अनुरोध किया है ।

डॉ. कांचन आर. बंटवाल

डॉ. पी बी.वच्छराजानी

डॉ. आशा दामोदरन

• "पूर्व-प्रसव रोगियों में फास्टिंग प्लाज्मा ग्लूकोज सहित जेस्टेशनल डायबिटिज मेलिटस का सर्वव्यापी निरीक्षण: 100 रोगियों का अध्ययन " विषय पर एक वैज्ञानिक लेख डॉ. (सुश्री) कांचन आर. बंटवाल, चिकित्सा अधिकारी, चिकित्सा प्रभाग, भापअ केंद्र द्वारा जनवरी 2002 में जनरल प्रैक्टिशनर्स एसोसिएशन, बृहन्मुंबई के 32 वें वार्षिक सम्मेलन में प्रस्तुत किया गया । यह लेख डॉ. (सुश्री) पी.बी. वच्छराजानी, प्रभारी चिकित्सा अधिकारी, देवनार (पूर्व) औषधालय एवं डॉ. (सुश्री) आशा दामोदरन, क्षेत्र प्रभारी, औषधालय सेवाएं, भा.प.अ. केंद्र के मार्गदर्शन में तैयार किया गया था । इस लेख को सर्वोत्तम वैद्यकीय लेख के रुप में चुना गया और इसे प्रतिष्ठित एस.डी. भंडारकर पुरस्कार प्रदान किया गया ।

• सुश्री सुष्मिता महापात्र, पर्यावरणीय मूल्यांकन प्रभाग, भा.प.अ. केंद्र को 8-9 मार्च, 2002 के दौरान नेहू, शिलाँग में आयोजित भारतीय विश्लेषणात्मक वैज्ञानिक समिति द्वारा आयोजित XVI राष्ट्रीय संगोष्ठी में प्रस्तुत किए गए एस. महापात्र, आर.एम. त्रिपाठी, एस. भाल्के तथा एस. सदाशिवन द्वारा पर्यावरणीय एवं खाद्य आव्यूहों में एन-नाइट्रोसैमिनों के निर्धारण हेतु ठोस अवस्था के सूक्ष्म निष्कर्षण के साथ संयोजन में जी सी -एम एस " शीर्षक के लेख हेतु डॉ.के.के. मजुमदार मेमोरियल एवार्ड प्रदान किया गया ।

• श्री संजय सेठी, लेसर एवं प्लाज्मा प्रौद्योगिकी प्रभाग, भा.प.अ. केंद्र को केंद्रीय चर्म अनुसंधान संस्थान, चेन्नई में 19-22 दिसंबर, 2001 के दौरान आयोजित केमकॉन-2001 संगोष्ठी में प्रस्तुत "अघुलनशील मक:संस्थापन एवं प्रचालन से विरल प्राकृतिक प्रोटेक्टिनियम की प्राप्ति के प्रायोगिक संयंत्र अनुभव" शीर्षक के "औद्योगिक प्रक्रम" के तकनीकी मुख्य सत्र में मौखिक प्रस्तुति के लिए प्रथम सर्वोत्तम लेख का पुरस्कार दिया गया ।

• सुश्री पी. अनुपमा, लेसर एवं प्लाज्मा प्रौद्योगिकी प्रभाग, भा.प.अ. केंद्र, को केंद्रीय चर्म अनुसंधान संस्थान, चेन्नई में 19-22 दिसंबर, 2001 के दौरान आयोजित केमकॉन-2001 संगोष्ठी में प्रस्तुत किए गए "प्रोटैक्टियम प्राप्ति संयंत्र में आयन क्रोमेटोग्राफी एवं इसके कार्यान्वयन द्वारा विरल मृदा, थोरियम तथा अन्य धातु आयन से प्रोटैक्टियम-231 के पृथक्करण हेतु उच्च वरणक्षमता प्रक्रम के विकास एवं कार्यान्वयन" शीर्षक के "औद्योगिक प्रक्रम " के पोस्टर - मुख्य सत्र में पोस्टर प्रस्तुति के लिए दूसरे सर्वोत्तम लेख का पुरस्कार दिया गया ।

BARC SCIENTISTS HONOURED

• Dr Kaushala P. Mishra, Head, Cellular and Free Radical Radiation Biology Section, Radiation Biology Division, BARC, has been elected a Member of the Council of Asia-Pacific EPR/ESR Society (APES) for a term of two years, 2001-2003, in the general meeting of 3rd APES held on October 30, 2001 at Kobe University, Japan. The Council has a total of 11 members representing the countries of Asia Pacific regions with its central office at Hong Kong. In recognition of his contributions in the field of ESR Spectroscopy and free radical research, the President and members of the Council have requested Dr Mishra to accept the responsibility of organising an International School on EPR/ESR Spectroscopy at BARC in Mumbai on the ocassion of 4th Asia-Pacific Conference on EPR/ESR Spectroscopy proposed to be held at Bangalore in India in the year 2003.

Dr K. Bantwal

Dr P.B.Vachharajani

Dr A.Damodaran

• A scientific paper on 'Universal Screening for Gestational Diabetes Mellitus with Fasting Plasma Glucose in Ante-Natal Patients - a study of 100 cases' was presented by Dr (Ms) Kanchan R. Bantwal, Medical Officer, Medical Division, BARC, at 32nd Annual Conference of General Practitioners' Association, Greater Mumbai, in January 2002. This paper was prepared under the guidance of Dr (Ms) P.B. Vachharajani, Medical Officer-in-charge, Deonar (East) Dispensary and Dr (Ms) Asha Damodaran, Zonal-in-charge, Dispensary services, BARC. This paper was selected as the Best Clinical Paper and was awarded the prestigious 'S.D. Bhandarkar Prize' for the same.

• Ms Suchismita Mahapatra of Environmental Assessment Division, BARC, was awarded Dr K.K. Majumdar Memoral Award for the paper entitled 'GC-MS in Combination with Solid Phase Micro Extraction for Determination of N-Nitrosamines in Environmental and Food Matrices' by S. Mahapatra, R.M. Tripathi, S. Bhalke and S. Sadasivan, presented at the XVI National Symposium, organised by Indian Society of Analytical Scientists held at Nehu, Shillong, during March 8-9, 2002.

• Mr Sanjay Sethi of Laser & Plasma Technology Division, BARC, was awarded the First Best Paper in the oral presentation in the technical main session 'Industrial Process' entitled 'Pilot Plant Experience of Recovery of Rare, Natural Protactinium from the Insoluble Muck: Installation and Operation', presented at CHEMCON-2001 symposium held during December 19-22, 2001 at Central Leather Research Institute, Chennai.

• Ms P. Anupama of Laser & Plasma Technology Division, BARC, was awarded the Second Best Paper in the poster presentation in the poster-main session 'Industrial Process', entitled 'Development and Implementation of a High Selectivity Process for Separation of Protactinium-231 from Rare Earths, Thorium and other Metal Ions by Ion Chromatography and its Implementation in the Protactinium Recovery Plant', presented at CHEMCON-2001 symposium held during December 19-22, 2001 at Central Leather Research Institute, Chennai.

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