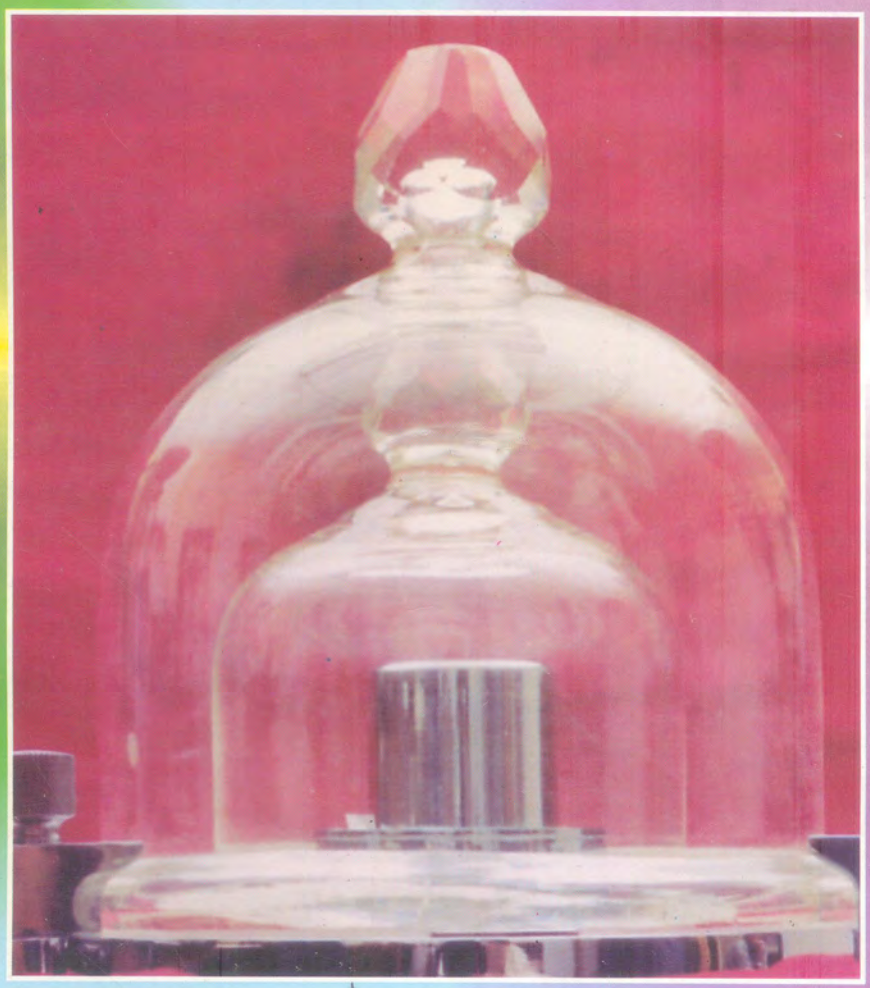
वार्षिक प्रतिवेदन
Annual Report
1997-98



राष्ट्रीय भौतिक प्रयोगशाला, नई दिल्ली

National Physical Laboratory, New Delhi

वार्षिक प्रतिवेदन

ANNUAL REPORT

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राष्ट्रीय भौतिक प्रयोगशाला, नई दिल्ली

NATIONAL PHYSICAL LABORATORY

Dr. K.S. Krishnan Marg, New Delhi-110 012

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Director's Report

It gives me great pleasure to present to you the annual report for the year 1997-1998. We are late in bringing out the report. The main reason being that we have changed the focus, content as well as the presentation of the report. We also have a relatively new team looking after it.

You will see in the report that the laboratory has made excellent all round progress during the year. It has its share of success and it has reasons to rejoice.

1997-1998 is the year of golden jubilee of NPL. It has come a long way and has to its credit 50 years of dedicated service to the nation. It has a glorious past, a vigorous present and a very bright future. I pay my tribute to the scientists of NPL and the past Directors who provided leadership to the laboratory.

This year also show a change of Director of NPL. Prof. E.S. Rajagopal retired from NPL after completing six years in office. The laboratory showed a good growth during his tenure. The experimental programmes were strengthened, number of new projects were initiated and the ECF of the laboratory showed a strong upward trend. I give full credit to Prof. E.S.R. for all the good work done by him for the laboratory.

A review committee headed by Dr. R. Chidambaram, Chairman, Atomic Energy commission was set up to advice NPL to set a new course in the years to come. The committee submitted report in September/October 1998 and had made a number of very important implementable recommendations for NPL. The review committee was very appreciative of the various strong programmes of NPL and its suggestion was to strengthen its strong areas and make an impact.

A new Research council (RC) was also appointed in January, 1998 under the Chairmanship of Dr. R. Chidambaram. The out going RC headed by Prof. Sreekantan had done an wonderful job for the laboratory. my sincere gratitude to Prof. Sreekantan and to all the members of the out going RC. I am looking forward to a very strong interaction and guidance from the new RC.

I took over as the Director of this great laboratory on October 1, 1997. After few months of acquaintance with the laboratory I had set upon the following tasks for myself which I would like to implement in the coming three years :

1. Modernization of the infrastructure in the laboratory for R&D work. This includes communication, access to modern information technology tools, library, power, cryogens and over all ambience.
2. Maximum utilization of available experimental facilities to the best interest of the laboratory and resource and facility sharing.
3. Internal consolidation through focus on fewer programmes and stop areas which are stagnating. In particular strengthen the area of primary standard of physical measurements.
4. Project oriented work plan, performance linked budget allocation and delegation of powers to project leaders.
5. A system based administration and organization leading to a quality system. Documentation

and dissemination of much needed information.

6. Reaching out to interact with other organizations in India in a collaborative mode, particularly in the areas of societal and national importance.
7. Human power training in needed areas at all levels.
8. Punctuality, attendance and accountability.

In this plan I am very strongly guided by the review comittee report. In the years to come we will find out to what extent we are successful. Our next stage of plan will very much depend on the success and out come.

We have a bright future but that can only come through hard work, a collective sense of responsibility, a scientifically enlightened and knowledge empowered culture and an enabling administration and infrastructure.

I am sure that you will like this new look annual report. I want to sincerely thank the publication group and the staff from various divisions who helped us to gather information and put it in a new format :

A K Raychaudhuri

(A.K. Raychaudhuri)

वार्षिक प्रतिवेदन 1997-1998

वर्ष 1997-1998 का वार्षिक प्रतिवेदन सहर्ष प्रस्तुत है। इस बार प्रतिवेदन कुछ विलम्ब से प्रकाशित हुआ जिसका मुख्य कारण यह है कि हमने इसके कलेवर, प्रस्तुतिकरण और विषय सामग्री को नई दिशा देने का प्रयत्न किया है। साथ ही अब इसके सम्पादन का कार्य एक नवगठित समिति ने सम्पन्न किया है। प्रतिवेदन में आपको प्रयोगशाला की सर्वतो मुखी प्रगति को देखकर प्रसन्नता होगी।

1997-1998 प्रयोगशाला का स्वर्ण जयंती वर्ष है। प्रयोगशाला ने राष्ट्र की सेवा में 50 वर्ष का सफर सफलतापूर्वक तय कर लिया है। प्रयोगशाला का इतिहास स्वर्णिम रहा है। हमारा सक्रिय वर्तमान एक उज्ज्वल भविष्य को साकार बनाने की ओर अग्रसर है। प्रयोगशाला के पूर्व वैज्ञानिकों व निदेशकों के प्रति मैं सम्मान प्रकट करता हूँ।

इस वर्ष प्रयोगशाला का नेतृत्व परिवर्तन भी हुआ। प्रोफेसर ई. एस. आर गोपाल छः वर्ष के कार्यकाल के उपरान्त सेवानिवृत्त हुए। इस कार्य काल में प्रयोगशाला ने अच्छी प्रगति की। प्रायोगिकी पक्ष इस दौरान प्रबल हुआ अनेक नई परियोजनाओं का शुभारम्भ हुआ और प्रयोगशाला की आय में बृद्धि हुई। इन उपलब्धियों का पूरा श्रेय मैं श्री राजगोपाल को देना चाहूँगा।

आगामी वर्षों में प्रयोगशाला को नई दिशा प्रदान करने के लिए प्रो चिदम्बरम, अध्यक्ष परमाणु ऊर्जा आयोग की अध्यक्षता में एक नई समीक्षा समिति का गठन हुआ। समिति ने सितम्बर–अक्टूबर 98 में अपना प्रतिवेदन प्रस्तुत किया जिसमें प्रयोगशाला के लिए अनेक महत्वपूर्ण तथा कार्यान्वयन योग्य सस्तुतियाँ दी गई। समीक्षा समिति ने प्रयोगशाला के अनेक कार्यक्रमों की सराहना की तथा पुष्ट क्षेत्रों को और अधिक सशक्त बनाने का सुझाव दिया जिससे उनका प्रभाव पूर्ण रूप से सामने आ सके।

जनवरी, 1998 में प्रो. चिदम्बरम की ही अध्यक्षता में एक नवीन अनुसंधान परिषद भी गठित की गई। प्रो श्री कंठन की अध्यक्षता वाली परिषद ने भी प्रयोगशाला के लिए प्रशंसनीय कार्य किया जिसके लिए मैं सभी सदस्यों सहित उनका आभार प्रकट करता हूँ। नई परिषद से मैं आगामी समय में महत्वपूर्ण विचार विमर्श तथा मार्गदर्शन की आशा रखता हूँ।

1 अक्तूबर, 1997 को मैंने इस महान प्रयोगशाला के निदेशक का पदभार ग्रहण किया। प्रयोगशालासे कुछ माह के परिचय के उपरांत मैने अपने लिए निम्नलिखित लक्ष्य निर्धारित किए हैं

जिन्हे मैं अगले तीन वर्षों के दौरान कार्यान्वित करना चाहूँगा:–

1. प्रयोगशाला की अनुसंधान एवं विकास सम्बन्धी अवसंरचना का आधुनिकीकरण ज़िसमें संचार, आधुनिक सूचना, प्रौद्योगिकी साधन, पुस्तकालय, बिजली तथा अतिशीतल द्रवों आदि उपलब्ध कराना सम्मिलित हैं।
2. प्रयोगशाला में उपलब्ध प्रायोगिक सुविंधाओं का पूर्ण रूप से प्रयोगशाला के हित में उपयोग तथा साधनों और सुविधाओं के उपयोग में सहभागी होना।
3. कम संख्या में कार्यक्रमों को चुनकर उन पर प्रभावी कार्यान्वयन तथा समकेन व अनुपयुक्त कार्यक्रमों को बन्द करना। विशेष रूप से भौतिक मापों के प्राथमिक मानको का संवर्धन।
4. परियोजना उन्मुख कार्यशैली, उपलब्धि के माप दंड पर आधारित बजट उपलब्ध कराना विभाजन तथा परियोजना प्रमुखों को अधिक अधिकार देना।
5. व्यवस्थात्मक प्रशासन तथा ऐसी व्यवस्था जो पूर्ण गुणवत्ता ला सके आवश्यक सूचना का प्रलेख पोषण तथा वितरण।
6. विशेषकर सामाजिक और राष्ट्रीय महत्व के वैज्ञानिक विषयों पर अन्य संस्थाओं के साथ सहयोग।
7. उपयुक्त क्षेत्रों में सभी स्तरों पर मानव संसाधनों का प्रशिक्षण।
8. समय की पाबन्दी, उपस्थिति और उत्तरदायी भाव।

इस योजना को तैयार करने में मुझे समीक्षा समिति के सुझाव प्रेरक रहे। यह तो भविष्य ही बता पाएगा कि हम इसमें कितने सफल रहे हैं।

दूसरे चरण की योजना पहले चरण की सफलता पर निर्भर रहेगी।

सुनहरा भविष्य हमारे परिश्रम पर निर्भर है। सामूहिक उत्तरदायित्व के बोध वैज्ञानिक रूप से जागृति और ज्ञान पूर्ण संस्कृति तथा कटिबद्ध प्रशासन और अच्छी अवसंरचना पर निर्भर करता हैं।

मुझे विश्वास है कि आपको यह नया वार्षिक प्रतिवेदन पसन्द आएगा। इसके लिए मैं प्रकाशन समूह तथा विभिन्न प्रभागों के सदस्यों का हार्दिक धन्यवाद करता हूँ जिन्होने सारी सूचना एकत्रित करके इसे नए कलेवर में प्रस्तुत किया।

ए. के. रायचौधुरी

(ए. के. रायचौधुरी)

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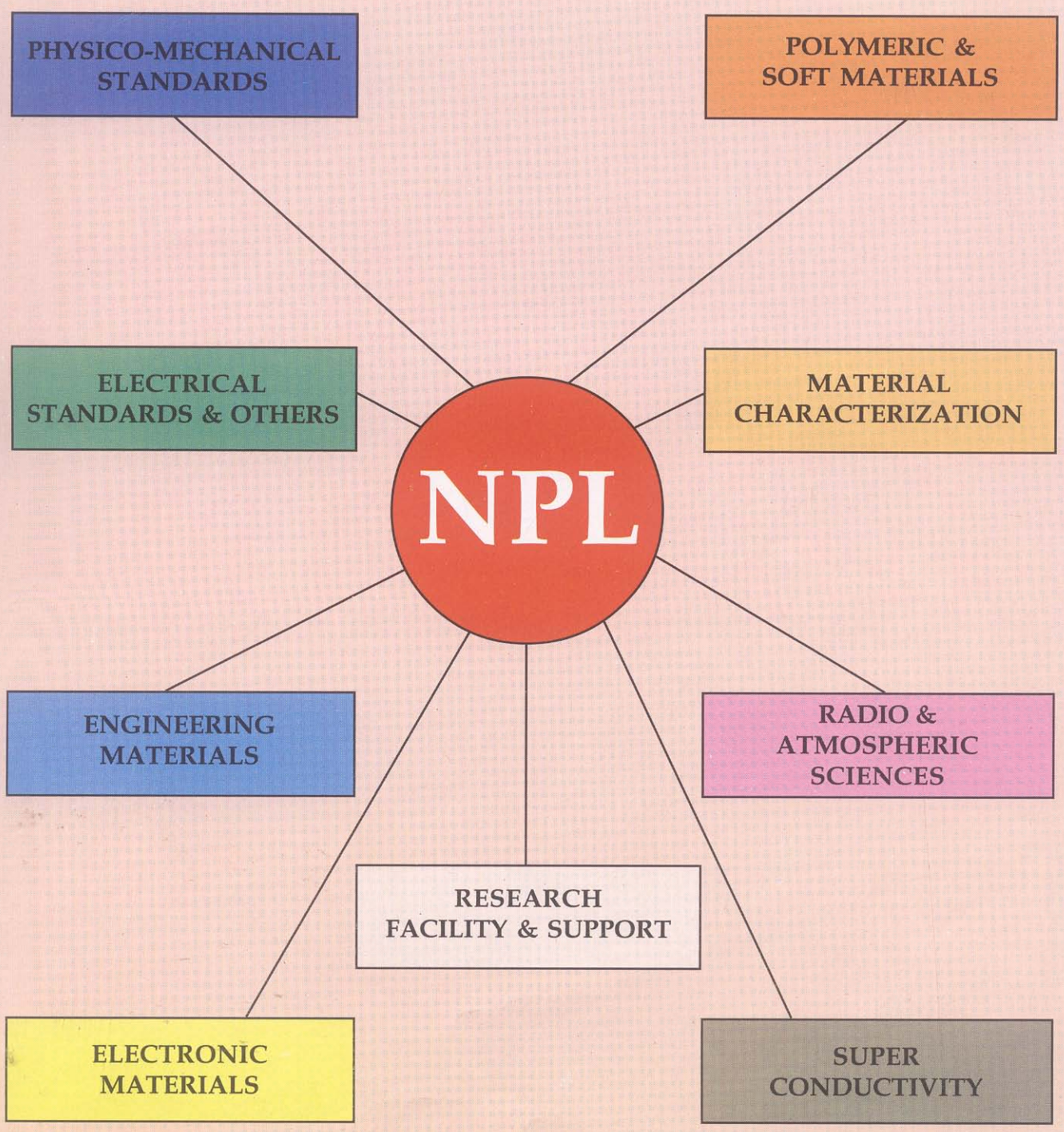
Major R & D Divisions



01 Physico-Mechanical Standards

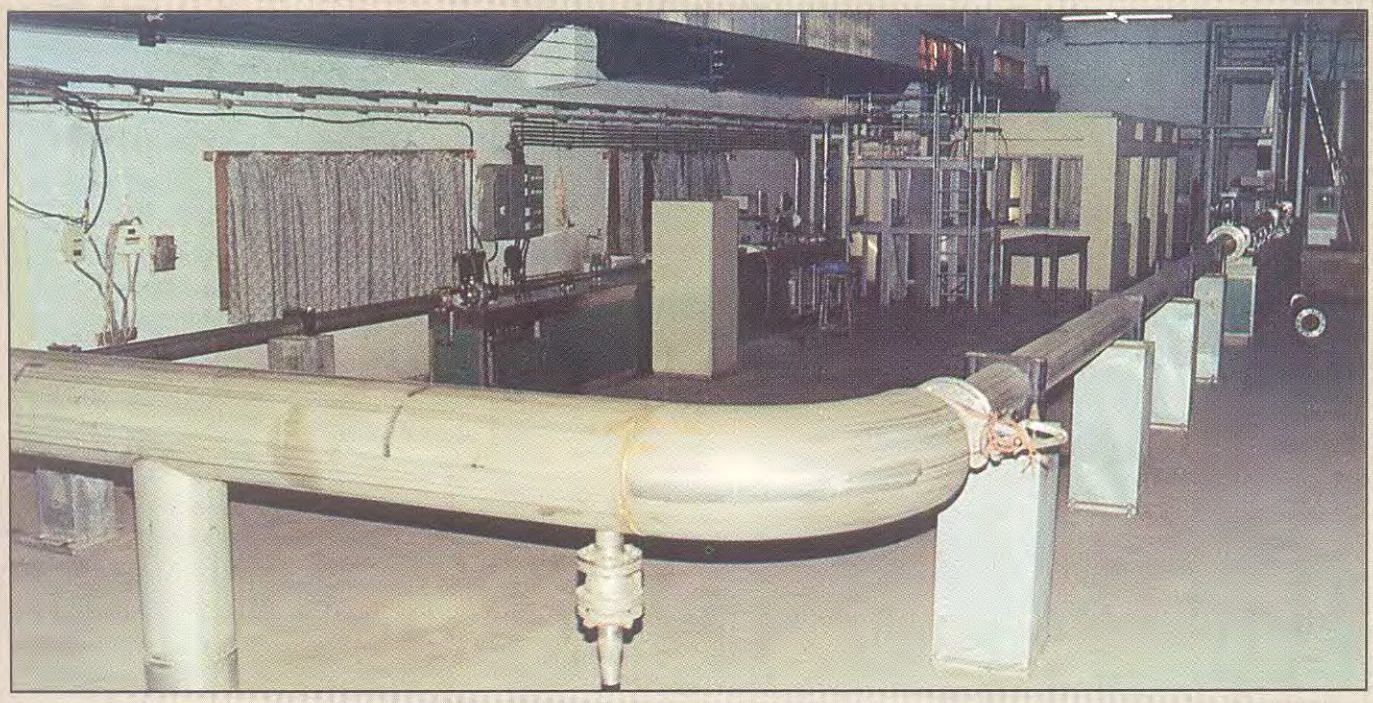


Fig. 1.1 (a) Calibration system for fluid flow meters test rigs

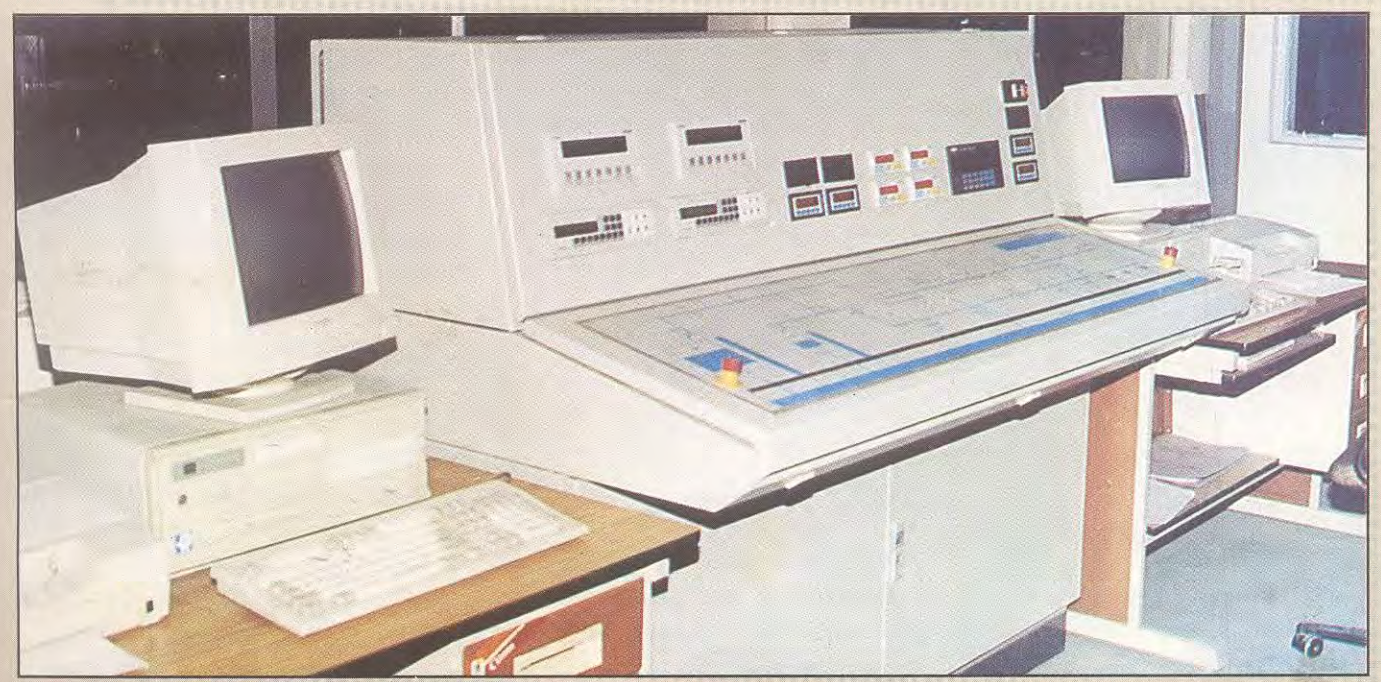


Fig. 1.1 (b) Calibration system for fluid flow meters computer console

The Physico-mechanical standards encompass acoustics, ultrasonics, length and dimensional metrology, pressure and vacuum, force and hardness, temperature, non-ionising radiation (ultra-violet, optical and infrared), mass, density and viscosity, surface physics and fluid flow. Various basic and derived parameters are realised through the established primary standards using absolute calibration. These standards are used to calibrate secondary/working standards which are in turn used to calibrate the instruments received from the quality control laboratories operating at Echelon II, III level or inside different industries. Continuous R&D efforts are made to update and reaffirm the measurement accuracies of the standards established at NPL. NPL very often participates in bilateral, regional and international key comparison exercises held periodically. These give an edge to the Indian industries to compete in the global market by providing them the national traceability, and international compatibility. It also provides services for obtaining NABL accreditation and ISO 9000 certification. This activity provides awareness on the role of calibration in building technical base and in dissemination of knowledge through interaction and training programme to people from India and other developing countries. This can be seen in the continuous increase in number of user industries.

The **Acoustics** activity undertook a systematic and simultaneous noise and vibration study under a sponsored project from the Archaeological Survey of India, New Delhi and established that there was no immediate threat to the structural integrity of the Khajuraho Temples due to the overflying aircraft in the vicinity. Similarly an extended experimental investigation was undertaken for Central Pollution Control Board, New Delhi to form a data base of the noise levels created by various types of firecrackers available in the market towards formulating suitable norms and guidelines w.r.t. the maximum sound pressure levels created by them at a testing distance of 4 m, viz. 140 dB $(Lin)_{pk}$ and 120 dB (AI). In the developmental side a new phased array antenna consisting of 104 piezoelectric transducer was designed for use in the acoustic wind profiler under development.

In **Ultrasonics** activity, a new method has been developed for evaluation of the quality of the material used for fabrication of ultrasonic NDT calibration block VI. A method to reduce the noise arising due to scattering by coarse grain aggregate in concrete was developed. Special trans-ducers in various frequencies were designed and supplied for testing of LCA wings made of carbon fibre composites. Acoustic parameters of NDT probes' backing material were studied at high hydrostatic pressures. Acoustic velocity in polymetallic modules of CIOB region were measured. A new method for the estimation of non-linearity parameter of liquids using parametric acoustic arrays has been developed. The experimental results of eight liquids have been explained on the basis of Rolleigh-Novikov theory.

Various parameters of MnO added lead zirconate titanate ceramics for new types of transducers have been studied by vector impedance spectroscopic technique. The systematic studies on modified lead titanate materials have resulted into a special transducer materials designated as NPLPT-97 possessing higher thickness mode coupling factor and voltage sensitivity. Near infrared absorption studies on quartz crystals in as-received, after electrodiffusion with hydrogen and replacement of alkaline conditions followed by irradiation have been done.

In the activity of **Length Standards**, the tuning characteristics of commercial diode lasers has been studied to utilise its frequency stabilisation for R&D work on the laser cooling of cesium atoms. A six window vapour cell has been fabricated for laser cooling of atoms in optical molasses configuration. Linewidth narrowing and single mode operation has been achieved by optical feedback in Littrow and Littman cavity configuration of diode lasers.

In the **Dimensional metrology** section a completely new facility for the calibration of dual axis auto-collimators with an accuracy of better than a second

has been established. The induction of the new computerised laser interferometer measurement system in the calibration chain has widely been used by the manufacturing industries. The addition of the later has proved very useful to maintain the uniformity in the dimensional measurements as it can be used to calibrate the NC, CNC and other components on site. Earlier these could only be calibrated with great difficulty as their transportation from one place to other was restricted being bulky/heavy.

BIPM sponsored international intercomparison in the **pressure** range up to 500 MPa was carried out at NRLM (Japan). Under this scheme, NRLM, NIST and NPL, Delhi were the participating organisations. The APMP (Australia) sponsored intercomparison in the range (a) 0.4-4.0 MPa and (b) 10-100kPa was done with NRLM. NPL has been selected to be the coordinating agency in the forthcoming APMP sponsored intercomparison programme for pneumatic pressure standard (4MPa). A new method for characterising the data obtained from different types of pressure measuring instruments by curve fitting has been suggested to improve the measurement uncertainty.

A low cost laser Raman spectrometer was set up using Ar-ion laser and Jobin Yvou-Spex (HR640) Monochromator with a notch filter (514.5 nm). The monochromator was calibrated against standard mercury lines. Raman signals were recorded for various samples such as diamond, carbon tetrachloride, benzene and ethanol.

The dynamic system (primary **vacuum standard**) for generating molecular flow pressure in the range 10^{-1} - 10^{-6} Pa was modified replacing the diffusion pump by turbomolecular drag

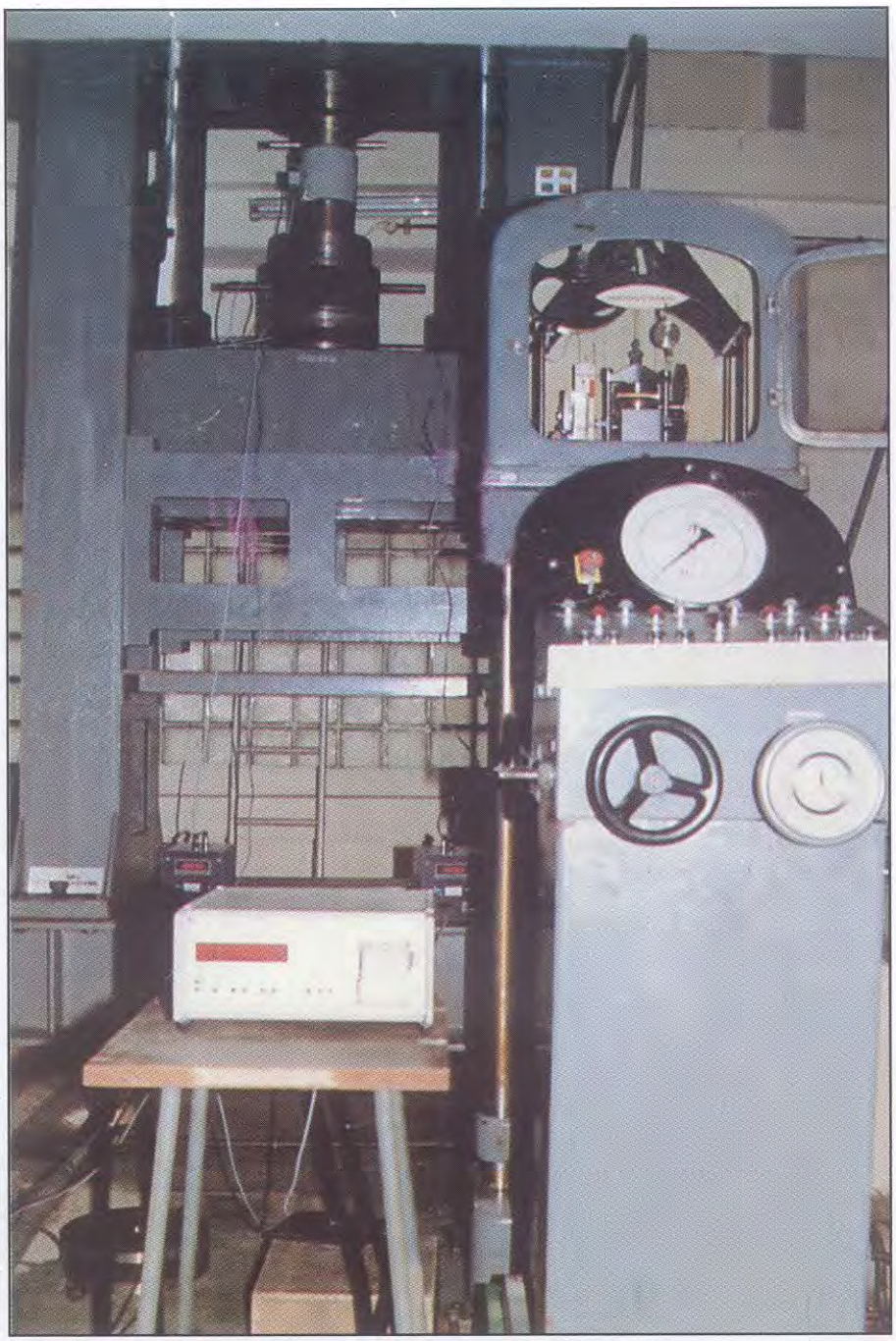


Fig. 1.2 : Hydraulic multiplication system (capable for generating the static forces upto 6 MN). It is widely being used our Force Standards Section in their Calibration work.

pump: (a) to improve the ultimate vacuum obtainable and hence increase the calibration range, (b) to avoid migration of oil vapours into the vacuum chambers and (c) to avoid dependence on liquid nitrogen. The influence of the electric power input and the molecular weight of the gases on the speed and critical backing pressure of an oil diffusion pump was investigated. A software was developed for the estimation of measurement uncertainty of pressure measuring instruments incorporating subroutines for necessary corrections for temperature, local gravity, air head and buoyancy.

In order to meet the specific requirements of defence, space and cement industries for the accurate measurement of forces in the higher range beyond 1MN, the **force standard** section set up a force standard based on the hydraulic multiplication system to realise forces beyond 1MN. The metrological characterisation of the force standard upto 3 MN gives an over all uncertainty of ±1% on the application of the forces.

To meet the requirement of the different key sectors such as defence, civil aviation automobiles etc., for the calibration of the special type of torque meters, a new torque standard has been established up to 2000 N m. A novel technique incorporating the horizontal double beam used in the system gives overall uncertainty of ± 0.05% in the application of the torque over whole of the range. Both these standards are now in regular use.

In the **temperature standards**, a new technique of fabrication of SPRT (0-660°C) was developed and the formalities towards patenting the process are in progress. Each unit costs Rs. 97,500/- compared to US$ 4000 of the imported piece. Four such thermometers have been constructed and calibrated at fixed points of TPW, Ga, Sn, Zn and Al covering the above temperature range. These are supplied to various institutions

Fig. 1.3 : The Ultrasonic C-scan system for characterisation of materials and calibration of ultrasonic probes.

on demand. Also Aluminium Temperature Standard (660.323°C) has been established to a reproducibility of ±2 m°C for SPRT work. The graphite crucibles for metal blackbodies have been fabricated.

In the **ultraviolet standards**, measurement and calibration facilities were extended for irradiance measurement of different types of UV radiation sources, calibration of intensity meters, transmission and bandwidth measurement of UV filters, calibration of portable UV-A and UV-B radiationmeters with an accuracy of ± 10%. Double beam photoacoustic spectro-photometer, designed and developed at NPL, was used for recording the spectra of non-gaseous materials. PAS investigation was done for aromatic hydrocarbons and substituted aromatic compounds.

In the **Optical Radiation Standards** a simple and improved method has been proposed for testing laser beam collimation using self-imaging phenomenon making new type of gratings. Another new technique for the determination of the spectral degree of coherence of field produced by broad band source from the spectral changes produced on interference has been proposed. The knowledge of the spectral degree of coherence combined with the space-frequency equivalence principle has been used to determine the intensity distribution across the source of the field. This method has been used for the measurement of angular diameter of stars. Also the monochromator studies showed that the state of spectral coherence of the light field incident at the entrance slit of a monochromator is modified considerably at the exit slits of the monochromator.

In the area of **Infrared Radiation** standards, an international compatibility in the spectral transmittance and reflectance measurements in the spectral region of 2.5 to 25 µm has been established by carrying out the bilateral intercomparison between NPL (India) and NIST (USA) under the Indo-US project.

The new transmittance and reflectance standards have been developed to establish the radiometric scale over the entire range of 0 to 1 for the transmittance/reflectance of PERKIN ELMER 399 IR spectrophotometer. The commercially available neutral density filters of specified transmittance of 0.1 and 0.32 characterised and have been used as the standards for transmittance.

A quality manual was also prepared for the **Mass standards** laboratory the calibration facilities are as per ISO Guidelines. Solid density standards were developed. Viscosity scale was extended to 30000 mm^2/sec.

SIMS and XPS study for **surface** compositional analysis were carried out on $CuGa_x$. In_{1-x} Se_2 thin films have been formed on glass substrate by spray pyrolysis technique. The work shows how to fabricate tailored solar cells of better efficiency by varying the composition of Copper Gallium & Indian Selenide films.

The controversy of the coverage of (3 x 3)-R30 surface phase was resolved by in-situ studies. It has been determined that three coverages of 0.33, 0.66 and 1 ML for the structure are possible and there exists a major restructuring of the substrate. Room temperature epitaxial growth of Mn on Si (III) has also been achieved. The template method to form high quality silicides ($\sqrt{3}$ x$\sqrt{3}$) has been achieved at temperatures as low as 250°C. The catalytic activity of Mn sub-monolayers in the oxidation of Sn at RT is demonstrated for the first time.

The water **Flow measurement standard** that may work as reference standard has been established using two 10,000 and 1000 kg water tanks. Measurement standard has been characterised with particular reference to the weight using the dead weights of 500 to 10-2 Kg, the density of the flowing water using an on line make density meter, diversion time error of the diversion system as per the ISO 4185. Considering the type A and type B components, the overall uncertainties of ±50% for the mass flow and ± 0.1% for volume flow have been estimated. These facilities are now being used to calibrate different flow measuring instruments.

02 Electrical Standards

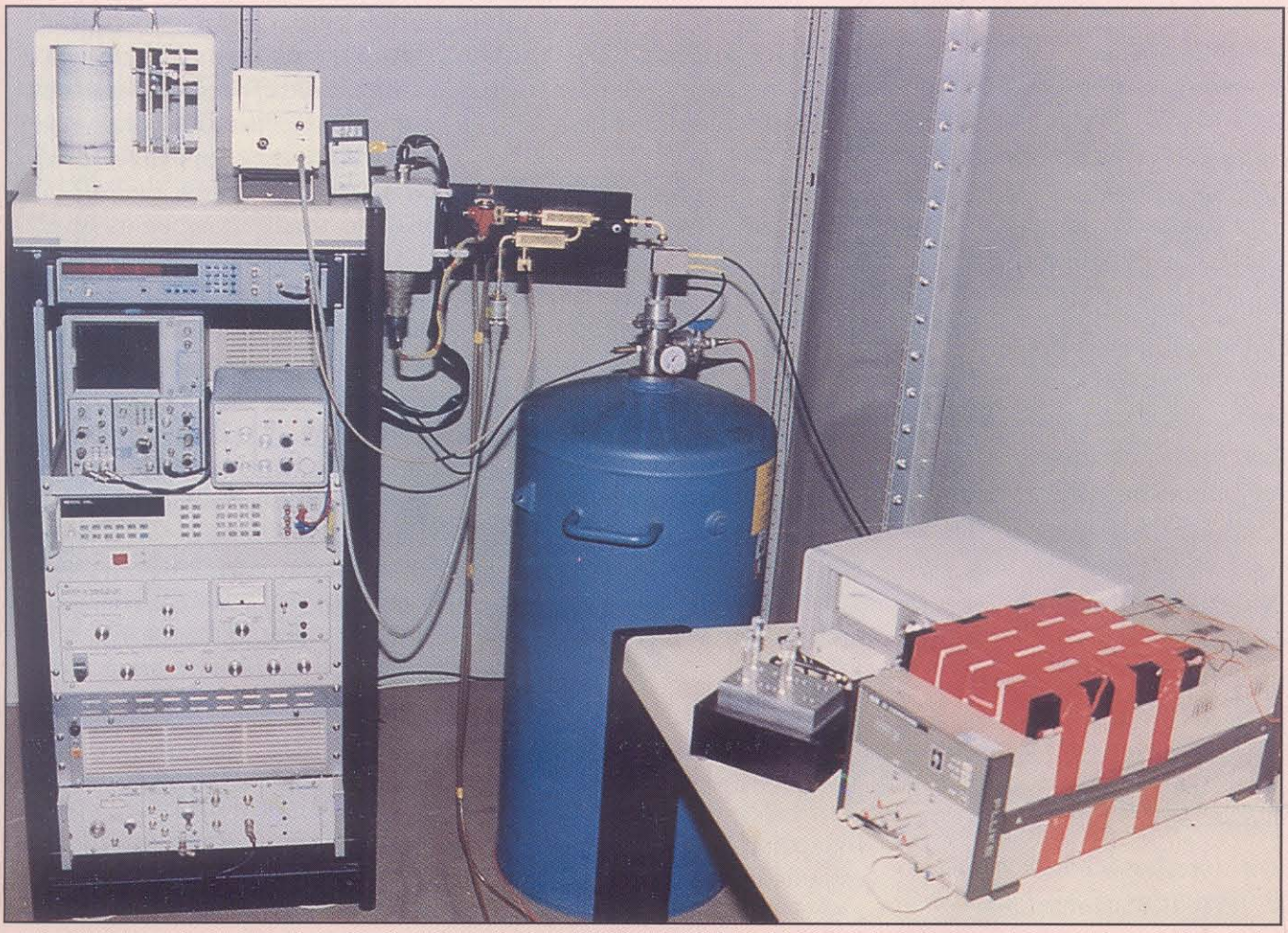


Fig. 2.1 : The Josephson effect based primary standard of (DC) voltage at 1 Volt level. The Zener reference standard calibrated against it has an uncertainty of ± 15 nV.

Electrical and Electronic Standards Division has the responsibility to establish, maintain and update, continuously by research, the national standards and calibration facilities for electrical and electronic parameters. The standards so far realized include DC Standards, Josephson Voltage Standard and Devices, AC & LF Standards and HF Impedance Standards, HF and MW Voltage, Current and Power Standards, HF and MW Attenuation and Impedance Standards, Time and Frequency Standards and Magnetic Standards. International compatibility of these standards is established through intercomparison with national standards maintained by various other countries under different programmes organized by BIPM, CCE, APMP etc. These intercomparisons provide our industries and trade a base to compete in the international market. Over the years the Electrical and Electronic Standards Division has built up considerable expertise enabling it to shift from mere artifact to quantum standards. Currently, the 'Second' is realized through a bank of Cesium atomic clocks, Farad is realized through a calculable capacitor linked with the length standard and having Ohm & Henry traceable to it. Josephson voltage standard at 1 V level has been established.

In **DC Standards** activity, facilities exist for calibration of standard resistors, Wheatstone and Kelvin bridges, milliohm meters, teraohmmeters, standard cells, electronic voltage standards, constant voltage sources, calibrators, high voltage sources and probes.

An international intercomparison of DC Voltage was carried out at 1.018 V level under Asia-Pacific Metrology Programme (APMP) during 97-98. The following countries participated in the intercomparison:

Japan, Hong Kong, Malaysia, Thailand, Sri Lanka, India, Korea, Taiwan, Mauritius, Pakistan, Australia and Singapore (Pilot Laboratory).

A Fluke 732B DC reference standard was used as travelling standard. It was compared against the Fluke 732A DC reference standard maintained at NPL and traceable to Josephson junction array at 1.018 V. The uncertainty in measurement is ± 1.5 ppm.

In **Josephson Voltage Standard** activity the primary standard of voltage based on Josephson effect has been established at 1 volt level, using a series array of $Nb/Al_2O_3/Nb$ thin film tunnel junctions. The internationally agreed value of $2e/h = 4835971.9$ GHz/V is used. The Zener reference standard has been calibrated against the Josephson standard at 1.0 V and 1.018 V levels with an uncertainty of ± 15 nV. This unique facility will be widely used for calibration of reference voltage standards of calibration laboratories and industries with compatibility to BIPM and other international standards laboratories.

The **RF-SQUID** has been fabricated on **$Hg_{0.8}$ $Tl_{0.2}$ Ba_2 Ca_2 Cu_3 O_{8+X} thin film** using natural grain boundary weak links. Voltage-flux modulations due to SQUID behavior have been observed upto a record high temperature of 121 K. The amplitude of V-Φ modulations remains constant in the temperature range of 77-118.4 K. It starts decreasing above 118.4 K, and finally disappears at 122 K. The flux noise density of the SQUID is $\approx 1\times10^{-3}\ \Phi_0/\sqrt{Hz}$ at 1 Hz and 77 K. It also remains constant in the temperature range of 77-118.4K. These results show that rf-SQUIDs fabricated using Hg-based superconductors could be operated at much higher temperatures. This feature may help in wide spread application of SQUIDs in industry due to easy availability of closed cycle refrigerators.

Harmonic generation in Hg (Tl)BaCaCuO films : A systematic study of harmonic generation has been carried out on thin films prepared by spray pyrolysis technique. The film has a $T_{c\,(R=0)} = 123$ K. The variation of the amplitude of second (V_2) and third (V_3) harmonics with dc field shows hysteresis effect. Variation of V_2 and V_3 with temperature shows a peak. All these features of harmonic generation can be understood in the framework of the critical state model.

In **AC High Current & High Voltage Standard activity,** the calibration work was carried out for the instruments like CTs, CTTS, CT burdens, Weld Testers. Clamp on meters. AC current shunts, CTTS Jigs, PTs, PTTS. PT Burdens. kV meters, HV Probes etc.

Calibration range of Weld Testers/scopes was extended from 15 kA to 20 kA at 50 Hz with an uncertainty of ± 0.5%. The technique makes use of ampere-turn concept through the window of the sensor of the weld tester. The current through the turns was measured by potential drop method.

Facility for the calibration of current transformers, without phase angle, was extended for any current ratio.

The **AC Power & Energy Standard** activity is providing test and calibration facilities for electricity meters and phase meters to power sectors and laboratories. The following facilities have been added for test and calibration of energy meters:

i. Influence of dc component in the ac curent circuit using multiple diodes. This test confirms the saturation of magnetic core used in current coils.

ii. A zero power factor standard set up for calibration of reference meters at zero power factor using a mutual inductor coil as a 90° phase shifter and inductive voltage divider.

iii. Automatic dosage of energy through 3Φ power source for dial registration test.

iv. A separate single phase calibration system with uncertainty of ±0.01%.

v. Prototype set up for influence of heating and cooling on the performance of energy meters.

vi. Influence of external magnetic field of 1000 ampere-turns for testing of energy meters.

vii. Semi-automation has been introduced for calibration of energy meters.

The **LF & HF Impedance Standards** activity is working to establish, maintain and update the primary and transfer standard of Capacitance, Inductance, ac Resistance and Q at low and high frequencies.

International intercomparison of 10-pF capacitance standard between NPL (India) and PTB (Germany) was carried out at 100 V and 1592 Hz. The results of intercomparison showed an agreement of 0.13 ppm among the national standards of capacitance of India and Germany.

Bilateral comparison of capacitance standard between NPL (India) and NML (South Africa) was carried out, using 10 pF ULE (Ultra Low Expansion) silica capacitor fabricated by NML (South Africa). Measurements were taken at 15 V and 1 kHz. The agreement in result of the two laboratories was

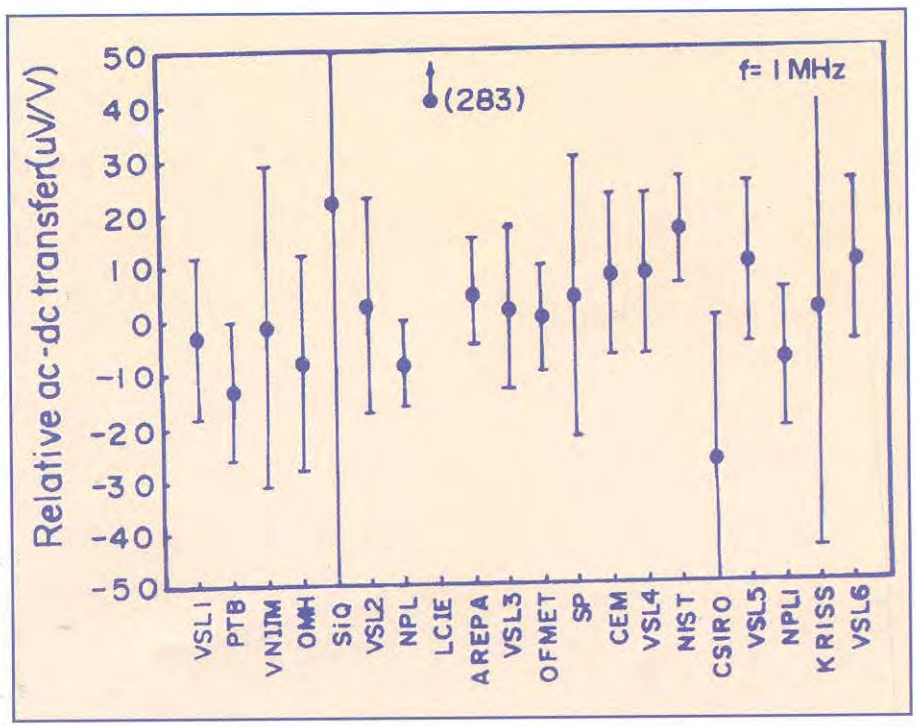


Fig. 2.2 : Measured ac-dc transfer difference normalized on the mean value at 1 MHz.

better than 1.0 ppm.

Value of primary standards of ac resistance, 1 kΩ resistance standard, has been reassigned using quadrature bridge, equal power bridge etc. The overall uncertainty in assigned value of 1 kΩ resistance is ± 5 x 10^{-7}.

This activity provides apex level calibration facilities for the LCR and Q standards and measuring instruments at low and high frequencies, inductive voltage dividers, turns ratio meters etc. to various industries and R&D organisations.

The **HF & MW Voltage, Current and Power Standards** activity is maintaining and updating the primary standards of (i) AC and LF voltage and current (10 Hz to 100 kHz), (ii) HF voltage (1 MHz to 1000 MHz) and (iii) HF and MW power (10 MHz to 18 GHz). These are (i) Multijunction Thermal Converters based on Joules Heating Law, (ii) Twin resistance power mount based on principles of calorimetry and (iii) Microcalorimeter based on principles of calorimetery, respectively.

The primary standard of HF voltage in the frequency range 1 MHz to 1000 MHz has been updated as a result of technical cooperation with the PTB, Germany. The measurement uncertainty has been reduced from ± 0.015% to ± 0.01% and from ± 0.8% to ± 0.5% at 1 MHz and 1000 MHz, respectively.

High frequency thermal voltage converters (transfer standard of HF voltage) have been made traceable to the updated primary standard upto a frequency of 1000 MHz.

An international inter-comparison in HF voltage has been carried out using 3 volt calibrated thermal voltage converter (TVC) and semi-automated TVC comparison set up under the auspices of CCE of BIPM at the frequencies of 1, 10,

Fig. 2.3 : Setup for Intercomparison of HF Voltage Transfer Standards

30 and 50 MHz. For the purpose of this comparison two thermal voltage converters were received from the Pilot Laboratory (Van Swinden Laboratorium {VSL}, The Netherlands). Fifteen countries including The Netherlands, India, USA, Germany, Australia, U.K., France have participated in this inter-laboratory comparison.

In **HF & Microwave Attenuation and Impedance Standards** activity the calibrations of coaxial fixed and step attenuators, T.P. testers and transfer standard WBCO attenuators have been carried out at 30 MHz and other microwave frequencies from 1 to 18 GHz using Audio Frequency and I.F. substitution techniques with an uncertainity of 0.01 - 0.02 dB/10 dB. The coaxial standard mismatches have also been calibrated by coupled sliding load technique.

The three APC-7 coaxial attenuators 3 dB, 10 dB and 20 dB were calibrated at 30 MHz, 5 GHz and 10 GHz for carrying out bilateral comparison of attenuation standards with Standard and Calibration Laboratory (SCL), Hong Kong.

The design of a coaxial reflection coefficient standard was investigated. The design of reflection coefficient standard consists of a quarter wave length long step up discontinuity on the inner conductor of a coaxial line terminated by a precision matched termination. The design approach has been validated at 4 GHz and 12 GHz for the VSWRs 1.3 and 1.5. Theoretical computation of the uncertainties has been carried out.

Time and Frequency Division disseminates the Indian Standard Time (IST) which is based on the time scale generated by NPL, New Delhi. This time scale designated as UTC (NPLI) is derived from an ensemble of Cesium atomic clocks (HP5071A). The UTC (NPLI) is traceable to inter-national UTC maintained by BIPM through monitoring of GPS time signals.

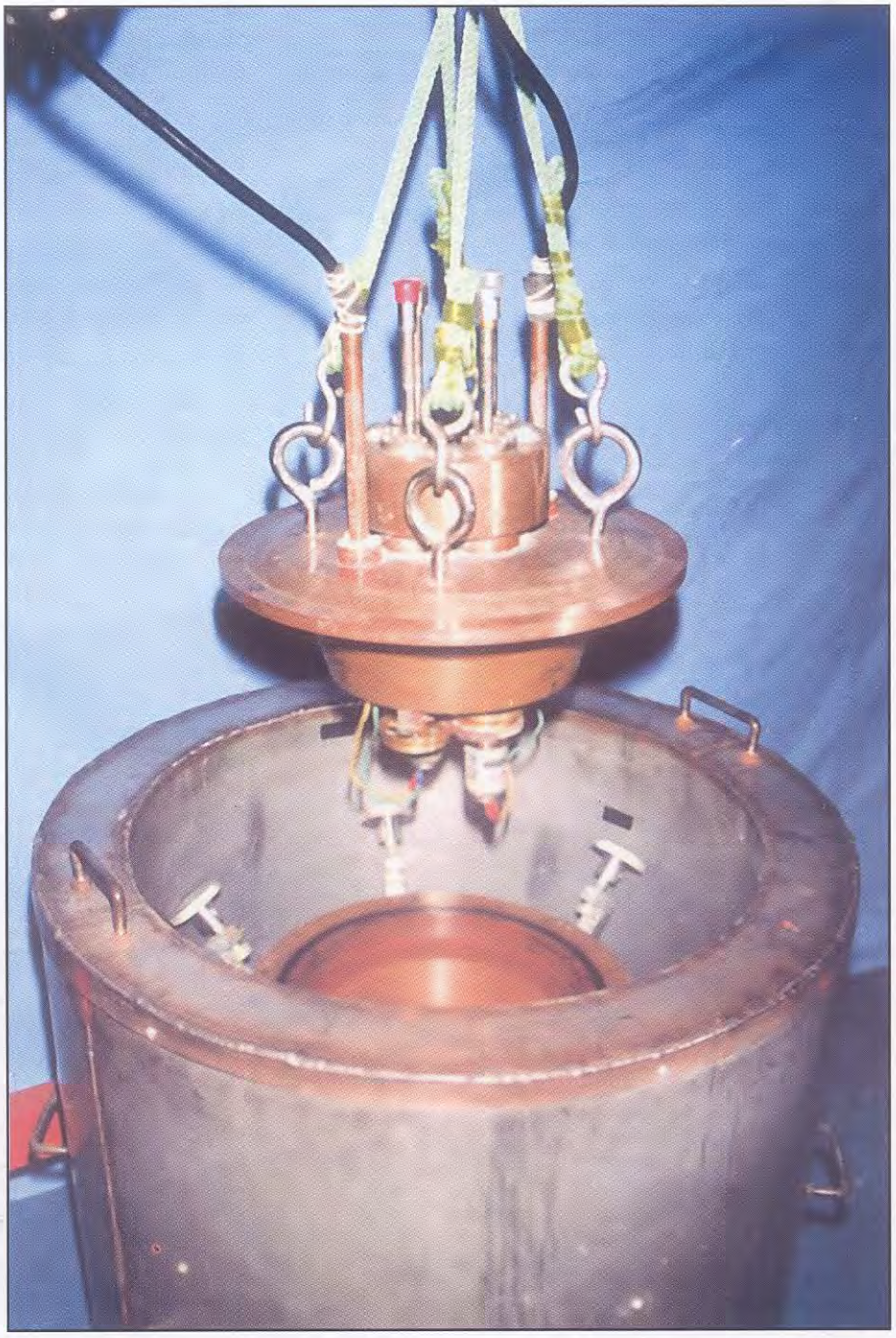


Fig. 2.4 : Microcalorimeter System, Primary Standard of HF & MW Power

This regularly received GPS data is periodically sent to BIPM. The status of the epoch of UTC (NPLI) is fed back by BIPM. The time scale derived thus is disseminated for the users throughout the country through INSAT satellite. The national Standard Time and Frequency Signal (STFS) dissemination service has been in operation since 1988. The users of this service are increasing every year and they range from power generation and distribution agencies to satellite tracking and astronomical observatories. The accuracy of time transfer using this service has been recently improved from ± 20 μs to ± 1 μs using Differential Standard Time and Frequency Signal.

An Indo-US project involving NPL, IIT Delhi and NIST, USA on improving frequency stability of Atomic Time & Frequency Standard by suppressing quantum noise through squeezed states has been initiated. Another Indo-US project with NIST, USA involves studies of H-maser and phase noise measurement studies. To initiate digital time data service via telephone network (Teleclock), the field trial has been done successfully. User equipment (Teleclock) has been designed and developed. The know-how of the Teleclock has already been transferred to one manufacturer.

For Establishing **Magnetic Standards** a precision electronic fluxmeter with measuring range 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4} Volt Second, was procured and it was calibrated against a precision electronic calibrator fabricated at PTB, Germany. This calibrated fluxmeter is to be used for calibrating search coil received from user organizations. Another important measurement was carried for calibrating NPL's

Fig. 2.5 : AC Magnetic Measurement System for Soft Magnetic Materials

Fig. 2.6 : AC Power & Energy Calibration System

Epstein frame with air compensation provision for the AC magnetic measurements on soft magnetic materials as per IEC standards. Five Standard Samples in the shape of strips, two grain-oriented and three non-oriented grains of electrical steel were provided by the PTB, Germany to be maintained as reference standards. Measurements were conducted on all the five samples mentioned above to determine the core loss, induction, field strength, apparent power losses and other relevant parameters.

Instrumentation

A smart micro-pressure sensor chip with p-type silicon piezo-resistors is designed and developed in the wheat stone-bridge form. This instrument measures arterial blood pressure from 0-500 mm of Hg in digitised form. Automation is attained by incorporating a computer.

Acoustic Lithotripsy

Measurements were made on focal transducers for specific applications. Ultrasonic, mechanical, electrial and physical properties including crushing strength, porosity and density etc. were made on invitro kidney stones (real calculi) and gall bladder stones. XRD study has also been completed.

03 Engineering Materials

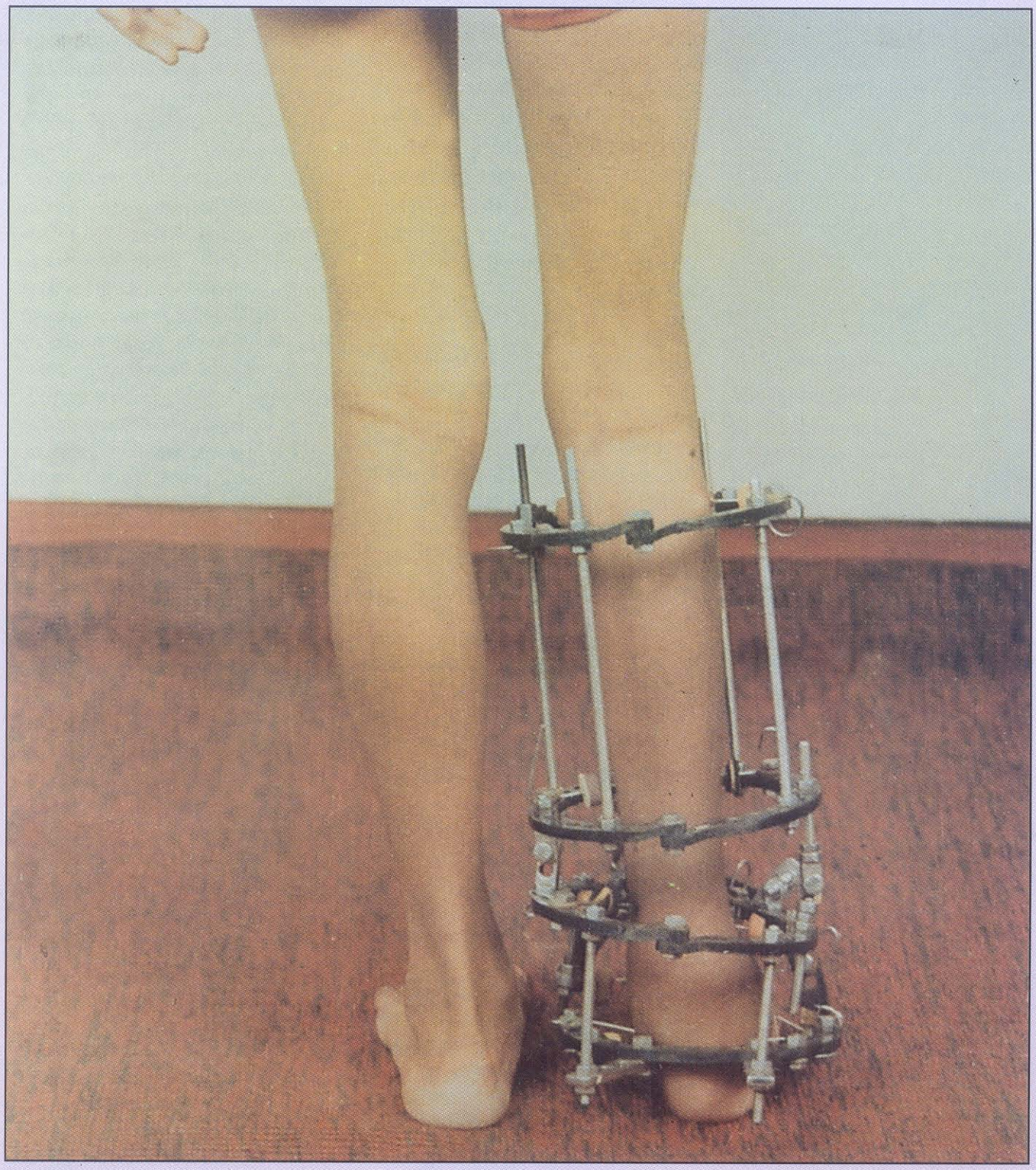


Fig. 3.1 : A Carbon ring now replaces conventional metallic ring in fixators for polio patients. A polio patient is shown with fixator.

The Advanced Carbon Products, Metals, Alloys and Composites, and High Pressure Physics and Technology are the main areas of activity of the division of Engineering Materials

The Division has been taking up focused projects mainly meeting the strategic and vital requirements of the country.

Three aspects of the work on **Carbon Composites** were addressed during this period. In order to enhance the oxidation resistance capability, carbon-carbon composites were prepared incorporating Silicon Carbide using sol-gel technique (*In situ*) as well as Silicon Carbide particulates. It has been found that Silicon Carbide incorporation using particulates is not a very good technique since the particulates are hard and at the same time they are in the range of diameter about 10 microns. As a result, we found that carbon fibres, during processing, get damaged. On the other hand, sol-gel technique has been found to give nano size SiC particules with fairly uniform distribution through out the composites. Thermo mechanical properties would be assessed after proper densification etc.

Work for studying influence of surface energetics of reinforcement in composites was extended further. Carbon-Carbon Composites developed using Panex fibres possessing surface energetics varying from 3.8-10.4 dyne/cm were processed to temperatures upto 2600 °C. It has been found that beyond 1500 °C temperature HTT, the fibres (possessing 6.5 dyne/cm surface energetics) in the composites show development of radial type of microstructure which is quite unusual for PAN based carbon fibres. The well established structure of such fibres is only onion type. This has been brought out for the first time that interface (a parameter that depends upon surface energetics) not only influences the microstructure of the composites as such but also of the reinforcement.

After optimising design of carbon composites ring for Ilizarov Fixator, these rings were found to show breaking load of around 150-200 kgs as compared to 90 kgs at the yield point of stainless rings. These rings have been supplied to Agrawal Orthopaedic Hospital, Gorakhpur for field trials on polio patients. These have been found to be successful. Further work for developing bigger diameter rings is in progress. Figure shows a patient fitted with Ilizarov Fixator using carbon rings for the purpose of straightening of polio effected leg.

For developing High Density High Strength Isotropic Graphite, efforts were made to develop this product using green coke rather than from graphite fibres or from mesocarbon micro beads. For this a suitable prepared coal tar pitch was heat-treated at 500-550 °C and a green coke prepared therefrom. The powdered green coke was carbonised to 1000 °C and subsequently graphitised to 2500 °C to obtain high density isotropic graphite. This graphite possessed a bulk density of 1.9 gm/cc, bending strength of more than 60 MPa, electrical resistivity of 1.5-3.0 m ohm cm and Young's modulus of 9-16 GPa along with

a homogeneous and isotropic microstructure, thus meeting the end objective. Besides this, a Consultancy project from Graphite India Limited relating to "Coke formation from tar pitches" was also completed.

The **Metals and Alloys** Group is engaged in primary and secondary processing of metals, alloys and composites. Al-Li MMCs (5 wt% Li) reinforced with 15 and 20 wt% SiC particulates were hot extruded and detailed mechanical and metallurgical characterization was carried out. The mechanical properties yielded an elastic modulus of 115 GPa with a density of 2.5 gm/cc. This work forms part of the collaborative project with Fraunhofer Institute of Materials Research (IFAM), Germany and has been concluded satisfactorily.

Developmental work on the hot extrusion of Square tubes of Mg alloy (ZK30) was continued. Required toolings were designed and fabricated. Thereafter, the actual sized square tubes were hot extruded, process parameters optimised and finally few sample tubes were supplied to VSSC (sponsorers) for characterization. All the target properties have been met and efforts will be made to achieve desired tolerances and finish of this product.

We have succeeded in forming oval shaped Aluminium alloy landing gear, initially with 90% of the actual dimensions. We are now on way to generate actual sized landing gear, which will be ultimately used in Advanced Light Helicopter, under the weight saving programme.

Extensive hot deformation studies have been undertaken to optimize extrusion process parameters of MMCs using 2124 Al-alloy as matrix reinforced with SiCp (10, 15 and 20 vol%). The extruded rods were extensively characterized for metallurgical and mechanical properties. Detailed investigations were carried out mainly to understand the effect of deformation parameters on the extrudability of these composites and their correlation with mechanical and metallurgical properties. Work hardening behaviour of extruded 2124 Al-SiCp MMCs was also studied as a function of deformation and volume fraction of reinforcement.

A consultancy project on "Prima Facie Techno-Economic Feasibility Report for the development of Automobile components using Cold Forging Technology" was taken up for M/s Hero Honda, New Delhi.

High pressure physics & technology group

Synthesis of cubic boron nitride was carried out from low ordered turbostratic and amorphous boron nitride as the starting material employing the catalyst-solvent process and a yield of about 50% was obtained. The graphite-diamond phase transformation was also studied from C-Cu system under high pressures and temperatures.

04 Electronic Materials

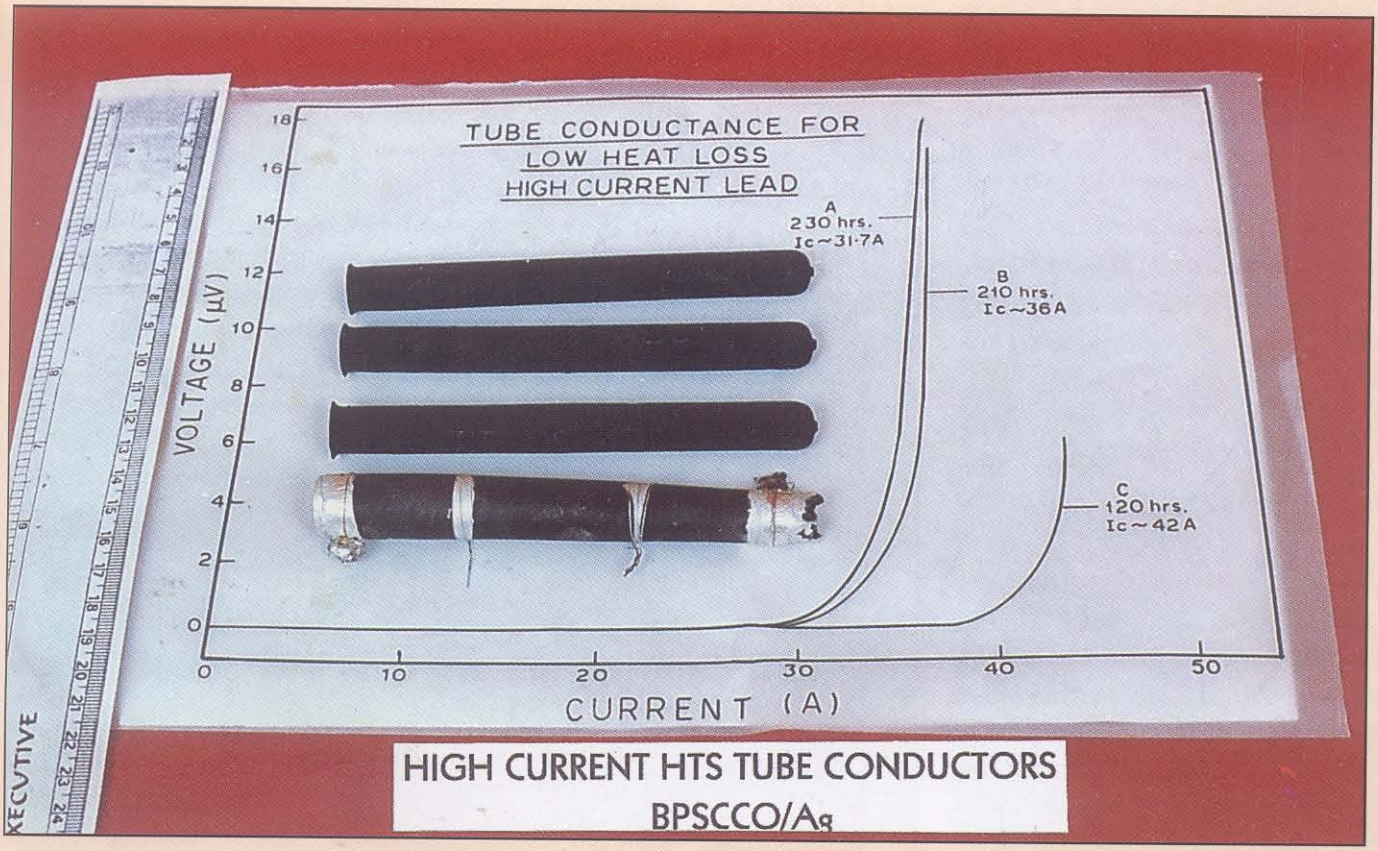


Fig. 4.1 : The BPSCCO/Ag HTS tube conductors.

The activities of this division is wide ranging from electro-ceramics to superconducting ceramics. Bismuth based superconducting tapes are developed for prototype magnet fabrication. Improvement in usual phosphors and electro-luminescent device development, thin film, infrared/optical filters, amorphous semiconducting thin film, thin film of Diamond like Carbon (DLC) and development of solar cells of high efficiency and low cost are other important areas.

The activities in this area consisted of semiconducting, superconducting and insulating materials in the bulk and thin film form and devices made out of them for eventual adoption by the electronic industries.

Crystalline Silicon Solar cell

Solar cell structure which may be suitable for fabrication of high efficiency large area (94 cm^2) solar cell was developed from low cost and low minority carrier lifetime (<10 μs) crystalline silicon wafers using aluminised substrate to substrate bonding (ASSB) of low lifetime base wafer and a thin high lifetime (>10 MS) active wafer. Two 10 cm x 10 cm pseudo square wafers were screen printed with aluminium paste and the binders were removed by heating them at about 400°C in air. Thereafter the wafers were stacked vertically with the aluminium coated sides pressing against each other and bonded together by heating at 825°C for 15 min. in a neutral ambient.

One of the bonded wafer was thinned down to 150 microns by selective etching of the exposed surface and then an n^+ -p-p^+ solar cell was fabricated by $POCl_3$ diffusion in the thin wafer and screen printed metallization. Because of the back surface field (BSF) produced by aluminium, the open circuit voltage was quite high, e.g., 580 mV even without oxide passivation. The short circuit current density was 20 ma cm^{-2} without any optical confinement. However, curve factor was only 0.58. This poor value of C.F. was attributed to high series resistance arising out of incomplete bonding in vertical configuration. However in the very first experiment we

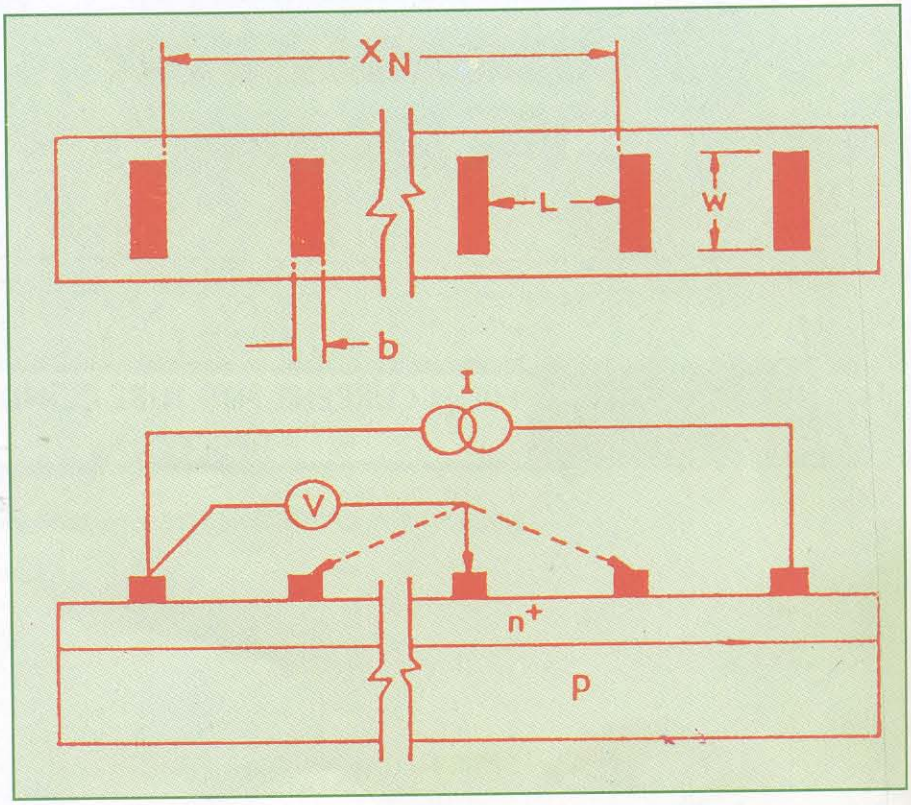


Fig. 4.2 : Schematic arrangement of determination of contact resistance of n+ front surface of solar cells.

obtained 6.7% efficiency which with optical confinement will easily go upto 8.5%. To enhance C.F. arrangements have been made to stack the wafers horizontally for bonding. This is expected to yield higher efficiency values.

An intercoating technique of aluminium and phosphorous co-gettering were developed and very useful results were obtained. This is an input technique needed for Solar cell fabrication.

A novel experiment was designed and performed to evaluate the specific contact resistivity (R_c) of the screen printed silver front contacts. The experimental arrangement is shown in Fig. 4.1 and the results in Fig. 4.2. The value of R_c comes around 10^{-3} Ω/□ depending on firing temperature and time. Three types of samples were used e.g. (i) textured, (ii) textured with oxide grown on it during diffusion, and (iii) chemically polished multicrystalline. It has been observed that contact resistance is less in the first case but current is higher in the second case. The measurements in the third case suggest that shallower junction can be used if metallization is made through SiO_2 because the dead layer thickness as obtained from spectral response data (Fig. 4.3) is smaller. As a part of industrial assistance the solar cells of M/s Telemat India Ltd. have been calibrated and spectral responsivity and other parameters of 10 cm x 10 cm polycrystalline solar cells of M/s Bharat Heavy Electricals Ltd. (BHEL) were measured.

Full and final report of the Ministry of Non-conventional Energy Sources (MNES) supported project- "Development of 15% efficient single and multi-crystalline silicon solar cell" has been submitted to the Ministry.

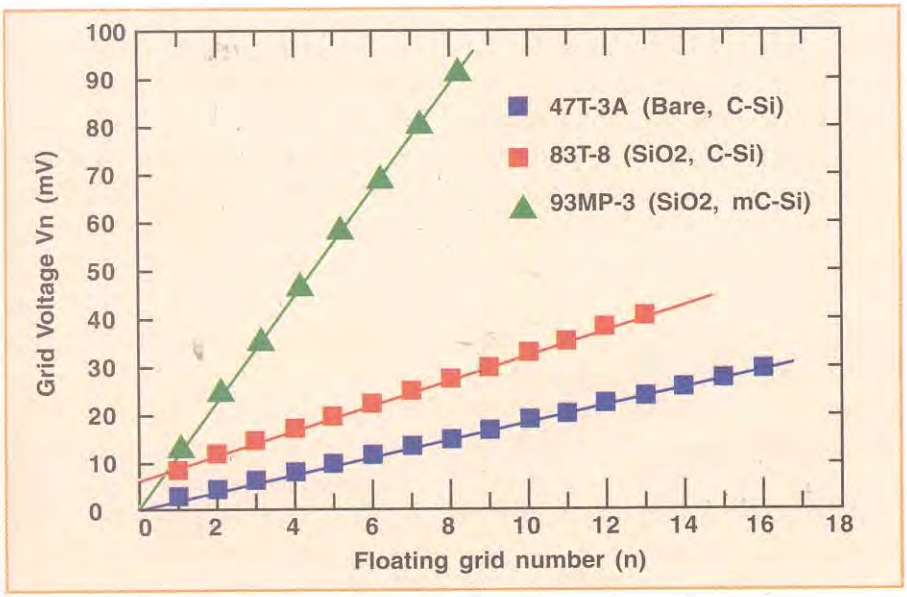


Fig. 4.3 : Voltage (VN) vs. floating grid number N plot for determination of R_c of solar cells.

Modelling of 2D - diffusion

The Grant-in-aid project "Development of Two Dimensional : VLSI PROCESS SIMULATOR, 2D-STEPS; Diffusion Modelling" sponsored by Microelectronics Development Division, Department of Electronics has been successfully completed on schedule. The main aim of the project was to develop a software for diffusion of dopants (pre-deposition and drive-in) of boron, phosphorous, arsenic and antimony in silicon under neutral ambient for microelectronic devices. This program is to be used with "2D-STEPS", a multi-institute project involving national laboratories, IIT's and a number of premier universities to develop an indigenous two-dimensional process simulator funded by DoE. The Diffusion package was given to DoE for integration into "2D-STEPS" along with the final project report.

To accomplish the set project goals and also to validate diffusion program under oxidizing ambient, it was essential to have program for two dimensional oxidation. Development of this program was not under the scope of the project. Special efforts have been made to develop the 2D oxidation program particularly diffusion with moving boundaries encountered during oxidation at NPL. Interfacing of this program with diffusion module resulted in a complete 2D process simulator named "2D-DIFFUSE" which can be used to simulate 2D diffusion and oxidation processes. It was decided to have intellectual property right

on the complete program. A document entitled " A SOFTWARE FOR THE SIMULATION OF TWO DIMENSIONAL DOPANT DIFFUSION IN SILICON UNDER NEUTRAL AND OXIDIZING AMBIENT FOR VLSI APPLICATION" has been submitted to the CSIR Intellectual Property Management to life and secure the copy right. The program runs using UNIX operating system on work stations. However, the graphics and visual display are available only on HP systems with "Starbase". Efforts are being made to make it more user friendly under DOS environment. "2D-DIFFUSE" is now available for users.

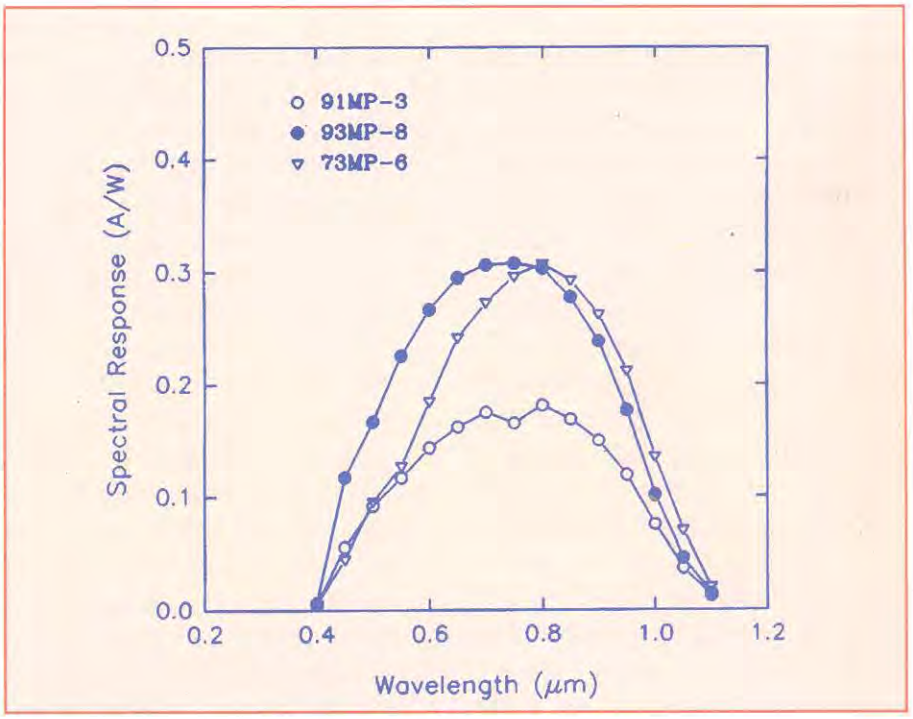


Fig. 4.4 : Spectral response curves of three multicrystalline Silicon solar cells.

Silcon & Carbon Based Thin Films, Devices and Systems

Diamond Like Carbon Film

Detailed field emission measurements have been carried out on diamond like carbon (DLC) films prepared by various techniques in the laboratory such as by conventional RF plasma CVD, VHF, CVD, pulse plasma CVD and utilising a saddle field fast atom beam source. For these measurement, DLC films were deposited on silicon wafers. The emission measurements were carried out in a parallel plate configuration with an anode of indium tin oxide coated glass kept at a separation of 40-50 μm from the DLC film under measurement in a vacuum of 10^{-5} Torr, maintained by a turbo pump. The emission current was found to obey the well known Fowler-Nordheim equation for field emission and $V_{turn\ ON}$ values for DLC films studied ranged from 4.0 V to 20 V and the corresponding values of barrier height for field emission ranged from 0.08 to 0.16 eV. The smaller values of $V_{turn\ ON}$ and barrier height are observed for nitrogenated DLC films and films prepared by the pulse plasma technique. Under a DST sponsored project a microwave PECVD facility with possibility of applying RF bias to the substrates is being set up and may be in operation in next few months. This is to prepare DLC films with low stress values and also to find the conditions where photo luminescence efficiency in the films can be maximised. The values of $V_{turn\ ON}$ and barrier height are found to depend on Sp^3 content of the films.

The process of optimising the growth of the highly tetrahedral amorphous carbon (Ta-C) films is in progress by a technique known as filtered vacuum arc discharge (FVAD). The Ta-C films are potentially useful for the fabrication of field emission type flat panel displays. Further improvement in the design of various parts of FVAD equipment such as mechanical striker for initiating the arc, water cooled cathode, pumping stack has been conceptualised after obtaining first few batches of Ta-C films of unacceptable quality.

Amorphous Silicon Solar cells

Multi-chamber plasma CVD reactor with cassette to cassette transfer of substrates of size 1260 x 610 x 280 mm with three chambers have been designed and fabricated involving M/s. HHV, Bangalore and ASSCP-BHEL, Gwalphari. In this system

transfer of substrates of size (300 x 300 mm) takes place on endless belts which can be moved, with different speeds, in different chambers. For this substrates are first put in a cassette. The systems is upstream mass flow controlled for reactant gases and downstream pressure controlled by capacitance manometer and throttle valve combination. Oil free advanced turbo drag pumps have been used in the pumping stack. The system incorporated elaborate safety gadgets required for working with explosive & poisonous gases and has a dedicated PLC. The system after detailed testing and improvement has arrived at NPL and will be installed shortly for growing large area amorphous silicon films and solar cells under sponsorship of MNES/BHEL/ASSCP.

Thin Film Optical Coatings

Development of narrow-band infrared optical filters for environment and pollution monitoring equipment and agri-electronic equipment

In a recently completed DST-sponsored project we demonstrated capability of monitoring film thicknesses to within 1% in multilayers of upto 140 quarter wave ($\lambda/4$) films, by upscaling upto 10 times the monitoring wavelength. Primary narrow band filters with centre wavelengths of 0.85-7 microns, half bandwidth 0.05-0.15 micron and peak transmission greater than 60% were fabricated. The design of complete narrow band filters have been completed, and effort are underway to undertake the fabrication of these filters in the modern vacuum coating plant at OLF Dehradun.

These narrow band IR filters are presently imported by Indian users at high prices, so the indigenous availability of these filters will satisfy the needs of several user agencies.

Mixed Composition Infrared Optical Thin Films

Mixed composition thin films of three different mixtures - Zinc Sulphide-Thorium Fluoride, Zinc Selenide - Cryolite and Magnesium Fluoride - Thorium Fluoride have been deposited and characterised for their refractive index, extinction coefficient, thickness, intrinsic stress, surface morphology, crystalline/amorphous structure, etc. These films are found to have tolerable refractive indices (in most cases), good IR transparency, low intrinsic stress for a particular composition, and very smooth surface morphology (no features seen upto 20 KX magnification). These films may prove useful for incorporation in multilayer thin film coatings for the infrared.

Yet in another DST sponsored project scheduled to be completed in Sept. 1998 certain other mixed composition films are being investigated. Some of the results have been accepted for publication.

The design of an antireflection coating on glass, for use with a Nd-YAG laser in MIG-27 aircraft, was required by HAL, Nasik. The design and fabrication details were completed and sent to OLF Dehradun under a consultancy project. The spectral characteristics of the fabricated coating met the target characteristics quite closely. The coated glass is being tested by HAL, Nasik.

Microstructure of Materials and Devices

Tellurides and Selenides

The MNES sponsored project "Development of electrodeposition technology for CdTe solar cells" has made significant progress. Small area solar cells with efficiencies > 6% have been fabricated. Upgradation of the process to larger area cells and lowering of contact resistivities to enhance the efficiency is in progress. A room temperature photo luminescence facility for defect characterization of CdTe films have been successfully set up. Ecosolar, Pune, the industry which has sponsored a project with our group has been provided with cell characterization and evaluation knowhow to optimize their production line.

The Se vapour selenization process has been further optimized. Modelling studies have been extended to Se/Te alloy sources and band gap and resistivity of Zn (Te) Se films are seen to correlate with Te/Se ratio in the gas phase calculated by the modelling studies. Preparation of low resistive wide band gap Zn (In) Se films by selenization of alloyed precursors followed by a vapour phase zinc

treatment at 400°C has been realized. The resistivities of 1Ω cm are suitable for device applications.

Thin film ferroelectric oxides

Studies on Ferroelectric PZT thin films prepared by electron beam evaporation followed by sintering being investigated as storage elements for high density DRAMS and ferroelectric switch for last non volatile memories have been continued. A novel observation has been the identification of relaxor behaviour on the B site. Preparation of Barium ferrite films by the spray pyrolysis of citrate precursors has been achieved. These films are being characterized for possible application as perpendicular magnetic recording media.

Ion beam development

Technology of the ion beam micro etching system has been developed as part of the DST sponsored project to achieve micro milling of a variety of materials for planar and cross-sectional specimen preparation for microstructure analysis by transmission electron microscopy.

High Temperature Superconducting Wires/Tapes

Keeping the possibility of use of high temperature superconductors as current carrying conductor in mind, NPL has been developing technology for fabrication of silver clad superconducting wires using high temperature superconductors. The work on current carrying high temperature superconducting BPSCCO conductors was done in three main directions : i) Fabrication of long length silver clad BPSCCO mono-filamentary, ii) Fabrication of silver clad mono-filamentary or multifilamentary tapes were done by the PIT (powder-in-tube) method and the process parameters were optimised for long length tapes.

Several coils made of 5-25 meters long mono-filamentary tape have been fabricated. These coils showed end to end superconductivity upto 25 meters length (Fig. 4.5) with a critical current density (J_c) of approximately 6000 A/cm^2 at 77 K in self field. Similarly, multi-filamentary tapes with 17 filaments were made upto a length of 2 meters. These tapes were sintered at 830-845°C for 250 hours with intermittent rolling. An I_c of 2.7 A for the multi-filamentary at 77 K and self field was recorded.

High current leads featuring rods or tubes look certain to be one of the first applications of ceramic superconductors in electrical power engineering as

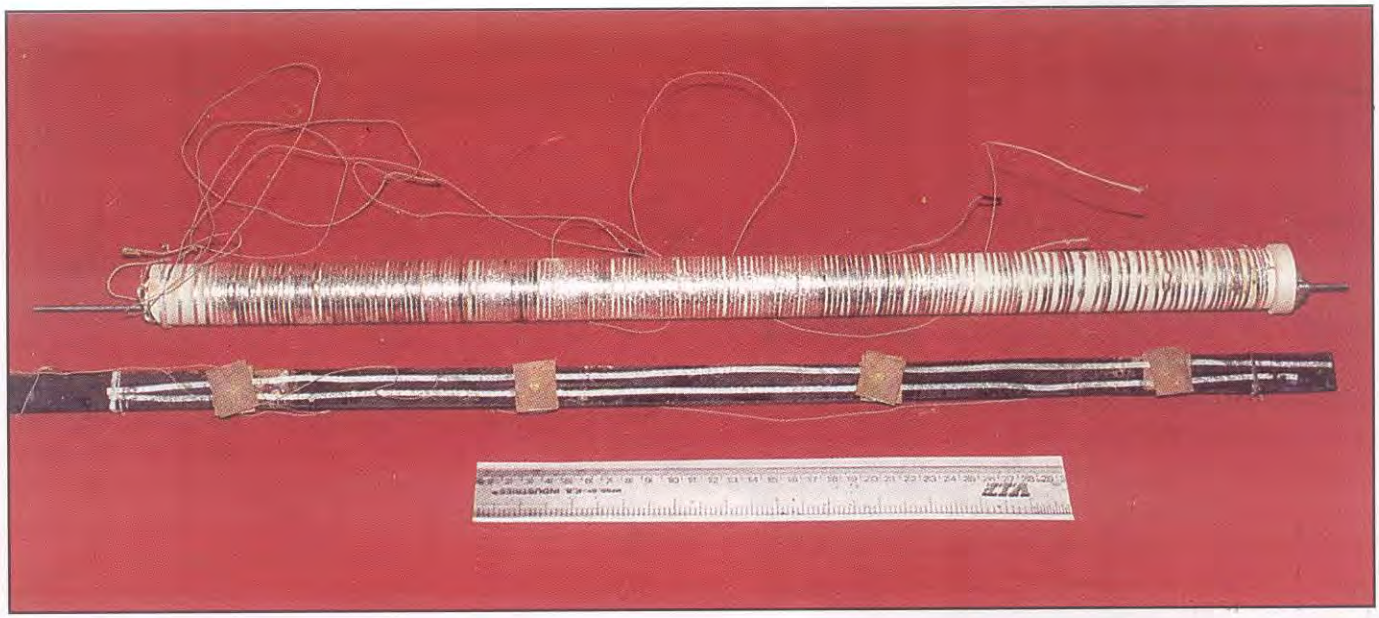


Fig. 4.5 : Long length silver clad BPSCCO tapes fabricated at NPL, which showed end-to-end superconductivity. The top one near the scale is a 1m long multifilamentary tape and the bottom one is a 25m long mono-filamentary tape.

they offer a major advantage over conventional all metal leads. A reduction of heat load at 4 K by more than a factor of 10 with a current of 500-1000 A for various applications like the leads for the superconducting magnets, generators, etc. can be obtained. NPL has prepared 10, 20 and 43 cms long tube conductors of Bi-2223 capable of carrying more than 120-200 A at 77 K in the superconducting state. These can be used as current leads for conventional superconducting magnets, particularly suitable for operation with cryogen free cryo-coolers.

Special Ceramics

Two projects : i) Development of beta alumina tubes for sodium metal production and ii) development of porous ceramic particulate filters for IC engine exhaust were undertaken during the year. The first project is a collaborative project with the Indira Gandhi Centre for Atomic Research (IGCAR) with funding from BRNS. Under the project, 26 nos. of 50 mm x 100 mm x 2 mm wall thickness one end closed beta alumina tubes were fabricated and joined to an alpha alumina header using special glass seals. The tube assemblies were supplied to user for use in the electrolytic cell for production of high purity sodium metal. In the second project, particulate filter based on porous sponge ceramics for IC engine exhaust is under development in collaboration with the Indian Institute of Petroleum (IIP) with funding from the DST. A new composition of cordierite was developed to get better strength in porous bodies. The process parameters of the slurry infiltration process were studied to obtain the best combination of porosity, permeability and strength. Porous bodies with porosity of 75%, gas permeability of more than 7 m^2/MPa/sec and fracture strength> 30 kg/cm^2 were obtained. Design of the filter element was frozen in consultation with IIP. One filter element was fabricated and sent to IIP for testing on a 2-stroke engine test bed.

Luminescent Materials & Devices

Particle Size Analyser

An industrial particle size analyser (PSA) based on the principle of photo-sedimentation has been developed that can either be operated manually or by using a personal computer. The necessary hardware and software for data acquisition and particle size analyser respectively has also been developed by the group. A patent is being filed for the same. The know-how has been transferred to M/s. Emerson Controls, New Delhi in 1997. Three manually operated PSA and one computerised version of the PSA have already been sold to private industries by the licensee. The size analysis software is being offered as consultancy package with the instrument to outside parties. Photograph of the unit attached (Fig. 4.6).

Long Decay Phosphor and Phosphor Coated Tapes

The work was continued to improve the performance and preparation process of long decay phosphor. The additional fluxes were tried and dopant concentration optimised for the required emission colour. In this connection, ZnS phosphor syn-

Fig. 4.6 : Photograph of "Particle Size Analyser" developed at N.P.L.

thesis without the use of H_2S gas was a significant achievement. Another problem of firing containers which were of high cost imported silica and recrystallized alumina based materials was solved with total indigenous materials and efforts. Application of long decay phosphor is confined to use under ordinary lighting conditions. To develop phosphor excitable by these radiations was a challenging and very demanding task. This required very close control of the quality of raw materials and processing conditions.

Various binders and substrates were tried to prepare phosphor coated tapes for optimum light output and decay characteristics. Thickness of the tapes also has to be optimised for the best substrate. Coated area of the tapes was gradually increased from a few sq.cm to 600 sq.cm. (30 cm x 20 cm).

Multistructured thin film EL cells based on ZnS were prepared for different emisson colours. The growth parameters of individual layers were controlled and studied. Special specifications for power supply for driving EL cells were laid down and a in complete page measuring.

05 Polymeric and Soft Materials

Fig. 5.1 Glucose Biosensor

Research and development activities in this Division centres around five main themes covering the physics and applications of liquid crystals, conducting polymers, biosensors, electro-chromic methods, X-ray imaging photoreceptors and xeroradio-graphy techniques. Materials produced at relatively lower temperatures (less than 1000 K) are of prime concern. These diverse materials include polymers, liquid crystals, solid electrolytes, gels, organic glasses, biomaterials and photoreceptors. Both fundamental science and the application of these advanced materials are being pursued. Some of the chief industrial and societal applications include spatial light modulators for image processing, light control, glucose biosensors for blood sugar monitoring, biochemical sensors for gases and microorganism detection, xeroradiography based X-ray imaging techniques for medical diagnostics, virus monitoring in water, FTIR spectroscopic techniques for sucrose level monitoring in sugar industries and electromagnetic interference shielding.

Liquid Crystal : Physics and Applications

The understanding of surface stabilized ferroelectric liquid crystal (SSFLC) mode is essential for bringing in the improvements in the liquid crystal electro-optic displays. Although SSFLC mode has the advantage of optical bistability, it lacks the capability of generating gray scale levels which is very important for display applications. This deficiency in case of a typical SSFLC structure has led to the search for alternate modes of FLC structures which combine both fast switching (microsecond) and gray scale generation (linear change of optical transmission with applied electric field). Recently we have demonstrated the gray scale capability in a thin (thickness : 3 microns) samples of high tilt angle ferroelectric liquid crystal materials, possessing chiral nematic to smectic C* phase transition. The gray scale characteristics appear due to the reorientation of the ferroelectric liquid crystal molecules linearly with applied electric field when the surface anchoring strength on one of the two surfaces of the FLC cell is very high. The gray scale characteristics in such samples has also been calculated theoretically using 2 x 2 Jones matrix. The theoretical calculations and the experimental results of gray scale phenomenon in FLC samples were found to be in good agreement.

A Volkswagen Foundation sponsored project entitled, **"Electrooptical and structural-studies of oriented nematic dispersions"** has been successfully completed. The work was carried out in scientific collaboration with Technical University Berlin (Germany). The project involved the development of techniques to produce oriented nematic dispersions and investigate their structural, scattering and electro-optical properties. This included the optimization of various fabrication and materials parameters such as shearing of the cell during phase separation, post shearing treatment, choice of polymers, choice of liquid crystals etc. The developed cells exhibit strong anisotropy in their scattering of incident light. The scattered light is linearly polarized and the polarization could be altered by application of electric field. Furthermore, the electro-optic response time measurements have shown that the switching speeds can be greatly altered in case of nematics with low cross-over frequency by appropriately choosing the frequency of the driving field.

Polymeric thin Film and wave guide Sensors

The focus of activities in this area is to develop sensors for detection of toxic gases and microbiological organisms. The feasibility of development of sensors for detection of pathogenic and non-pathogenic microbiological organisms has been established. The behavioral acceptance tests like sensitivity, specificity, fast response, instant recovery, ambient temperature operation, cost effectiveness and ease of fabrication indicate the

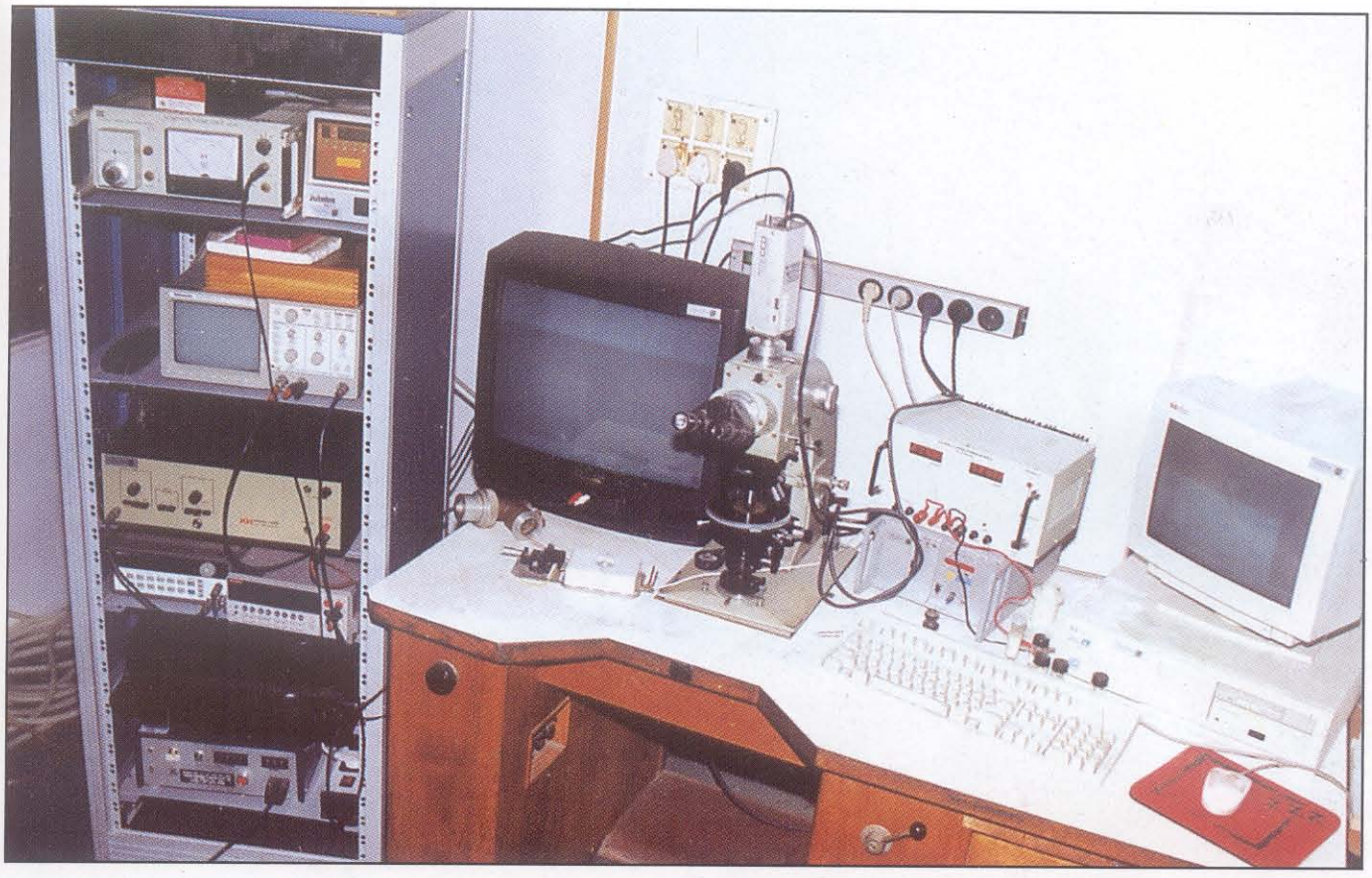


Fig. 5.2 : Setup for the electro-applied measurements of liquid crystal cells

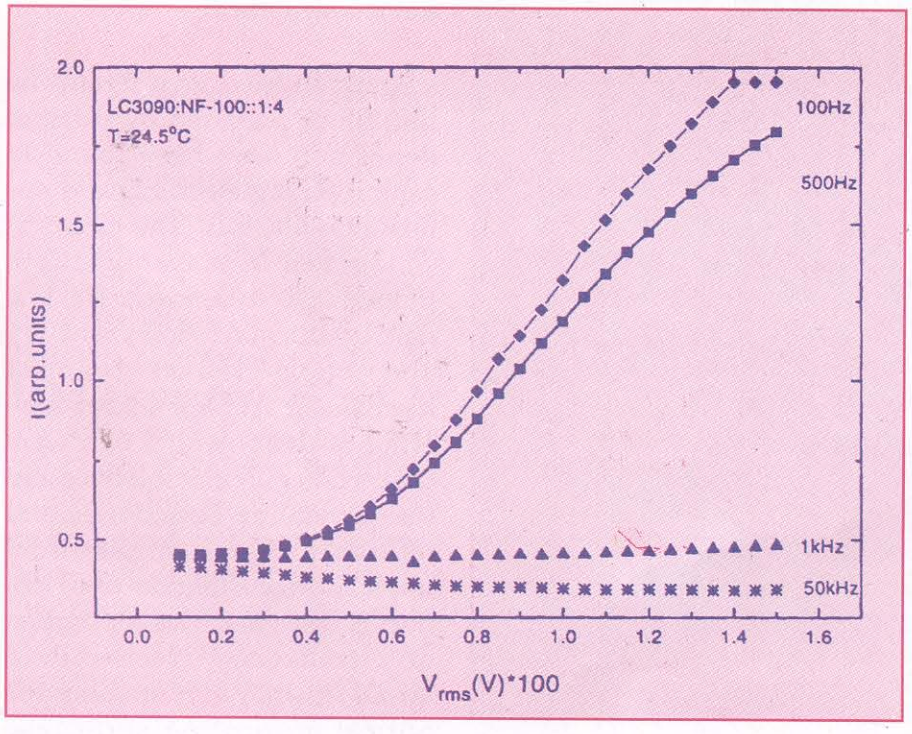


Fig. 5.3 : Transmission intensity versus applied voltage at various frequencies.

potential of these sensors for detection of toxic gases and microbiological species. Experiments have indicated the sensitivity of these sensors towards CO, NH_3, soil bacteria, E-Colii, and certain other microorganisms. These polymeric sensors found use in food processing industry as well. These sensors have shown excellent sensitivity towards micro - organisms like E.Coli, Fungus and Yeast normally encountered in food processing and can be for on line monitoring of the food processing chain.

Polymeric systems offer the advantage of flexibility in fabrication of films of optical quality, which makes them suitable for integrated-optical

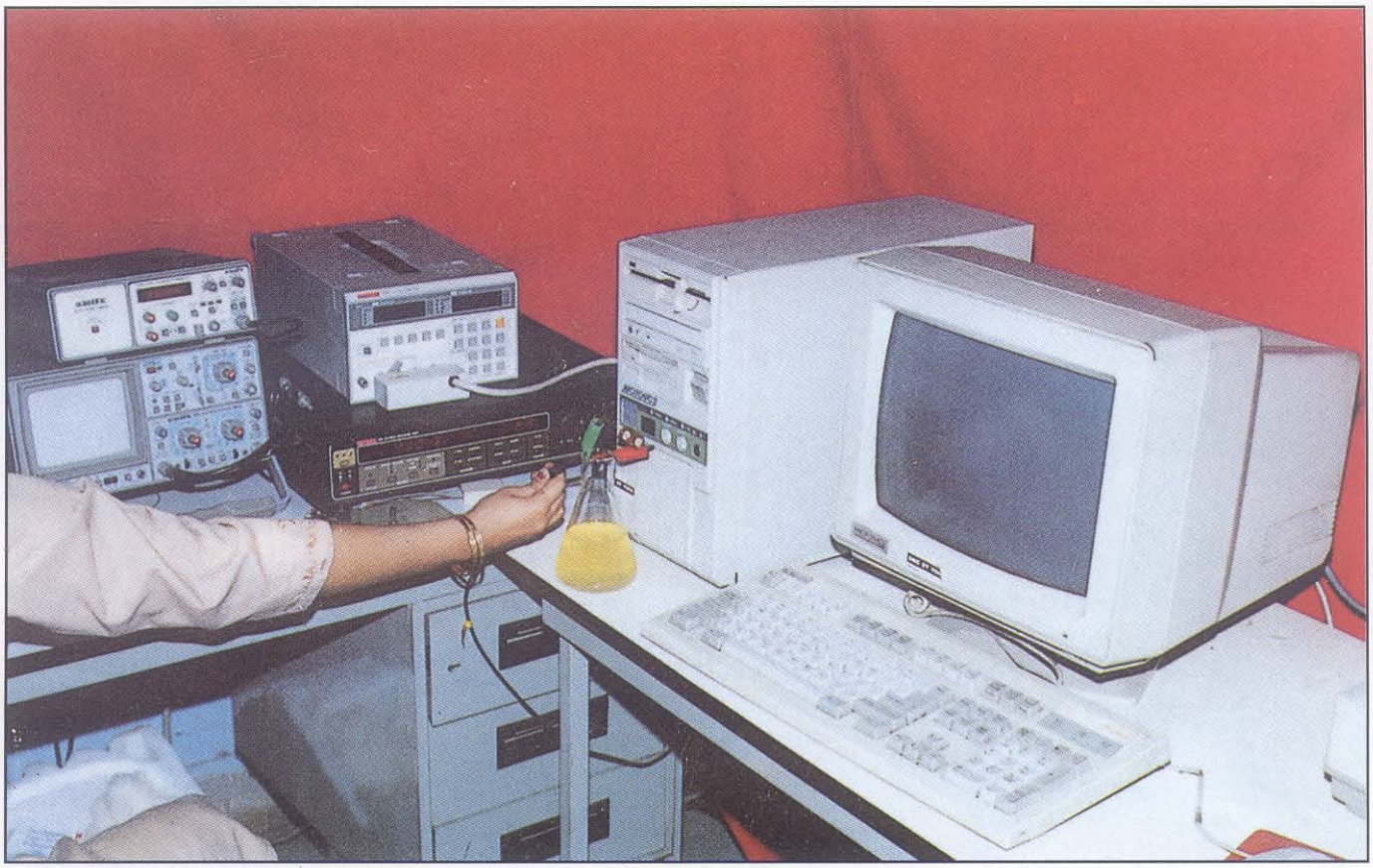


Fig. 5.4 : Set up for measurement of sensitivity of polymer films towards micro organisms.

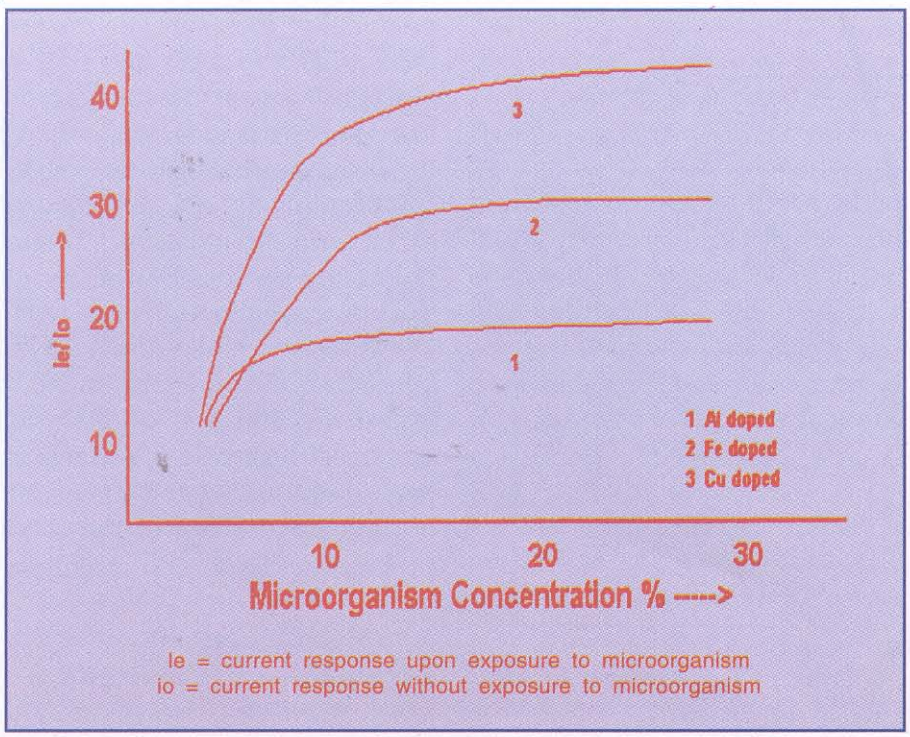


Fig. 5.5 : Sensitivity of Polymeric Thin Film sensors for Yeast Con-centration

device structure.

Semiconducting polyaniline thin films, prepared by vacuum deposition have been found to exhibit strong electrical and optical non-linearity. The electrical conduction in polyaniline thin films is field dependent. The low field conduction follows Schottky and Poole-Frenkel type of mechanism. At high fields a lowering of the potential barrier at the metal - polymer interface and intercrystallite boundaries and release of charge carriers from traps and contribution from donors is observed. The application of a transverse electric field across the thin film modifies the optical absorption and cause electro-optic modulation of the

optical properties. The conduction in vacuum deposited polyaniline thin films is dependent upon the contribution from thermionic emission (Schottky) trap assisted (RS, PF) and that from the localized states, tunneling through the grains and the defect levels.

refractive index 1.590 and excellent transmission (80-90%) in the wavelength range 350-650 nms.

Application of FR technique

Extensive work has been carried out related to line determination and systematic recording

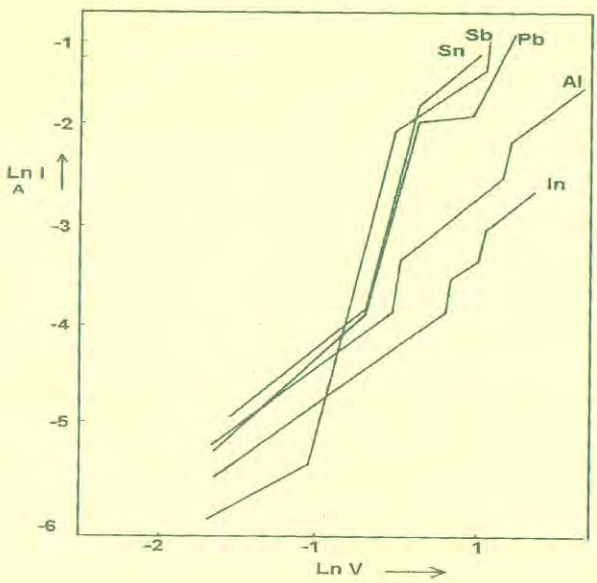


Fig. 5.6 : Electrical non-linearity in polyaniline thin films

The vacuum deposited polymeric waveguides from polycarbonate, polyacrylate and polyaniline have been prepared on glass substrates. The waveguide parameters viz. Refractive index. propagation losses etc. for the vacuum deposited polymeric thin films have been optimized. For both the second and third-order processes, the optical losses and propagation length decide the performance of a device for a particular application. Vacuum deposited polyaniline waveguides exhibit low optical attenuation (<2dB/cm), having

of sugar contents in sugarcane juices and sugarcane solids. This programme is a part of a Sugar Tchnology Mission Sponsored Project. Samples of pure sucrose solution and real cane juices have been analysed using three different techniques based on Infrared spectroscopy, polarimetry and chemical methods. Our analysis has shown that FTIR technique and methodology developed by us is more accurate and repeatable as compared to other standard laboratory techniques. The infrared technique has proven to be superior over other commercial techniques used in sugar industries for analysis of sugarcane liquids. Further, a number of samples of sugarcane solids have also been analysed. The experiments have been carried out at the sugar factory premises itself. For sugar extraction from bagasse and prepared cane, three different methods have been used, viz. Rapipol, Mixie and reflux. Merit and demerits of each method has been critically examined in order to develop a standard method and calibration procedure for this purpose which may prove highly useful for sugar industries.

New technical and competitive fields of Electrochromic Devices (ECDs) such as Energy Efficient Windows or the socalled "Smart Windows" and the automotive mirrors demand large area fabrication of all the components of ECDs. Sol-gel technique offers the best solution for depositing large area and cost-effective electrochromic (EC) films. Adopting sol-gel technology, attempts have been made to deposit WO3 based EC films that cn be used for different applications. Precursor materials to deposit the EC films were prepared by two different routes. One of the precursor materials - Polytungstic Acid, was prepared by ion-exchange method and films were prepared by spinning. The other precursor materials - Peroxotungstic Acid in solid form, was prepared by digesting tungsten metal with cold hydrogen peroxide, followed by heating and drying. Films were prepared by spinning the solution of the peroxotungstic Acid in water, followed by an

appropriate heat treatment. Films prepared by both these routes have been characterized and compared with those obtained by conventional techniques. Sol-gel deposited WO3 films have shown suitability for ECDs.

Conducting Polymers

In our glucose and lactate **Biosensor** programme new enzyme-immobilization materials have been explored. Poly (0-aminobenzoic acid) [PAB] has been chemically prepared and covalently coupled with the enzyme glucose [GOX] couple responds to glucose at 0.7 V and 0.4 V (vs. Ag/AgCl) in presence of tetrathiofulvalene (TTF) and ferrocene carboxylic acid (FCA) respectively. It has been found that response is linear upto 35 mM, response time is 60 sec. It has been observed that GOX bound to PAB retains about 60% of its initial activity over a period of about six days between 5-10°C. This project, a part of DST sponsored nationally coordinated project has led to technology testing on glucose monitoring equipment.

Lactate dehydrogen (LDH) has been physically adsorbed on electrochemically prepared polyaniline film. The enzyme activity has been assessed as a function of time, pH and pyruvate concentration, respectively. LDH/PANI electrodes show linearity in the region 0.05 - 0.15 mM. The shelf life of LD/PANI electrode is presently about 15 days at 4-10 C. These electrodes have a response time of 90 sec., and the value of Michaelis Meriten constant (Km) determined by Eadie Hofstee plot as 0.17 mM. The enzyme activity of LDH has phosphate buffer, shows constant activity between pH 7.2 to 7.5 physical adsorption and physical entrapment techniques have been used for the immobilization of lactate dehydrogenase (LDH) on tetraethyl orthosilicate (TEOS) derived Solgel films. The results of photometric response show that the response time is 1 minute, linearity over a concentration range of 0-1.5 x 10^{-3} M and detection limit of 5 x 10^{-5} M. It has been seen that the TEOS sol-gel films containing LDH enzyme is stable for about 30 days at temperatures 4-10° C.

Conducting polymers that are inexpensive, light weight and easily processable have stimulated much interest because these materials **find wide applications in solid state devices such as Schottky junctions, solar cells, EMI shielding, rechargeable batteries, displays; sensors, light emitting diodes, microbial sensors and microelectronics.** Polypyrrole (PPY) and its copolymer; poly (N-methyl pyrrole-pyrrole) [P(NMPY-PY] have been used for making conducting polymeric membranes to monitor water borne viruses. It is most essential to have pure water for drinking purposes. Hence the determination of virus concentration in water has become essential mainly due to the concern about the viral diseases. Water borne viruses such as polio, coxsackie, rota, hepatitis A virus, etc. can cause serious health hazards if they are present in drinking water. The challenge before us is to develop a low cost device which can monitor viruses in water preferably with indigenously produced polymeric membranes. This can be useful for thousand of villages where the water level is high and wells are contaminated or where the primary supply is through a contaminated source. Keeping in view polymer based membranes have been developed which can arrest viruses from water. These developed membranes have been tested for virus retention on it by Department of Microbiology, AIIMS, New Delhi. The preparation parameters of the membranes are being optimized. A patent has been filed on the process for the preparation of conducting polymeric membrane.

A considerable effort has been devoted to the investigations of electronic charge properties of junctions between metal and semiconducting polymers. We have performed a detailed study of the I-V characteristics of the junction between metal and different polymers viz. PPY, [P(NMPY-PY] and poly (N-methyl pyrrole) [P (NMPY) having different compositions. The formation of the junctions have been confirmed by capacitance-voltage characteristics and Chot plots. Fabricating a device from the copolymer with 0.025 M pyrrole and 0.075 M (N-methyl pyrrole) having a conductivity of 10^{-2}–10^{-3} $\Omega^{-1}cm^{-1}$ cannot be ruled out because of the better values of ideality factor; η (1.38) and rectification constant; r (1500).

The other major aspect in the

field of conducting polymers is the study of charge generation and its transport. We have reported earlier the validity of Mott's VRH model in the lightly doped samples of PPY family of polymers. In order to understand the mechanism of charge transport in the light of Mott's VRH model, we have performed ESR, dc conductivity and di-electric constant measurements on PPY, P(NMPY-PY) and P(NMPY) having different doping levels. The values of site spacing d calculated from ESR data and dielectric constant measurements show that there involve one active site per four to ten monomers. These values are in good agreement with those calculated using $N(E_F)$ evaluated from Mott's relation. The role of ESR studies has been significant not only to identify the charge carrier species but also supporting the validity of Mott's VRH model in these systems.

Apart from PPY the conduction mechanism has also been studied in polyaniline (PAN) doped with monovalent and multivalent ions such as chloride (C1) and phosphate (PO_4^{3}). Scanning electron micrographs (SEM) of these samples reveal that the sharp changes induced by doping are more prominent at the pH where the transformation of PAN lattice takes place. A channel formation has been observed at a pH 3.0 in the case of HCl and pH 2.5 in the case of H_3PO_4 doping, with flattering of the structure. Mott's 3D variable range hopping (VRH) is the mechanism responsible for charge transport at low temperatures for HCl as well as for H_3PO_4 doped samples. However, lightly doped H_3PO_4 doped samples, give a $T^{1/4}$ dependence. At a moderate doping level (pH 2.5), a deviation from 3D VRH is observed at higher temperatures, indicating there by a composition and temperature dependent charge transport.

Conducting polymer composites have been developed at NPL for their applications in electrostatic charge dissipation and shielding of electromagnetic radiations. These composites would not only drain the static charge from the plastically dressed operator (in electronic industry) but would also provide a barrier to the radiation generation. Grafting of conducting polymers on insulating surfaces have also been carried out in the laboratory which shows a shielding effectiveness of 20 to 40 dB at 101 GHz. A new project on metallization of fabrics as a shield against electromagnetic interference has recently been initiated, sponsored by Indian

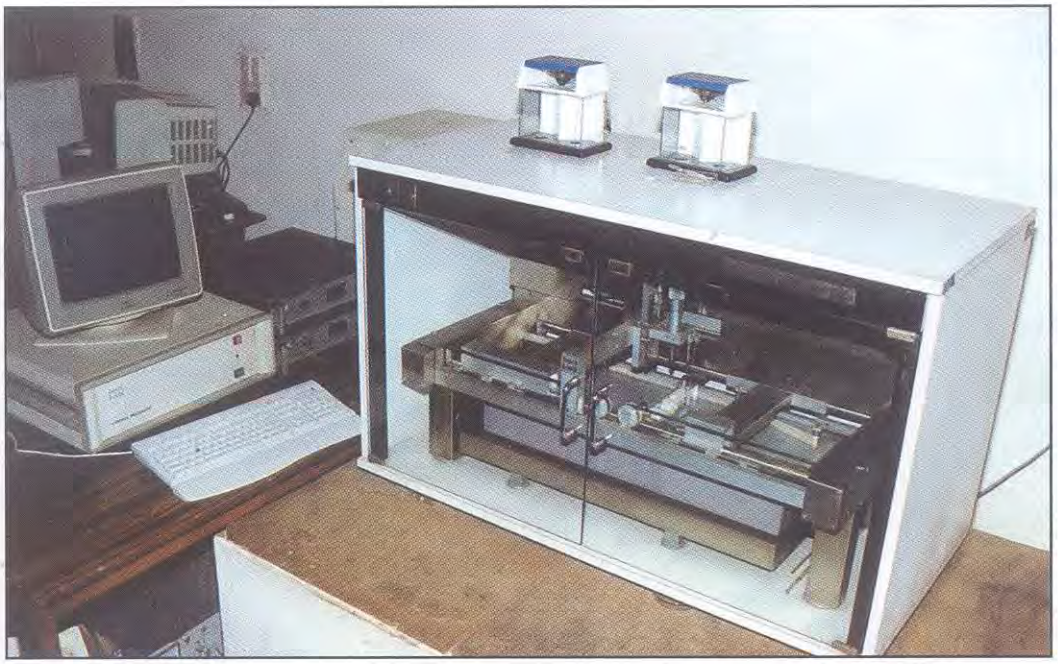


Fig. 5.7 : Langmuir - Blodgett film deposition system for fabrication of molecular mono/multilayers

Space Research Organization.

Designing of phase based Oaslm using parallelly aligned nematic liqud crystals

The NPL has fabricated phase only Optically Addressed Spatial Light Modulator (OASLM) using a parallel alliged namatic liquid crystal. The liquid crystal layer provides a continuously varying large phase dynamic range with minimal effect on polarization and intensity. Optical addressing is achieved by the use of photosensitive layer of hydrogenated amorphous silicon (a - Si : H). The optical isolation of read out beam from the write-in beam is explored by the use of 19 layer dielectric mirror comprisng of $\lambda/4$ wave thick layers of TiO2 and ZiO2. Using phase modulation in optical correlators one can preserve the space band-width product and better output correlation signal to noise ratio in comparison to amplitude modulated case. The OASLM device is operated in Fourier domain in transmission of a continuously toned picture. Liquid crystal enables two dimensional modulaiton of an optical phase in continuous fashion between 0 and 2π, which meets the most important requirement of an optically correlated device. It is achieved by coupling computer electronically to a polarized liquid crystal. The measurement are still in progress.

Xeroradiography

With a view to develop better x-ray sensitive imaging materials for **xeroradiography (XR)** photoreceptors we studied a variety of polymers and polymer/selenium combinations and made pioneering contributions in the understanding of their mechanisms of controlling charge storage, photoconductivity and x-ray sensitivity. In vacuum deposited PVF (polyvinylfluoride) we discovered, for the first time, the space charge distributed relaxations which was attributed to the migration of charge carriers, injected from the electrodes, or present inherently, over macroscopic distances

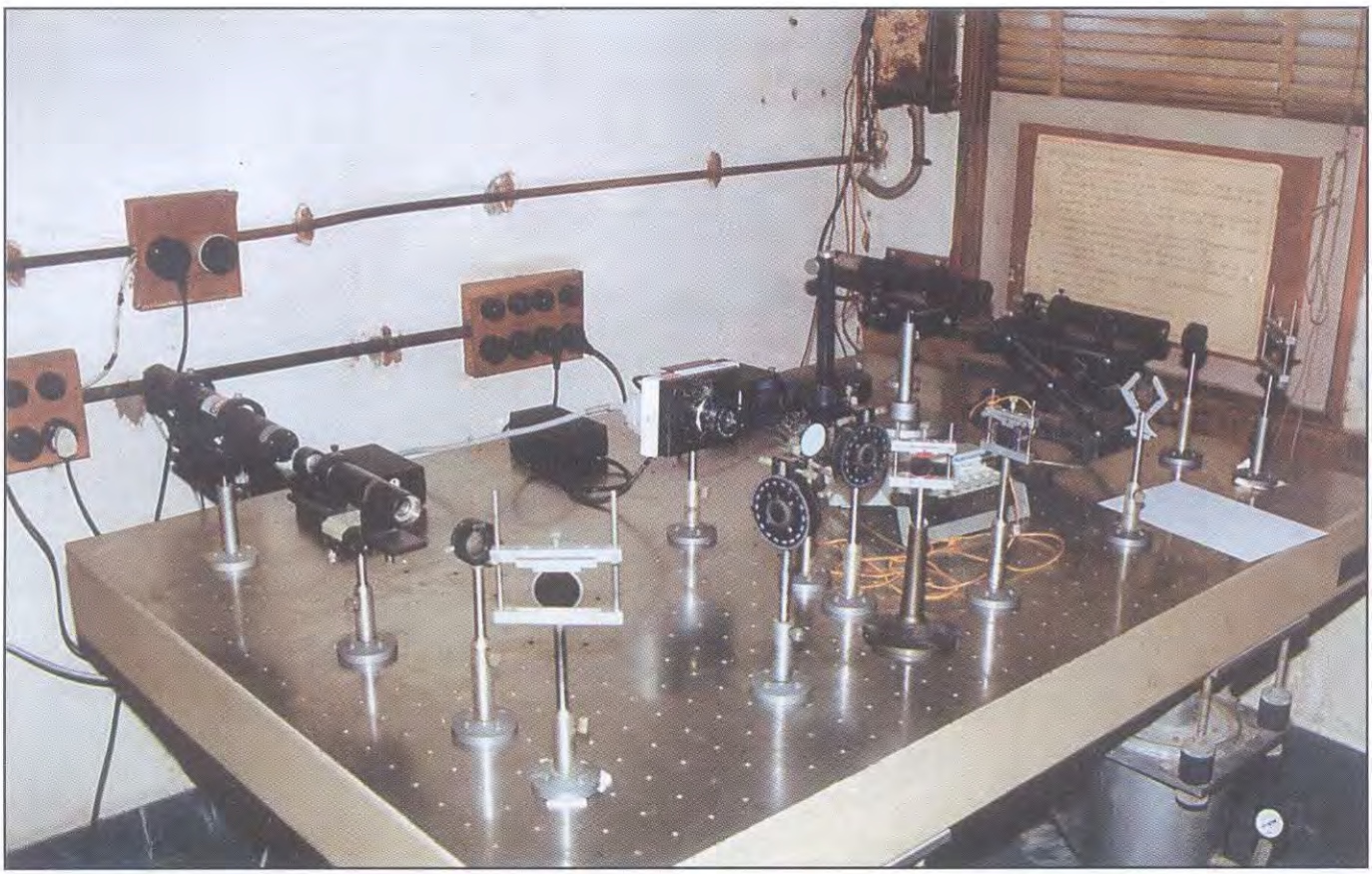


Fig. 5.8 : Special Light Modulator

Fig. 5.9 : X-ray Scan of a Hand on Plain Paper

and their subsequent trapping; the trapping levels being distributed in the range of energies 0.55 to 0.69 eV. In polyvinylcarbaole/ selenium combination we observed some interesting results with regard to the reduction of residual potential in selenium photoreceptor films on the incorporation of the interfacial barrier layer of polymer PVK. Further we are the **first** to discover the lowest value of ~ 21eV per pair of electron-hole generation energy (thus highest x-ray sensitivity so far) in chemically modified amorphous selenium. It is a significant achievement and an improvement on its previously internationally reported lowest value viz. 30 eV per pair which is expected to lead into the development of a **series of new** and better x-ray sensitive imaging materials for XR photoreceptors. This has put us in frontiers of the world in terms of achieving highest sensitivity reported so far in XR photoreceptor materials.

To develope a portable x-ray xerography unit, design and developmental work pertaining to various constituents of XR machine was undertaken. The components developed for achieving this objective include Photo-receptor Corona Sensitiser, Image Development Triboelectric Chamber, Image Development Electrodes, Venturi Generator for Image Development, etc.

06 Material Characterization

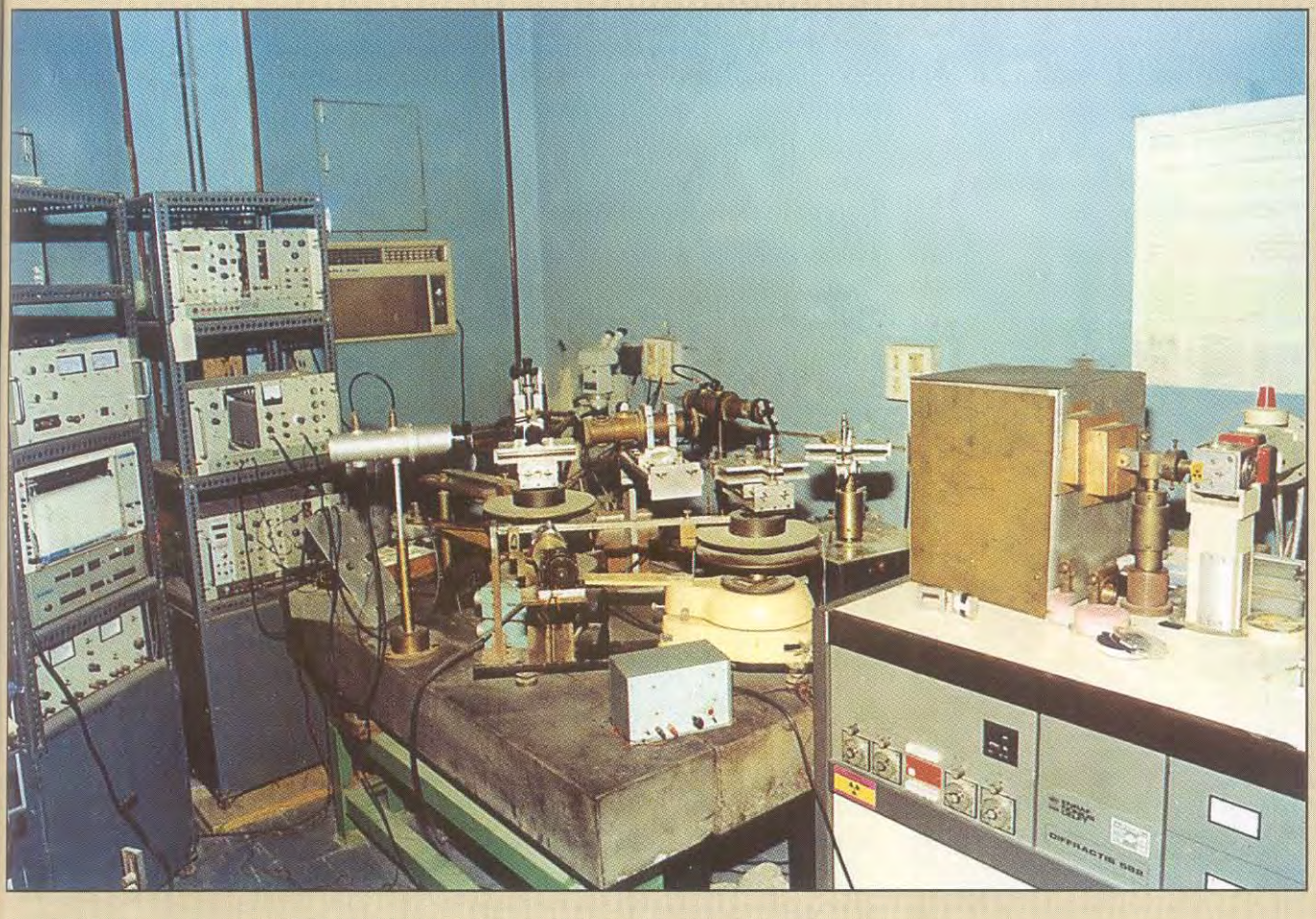


Fig. 6.1 : Five crystal high resoiution X-ray diffractometer developed at NPL

Industrialised societies require large quantities of different types of materials. The materials are required to conform to stringent specifications in terms of their properties for meeting different requirements, particularly in advanced sectors of technology. For fundamental understanding of materials it has also been necessary to co-relate properties of materials with four basic characteristics namely, com-position (major constituents), purity (minor constituents), crystallographic structure and defects in the structure. This knowledge enables reproduction of materials with given characteristics and properties on large scale and conversion of these into useful devices.

At the National Physical Laboratory, a wide variety of chemical, spectro-chemical and physics based techniques and facilities are available for characterization of materials.

The materials could be in different phases viz. liquid, solids and gas phases. These may be bulk materials or thin films or fine powders. The characterization can be done for the volume of the material or for its surface. Also, it is possible to characterize interfaces between solid materials and thin films deposited on the same. Some of the trace impurities can be detected below 1 ppb level. Structural characterization enables not only identification of phases but also determination of preferred orientation and crystallite size in the case of polycrystalline materials. If structural deformations are present these can also be characterized. A variety of high resolution X-ray diffractometers have been developed including a Five Crystal X-ray Diffractometer (Fig. 6.1) with state-or-the-art level resolution. These enable us to characterize all major defects like boundaries, dislocations, point defect clusters and isolated point defect in bulk crystals, thin films and interfaces.

Singh crystals used in different applications like integrated circuits or chips, lasers and a variety of detectors are required to possess properties which can only be achieved if strict control over material characteristics is enforced during their production and processing. The techniques of high resolution X-ray diffraction are particularly useful for growth of single crystals with high degree of perfection. Bismuth germanate crystals of high degree of perfection have been successfully grown by using a relatively new technique of low thermal gradient Czochralski method.

A considerable expertise has been developed for design, development and fabrication of advanced equipments. Sponsored projects are being pursued in this field.

The techniques and facilities mentioned above are being employed to support in-house projects, to provide service to outside users and for undertaking consultancy and sponsored projects. Several collaborative projects with advanced laboratories in countries like USA. Germany and Russia are also being pursued under which several scientists from these countries come to work on some of the unique facilities at NPL.

Crystal Growth & Characterization

Structural Characterization of heterostructures

A five crystal X-ray diffractometer, designed and developed at NPL has been extensively used for structural characterization of a variety of heterostructures. Diffractometry, topography and curvature measurements were made. The specimens included the following:

1. HgCdTe epitaxial films on (111) CdTe substrates for infrared detectors
2. GaSb epitaxial films on (100) GaAs epitaxial films for

Resonant Tunnelling Diodes

3. CdZnTe epitaxial films on (111) Si for infrared detectors
4. GaAs/In As/GaAs MBE grown heterostructures on (100) GaAs for THz applications
5. GaAs/AlGaAs/GaAs on (100) GaAs for HEMT applications
6. Porus Si on (100) Si for Si - 2 based optoelectronic applications.

The HgCdTe epitaxial films of thicknes 20 μm were grown by liquid phase epitaxy on (111) CdTe wafers. Films were supplied to NPL by SSPL, Delhi for characterization. Diffraction from (111) lattice planes as well as ($\bar{2}20$) planes were studied in symmetrical Bragg geometry. In this (111) diffracting planes were parallel to the flat surface of the wafer. For the ($\bar{2}20$) planes on the other hand diffraction from straight edge was investigated. MoKα_1 radiation was employed with exploring beam width of ~ 25 μm. Experiment were performed in (+, -, +) configuration of the diffractometer. In case of ($\bar{2}20$) diffracting planes experiments were performed at two extremes of the edge; one covering the substrate region and the other covering the film and the substrate interface. Deposition of expitaxial films produced significant broadening of diffraction curves of even the nearly perfect substrates. In one typical case, the half width increased from 10 arc sec to 64 arc sec and smoothness of the peak was destroyed due to film deposition. Diffraction curves from edges were considerably broad with half width of ~250 arc sec. The diffraction curve from the edge with film interface gave a peak with a hump showing that study of cross-section is potentially useful technique to investigate interfaces.

GaSb, In As, AlGaAs hetero-epitaxial films grown at S.S.P.L. Delhi by molecular beam epitaxy on (100) GaAs substrates were sent to NPL for characterization. The film thickness were in the range : ~ 4nm - 5μm. It was demonstrated that in addition to the usual lattice mismatch between the substrates and epitaxial films an additional mismatch has also substantial value. It is the physical orientational mismatch between the films and the substrates. Values of lattice mismatch $\Delta d/d$ and the angular tilts between the film and the substrate lattice planes were determined quantitatively. Half widths of the diffraction curves of GaAs substrates were in the range : 14 arc sec - 22 arc sec [(400) diffracting planes; MoKα_1 radiation]. This shows that the substrate wafers have good degree of crystalline perfection. To study lattice mismatch and angular tilt between film and substrate lattice planes, two azimuthal orientations (180° apart) were identified experimentally at which the diffraction vector of the film and substrate lie in the plane of diffraction. Diffraction curves were recorded at these two orientations. The values of $\Delta d/d$ were found to be in the range 0.071925 - 0.072639 and angular misorientation was in the range : 37 arc sec to 103 arc sec. Half widths of the diffraction curves of films varied in the range : 164 arc sec to 527 arc sec. The introduction of buffer layers improved the crystalline quality of the film.

Fig. 6.2 shows a set of typical diffraction curves for a GaAs-InAs-GaAs heterostructure for THz applications. It is seen that the In As film is a single crystal though its diffraction curve is rather broad. Also, diffraction maximum of GaAs epitaxial film is displaced from that of the substrate, showing there is angular misorientation between their corresponding lattice planes. This physical misorientations were determined experimentally. This R&D work was carried out under an Indo-German Project.

Recent discovery of the room temperature photoluminescent and electroluminescent properties of porus silicon (PS) have stimulated much activity. (100) Si samples with 10-50 μm thick porus silicon on them were structurally characterized to study their crystalline quality. These samples were prepared by a standard electrochemical process. Different HF and ethanol concentrations were used. Half width of high resolution X-ray diffraction curves for porus silicon for (400) diffracting planes were in the range 80-100 arc sec and those for silicon substrate were in the range: 14-19 arc sec. Also, diffraction maxima of the substrate and

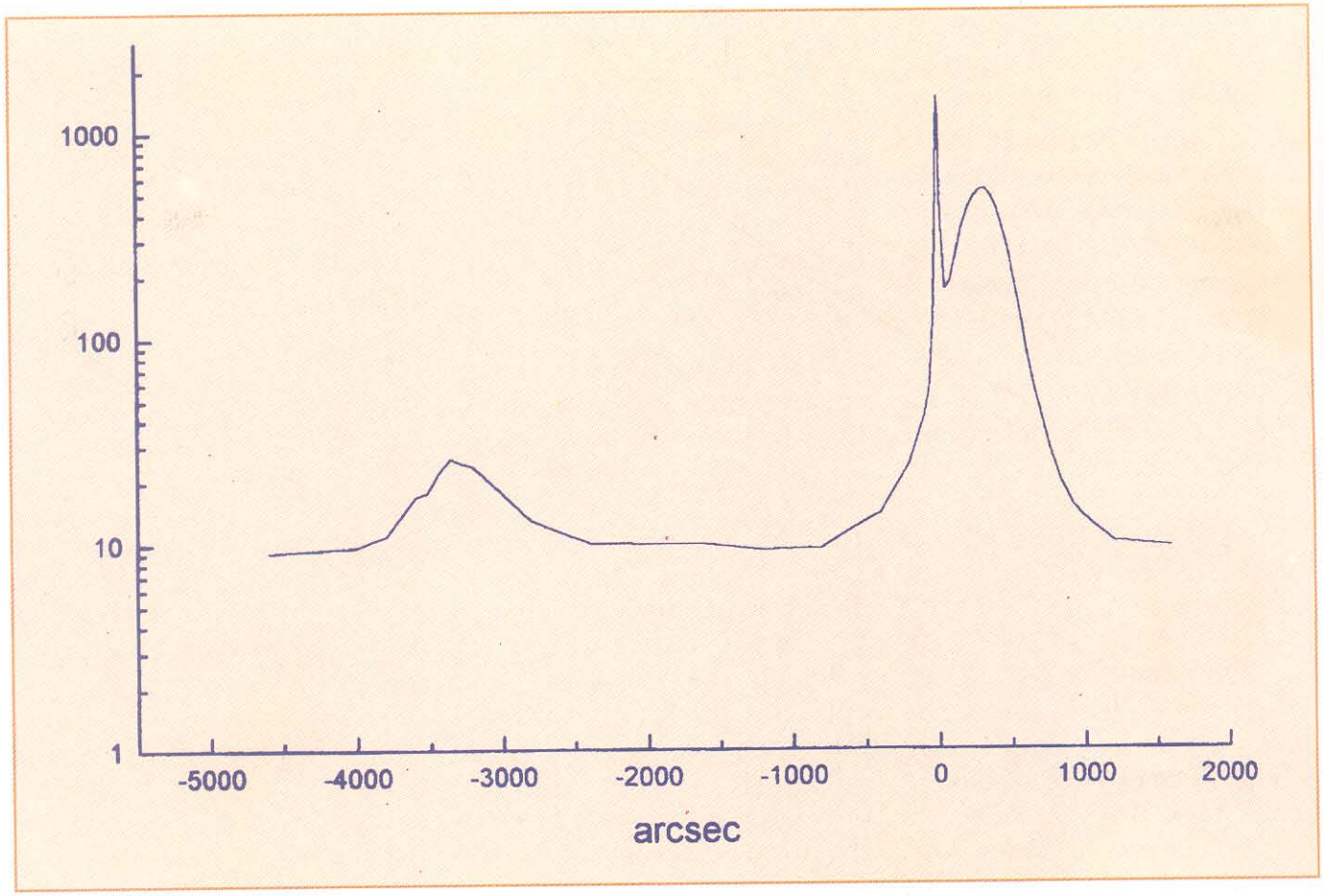


Fig. 6.2 : High Resolution X-ray Diffraction Curve (GaAs-InAs-Ga As) Structure for THz Diodes. (Azimuthal orientation 180°, Linear position 11.63)

porous silicon crystals were angularly separated. The angular separations were in the range: 230-320 arc sec.

Study of point defect clusters in as-grown and annealed BGO single crystals

High resolution diffuse X-ray scattering (DXS) measurements have been made to characterize point defect clusters in bismuth germanate ($Bi_4Ge_3O_{12}$) single crystals grown at NPL by low thermal gradient Czochralski method (Fig. 6.3). Crystals free from grain boundaries and dislocations have been chosen for these studies. A multicrystal X-ray diffractometer employing a well collimated and highly monochromated MoKα_1 beam set in (+, -, -, +) configuration has been used. The half width of the diffraction curves for the as grown specimens is around 10 arc sec for (400) diffracting planes. As the curves were narrow, DXS measure-ments could be made very close to the reciprocal lattice point (RLP) and at small incremental values in the magnitude of the scattering vector. Experimental data of DXS intensity has been analysed by using a pheno-menological model for small concentration of dislocation loops wherein the point defects are loosely clustered with inter-actions among them. For this analysis the cluster radius R_{cl}, cluster volume A_{cl} and the number of point defects within a cluster N_{cl} have been determined. The values of R_{cl}, A_{cl} and N_{cl} for as grown crystals are respectively 3.78 x 10-5 cm, 3.75 x 10-17 cm^3 and 3.24 x 10^4. The as-grown specimens have been annealed at 500°C, 700°C and 900°C for about 8 hours in the ambient atmosphere. Upto 700°C no change in half width of the diffraction curves and the distribution of diffuse scattering was observed. But at 900°C there was a considerably change in the half width of diffraction curves and the distribution of diffuse

scattering. The half width increased from 11 arc sec to 26 arc sec. The values R_{cl}, A_{cl} and N_{cl} are changed respectively from 3.78 x 10^{-5} cm, 3.75 x 10^{-17} cm^3 and 3.24 x 104 to 1.4 x 19^{-5} cm, 5.14 x 10^{-18} cm^3 and 4.45 x 10^3. In comparison to the as grown state the concentration of point defect clusters increased by a factor of ~200 accompanied by a reduction in volume by a factor of ~0.14 after annealing at 900°C.

Study of influence of oxygen on structural perfection of silicon crystals

Our earlier high resolution X-ray diffractometry and diffuse X-ray scattering (DXS) measurement studies made on as grown Czochralski (Cz) and Float-Zone (FZ) crystals had indicated that Cz crystals possess higher level of perfection than FZ crystals. This result indicated that the presence of oxygen (which is a prominent impurity in Cz crystals) has a role in influencing the crystalline perfection of silicon crystals. To investigate this aspect experimentally, FZ crystals have been annealed under oxygen ambience in the temperature range : 300°C - 1100°C. These samples have been studied by high resolution X-ray diffractometry and DXS measurement techniques supported by infrared (IR) absorption measurements. Upto annealing temperatures T_A of 600°C, there was no appreciable change in oxygen content as well as in the degree of perfection. As the level of oxygen is increased with increase in the annealing temperatures, upto 1000°C, remarkable improvement in the crystalline perfection is observed. The half width of diffraction curves decreased remarkably from ~ 11 arc sec (as-grown, no annealing) to ~ 7 arc sec. Similarly, the absolute value of integrated intensity decreased from 3.5 x 10^{-5} rad to 2.4 x 10^{-5} rad upon annealing at 1000°C. However, annealing at temperatures above 1000°C leads to deterioration in lattice perfection.

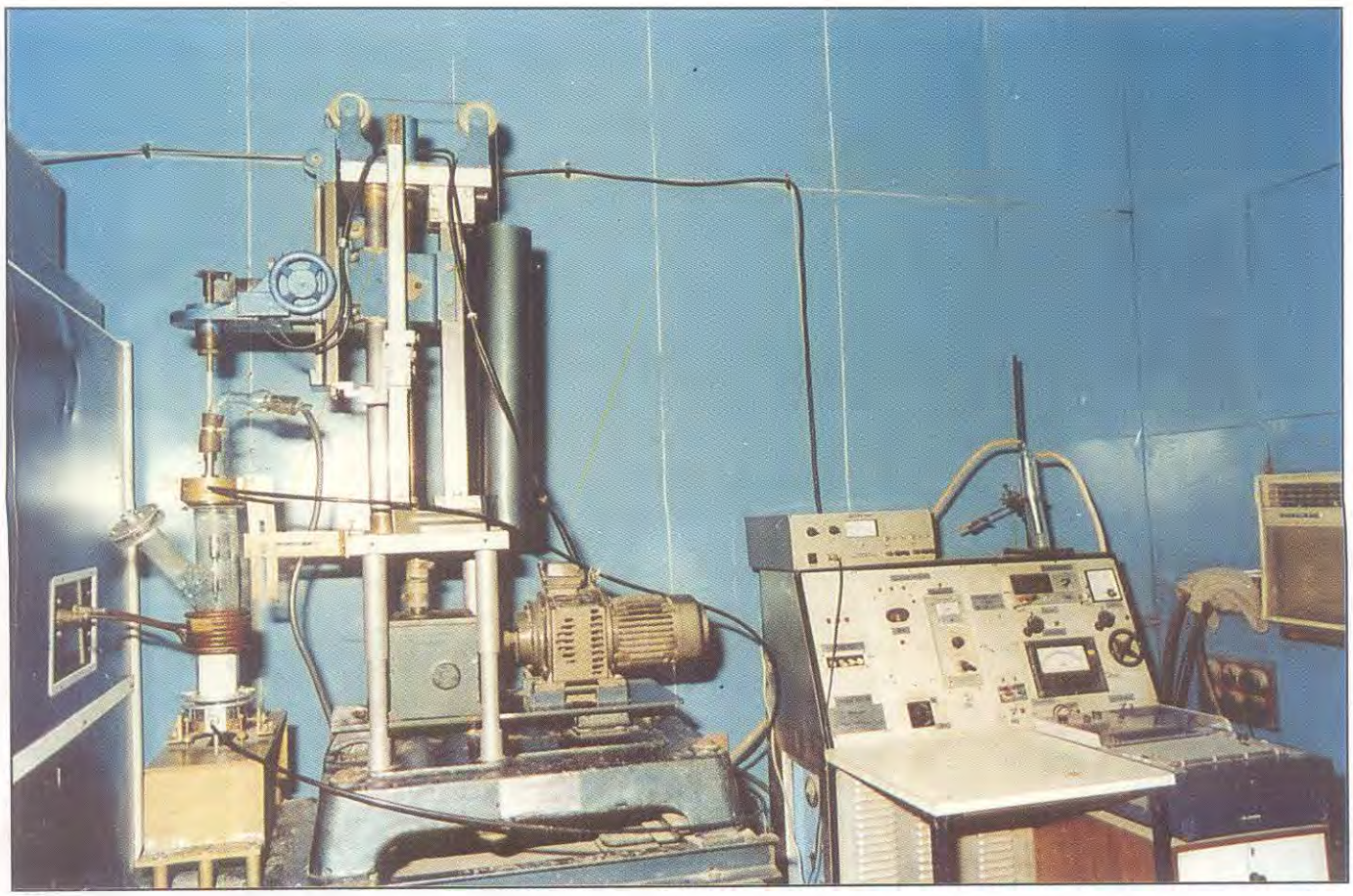


Fig. 6.3 : The C_z Czochralski Crystal growth system (Indegeniously developed at NPL)

The results of DXS measurements showed remarkable changes in the nature of point defects and their clusters with change in T_A. Upto TA = 700°C, the defects were predominantly vacancy clusters. In the temperature range : 800°C to 1000°C, the predominant defects were isolated interstitials. Above 1000°C, the interstitials were agglomorated into clusters, with an increase in concentration by a factor of 1.3, with respect to the initial value, leading to deterioration in perfection. The present study has demonstrated that if the level of oxygen in FZ crystals is increased from ~ 1.3 x 10^{17} cm^{-3} (as grown) to 1.3 x 10^{18} cm^{-3} (annealed at ~1000°C) as in typical as grown Cz crystals, even FZ crystals show comparable degree of perfection.

Development of sophisticated instruments

Under a joint collaborative project between NPL, New Delhi and RRL, Trivandrum under sponsorship from DST, fabrication of an X-ray diffraction topography system as per design developed at NPL is in progress. Different parts of X-ray diffractometer have been fabricated and assembled in NPL Workshop. This is ready for testing. Electronic counting system to be coupled with this system is being acquired.

A new high vacuum chamber for *insitu* measurement of stress induced in silicon single crystal due to thin film deposition has been designed and got fabricated. It has been tested for vacuum and found that vacuum inside the chamber is ~10^{-5} Torr. X-ray diffractometer would be installed inside the chamber for the diffraction measurement.

A scintillation counter designed, developed under the DST sponsored project "Development of Powder X-ray Diffractometer" has been used for recording the X-ray diffractograms of silicon powder on the powder X-ray diffractometer developed at NPL. The X-ray pattern has been compared with the pattern obtained earlier by using the commercial scintillation counter. The two diffractogram patterns are found to be very close to each other in respect of intensity and half-width of the diffraction lines. This shows that we can reduce the cost substantially by using this detector rather than the commercial systems. Essential parts of the three more diffractometers have been fabricated and assembly is at advanced stage : main parts include central turn tables which consists of a central shaft, two identical gears with 180 teeth, worm gear etc. have been fabricated. The worm housings have been designed in such a manner that the worms can be disengaged from the wheel for quick fast order adjustment. The stepper motors have also been incorporated into the systems.

Automation part of the Powder X-ray diffractometer is going on. Several firms have been contacted for this purpose. Out of them M/s. Vinytics Peripherals Pvt. Limited, Delhi had able to give illustrative demonstration by recording of X-ray diffractogram on our diffractometer. The simultaneous movement of θ-2θ rotation and data acquisition of X-ray intensity with the help EIA card in the counter timer module and interface card in the computer are demonstrable.

Indian Reference Materials

Preparation, Dissemination and Certification of Bharatiya Nirdeshak Dravyas

Work on preparation, dissemination and certification of Bharatiya Nirdeshak Dravyas (BNDs) i.e. Certified Reference Materials has been continued. During the year Two BNDs i.e. multi element standard consisting of zinc, iron and copper in high purity water in a nominal concentration of 100 mg/L and silicon powder for x-ray diffraction have been finalised and these are ready for release. Ten liter stock solutions of four new single element BNDs namely zinc, iron, copper and nitrate in high purity water have been prepared and distributed to the participating laboratories for their evaluation. Our old stock of BNDs of lead, cadmium, arsenic and chromium in high purity water is nearly exhausted. To maintain continuous supply of reference materials to the users a new batch of these BNDs have also been prepared and these are under the process of

characterization. Certified value, standard deviation and random uncertainty will be assigned to these BNDs after receipt of the analytical data from participating laboratories.

International Intercomparison

NPL has participated in international water proficiency testing programme organized by National Association of Testing Authorities (NATA), Australia. Twelve water samples were tested for different test parameters namely Total Organic Carbon Contents, Total Solids dried at 103-105°C, Total Suspended Solids dried at 180°C, pH and Al, Cd, Cr, Co, Cu, Fe, Pb, Ni, Zn and SO_4 contents. 207 laboratories from 13 countries had participated in this programme. All measurements except one measurement of Cr content in one sample were found to be in the acceptable limits.

X-Ray Analysis

X-ray diffraction and fluorescence studies were carried out for about 115 samples of materials including high Tc superconductors and their films, polymer electrolyte films, AlSb, WO_3, β''-Al_2O_3, Ni-ferrite, boron nitride, cordierite, carbon composites & fibres, CdS, SiC, gall bladder stones etc. Assistance was provided to Central Revenues Control Laboratory, New Delhi, M/s Garg Associates Pvt. Ltd., Ghaziabad and M/s MEPCO Industries, Madurai regarding the X-ray analysis of their materials.

In the Ga-Te system, the semiconducting compound Ga_2Te_5 synthesized earlier were of poorly crystalline. A single and crystalline phase has been obtained by annealing at 300°C for about 8 months. It crystallizes in the tetragonal cell with a = 7.906 Å, c = 6.821 Å, Z = 2. Also, CuInSeTe was synthesized by the melt and anneal technique. This compound crystallizes in the chalcopyrite structure having space group I42d with Z = 4. Complete X-ray powder diffraction data has been finalised and the unit cell parameters were calculated as a=5.985 Å, c=11.984 Å. X-ray density D_x = 5.96 gm/cc and the parameter u which locates the group VI atoms positions in the unit cell is found to be 0.249.

Powder X-ray diffraction studies were carried out in Pr-doped high Tc material $Bi_{1.6}Pb_{0.4}Ca_{2-x}Pr_xSr_2Cu_3Oy$ with $0 \leq x \leq 1$. Pr is shown to substitute in the (BiPb) -2223 system with a simultaneous formation of Pr-doped (BiPb) -2212 phase in the samples. The X-ray analysis indicates that the latter phase grows continuously with increasing Pr Concentration up to X=0.4. For $X \geq 0.4$ only Pr-doped (BiPb) -2212 Phase observed in the samples.

XRD studies were also carried out on viscos rayon based activated carbon cloth and correlated with the adsorption studies. The study reveals that the ACC becomes progressively disordered as the heat treatment temperature is increased and leads to pore widening and increasing BET surface areas. It seems that the rearrangement of the graphite microcrystallites takes place leading to the opening up of some closed/partially closed pores.

Work on ferrofluid-polymer composite films have been further carried out using different base ferrofluids. These films were prepared under the influence of magnetic field and without field and were characterised by XRD, TEM & SEM techniques. It has been observed that the particle size and the number density of water base ferrofluid-composite film is quite high as compared to ionic or diaster base ferrofluids. The lattice strain and microstructural changes have also been developed in the preparation of the films, making its properties more versatile for devices based upon them.

GaN powder was systhesized by reaction of Ga_2O_3 powder with NH_3 gas at high temperatures. The starting material and the intermediate reaction products at various reaction temperatures were analysed by XRD. It is concluded that at 900°C, a single phase of hexagonal GaN has been formed with good crystallinity.

Apart from above, XRF studies for Cu, Mn and Fe have been carried out for gall bladder and

07 Radio & Atmospheric Sciences Division

Fig. 7.1 : Monostatic acoustic sounder and 28 m instrumented tower installed at "Maitri", Antarctica

The Radio and Atmospheric Science activities cover at present studies related to Global change, Antarctic atmosphere and radio environment. Earth's environ-ment is experiencing global scale changes which are responsible to effect atmosphere, hydrosphere and land cover. Infact these changes are influencing our ecosystem, which is vital for existence of human life. Both global warming and ozone depletion are the well known problems NPL has setup instrumentation for monitoring green house gases, aerosols etc. along with study of uV, visible radiation effects on board ship cruises and at 'Maitri' Antarctic Station. INDOEX is a multi-agency program for studying aerosols over Indian Ocean. NPL has prepared National Inventory for Green house gases.

The NPl has participated in all the 18 annual Indian scientific Expedetions to Antarctica organised by the Department of Ocean Development (DOD). Besides above studies, NPL Radio and Atmospheric Sciences Division conducts both experimental and theoretical studies to characterise the radio environment over the Indian region. A post earth-quake Rescue system is developed by NPL. It uses a microwave signal at certain frequency which passes Through rubble and gets modulated with the breathing/heartbeat of the trapped victim.

1. Global Change

Anthropogenic activities have made global scale changes in Earth's environment affecting atmosphere, hydrosphere, land-cover and ecosystems dependent on them.

Understanding the causes and the pace of these changes and implications of these changes to human life has become critical.

There are two major features in relation to global scale atmospheric changes : global warming and ozone depletion. Ozone depletion is caused by emissions of chloro-fluoro-carbons (CFCs) from refrigeration, air-conditioning and aerosol sprays, while, global warming occurs due to exponentially increasing concentrations of greenhouse gases (like, CO_2, CH_4, N_2O, etc.) in the Earth's atmosphere. Increasing levels of aerosols on the other hand, although a potential health hazard, can contribute to decreasing of global warming.

NPL has set up a number of sophisticated facilities to monitor these greenhouse gases, aerosols, related minor constituents and also atmospheric radiations at ultraviolet, visible and infrared wavelengths. Some of these measurements have been carried out onboard ship-cruises and also from the Indian Antarctic Field Station - 'Maitri'. NPL scientists also use the National MST Radar Facility located near Tirupati in its research programmes. The laboratory has also played a lead role in creating a system for preparation of national inventory of greenhouse gases (GHG). Due to these activities, NPL has emerged as one of the most significant contributors in South Asia to various international programmes for study of Global Change.

A Solar Infrared Spectro-radiometer to measure column contents of minor constituents and altitude profiles of certain GHGs, an Infrared Sun calculations, Surface Ozonometer, Differential Absorption LIDAR and a Multi-Wavelength Radiometer are among the facilities operated regularly by NPL. A multiwavelength spectroradiometer Laser Heterodyne System and a Millimetre Wave Radiometer, (both for ozone measurements), have been developed by the laboratory suiting to operations under the extreme climate of Antarctica.

1.1 Indian Ocean Experiment (INDOEX) - A Study of Oceanic Aerosols

NPL is providing the Indian Scientific lead to this multi-nation multi-agency large scale experimental programme being conducted during 1997-2000 for studying sources, size distribution, transformation and dynamics of aerosols over the Indian Ocean in the months of February-March and the manner these aerosols and other pollution influence cloud formation processes in months preceding monsoon. Several institutions in India along with USA, Germany, France, Sweden, The Netherlands, Maldives and Mauruitius

are participating in the INDOEX programme. It involves ship-borne, aircraft, balloon and satellite borne observations of aerosols, acid rain, minor constituents, particularly CH_4, NOx, O_3, planetary boundary layer, oceanic mixing layer, etc. All data from Indian measurements are achieved by NPL.

New Result

Observations of vertical ozone distribution, carried out by NPL scientists onbord Sagar Kanya during the First Field Phase of INDOEX from 15°N - 20°S in February-March 1998, have indicated a latitudinal gradient in ozone mixing ratio from southern (pristine air) to northern (pollutant air) hemisphere in the troposphere. Within the northern hemispheric region monitored by the experiment, the ozone mixing ratio remains around 50 ppbv except in the region 5°-8°N where it shoots up to 120 ppbv. This phenomenon is attributable to flow of continental air mass accompanied with advection of photochemically produced ozone from stratospheric heights pushed down to upper troposphere through a weakened tropopause.

1.2 Stratospheric flow from tropical to extra-tropical regions

The tropical stratosphere above about 20 km is known to be effectively isolated from the extratropics. However, observations of various tracers, such as water vapour, as well as numerical simulation studies show episodic events when tropical air trends into the midlatitudes. In a study by NPL using SASGE II and UARS satellite data several water vapor profiles at midlatitudes (SAGE II) having remarkable similarities with tropical profiles (UARS) have been detected. An analysis of occurrence

Fig. 7.2 : The permanent Indian Antarctic Station "Maitri" and the surrounding huts housing NPL experiments. In the back ground is seen the polar glacier.

characteristics of these events shows that these profiles when observable in extratropical regions are indicators of filaments of air that have transcended from tropics to extratropics at stratospheric heights.

1.3 Global warming and ionospheric trends

Theoretical calculations by other workers predict that CO_2 doubling in Earth's atmospher could produce a 50°K decrease in thermospheric temperature which can result in 20 km decrease int he F2 layer peak height (hmF2) and a minor change in the F2 layer critical frequency (foF2). NPL scientists have analyzed long term trends in the ionosonde data from 31 stations around the globe to study anomalous behaviour of hmF2 and f0F2 not explainable by variations in solar activity during the same period. The anomalies are found to have positive trends for some stations and negative for others. It has therefore been concluded, in contradiction with the results published elsewhere, that *the presently available data do not provide a definitive evidence* of any long term global trend in F2 layer characteristics attributable to global warming and doubling of CO_2.

1.4 NPL prepares national inventory of greenhouse gases

National Physical Laboratory is the core organization which in association with other sister laboratories of CSIR has been developing inventory of strengths of sources and sinks of greenhouse gases covering all the regions of India covering various sectors including energy, industry, agriculture, land-use change and municipal waste. The 1998 inventory report from NPL is the most comprehensive one to date and has been computed using 1990 as the base year as per the internationally adopted guidelines, namely, the IPCC methodology. The total national emissions are given in Table 1 and sector wise distribution in Fig. 1.2

2. Antarctic Atmosphere

Antarctica is the coldest, windiest and the driest among the seven continuents. Lower tropopause & stratospheric heights and katabatic winds characterize the Antarctic atmosphere.

The ozone hole phenomena was discovered here. Some other symptoms of global change can also be monitored here.

NPL has been taking active part in the Indian Antarctic Programme and is the only CSIR laboratory which has participated in all the 18 annual Indian Antarctic Expeditions organized so far by DOD. Along with IMD, NPL leads the Antarctic atmospheric research activity, conducted from the permanent Indian Field Station - 'Maitri' - established in the Schirmacher region of Antarctica. Under this programme NPL has organized measurements using UV-B sunphotometer, biometer, acoustic SODAR, weather station, etc. Observations with the Laser Heterodyne System and an all weather Millimeter Wave Radiometer - the two sophisticated experiments which were developed specifically at NPL for measurement of ozone profiles over Antarctica - have also been carried out. Concurrent measurements from Delhi by NPL over all these years have enabled differentiate changes in long term trends in the Indian region atmosphear vis-a-vis global changes as seen from the Antarctica.

Some results

- An analysis of Sunphotometer observations taken during past one decade in Antarctica show that there is an *increasing trend of aerosol loading in the Antarctic environment.*
- A comparison of UV-B Biometer measurements over Delhi and Maitri shows that

Table 1 : Estimated total emissions and removals of greenhouse gases from India in Gigagrams.

Greenhouse gas sources and sinks	CO_2 emissions	CO_2 removals	CH_4	N_2O	N Ox	CO
Total National Emissions and Removals	584 866	-50 599	18 672	255	3 193	18 005

at times the erythemal dose at Maitri are comparable or higher even during lower solar elevation angles (<25°). This is found to happen during the occurrence of ozone hole over Antarctica.

- An analysis of observations conducted at Maitri, using mono-static Acoustic Sounder during the XVth expedition, has revealed that the surface layer of the Antarctic atmosphere remains in static condition 90% of the time. This implies that the surface temperature in Antarctica remains lower than the temperature of the air aloft up to the inversion height for 90% of the times. Such a condition prevails over northern India only 60% of the time.

- The observations of katabatic flow of winds at Maitri indicate that only 400m thick layer near the surface flows out of the continent keeping the higher layers unaffected by this flow. The direction of this flow is found to continue to the South-East quadrant only.

3. Radio Environment

An accurate knowledge of our radio environment is essential for planning of Modern High Reliability Radio systems. Information on Radio Refractivity Index (RRI) profiles, water vapour content, rainfall rates, atmospheric turbulence parameter is cardinal to design of any tropospheric communication system.

The performance of satellite based radio systems can be severely limited by the ionized layers present in our upper atmosphere and by the imbedded irregularities in them. Satellite-based radio systems find application in several areas of human interest such as communications, navigation, position fixing, geodesy, remote sensing etc.

3.1 Characterization of Radio Environment

Radio and Atmospheric Sciences Division conducts both experimental as well as theoretical studies to characterize the radio environment over the Indian region.

- Several spaceborne payloads, designed & fabricated by NPL, have been flown onboard balloons, rockets and satellites for in-situ measurements. The Retarding Potential Analyser satellite-experiment of NPL, onboard Indian SROSS-C2 satellite launched in 1994, is since then being operated on daily basis by NPL for collecting data on the irregularities, temperature and concentrations of charged particles in the upper atmosphere (400-600 km) over the Indian region. Data is preprocessed here before analysis by NPL and other laboratories.

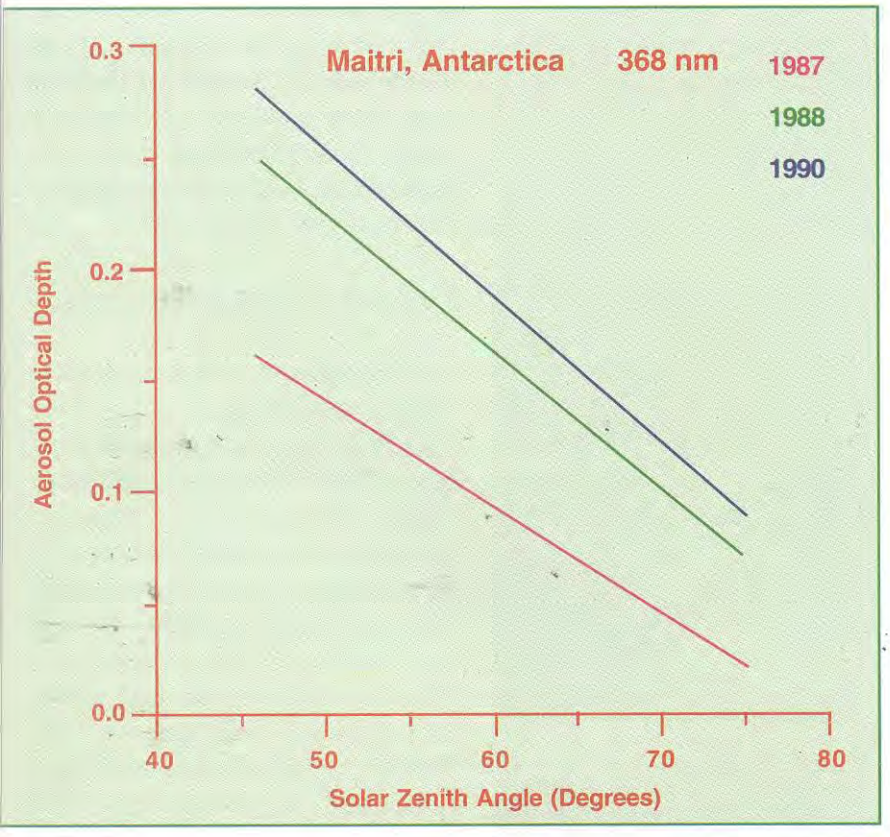


Fig. 7.3 : Variation of aerosal optical depth over Antarctica shows an increase over the succeeding years.

- Ionospheric electron content measurements are being made using Satellite radio beacons and Global positioning System (GPS) satellite signals.
- Line-of-Sight microwave links, TV and Broadcast transmissions are being monitored to study radio propagation parameters.
- Radiometers at 9.6 GHz, 11.0 GHz, 19.4 GHz and 22.23 GHz for monitoring water vapour content were also built.

Table 2 : A typical daily message issued by the Regional Warning Centre (RWC), New Delhi containing information on observed solar and magnetic indices/events and forecasts on solar and geomagnetic conditions.

RWC (NEW DELHI) DAILY MESSAGE
Issued on 21 Nov. 1997

1. **Observed values** - 20 Nov. 1997

Sunspot No.	:	057
10 CM Solar Flux	:	089
Geomagnetic index, Ak	:	02
Solar Wind Speed (18-21, Nov. 1998)	:	500 - 300 Km/s

2. **Recent Solar Energetic Events**
   Long duration C 1.6 X-ray event : 19 Nov. 97, 1700-1910 UT
   Type IV Radio event : 19 Nov. 97, 2017-2220 UT
3. **Forecast for the following 24 to 48 hours**

Solar Activity	:	Expected to be at low levels
Magnetic Activity	:	Active Magnetic conditions are expected at low latitude 54 des.

3.2 Meteorological effects on coastal region microwave links

Several microwave links, located in different regions of Southern India, were monitored by this laboratory for their performance assessment. The links located over the coastal regions were found to perform poorly with severe fading. For example, the microwave link between Nellore-Chittedu was found to suffer total fade outs with deep fades as large as 50 dB. The simultaneous examination of radio and meteorological data showed that that fading observed in the afternoon hours is due to onset of sea breeze.

3.3 Anomalous TV propagation

It has been observed that high power TV signals from Tirupati are being received around Pondicherry area - a phenomenon not expected under normal conditions. To study this problem a special campaign mode study was conducted at Pondicherry to monitor TV signals from Tirupati and data analyze to identify modes responsible for this anomalous long distance propagation of TV signals.

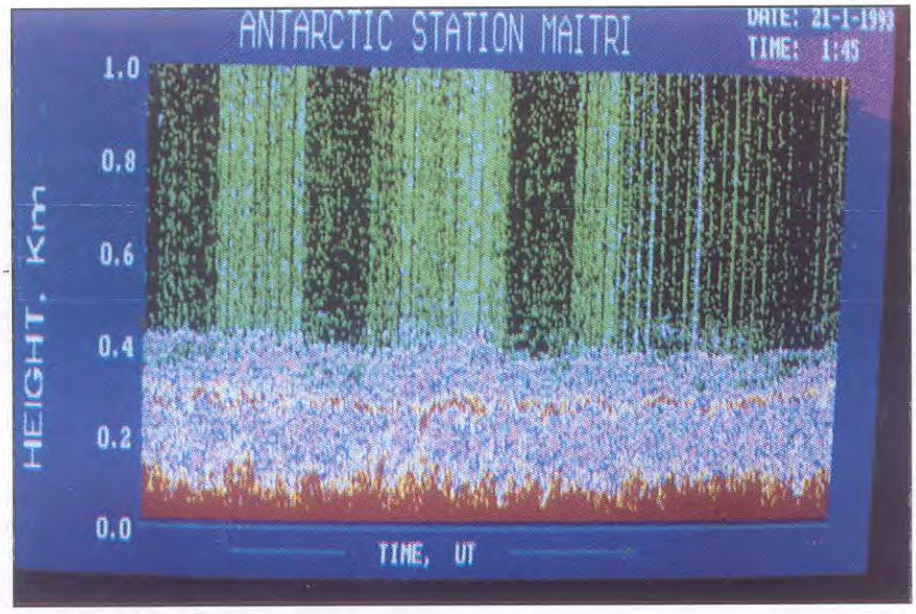


Fig. 7.4 : An observation of 400m thick layer of katabatic winds around Maitri.

3.4 Space weather forecasts

NPL operates the Regional Warning Center (RWC, New Delhi) as a part of International Space Environment Services (ISES) programme. RWC is responsible for rapid exchange of observational data on solar and geophysical parameters between the various RWCs around the globe and also for issuing short-term forecasts on space weather. The users include Indian Space Research Organization for tracking of low orbiting satellites, Radio communicators, Ground-based and rocket experimenters.

4. Post Earthquake Rescue System

A post earthquake system is being developed to detect live victims trapped under the rubble. This is based on the principle that a microwave signal at an appropriate frequency if sent throught the rubble will be modulated by the breathing/ heart beat of the trapped victim.

5. Kelvin-Helmholtz instability leading to atmospheric turbulence

Measurements with the Indian MST Radar at Gadanki (13.5°, 79.2°E) near Tirupati have revealed the presence of a Kelvin-Helmholtz Instability (KHI) in between two stratified layers around meteorological tropopause height. The KHI was found to occur at the shear maximum of 17.7 km and resulted in a 3m scale size turbulence in the region where KHI was noticed.

6. Planetary Atmospheres

Studies have been conducted on the planetary atmospheres in particular on those of Venus, Mars and Jupiter. One recent study is regarding the role of surface sinks of water like the polar ice caps and hydrated clay minerals in influencing the evolution of water inventory on Mars.

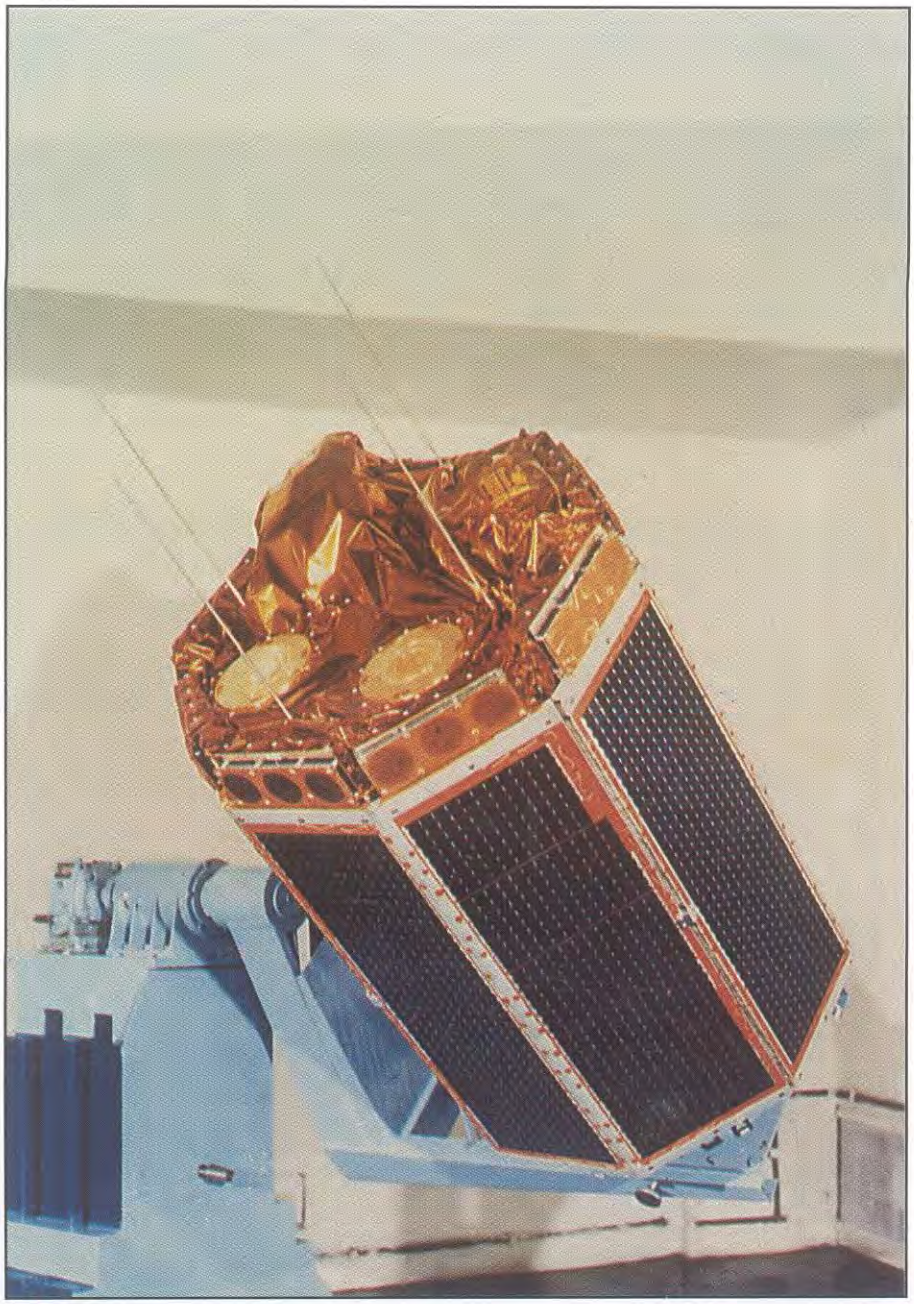


Fig. 7.5 : The Retarding Potential Analyser Satellite experiment of NPL mounted onboard the Indian SROSS - C2 Satellite.

08 Superconductivity (Experiments & Theory)

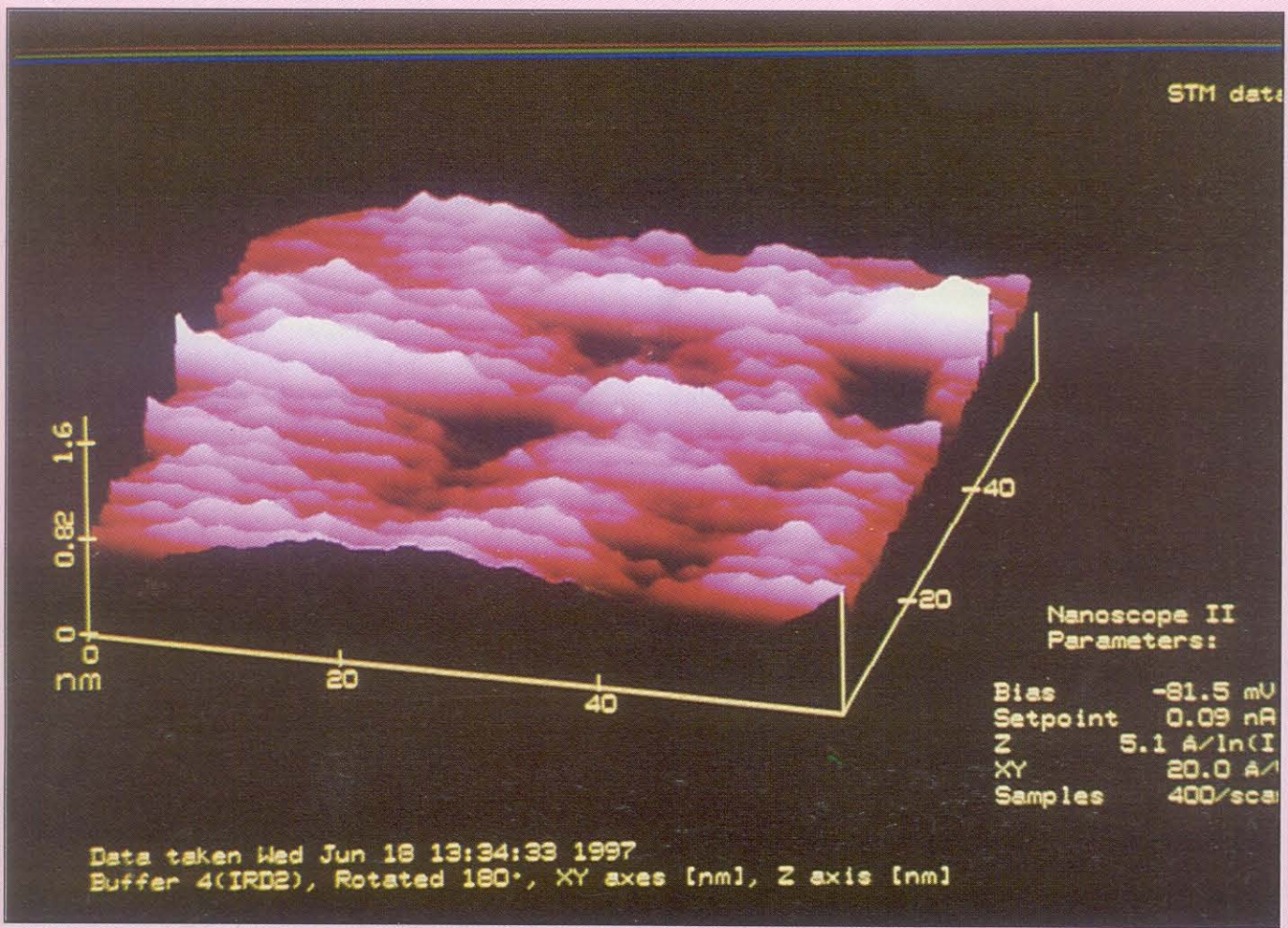


Fig. 8.1 : STM image of BSCCO Single Crystal (1 x 10^{11} ion cm^{-2}) irradiated with 250 MeV ag^{+17} ions.

The main focus of the activities of superconductivity division is to understand the high Tc phenomenon and unusual normal state properties of cuprates and related systems. The approach followed is to investigate the substitutional effects in the properties of various systems. Cationic substitutions in cuprates essentially lead to formation of defects and disorder. Such site dependent singularities can lead to a host of mutually competing phenomena such as localization, dimensionality change, interlayer coupling effects, local changes in electronic properties etc. which play a paramount role in superconducting and normal state behaviour. The ion-beam irradiation offers yet another approach to introduce different types of crystal defects which again influence the properties of these materials. The work carried out has a substantial collaborative component with the universities, laboratories and premier R&D institutes both at national and international levels.

Substitution of Pr at the Ca site in $Bi_{1.6}Pb_{0.4}Ca_{2-x}Pr_xSr_2Cu_3O_y$ with $0< x <1$ was investigated. Pr is shown to substitute in the (Pb) 2223 system, albeit with a simultaneous formation of Pr-doped (BiPb)-2212 phase in the samples. The x-ray analysis indicates that the latter phase grows continuously with increasing Pr concentration upto x = 0.4, For x<0.4 only Pr-doped (BiPb) 2212 phase is observed in the samples. The superconductor transition temperatures measured resistively shift to lower temperatures, with increasing Pr, at a rate of 5 K (%Pr). The normal-state resistivity value and its temperature dependence are found to depend on the amount of Pr doping. We have further analyzed the resistivity data of the pure and 5% (x=0.1) doped samples for the fluctuation conductivity. Both samples exhibit 2D behaviour for the superconducting order parameter in the critical regime, within the Aslamazov-Larkin formulation.

Superconductivity, structure and normal state magnetism of the $CaLaBaCu_{3-x}$ $(Zn, Fe)_xO_7$ was studied by x-ray diffraction and SQUID magnetization measurements. X-ray diffraction results show that both Zn and Fe substitute isostructurally in $CaLaBaCu_3O_7$ system. The superconducting transition temperature Tc of the samples, determined from ac susceptibility measurements decreases with increasing Zn or Fe concentration. The relative Tc depression rate (dT_C/dx), is larger (12K/%) for Zn than the Fe (6K/at%) substituted samples. For both the Zn and Fe substituted samples a Curie-Weiss behaviour is observed due to the presumed creation of local moments on Cu for Zn doped samples, and to the magnetic moment of Fe^{3+}/Fe^{4+} ions in case of Fe substituted samples.

The structure, superconductivity and normal state, i.e. above Tc, magnetism of the $CaLaBa Cu_{3-x},FeO_7$ superconductor was measured using powder X-ray diffraction and a SQUID magnetometer. The critical temperature of the pristine sample determined from ac susceptibility measurements decreases with Fe concentration. The normal state high field (5kOe) dc magnetism of these samples infers a nearly temperature independent and relatively small molar susceptibility for the x=0.0 sample, while for the Fe doped samples the same follows a Curie-Weiss temperature dependence, in terms of a localized moment presumably on doped Fe ions. The effective paramagnetic moment on Fe in the doped samples appears to be less than known Fe^{2+}/Fe^{3+} moments. Namely it is 5.09, 4.532.79 and 3.37 respectively for x=0.0, 0.06, 0.12 and 0.24 samples. The reduced moment of Fe is probably due to the presence of crystal field effects in these systems, which has an increasing trend with an increase in Fe concentration.

Superconductivity and magnetic ordering of Pr in tetragonal $CaLa_{1-x}Pr_xBaCu_3O_7$ system was explored by magnetic susceptibility and heat capacity measurements. The X-ray and neutron

diffraction results show that Pr substitutes isostructuraly until x=1.0 in $CaLa_{1-x}Pr_xBaCu_3O_7$ system with a few small intensity lines of unreacted $BaCuO_2$ and $CaCuO_2$. Ac susceptibility measurements show that the transition temperature Tc of the unsubstituted sample decreases with an increase in the Pr concentration. Normal state dc magnetic susceptibility measurements performed in an applied field of 0.5 T show a Curie-Weiss behaviour in terms of the paramagnetic moment of Pr. The effective paramagnetic moment of Pr appears to be intermediate between those of the free Pr3+ and Pr4+ ions. For the nonsuperconducting samples i.e. x=0.70 and 1.0, we observe an antiferromagnetic ordering temperature TN of nearly 4 K and 8 K respectively. The X-ray diffraction results show that the $CaPrBaCu_3O_7$ compound is free from other phases, having a minor (less than 8% in terms of peak intensity) impurity phase. The lower TN (8K) of $PrBaCaCu_3O_7$ as compared to the known antiferromagnetic ordering temperature of 17 K for $PrBa_2Cu_3O_7$ indicates a less deleterious effect of Pr in the present case.

The stability of the $YBa_2Cu_4O_8$ superconducting phase upon exposure to air and saturated humidity at ambient temperature has been studied by thermogravimetry, X-ray diffraction, and ac susceptometry. Extent of phase conversion was monitored by TG and confirmed by XRD and ac susceptometry, 124 samples upon prolonged exposure to air were found to be no longer phase-pure, with partial conversion to 123 and CuO. On oxygen annealing, reconversion of 123+CuO to 124 was observed. However, upon prolonged exposure to saturated humid conditions, phase-pure 124 dissociated irreversibly into 211, CuO, and a highly disordered 124-like structure with planar defects along many hkl indices and was found to be nonsuperconducting even upto 60K.

Conductivity fluctuation effects in $YBa_2Cu_4O_8$ superconductors studied by using Angerson-Zou model for normal state resistivity show 3-dimensional order parameter fluctuations. Critical region widths have been calculated. It is found that the experimental widths are larger than the GL theoretical widths. Anisotropy and binding energy considerations indicate larger critical region widths and fluctuations in Y124 compared to Y123 system.

Excess conductivity in c-axis oriented laser ablated epitaxial thin films of pure, 0.33% Zn doped, and 0.30% Fe doped $YBa_2Cu_{3-x}M_xO_{7-y}$ (M=Zn, Fe) superconductors in the mean-field region using Aslamazov Larkin theory with Anderson-Zou model for background resistivity were examined. Results show that the superconducting order parameter has a dimensionality cross-over in the pure film, a 3D behaviour in the 0.30% Fe doped film and a suppression of 3D fluctuations in the Zn doped film causing these to behave essentially as two dimensional. Crossover temperature deviations suggest that relative to the undoped Y123 film a fast suppression of superconductivity is seen in 0.33% Zn doped film compared to 0.30% Fe doped film. The correlations amongst various parameters suggest that the dimensionality of the order parameter fluctuations is directly proportional to the mean field critical temperature (Tcmf) and excess conductivity is weakly dependent on the system resistivity.

Single crystals of $CuBa_2Ca_3Cu_4O_y$ (Cu-1234) with dimensions upto 200 x 100 x 20 μm^3 have been synthesized under high pressure using a belt type anvil apparatus. The impurity of Au, emanating from Au capsule, was found in the crystals by SEM-EDS analysis. These crystals showed superconducting transition temperature ranging from 105K to 68K and are lower than that of Au-free polycrystals (Tc=118K). The Tc values are found to decrease linearly with Au content at a substantially high rate of 7.0 + 0.4 K/%, indicating the substitution of Au ions for Cu-sites. Superconducting anisotropy as estimated from the resistivity data of Cu-1234 single crystal just above Tc (=102 K) has been found to be higher (y=5.8) than that for the Au-free polycrystals.

A phenomenological model has been developed for explaining the c-axis resistivity of cuprate superconductors on the basis of the correlation effects occuring in the Cu $3d_{x^2-y^2}$ and Cu $3d_{3z^2-r^2}$ orbitals. The experimentally observed temperature dependence

of the c-axis resitivity is explained reasonably well by the present model for a number of samples of La_{2-x} Sr_x Cu O_4, Y Ba_2 Cu_3 O_{7-y}, and Bi_2 Sr_{2-x} La_x Cu Oy with different dopings.

Granular **$YBa_2Cu_3O_{7-y}$** samples were **irradiated with 60 Co g-rays.** The temperature dependence of the out-of-phase susceptibility was measured under the zero field cooling (ZFC) and field cooling (FC) configurations. DC field of different magnitudes was superimposed on a fixed 1 Oe ac field of frequency 111.1 Hz. A modified form of the Anderson-Kim model has been invoked to compute the critical density (Jc) and the pinning force density (fp). Jc has been seen to be a non linear function of the increasing radiation dosage. Both Jc and fp are found to be higher for the FC case than for the ZFC case. Attempts have been made to account for the experimental results in terms of the formation of point defects like vacancies, interstitials and their recombination during irradiation.

$YBa_2Cu_3O_{7-d}$ thin films and $Bi_2Ca_2Sr_1Cu_2Oy$ single crystals were irradiated with 250 MeVAg^{+17} ions to produce columnar amorphized tracks. Different doses between 2.5 - 20 x 10^{10} ions/cm^2 were tried on different YBCO and BSCCO samples. With STM studies we are able to identify, the study in detail, the amorphized and distorted regions (5-10 nm, see Fig. 1) on the sample surface due to irradiation damage. Low field ac susceptibility studies on BSCCO crystals before and after irradiation demonstrate the influence of irradiation damage on their irreversible magnetic properties until very near to T_c.

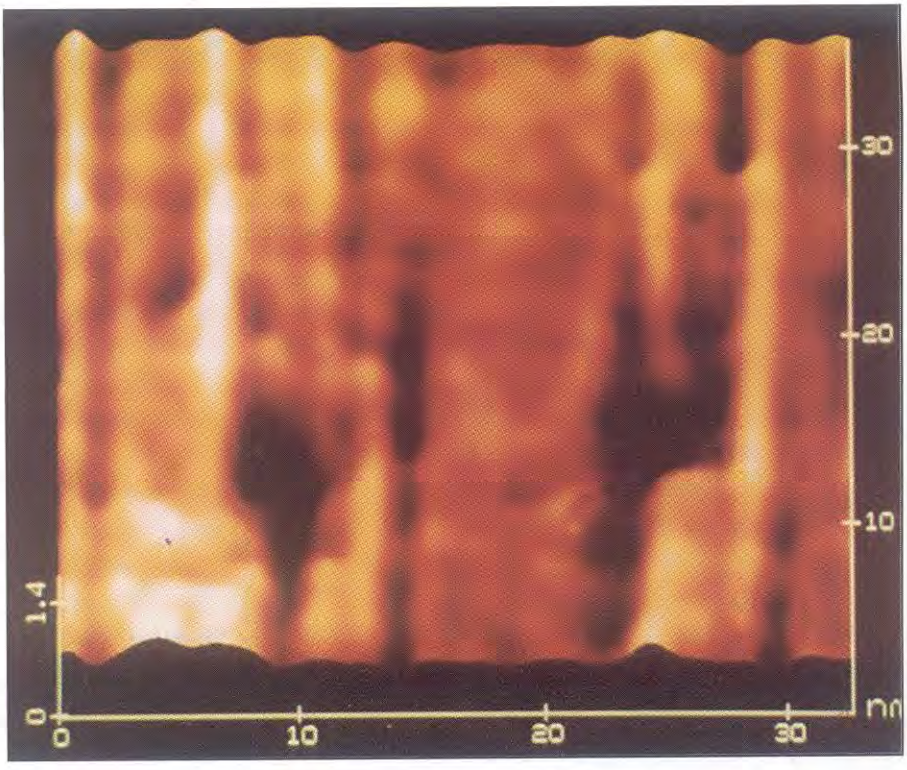


Fig. 8.2 : STM images of 250 MeV Ag^{+17} ion irradiated (a) YBCO thin film ($5x10^{10}$ ions/cm^2).

Theoretical Physics

The study of vibronic interaction in icosahedral symmetry for an isolated C_{60}^- ion is extended to the vibronic interaction in cubic symmetry pertaining to a C_{60}^- ion with surrounding ligands. The ground T1u state and the close by T1g state of C_{60}^- are both susceptible to Jahn-Teller interaction due to h_g mode of an icosahedral symmetry and also the two are admixed under an odd parity vibration of τ_{1u} mode. In cubic symmetry the h_g mode is split into τ_{2g} and ε_g modes while τ_{1u} mode remains unsplit. This $(T_{1u} + T_{1g}) \otimes (\tau_{2g} + \varepsilon_g + \tau_{1u})$ vibronic problem in cubic symmetry is analysed and compared with experi-mental results on infrared reflectivity and ESR behaviour of C_{60}^- ion in solid and liquid environments.

09 Research Facility and Support

Fig. 9.1 : The 2.35 T superconducting magnet for NMR application with shim coils and persistent switches.

Under the DST sponsored project on the "Development of a unit for the destruction of benign and malignant tumors in the ENT area using High Refrigeration Joule-Thomson Cryoprobes", three such units have been fabricated and assembled. One unit has been rigorously tested at NPL for its refrigeration capacity, temperature profile on liver meat piece, ice-ball formation with various cryo-tips at different interval of time.

These cryo-units are modified version of the proto-type already made and used by ENT specialists. This commercial model developed will be soon on clinical trial by the ENT Surgeons before technology is transferred.

In collaboration with BHU we worked on development of "Module hydride air-conditioner". The BHU group has supplied 1kg each of two types of metal hydrides. We have designed and fabricated four heat reactors (heat exchangers). We have also designed so called 11 valve system needed for the complete cooling cycle. The total system has been assembled and is ready for initial charging by hydrogen gas. The project was funded by DST.

The water cooler of 10 litre capacity based on Lithium Bromide-Water vapour absorption cycle was put to trial during last year and we found that some modifications are required. A new system in stainless steel with required modifications based on previous experiments is being carried out. On completion its testing and trial runs will be conducted.

Sophisticated Research Facilities, Technical Support and Technical Secretariat.

The division has following major activities :

1.1 Cryogenic facilities

1.2 The superconducting magnet program

1.21 The 100 MHz NMR magnet

1.22 Seven tesla SC magnet for laboratory experiments

1.23 Magnet for transport dewars (Room temperature base)

1.24 Humidity standard

2. Library and technical information services.

3. Computer services.

4. Technical support services and campus Management.

5. Technical Secretariat.

All the divisions in NPL use liquid nitrogen for various

Fig. 9.2 : A cryosurgical unit for ENT cancer developed at NPL.

applications. The current consumption of liquid nitrogen varies between 500 litres - 1000 litres a week. This is generally supplied by a combination of in house production and commercial borrowing. The facility was streamlined in the later part of this year to ensure that major demands of liquid nitrogen are made.

During the year three cryo-surgical units with specially designed cryo-pencils were given to All India Medical Institute (AIIMS) for testing.

1.2 The superconducting magnet programme.

The activity comprises design and fabrication of super-conducting magnets suited to various applications such as NMR spectrometer accessory High gradient separats laboratory magnets and inserts combining sample holder and super-conducting coil. This work is under taken for outside laboratories as well.

NPL is the leading centre for design and fabrication of superconducting magnet in this area. NPL has built a number of 7T magnets based upon Nb-Ti conductor technology with a variety of bore dimensions, impregnation materials and in multisections. In early nineties NPL succeeded in making hybrid superconducting magnet producing a high field of II Tesla. In this system Nb-Ti magnet provides a background field of 7.8 T and the Nb3 Sn insert an additional 3.2 T. Nb3 Sn insert was made using wind and react technology. More recently a number SC magnet systems have been developed which are briefly described below.

1.21 The 100 MHz NMR magnet

All the shims are connected in series and operated by a single bipolar 25 A power supply. Each shim is operated through a persistent switch. All these switches and the one for main magnet have been developed at NPL.

The magnet is housed in a liquid helium cryostat with a

Fig. 9.3 : The liquid helium cryostat housing the 2.35 T Superconducting magnet. The cryostat has a 52 mm room temperature bore, 1.35 1 pr day L-helium evaporation and a refill time of 90 days.

room temperature bore of 52 mm. Fig. (3) is the photograph of this LHe-cryostat. The cryostat has an annular LHe vassel with a capacity I97 litres, an annular LN_2 container with a 20 K radiation shield in between. Superinsulation has been used in the interspaces. The cryostat in steady state and with magnet in persistent mode has an evaporation rate of I.35 I/day and thus a refil time of 90 days. The magnet provides a field stability of 0.22 ppm/hr. As a first ever attempt the system has proved to be successful. Joint experiments with I.I Sc made I00 MH_2 NMR spectrometer are now in progress to find the compatibility of the two systems.

NPL jas built a 2.35 T SC magnet with winding dia. of 112 mm amd a winding length of 380 mm with a sixth order compensating coil. Active (SC) shim coil have been provided for field correction. Two circular shims (z and Z^2)/provide axial correction and six sets of shims namely, X, Y, XZ, YZ, xy and X^2 - Y^2 provide radial correction to the field homogeneity to $I0^{-7}$ to $I0^{-8}$ order in I0 mm SDV. Fig. 9.2 is the photograph of this magnet. Seen in the picture are persistent switches.

Fig. (9.4) is a photograph of the prototype of this magnet tested at 4.2 K. The magnet produces a field well above 7 T at a current level of I00 Amp. The magnet is energised by vapour cooled copper electric leads.

1.22. 7T SC Magents for Laboratory Experiments.

7T magnet has become a standard facility for conducting solid state physics experiments, but still continues to be imported at an exorbitant price. We have decided to build even such systems to be given tovarious R & D laboratories. These systems will be more or less indigenous except the Nb-Ti MF wire. The magnet will have a clear working 4.2 K bore of 50 mm, will be housed in a I70 mm dia. superinsulated LHe - SS dewar.

Progress was done in a DST funded project on Development of Module Hydride Air-Conditioner of 250-500 Watt cooling capacity. This is in collaboration with Banaras Hindu University. The BHU group has supplied I Kg each of two types of Metal hydrides. During this year heat reactors (exchanger) were tested on MSLD after assembling. The design of II solenoid valves system were tested extensively. The metal hydrides were got characterized at IKE, Gemy (IKE, Germany) in terms of pressure. Composition isotherm (PCT). The proto type unit is ready and the trials for checking its performance in terms of cooling capacity is in progress.

We have recently completed a contract project with M/s Leader Engg. Works Jalandhar, pioneer in valve manufacturing and wanted NPL to help them to develop a test rig for such valve as per BS 6364. The photograph of the liquid nitrogen tank housing the cryogenic valves with inlet outlet gas feeds and thermocouples is shown in fig. 5. The FRP liquid nitrogen tank was developed at NPL. It is double walled with PUF insulation in the inter space. The system is capable of taking valve of size NW 50 to I50. The system consists of a LN_2 tank, cryogenic valve, lifting system control panel with inlet outlet Helium gas high pressure line, bubbler and a gas flow meter. the rig is designed to carry out leak tests in the valve at 77 K up to a pressure of 22 psi, Helium gas from a cylinder is allowed to pass through (a control valve at a pressure of 22 psi), a coil immersed in LN_2 and then through. The valve seat is closed to a specified torque. Any leak through the valve seat is monitored by a flow meter connected to the output of the valve. The system was despatched to the companies site for installation and use.

1.23. A 3T Magnet for transport dewars (Room temperature base)

Not all the physical measurement need intense magnetic field. 2-3 T field is sufficient for the majority of experiment in solid state physics. We have built a 3 T insert SC magnet with a clear bore of 28 mm. This magnet is used as an insert in a I00 litres liquid helium storage container, doing away with the usual requirement of a magnet cryostat and the vessel of liquid helium transfer. The magnet can be taken out after the experimental run. The magnet has an FRP support cum guide system wth radiation baffles and dump

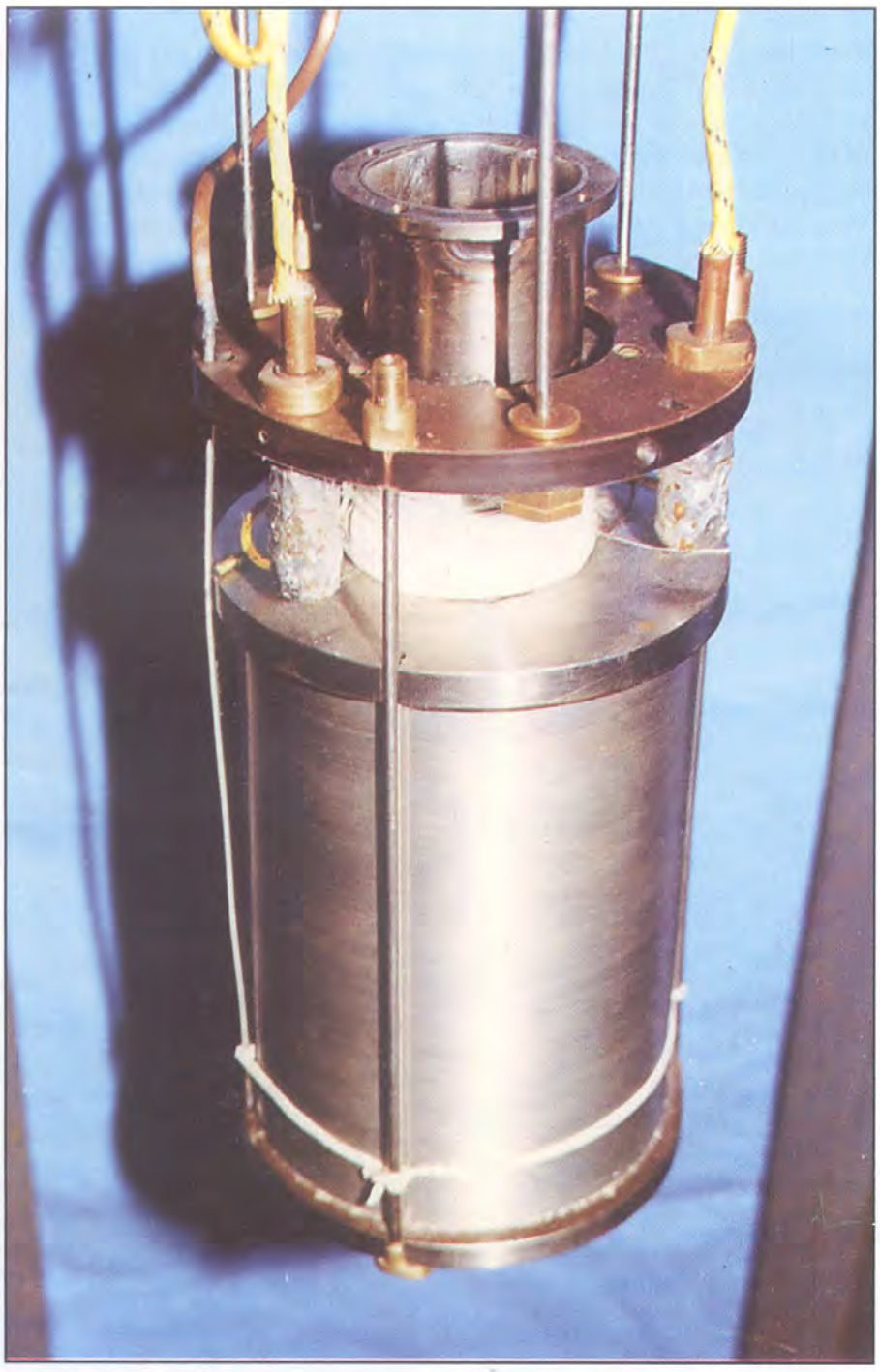


Fig. 9.4 : A prototype of 50 mm superconducting magnet producing magnet field in excess of 7T. NPL proposes to make a number of such magnets for different R and D institutions.

resistor junctions. Since the vortex pinning energy (U), in such a network, depends on the variation in the junction coupling energy Ej (~$hI_c/2e$), the flux pinning is weaker in silver added samples. The critical current density in such a network depends on U as well as the effective current carrying cross-section. Our experiments show that the silver addition leads to an improvement of the latter and degradation of the former. We show, from simple heuristic argument, using two-dimensional ordered junction network scenario that the critical current density (J_C) follows $J_C \sim \exp(-K(T). \Delta T_C/T_{CO})$ pattern and U follows $U \sim \Delta T_C$ relation where $K(T) = E_{jO}/2K_b T$ and T_{CO} is an equilibrium transition temperature of the network. The transition width ΔT_C measures the degree of inhomogeneity within the entire network. The results highlight that in order to have high J_C yet slow decay rate, optimization of the grain boundary junction characteristics aross the network is necessary. Such correlation between U and the effective current carying cross section is normally not observed in continuous medium.

Humidity Standards

Humidity Standards is one of the recent activity of the laboratory with an objective to establish National Humidity Standard and to provide calibration services for hygrometers to various industries. During this year the group has made the following progress.

1. Developed proto-type humidity generation system using divided (mixed or two) flow technique.
2. Installed Humidity Oven for calibrating RH sensors at different temperatures with varying humidity.
3. Installed chilled mirror dew

point meter and intercomparison between three different techniques of measuring RH namely aspirated psychrometer, dew point meter and capacitance type hygrometer.

4. Some initial progress has been made on the development of portable humidity generator.
5. Completed the design, fabrication and testing of saturator.

2. Library and technical information services

NPL library has been one of the largest subscriber of Physics Journals and books. At present the library holds". 65000 volumes of journals and 42683 volumes of books.

The library added 1406 volumes of journals and 308 volumes of books in 1997-98. In addition to staff of NPL this library also provides services to other users particularly in the University sector. In this year the library has initiated services based on CD-ROM searches.

Technical information in the form of Annual report and technical reports are supplied by the publication group. This year NPL initiated an in house monthly magazine npl - info.

3. Computer Services

NPL does not maintain any mainframe computer. The computer services are done through PC's and work stations. At present the computer centre maintain's e-mail accounts of the NPL staff and a dial up facility to NPL is used. Giving the need for the laboratory the computer centre has worked out a place for internet access through satellite and a local area network for the laboratory for implementation in 1998-99.

4. Technical Support services and Campus Managements

Maintenance of infra structure like electricity, water supply, air

Fig. 9.5 : A 3T, 28 mm bore superconducting magnet which can be used as an insert magnet in a standard 100 litres liquid helium container.

conditioning and general campus maintainance is the responsibility of this division

Different type of workshops are established to cater to laboratory R & D need and to cater to outside orders. NPL mechanical workshop has milling and lathe facilities for normal mechanical jobs. It has computer operated milling machines to grind complicated shapes such as wire bottles. It also has autocad based drawing and tracing facilities. In 1997-98 the central workshop did 1096 jobs for NPL users and 36 for outside users.

NPL photography shop : It handles in both commercial and technological photography work.

NPL highpressure shop and metal extrusion shop. These cater to both laboratory R & D and outside contractual work.

Glass Technology Unit (GTU) in addition to NPL job under - takes jobwork from outside users. In 1997-98 GTU did 227 jobs for NPL and 52 jobs for outside users.

5. Technical secretariat

Technical secretariat is at the core of R and D management in the laboratory. The technical secretariat carries on its activities with cells :

5.1. Planing & Coordination Cell.

5.2. IPR Cell

5.3. Marketing and liasion cell

5.4. ISTAG Cell

5.5. HRDG Cell

5.6. Hindi Cell

5.7 Publication & Documentation Cell

The cells together provide the R and D Management activities of the laboratory. In 1997-98 the P and C Cell handled 18 new project proposals 25 on going projects and 10 projects were formally closed. P and C cell also handles the matters related to the research council. The research council met three times in 1997-98 on April 25, 26 July 24 and November 22. The cell also provided complete information including manpower information to the review committee headed by Dr. R. Chidambaran.

The IPR cell helped in filing 3 patents in India.

Marketing Cell handled (37) cosultancy project proposals ISTAG Cell processed 77 deputations of NPL staff to various international destination. The K-S-Krishnan Memorial lecture by Prof. R. Mossbauer, Noble Laurette in Physics was arranged on 12-2-98.

The HRDG Cell processed 217 cases of application by NPL staff for attending conferences and symposia within India and also arranged 10 training programmes.

The Adminstrative Wing

Administration, Finance and Accounts, Stores and Purchase Comprise the Administrative Wing of NPL. This year witnesed intensification of efforts in computerisation of office records and in training up the junior level staff in getting training in computer based operation systems.

One of the important activities that the Administration undertook during this year was the cleaning up of the back-log of the promotion of scientific and Technical staff who had become due for promotion under the Merit and Normal Assessment Scheme (MANAS) for the year 1994-95, 1995-96 and 1996-97, as also the promotions under the bye-law 71 (b). In addition a lot of work was also done in screening of applications for the few posts filled up during this period. This work involved processing of cases through the Management Council of which the controller of Administration is the Member Secretary, as also through the Research Council whose secretariat is looked after by the planning and Coordination Group.

The quantum of work done by the Accounts Branch and the Stores and Purchase Sections during 1997-98 can be judged from the figures relating to the expenditure incurred during the year under various budget-heads, and the external cash flow and earnings during the year 1997-98. The Central Stores also undertook the task of disposal of surplus hardware stores and electronic and electrical items during the year.

The Adminstration and finance branches fixed and paid salaries to nearly 1186 staff and 300 Pensioners as a part of implementation of the 5th pay commission.

The purchase branch handled 95 foreign indents of value Rs. 2,97,50,560 & 461 Indian indents of value Rs:1, 31, 89, 180/-.

Adminstration also handled appointments of 53 persons (including 6 Scientist B) to NPL and promotions of 65 Group IV, 30 Group III, and 10 Administrative staff and about 24 promotions through DPC.

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Appendices

Sponsored/Supported Projects

Sl.	Title	Agency	Amount Received (Rs. in Lakhs)
NEW			
1.	Development of Piston Gauge Transfer Pressure Standard upto 80 mpa	DST + Pvt. Ind.	0.60
2.	Development and supply of ZK 30 Magnesium - Alloy Square Tubes (CP)	VSSC, Trivandrum	2.50
3.	X-ray diffraction study of solid state electrolysis in quartz crystals (CP)	DST/RRL (GD)	8.00
4.	SASCOM Activity as meeting on Indo -gangetic plain research effort (CP)	Int. START Sect. (FO)	2.80
5.	A study of the effect of Aircraft indiced vibration on Mahadeo Temple, Khajuraho (CP)	ASI (GD)	4.00
6.	Operation of the South Asian Regional Research Centre (SAS-RRC) for study of Global Change under SASCOM (CP)	Int. START Sect. (FO)	20.67
7.	Surface order and structure studies of polymer - solid Interfaces (CP)	INDO-US (FO)	10.68
8.	To improve Frequency stability of Atomic Time and Frequency Standards by suppressing Quantum Noise through squeezed states (CP)	NIST	8.70
9.	Development of oval shape tubes, as Skid Landing Gear, for Advanced Light Helicopter (Phase-I) (CP)	HAL (PVT)	1.50
10.	Development of Polymeric Opto-electronic Devices (CP)	INDO-UK (FO)	0.44
11.	Development of an Acoustic Wind Profiler (with multi beam acoustic array antenna) for remote atmospheric wind measurement (GA)	DST (GD)	18.50
12.	Metallisation of Fabrics as shield against Electromagnetic Interference (GP)	ISRO (GD)	1.45

13.	Metallization of fabrics as a shield against EMI (GA)	ISRO (GD)	2.43
14.	Non-Linear Dynamics and Vertex flow in AC-Driver Josephson Junction Arrays (GA)	DST (GD)	2.00
15.	Investigation of Materials under Ultra High Pressure Metrological applications (Phase-II) GA)	DST (GD)	27.40
16.	To compose monographs on noise pollution (GA)	DST (GD)	0.75
17.	Studied on Potentialities of Glonass for positioning and timing vis-a-vis application of GPS (GA)	DRDO+DOE (GD)	16.00
18	Testing and evaluation of a Superconducting Magnet for making it compatible with FT-NMR Spectrometer (GA)	DST (GD)	5.50

CONTINUING

1.	A Study of Biomass as energy source and Technical option for Greenhouse Gas Emission Reduction (CP)	AIT, Thailand (FO)	1.98
2.	Use of Laser Hetrodyne System with Acoustic-optic Spectrometer for Atmospheric studies over Tropical Latitudes (CP)	INDO-FRENCH (FO)	2.47
3.	Influence of the Surface Energetics of Micro-Structure of Matrix and Fibre/Matrix Interaction in composites (CP)	INDO-FRENCH (FO)	4.50
4.	On line Determination and Systematic Recording of sugar content in sugarcane, sugarcane juice and sugarcane solids (CP)	DST (GD)	8.40
5.	Interaction with University/Lab in the area of Superconductivity (CP)	UGC (GD)	2.00
6.	Standardization of Techniques for Immobilization of Proteins/Enzymes in some Conducting Polymers (CP)	INDO-US (FO)	3.47
7.	Development of Beta Alumina tubes for Sodium Metal Production (GA)	DAE (GD)	4.52
8.	Development of a superconductivity magnet system with a long hold Devar for a 100 MHz FT-NMR Spectrometer (GA)	DST (GD)	5.50
9.	Electron Acceleration using Radiation Characteristics and Development of Solar Flare Model (GA)	DST (GD)	0.60
10.	Characterisation of Tropospheric and Ionospheric Media in Aid in Radio Communication (GA)	DST (GD)	2.25
11.	Global Atmospheric Science Programme on Centre on Global Change (GA)	DST (GD)	6.00
12.	Study of Least Cost Green House Gas Abatment Strategy for Asia (GA)	ADB (FO)	92.50

13.	Spray Deposition and property evaluation of Aluminium Matrix Composites (GA)	ARDB (GD)	2.20
14.	Spectral shift due to source correlation and its implications in optical measurements (GA)	DST (GD)	0.75
15.	Development of Electro luminescent Display Device (GA)	DST (GD)	1.25
16.	Calibration Service Programme under NABL Programme (GA)	DST (GD)	28.35
17.	Deposition and Properties of Mixed Composition Infrared Optical Thin Films (GA)	DST (GD)	1.50
18.	Development and fabrication of a system for Ion Beam Microetching of Materials for Micro structure Analysis by Transmission Electron Microscopy	DST (GD)	0.44
19.	Development of powder X-ray Difractometer (GA)	DST (GD)	5.00
20.	Carbon Composite Ring based Ilizaror Fixator for Orthopaedic Application (GA)	DST (GD)	2.00
21.	Development of conducting polymetric filters for virus monitoring in water (GA)	DST (GD)	1.80
22.	Laboratory level technology development of some Biosensors and related Biomaterials (GA)	DST (GD)	4.50
23.	Optical and Electrical Properties of Langmuir Blodgatt films (GA)	DST (GD)	0.70
24.	Development of a Unit for the Destruction of Benign and Malignant Tumors in the Region of ENT based on High Refrigeration Capacity J.T. Cryopr	DST (GD)	1.53
25.	Amorphisasium of Boron Nitride and study of its behaviour under pressure and temperature (GA)	DST (GD)	2.00

COMPLETED

1.	Development of Micro Base graph Units (CP)	IIG	1.50
2.	Development of Process and Coating System for Fabrication of Infrared Optical Filters for use in Environmental and Pollution control Instruments	DST	12.67
3.	National Mapping of Science Using INSPFC Database (GA)	DST	2.19
4.	Nitrous Oxide Emission from Agricultural Fields and Wet Lands in Northen India (DST) GP	DST	2.99
5.	Electron Acceleration using Radiation Characteristics and Development of Solar Flare Model (DST)	DST	3.47

6.	Use of the Laser Heterodyne System with Acousto-optic Spectrometer for Atmospheric Studies over Tropical Latitudes Indo-French	Indo-French	18.00
7.	Development of Suitable Antimine Material for Boot Antimine (DRDO)	DRDO	7.00
8.	Development of Solid State Electrochromic Devices (ECDS) for Display Applications (DOE)	DOE	28.40
9.	Weight, Measures & Dimensional Metrology Instrumentation & Techniques (a book on Dimensional Metrology) (DST)	DST	1.80
10.	Synthesis, Characterization and Application of some conducting Polymers (Phase-III) (Indo-EEC)	Indo-EEC	24.12

R&D Collaborations

INDIA

Institutions	Subject
Central Building Research Institute, Roorkee Central Food & Technology Research Institute, Mysore Central Glass & Ceramic Research Institute, Calcutta Central Salt & Marine Chemical Research Institute, Bhavnagar Indian Institute of Chemical Technology, Hyderabad Indian Institute of Petroleum, (Dehradun)	Preparation & dissemination of certified reference materials
Solar Energy Center of the Min. of Non-conventional Energy Sources Usha Indian Ltd. Faridabad, Haryana	Silicon Solar Cels
S.V. University, Tirupati	Radio Communications
All India Radio, New Delhi Indian Statistical Institute, Calcutta & Sri Krishnadevaraya University, Anantapur	Radio Communication Experiments
Tirupati, Delhi Univ., NAS College, Meerut, Rajendra College, JP University, Chapra, Bihar, Physical Research Laboratory, Ahmedabad & Vikram Sarabhai Space Center, Trivandrum	MST Radar
NML Jameshedpur, Deptt. of Astronomy & Space Sciences, Punjab Univ., Patiala, Indian Statistical Institute, Calcutta, Industrial Toxicology Research Centre, Lucknow, Maulana College of Engg., Bhopal	BPL Activity
Solid State Physics Laboratory, New Delhi	X-ray Characterization
Univ. of Delhi, EMR (CSIR)	Effect of Asphericity of Electron density
Regional Research Laboratory, Thiruvanathapuram, Kerala	Solid State electrolysis in quartz crystals
Indial Instt. of Technology, New Delhi (IIT, NPL MOU)	

Sardar Patel Univ. Gujarat (EMR, CSIR)	Structure of Multicomponent Ceramics
Indian Toxicology Research Centre, Lucknow	
	University of Delhi, Delhi
Univ. of Delhi	PZT films for memory devices
IIT Delhi	Dilute magnetic semiconductors
Solid State Physics Laboratory, New Delhi	X-ray Characterization
Technical University, Darmstad, Germany	Future electronic Quantum Devices and Sensors : CSIR-DRL Project)
NIST Gaithersburg, Naval Research Laboratory and Unvi. of Maryland, USA	Resolution X-ray Diffraction Imaging
Sugar Technology Mission, TIFAC, DST, New Delhi Sriram Industrial Enterprises Ltd., Siel, New Delhi	Sugar contents in sugarcane (Juices and Solids)
Dept. of Microbiology, AIIMS, New Delhi Maitreyi college (Delhi Univ), Chankaya Puri, New Delhi Deptt. of Physics and Astrophysics, Delhi University, Delhi Defence Laboratory, Jodhpur	
CEERI, Pilani Physics Department, MD University, Rohtak I.P.C.L., Vadodara Vikram Sarabhai Space Centre Thiruvanthapuram, Kerala	Characteriation of Materials
Centre for Electrochemical and Energy Research, Chennai Centre for Explosives and Environmental Safety, Delhi (DRDO) Indian Institute of Technology, New Delhi	
Univeristy of Delhi	PZT films for memory devices
IIT Delhi	Dilute magnetic semiconductors
Dept. of Environment, New Delhi Central Pollution Control Board, New Delhi Bureau of Indian Standards, New Delhi Archaeological Survey of India, New Delhi CPWD, PWDs	Acoustics
Weigh India	Mass
I.I.T., Delhi	Ultrasonics

I.I.T., Delhi	Surface
I.I.T., Kharagpur	
Indian Association for Cultivation of Science, Calcutta	
Indira Gandhi Centre for Atomic research, Kalpakkam (Surface)	

OVERSEAS

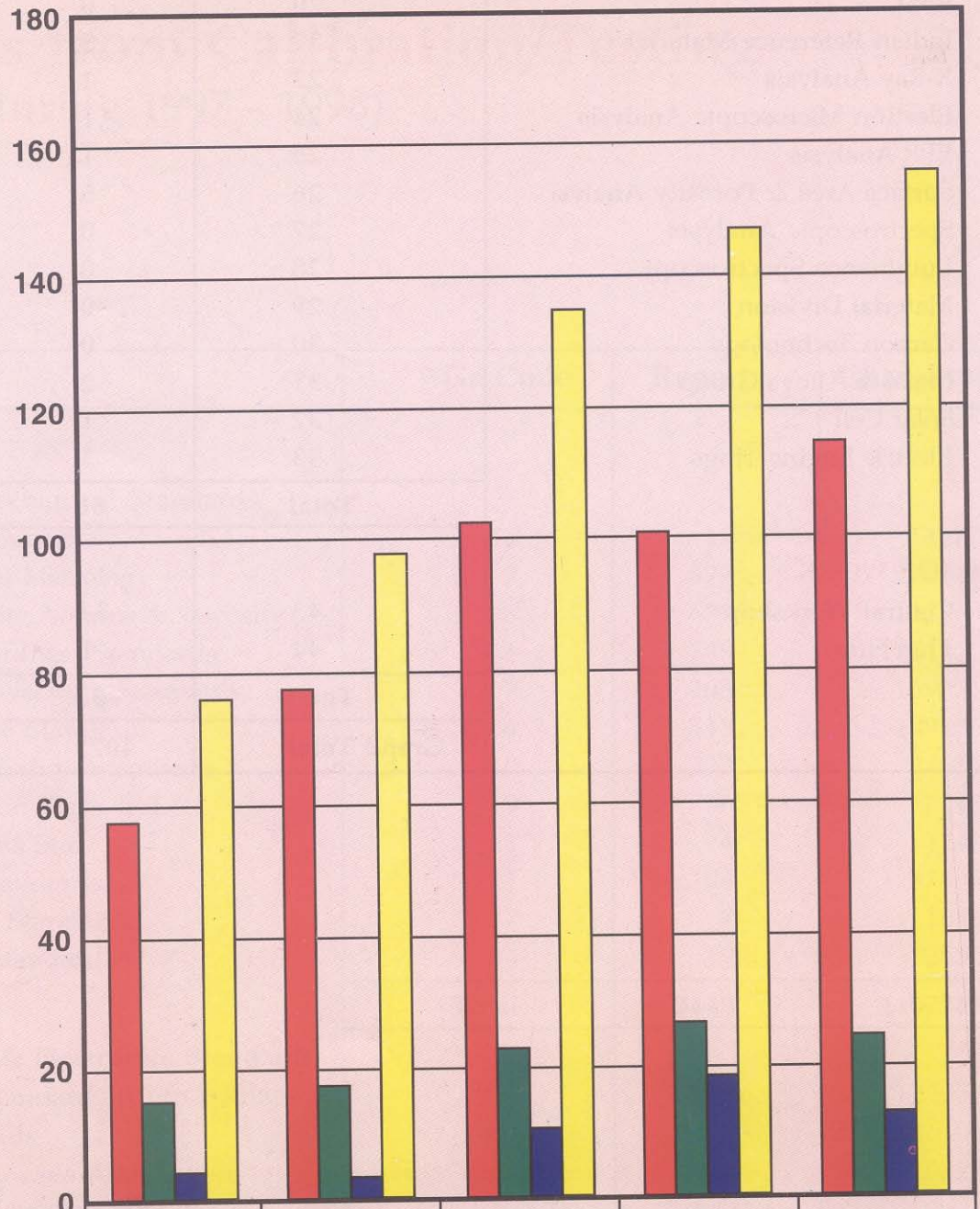
National Association of Testing Authorities (NATA), Australia	International Inter comparison Chemical Measurements
Institute for Reference Materials and Measurements - European Commission Joint Research Centre, Belgium	
Technical University, Darmstad Germany	Resolution X-ray Diffraction Characterization of Semiconductor Structures
NIST, Gaithersburg, Naval Research Laboratory and University of Maryland, USA	Resolution X-ray Diffraction Imaging
Institute of Inorganic Chemistry, Novosibirsk, Russia	Characterization of MBE A B Compound ILTP Project)
Mechanical Engineering Laboratory, Ibaraki. Tsukuba, Japan Fraunhofer Institute for Applied Materials Research, Dresaden, Germany.	Plasticity
Boulder, Sydney, Paris, Moscow, Tokyo, Paraha.	Regional Warning Centres
Indo-French Centre for Promotion of Advanced Research Meudon Observatory, Meudon, France	Laser Heterodyne System
Max planck institute, Stuttgart, Germany Electrochemical Laboratory, Tsukuba, Japan Universidad Federal de Pernambuco, Brazil University of Woolongong, Australia Oxford University, U.K.	
NIST	Infrared
NPL, U.K., PTB Germany IFA/CNR Italy	Acoustics
PTB Germany, National Research Laboratory of Metrology, Japan	Pressure & Vacuum
The Pennsylvania State University, USA Research Institute for Scientific Measurements, Tohoku Univ., Japan Institute of Automation and Control Processes, Russia	Surface Physics

Earnings from Calibration/Testing
(Realised during 1997 - 1998)

Activity	Gr. Code	Reports	Charges (Rs)
I. CALIBRATION			
i. **Physico-Mechanical Standards**			
Length Standards	16	17	142700
Dimensional Metrology	7	873	2709900
Mass, Density, Volume & Viscosity	8	679	1328600
Force & Hardness Standards	5	749	2514200
Pressure & Vacuum Standards	9	203	1693350
Temperature Standards	6	545	1891550
Optical Radiation Standards	10	213	846550
UV Radiation Meas. Std.	19	36	62450
IR Radiations Std.	21	4	17400
Acoustic Standards	11	104	378050
Ultrasonics Standards	17	7	16850
Humidity Standard	34	19	25500
	Total	**3449**	**11627100**
ii. **Electricals & Electronics Standards**			
AC & LF Standards (Upto 1 Khz)	1	212	1220500
DC Standards	2	116	464000
HF & Microwave Attenuation And Impedence Standards	3	11	106250
LF & HF Impedence Standards	4	66	101250
HF & Microwave Standards of Power, Voltage, Frequency & Noise	15	54	563850
Magnetic Measurement Activity	18	12	34350
Time & Freq. Standards	14	42	135500
	Total	**513**	**2625700**

II. TESTING			
Material Characterisation	12	0	0
Chemical Analysis	13	61	110550
RSD	20	0	0
Indian Reference Material	22	5	42000
X-Ray Analysis	23	1	20000
Electron Microscopic Analysis	24	1	3300
EPR Analysis	25	1	3150
Surface Area & Porosity Analysi	26	5	18350
Spectroscopic Analysis	27	0	0
Luminance Spectroscopy	28	0	0
Material Division	29	0	0
Carbon Technology	30	0	0
Metal & Alloys Group	31	2	5100
Solar Cell	32	1	1200
Electric Engineerings	33	3	17000
	Total	**80**	**220650**
III. JOB WORK			
Central Workshop	43	34	1056950
Thin Film	44	1	21200
	Total	**35**	**1078150**
	Grand Total	**4077**	**15551600**

YEARWISE FINANCIAL GROWTH FROM TESTING & CALIBRATION SERVICES



	1993 - 94	1994 - 95	1995 - 96	1996 - 97	1997 - 98
Phy. Mech. Std	57.5	77.6	101.3	100.9	116.3
Elect. Std	14.4	17.1	23.2	27.7	26.3
Other Services	3.8	3.4	11.1	18.7	12.9
Total	75.7	98.3	135.8	147.8	155.5

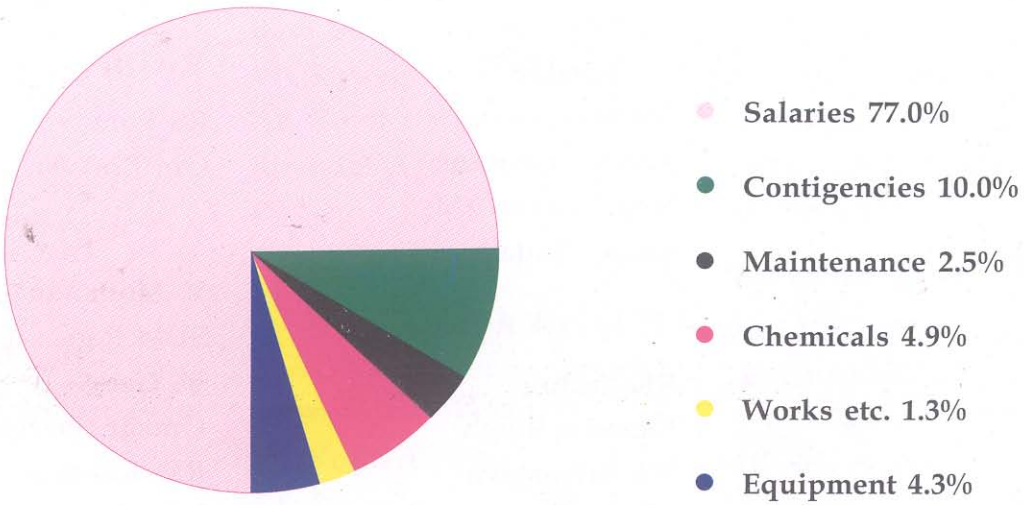
Consultancy

	Nature of Consultancy	Party	Value of Contract (Rs. Lakh)
1	Characterisation of Dead Weight Tester	Ravika Industries, New Delhi	0.4
2	Advice on Dev. of Software for Triaxial testing	Hydraulic & Engg. Instru. New Delhi	0.20
3	Calibration Lab Project report	Quality marking Centre, Faridabad	0.2
4	Dev. of standard Interface and instrumentation Amplifier	AIMIL, New Delhi	0.21
5	On calibration Lab	Sitrac, Coimbatore	2
6	Structural vibration studies	Rashtrapati Bhavan	2
7	Modelling/assistance in core cavity electrodes for lunch boxes	Jaypee Technoplast, Jammu	0.5
8	To help in fabrication of precision weights	M/s Weigh India, Bihar	
9	Setting up of Calibration Centre	Vaibhav Engg., Faridabad	0.32
10	Assistance in development of high speed cams	SS Engineering Swaran park, New Delhi	1.5
11	Computerisation & Networking New Delhi	National Council for Hotel Management,	0.25
12	Carbonisation studies	IIT, Delhi	0.25
13	Interference calculation on VSNL link	VSNL, New Delhi PS LAR	.20
14	Test Ring for testing of cryogenic values	M/s Leader Engineers, Jallandhar Pvt. Med.	4.30
15	Mandrel testing for PVC processing	M/s Gwalior polypipe kota, Rajasthan Pvt. MEd.	.05
16	One Litre Standard Vol.	M/s Vayubodhan, New Delhi Pvt Med	0.10
17	Quality evaluation of Almond Kernels	M/s RL Aggarwal, New Delhi Pvt SM	.45
18	Accuracy Improvement of pressure measure by Dead Weight Tester	M/s NCCB, Ballabhgarh GD	5.55
19	Accoustic Treatment at Jhansi	PWD, Jhansi GD	.35

20	Studies of Encapsulated Hydrophones and arrays	IIT, Delhi	1.35
21	Characterisation of Mercury Cad Telluride	SSPL, Delhi	2
22	Assistance in setting up of Indian Std. time	ISTRAC, Bangalore	1.75
23	Assistance in setting up of T&F Calib Facility	STIC, Cochin University	1.5
24	Modelling & Assistance in CNC Machining of core cavities	Jaypee Technoplast, New Delhi	0.75
25	Coke Formation from coal, tar pitch	Graphite India, Calcutta	3
26	Guidance in calibration of Single phase/poly phase energy meters	Avon Metyers Pvt. Ltd., New Delhi	0.06
27	Shayam Telecom New Delhi trivector static Electronic Energy parameters	Guidance in calibration of 3 phase	0.14
28	Premium Mouldings & Pressings New Delhi	Assistance in modeeling and CNC machining of Core, Cavities	0.9
29	Assistance in modelling & CNC Machining of Cores and cavities	Premium Mouldings New Delhi	0.9
30	Assistance in synchronisation to IST of the PDP 1170	Power Grid Corporation MIDC, Bombay	3.3
31	Determination of three term PID Controllers	Naimex House, New Delhi	0.16
32	Setting the Rb Frequency STd to optimisation	DG Deptt of Light house Govt of India, New Delhi	1.5
33	Synchronisation of IST of the R-30 Computer	MSEB, Mumbai	3.39
34	Setting up of Calibration Laboratory	Vaibhav Engg., Faridabad	0.32
35	Assessement of energy parameters of ref. meters	CG Schlummberger, Gurgaon	0.25
36	Characterisation of Dead weight Testers	Indo Gulf Fertilisers, Sultanpur	0.45
37	Design of optical Multilayer coatings for Gun Sight Reflector	Gen Manager, OLEF DRDO, Dehradun	0.3
38	Determination of precise coord.	Airport Authority of India	0.25

Actual Expenditure
(1997 - 1998)

Budget Head	Rs. (Lakhs)
Salaries (Pay & Allowances)	1496.306
Contingencies	196.704
Maintenance	48.967
Chemicals	94.737
Work etc.	26.129
Equipment	84.812
Total	**1947.655**
Sponsored Projects	**292.445**



Human Resources

SCIENTISTS OFFICERS

(In order of Gp. IV to Gp. III as on 1.4.98)

DIRECTOR

ESR Gopal
till September, 1997

A.K. Raychaudhuri
from October 1, 1997

PHYSICO MECHANICAL STANDARDS

LENGTH & DIMENSIONS

RP Singhal
VG Kulkarni
LS Tanwar
KP Chaudhary
Shanta Chawla (Smt)
M Karfa
Rina Sharma (Smt)
V Roonwal (Smt)
NK Aggarwal
BK Roy
AK Kanjilal
SL Thind

MASS

DC Sharma
SN Nangia
Tripurari Lal
ML Das
B Sinha
T.K. Parameshwaran

FORCE

KK Jain
JK Dhawan
MK Chaudhary
Anil Kumar
Ganga Prasad
Rajesh Kumar
VD Arora

PRESSURE & VACUUM

AC Gupta
AK Bandyopadhyay
BR Chakraborty
DR Sharma
Pardeep Mohan
C Anandan
SM Sivaprasad
Arjun Vijaykumar
Nita Dilawar (Ms.)
Sanjay Yadav

TEMPERATURE

RK Luthra
Joginder Singh
NK Srivastava
YP Singh
Mansha Ram
NK Kohli
SK Nijhawan
JK Gupta
PR Sengupta
Gurcharanjit Singh
V.P. Sharma

OPTICAL RADIATION

JS Vaishya
S Manrai (Smt)
HC Kandpal
SSK Titus
Jai Bhagwan

INFRARED RADIATION

SP Varma
D Gupta

ULTRAVIOLET RADIATION

RS Ram
Om Prakash

ACOUSTICS

V. Mohanan
SUM Rao
BS Gera
Omkar Sharma
RM Khanna
HLB Bhaskar

Mahavir Singh
VK Ojha
Gurbir Singh

ULTRASONICS

Janardan Singh
Ashok Kumar
SK Jain
Ved Singh
Harish Bahadur
Mukesh Chandra
Subhash Chandra
Jagdish Lal
Reeta Gupta (Smt)
NC Soni
GS Hans
VK Hans
Yudhisther Kumar

FLOW MEASUREMENTS

JN Som
Raj Singh
Virendra Babu
IS Taak

ELECTRICAL STANDARDS

TIME & FREQUENCY

BS Mathur
P Banerjee
A Sengupta
GM Saxena
AK Hanjura
M Saxena (Smt)
A Chatterjee (Smt)
C. Sri Kumar
Gurdial Singh
AK Suri

JOSEPHSON VOLTAGE

Ashok K Gupta
ND Kataria
VN Ojha
VK Gumber
Manmohan Krishana
Neeraj Khare
AK Goel

DC MEASUREMENT

SK Mahajan
Ajit Singh
PK Mittal
B Sircar

HF IMPEDANCE & AC, LF

Omkar Nath
Gurmej Ram
SR Gupta
MK Mittal
AK Saxena
Kewal Krishana
Naib Singh
JC Biswas
AR Kaushik (Smt)
Mohammad Saleem

HF & MW VOLTAGE, POWER FREQUENCY & ATTENUATION

VK Agrawal
RS Yadava
Ram Swarup
VK Rustagi
AK Govil
Ritander Aggarwal
PS Negi
Ranjit Singh
RL Mendiratta

MAGNETIC MEASUREMENTS

PC Kothari
RK Kotnala

NABL PROGRAMME

Mahesh Chandra

TESTING & CALIBRATION

HS Dahiya
ML Sharma
SP Sharma
PC Sharan
GK Kapoor
J.N. Prasad

ENGINEERING MATERIALS

CARBON PRODUCTS

OP Bahl
Gopal Bhatia
RK Aggarwal
RB Mathur
TL Dhami
V Raman (Smt)
Chhote Lal
DP Bhatt
SR Dhakate
SK Rai
PR Sengupta

HIGH PRESSURE TECHNOLOGY

AK Aggarwal
BP Singh
SK Singhal
Rajeev Chopra
KD Sharda

METALS & ALLOYS

Anil K Gupta
RC Anandani
Ajay Dhar
AK Srivastava
IA Malik

Rajiv Sikand
HB Singh
Jaswant Singh
Rakesh Khanna

ELECTRONIC MATERIALS

SILICON, CERAMICS & SUPERCONDUCTORS

BK Das
AC Rastogi
SN Singh
RB Tripathi
ST Lakshmikumar
Mohan Lal
SN Ekbote
BR Awasthy
BC Chakravarty
NK Arora
PK Singh
Kiran Jain (Smt)
S Singh (Smt)
VK Sankara Narayanan
Shailesh Sharma
SM Khullar
HS Kalsi
RC Goel
Prem Prakash
KS Balakrishnan (Smt)
BS Khurana
SK Sharda
HP Gupta
Ravi Kumar
MK Banerjee
TR Pushpangadan
Mukul Sharma
ML Sharma
VK Singhal

LUMINESCENT MATERIALS

PK Ghosh
V Shankar
Harish Chander

THIN FILM SYSTEMS

R Bhattacharya
A Basu
BS Verma
M Kar (Smt)
PN Dixit
OS Panwar
SS Rajput
KMK Srivastava
TD Senguthuvan
TK Chakraborty
TK Bhattacharya

POLYMERIC & SOFT MATERIALS

Subhas Chandra
SC Jain
SS Bawa
MN Kamalasanan
SCK Misra
Suresh Chand
AM Biradar
SA Agnihotri (Smt)
Ramadhar Singh
BD Malhotra
CP Sharma
VS Panwar
S Dwivedi
KK Saini
Ranjana Mehrotra (Ms)
RK Sharma
SK Dhawan
Chander Kant
GD Sharma

MATERIALS CHARACTERIZATION

CHEMICALS & POROSITY

HP Narang
JN Bohra
AK Sarkar
R Ramchandran (Smt)
AK Aggarwal
PK Gupta
Ranjan Kothari
S Kalyan Kumar
MK Dasgupta
Niranjan Singh
RC Sharma
RK Saxena

IR & EPR SPECTROSCOPY

SK Gupta
RK Garg
Manju Arora

X-RAYS

DK Suri
U Dhawan (Smt)
Rashmi
RP Pant
DP Singh

ELECTRON MICROSCOPY

SK Sharma
Ram Kishore
Kasturi Lal
Sukhbir Singh
KN Sood
KB Ravat

CRYSTAL GROWTH & CHARACTERIZATION

Krishan Lal
RV Ananthamurthy
Vijay Kumar Kohli
SK Haldar
G Bhagawannarayana
SNN Goswami (Smt)
SK Rastogi

THEORY

Ramji Rai

RADIO AND ATMOSPHERIC SCIENCES

KK Mahajan
SC Garg
M.K. Tiwari
DR Lakshmi (Smt)
RC Saksena
SL Jain
PK Banerjee
AB Ghosh
HN Dutta
MK Raina
SK Sarkar
Lakha Singh
RK Pasricha
KS Zalpuri
MC Sharma
PN Vijaya Kumar
MK Goel
PL Malhotra
RS Arora
Mahendra Mohan
Madhu Bahl (Smt)
JK Gupta
SD Sharma
RS Dabas
DR Nakra
VK Pandey
P Subrahmanyam
MVSN Prasad
BC Arya
NK Sethi
SK Singhal
HK Maini
VK Vohra
P Chopra (Smt)
Thomas John
CB Tandel
Jayanta Kar
Risal Singh
Meena Jain (Smt)
RS Tanwar
SK Shastri (Smt)
Abdul Hamid
Didar Singh
Raksha Marwah (Smt)
DB Sharma
VS Yadav
Iqbal Ahmed
SK Bhatia (Smt)
R Kohli
KGM Pillay
DS Chaunal
Shambu Nath
AK Goghar

SUPER CONDUCTIVITY

AV Narlikar
BV Kumaraswami
PK Dutta
Ratan Lal
SK Aggarwal
UC Upreti
Anurag Gupta
SB Samanta
VS Yadav
AK Goel

CRYOGENICS AND HUMIDITY STANDARDS

RG Sharma
Hari Kishan
BV Reddy
RB Saxena
SS Verma
NK Babbar
PL Upadhyay
TK Saxena
MA Ansari
D. Bhattacharya
GS Bhambra
Bhikam Singh
MC Singh

RESEARCH FACILITY & SUPPORT

RS Khanduja
PK Ashwini Kumar
FC Khullar
TK Chakraborty
SK Sharma
Shikha Mandal (Smt)
Indra Tewari (Smt)
MK Chibber
SS Bhakri
AK Suri

LIBRARY

SM Dhawan
SK Phull
DK Tewari
NK Wadhwa
Hasan Haider
Jagdish Prasad
S Bhatnagar (Smt)

COMPUTER

MS Tyagi
Ravi Mehrotra
Sher Singh
Kanwaljit Singh
Ashok Kumar
Vijay Sharma

INSTRUMENTATION

VR Singh
DS Sachdeva
YPS Negi

WORKSHOP

JR Anand
SC Gera
HNP Poddar
Ravi Khanna
Kewal Krishan
Ram Swarup
Bhupender Singh

PUBLICATION & REPORTS

V.S. Tomer
N.S. Verma
V.K. Sharma

GLASS WORKSHOP

MC Jusht
Mohan Lal
JP Vashist
Karnail Singh
Jai Bhagwan

TECH. SERVICES

CSP Kumar
JC Sharma
JS Dhama
Shashi Bhushan
RS Singh
SL Sharma
BK Chopra
KL Ahuja
Harbans Singh
SK Kulshrestha
BS Negi
KN Rao
Damodar Prasad
Krishan Kant
Deepak Bansal
Hitesh Jain
PS Tripathi

STAFF ON DEPUTATION

VT Chitnis
AR Jain
RP Tandon
K. Varadan (Smt.)
S.K. Gupta

SCIENTISTS, FELLOWS, RESEARCH ASSOCIATES & POOL OFFICERS

AP Mitra, Homi Bhabha Fellow
SK Joshi, Emer Distinguished Sc CSIR
TR Anantha Raman
Ajay
Sangeeta Khare
R. Murli Krishna
Y. Aparna
Subrata Bose
B Veena
Indu Dhingra
Ranu Gadi
Suchitra Ghosh
AS Grover
Alesa Gupta
Sandip Kohli
Rupa Mitra
DS Mehta
Jaya Naithani
GK Padam
Pradeep Kumar
Rashmi Paul
Satyendra Sharma
Sushil Kumar
Mansumi Seth
Sandeep Singh
Sanjay Srivastava
Hari Om Upadhyay
MM Verghese
UC Kulshrestha

ADMINISTRATION, ACCOUNTS, STORES/ PURCHASES

HR Gupta
LR Meena
Ramesh Chandra
SC Santosh
S Chandrahas
AK Gautam
Ravinder Kumar
C Ramesh
Satish Kumar
H Chongloi
JM Bhardwaj
DK Slone
OP Meni
C. Tobden
Bijendra Kumar
SK Sethi
RC Joon
AK Ghosh
S Sharma
RC Gupta
RK Bhasin
Paramjit Kaur
Mange Ram
SA Joseph
Shish Ram
Vijay Kumar
Lakhpat Singh

RETIRED

Hem Chander, May
BS Ahuja, June
GS Rawat, June
SS Mehra,June
BK Arya, June

YS Reddy, June
RC Bansal, June
Ved Prakash, July
N Kundu, July
JP Tonk, July
DC Parashar, August
S Aggarwal, August
Inder Dev., August
Jugdishwar Tyagi, Aug.
Sardara Singh, August
Dharam Chand, Sept.
ESR Gopal, Sept.
CP Singh, October
VK Amar, October
Devindra Singh, Nov.
JC Trehan, November
NN Sawamy, November
PD Joshi, November
Tek Bahadur Mal, Nov.
OP Vaish, Dec.
Chander Dutt, Dec.
Ram Kankawar, Dec.
DR Pahwa, December
Sita Ram, December
Kanta Chadha, Dec.
Mohd. Abbas, Jan.
M Vasudevan, Jan.
Nek Ram, January
Trilok Singh, January
VP Verma, January
MM Pradhan, Feb.
YV Ramanamurthy, Feb.
RS Sharma, March
HM Bhatnagar, March

OBITUARIES

Namtej Singh, June
Kanhaya Lal, July
Satbir Singh, October
Raj Kumari Bhatnagar, Nov.
DR Sharma, Nov.
Sant Ram, Feb.
Sat Dev, Feb.
Kuldip Singh, March

Staff Strength
(as on 31.3.98)

Category		Grade	Number
(A)	**Scientific & Technical Staff**		
1.	Scientific Staff	Gr-IV	269
2.	Technical Staff	Gr-III	150
		Sub- Total 1+2	**419**
3.	Engineering Cadre Staff	Gr-V	–
4.	Supporting Technical Staff	Gr-II	334
5.	Supporting Technical Staff	Gr-I	110
		Total S & T Staff :	**863**
(B)	**Administrative & Non-Technical Staff**		
6.	Administrative (Gazetted)	Group A	8
7.	Administrative (Gazetted)	Group B	16
8.	Administrative (Non-Gazetted)	Group C	136
9.	Non-Technical Staff	Group D	114
		Total Administrative & Non-Tech. Staff	**274**
		Grand Total (A) + (B) :	**1137**

Ph. Ds. Awarded

S.N.	Name	Title	University	Guides
1.	S.S. Pandey	Synthesis Characterization and applications of some conducting Polymers	Gorakhpur	Prof. V.K. Shrivastava Gorakhpur University Dr. B.D. Malhotra NPL
2.	Ms Manju M. Verghese	Application of some conducting polymers : polyaniline and polycarbazole	Jamia Millia Islamia	Prof. S.M. Ashraf Jamia Millia Dr. B.D. Malhotra NPL
3.	Amarjeet Kaur Narula	Mechanism of charge Transport in poly pyrrole, poly (N-methyl pyrrale) and poly (N-Methyl pyrrole-Pyrrale).	Delhi University	Prof. Abhai Man Singh Delhi University Dr. R.P. Tandon, NPL
4.	P.K. Basu	Fabrication and Characterization of small and large area n^+-P-P^+ silicon solar cell	Birla Institute of Science and Technology, Pilani, Rajasthan	Dr. S.N. Singh NPL
5.	Mrs. Kiran Jain	Processing and studies on textured BSCCO materials for improved critical current density.	Delhi University	Prof. P.N. Dheer Delhi University Dr. B.K. Das NPL
6.	R. Jaya Kumar	Studies on preparation & Characterisation of selenide semiconductor films for photovoltaic application	Delhi University	Dr. S.T. Lakshmi Kr. NPL
7.	Mrs. Meena Jain	Study of atmospheric minor constituents with special reference to ozon.	Delhi University	Prof. M.M. Bajaj Delhi University Dr. N. Kundu NPL
8.	Mrs. B. Veena Dhari	Tropical Ionosphere and HF communications	Delhi University	Dr. K.M. Aggarwal Delhi University Dr. D.R. Lakshmi NPL

S.N.	Name	Title	University	Guides
9.	Yudhisther Kumar	Characterization of metal rods using ultrasonic nondestructive methods	BITS Pilani	Dr. Ashok Kumar NPL
10.	Deepak Varandani	Specific heat and other studies on some pure and substituted HTSC cuprates	BITS Pilani	Dr. A.K. Bandyopadhyay NPL
11.	Pradeep Kumar	Photoacoustic Studies of Some Solids	Jamia Millia Islamia New Delhi	Prof. Z.H. Zaidi, Jamia Millia Islamia New Delhi Dr. R.S. Ram NPL
12.	R.K. Garg	Photoacoustic Spectroscopic Studies of Some Substituted Polyclyclic Aromatic Hydrocarbons.	Jamia Millia Islamia New Delhi	Prof. Z.H. Zaidi, Jamia Millia Islamia New Delhi Dr. R.S. Ram NPL

Honours and Awards

1. Dr. Krishan Lal was invited to serve as an Editor, Zeitschrift fur Kristallographie, the oldest and one of the most prestigeous journals of Crystallography w.e.f. 1977.

2. Dr. Krishan Lal has been invited to serve as Member, Technical Advisory Group of UNIDO sponsored International Centre for Advanced Materials Evaluation Technology, Taejon, Republic of Korea, 1996-1999 (Also invited to serve as a consultant during Planning phase).

3. Dr. Krishnan Lal has been conferred with Honorary Doctorate Degree by Russian Academy of sciences (Siberian Branch) Institute of Inorganic Chemistry, Novosibirsk, Russia.

4. Dr. Krishan Lal was elected Member, Asia Pacific Academy of Materials 1997-98.

5. Dr. Krishan Lal was elected Member, International Academy of Electrotechnical Sciences, Moscow and President, Indian Branch.

6. Prof. Dr. A.V. Narlikar, was elected a Full Fellow of the International Academy of Electrotechnical Sciences, Moscow, Russia.

7. Dr. H.N. Dutta was honoured by the Hon'ble Minister, Govt. Of U.P. on behalf of the Academy of Environmental Biology, for my contributions to Environment, the inaugural session of 18th AEB Annual meeting held at Industrial Toxicology Research Centre, Lucknow, Dec. 1997.

8. Dr. H.N. Dutta was awarded "Rashtriya Nirman Puruskar" by the International Business council & Indian Solidarity council for contributions in the field of Environmental Science & Technology, at Lodi Hotel, February 25, 1998. The award was presented by Hon'ble Shri Satya Narayan Reddy Ex-Governor, U.P. It carries a momento.

9. Dr. H.N. Dutta was awarded Best Paper Presentation for indigenous development of technology to the paper entitled, "Indigenous design and development of shipborne acoustic sounding system for probing atmosphere over ocean" presented in the National Conference on "Environmental Pollution'98' held at NPL, New Delhi, March, 1998. It carries a certificate and a Cash award of Rs. 1000/-.

10. Dr. A.K. Agarwal nominated as a principal member of Chemical Standards Committee (CHD 001) of bureau of Indian Standards, New Delhi.

11. Dr. S.K. Agarwal, received the prestigeous Foreign Specialist Research Award from the Japan Government, PM Office (Nov-Dec. 1997).

12. Dr. S.K. Agarwal, has been nominated as a member of the Editorial Advisory Board of the "Material Science Foundations" (Trans Tech Publications, Switzerland).

13. Dr. S.K. Gupta, Scientist has been invited as Regional Scientific Officer for India for organising the '5th International Symposium on ESR Dosimetry and Applications' to be held at Obninsk/Moscow (Russia) during June 22-26, 1998.

14. Dr. T.L. Dhami was awarded Raman Fellowship for the year 1997-98.

Visits Abroad (1997 - 1998)

1. Dr. B.R. Chakraborty Sci. EII visited USA on sabbatical leave for six months starting from April 97 to work as a visiting scientist in Deptt. of Chemistry, Pennensylvania, USA.
2. Dr. K.K. Jain Sci. EII was deputed to USA for 3 months w.e.f. 1.4.97 to 30.6.97 under the ongoing project "Charge carrier transport in crystalline materials application to metrology.
3. Dr. V.K. Agarwal, Sci. F visited Germany from 7.4.97 to 24.7.97 under NPL-PTB Technical Cooperation programme.
4. Dr. A.K. Agarwal, Sci. EI was deputed to Belgium during 21.4.97 - 25.4.97 to attend and present a paper at 7th Int. Symposium on Biological and conventional reference materials.
5. Dr. P.C. Kothari & Dr. R.K. Kotnala were deputed to Germany PTB during 9 May to 30th May, 97 for attending ISEN Congress and training programme under NPL-PTB collaboration project.
6. Dr. K.K. Mahajan Sci. G visited USA from 19th May to 20th June 97 to visit Phillips Lab. to give lecture and discuss about the possibilities of collaborative project under USIF programme and to spend 4 weeks with Dr. S. Chandra NASA/GSF for collaborative programme in the area of global change.
7. Dr. D.C. Parashar, Sci. F visited OSLO Norway from 22-25 May, 97 for attending the Int. Workshop on dissipation of N from the human N dioxide and SIS rates in present and future N O emission to the atmosphere.
8. Dr. E.S.R. Gopal, DNPL visited Germany during 11-20 May, 97 (a) Discussions on the future of collaboration with PTB, Braunschweig (b) attend the ISEM Conference in PTB & (C) Fraunhofer Instt. Dresden with which CSIR/NPL has strong cooperation under PTB-CSIR cooperation.
9. Mr. V.K. Rustogi, Sci. EII was deputed to Germany from 21st May to 19th June 97 under NPL-PTB cooperation programme
10. Dr. R.P. Singhal, Sci. F visited Germany from 23.5.97 to 13.6.97 under NPL-PTB Technical Cooperation Programme.
11. Mr. K.P. Chowdhary, Sci. B was deputed to Germany from 23.5.97 to 29.6.97 under NPL-PTB Technical Cooperation Programme.
12. Dr. Pradeep Mohan Sci. C visited Germany and Italy from 2nd June 97 to 10th June 97 to present a paper at 2nd Int. Workshop on Problem of Vacuum measurement at Magdeburg and visit to IMGC to discuss with Dr. Calcatelli about writting collaborative project of Vacuum std.
13. Dr. D.C. Parashar Sci. F visited DPR, North Korea from 1.6.97 to 10.6.97 to train the North Korean Scientists in the measurement of Methane Emission.
14. Dr. A.V. Narlikar, Sci. G visited France & UK from 30.6.97 to 15.7.97 under INSA-FAS programme and visit to Univ. of Oxford for scientific discussions.
15. Dr. B.S. Mathur Sci. G visited France from 24-26 June 97 to attend 21st meeting of Consultative Committee of Electricity
16. Sh. Tripurari Lal Sci. EII was

deputed to Saudi Arabia for one year from 12.6.97 under CSIR-SASO Technical Cooperation Programme.

17. Dr. Mahesh Gupta Sci. EII visited SASO, Saudi Arabia from 27.6.97 to 3.7.97 as amember of delegation
18. Dr. B.S. Mathur, Sci. G visited SASO Saudi Arabia during 27.6.97 to 3.7.97 as a member of delegation
19. Dr. Lakha Singh, Sci. EII was deputed to Hungary from 30.6.97 to 5.7.97 to attend Int. Beacon Satellite Symposium
20. Dr. Om Prakash Sci. EII was deputed to UK for 3 months from 1.7.9' to Univ. of Glasgow under INSA Royal Society Exchange Programme.
21. Dr. S.K. Jain was deputed to Netherlands from 2-4 July, 97 to attend Ultrasonic International at Delft.
22. Dr. R.G. Sharma, Sci. F visited Japan from 2.7.97 for 3 weeks under INSA-JSPS Exchange Programme.
23. Dr. R.P. Pant Sci. B was deputed to Japan from 18-20 June, 97 to attend Int. Symposium on Hydronamics of Magnetic fluids and applications.
24. Dr. A.K. Gupta, Sci. F visited Germany from 29.3.97 to 28.4.97 to work on ongoing cooperative project entitled "Development of New AC-LI materials with low density and high stiffness.
25. Dr. R.P. Tandon, Sci. EII was deputed to South Korea from 22-29 Aug. 97 to deliver lecture at Pahed University to attend and present a paper at 9th Int. meeting on ferroelectricity.
26. Dr. S.P. Verma, Sci. F visited USA from 25.8.97 to 9.10.97 to do collaborative research work with NIST under INDO-US aid programme.
27. Dr. J.R. Anand, Sci. F visited Germany, USA, Italy, Switzerland and Japan during 27.8.97 to 18.9.97 for short term Research visit for study of face (free air Co enrichment)
28. Dr. S.C. Garg, Sci F visited Italy, USA, Japan and Switzerland during 30.8.97 to 15.9.97 for short term Research visit for study of face (free air Co enrichment).
29. Dr. Rina Sharma, Sci. B was deputed to Germany during 6.9.97 to 7.12.97 under PTB Technical Cooperation Programme.
30. Dr. B.D. Malhotra Sci. EI visited UK, France and Poland from 7th Sept. 97 to Ist Oct. 97 to undertake magneto resistance studies under the EEC project and to finalize the collaboration projects with M/s Thomson GSF, France under IFCPAR.
31. Dr. R.B. Mathur Sci. EII was deputed to France for 42 days from 5.9.97 to characterize c/c composites developed at NPL under the IFCPAR sponsored project 'Influence of surface energetics of the reinforcement on the development of microstructure of the metro and fibre/matrix interactions in composites.
32. Dr. K.S. Zalpuri, Sci. EII visited USA from 8.9.97 to 12.9.97 to visit National Centre for atmospheric research in boulder and to attend INDOEX workshop.
33. Dr. A.K. Bandyopadhyay Sci. E-II visited Japan for 30 days w.e.f. 1.9.97 under foreign research invitation programme for 1997 Agency of Industrial S&T (AIST) Japan.
34. Dr. S.K. Mahajan Sci. E-II was deputed to Germany from 1.9.97 to 30.9.97 under NPL-PTB programme for training in D.C. High voltage.
35. Dr. V.G. Kulkarni, Sci. E.I was deputed to Russia for 15 days from 17.9.95 under ILTP Programme.
36. Dr. O.P. Bahl, Sci. F visited USA from 9th July 97 to 25th July, 97 on Business promotion visit.
37. Dr. B.S. Gera, Sci. EI was deputed to Turkey from 23-26/9/97 for attending Int. Symposium of air Quality Management st Urban, regional and Global Scales.
38. Dr. Hari Kishan, Sci. EI was deputed to germany from 11.11.97 to 31.1.98 under CSIR-DAAD Exchange programme.
39. Dr. K.P. Chawdry, Sci. E.I. and Ms Sunita Rani, STA were deputed to Germany from 17th Oct. - 25th Oct. 97 under NPL-PTB Technical Cooperation Programme.
40. Dr. Krishan Lal Director grade Scientist visited Russia for two weeks from 8.10.97

under ILTP Programme.

41. Dr. Mahavir Singh, Sci. B was deputed to Germany from 26.10.97 to 15.11.97 under NPL-PTB Technical Cooperation programme.

42. Dr. A.K. Gupta, Sci. F, Dr. R.C. Anandani, Sci. EI & Sh. R. Sikand, Sci. B visited South Korea from 13-31 Oct. 97 under CSIR-AIST S&T Programme.

43. Dr. S.K. Agarwal, Sci. C was deputed to Japan for 45 days from 11.11.97 to carry out Research work on the Synthesis of new High Temperature Superconductivity (HTSC) Materials at Electro Technical Lab. Tuskuba.

44. Dr. A.B. Ghosh, Sci. EII visited Japan from 10.11.97 to 13.11.97 to attend the ISTAG Int. Symposium on Atmospheric Chemistry and Future Global Environment.

45. Dr. H.P. Narang, Sci. EII was deputed to Thailand from 24-26 Nov. 97 to attend the annual reviewed workshop of the Asian Regional Research Programme in energy Environment and Climate.

46. Dr. Krishan Lal scientist (Director's Grade) visited Singapore from 3-5-Nov. 97 to attend the Int. Symposium on laser and non-linear Optical Materials 97.

47. Dr. V.R. Singh, Sci. F visited USA during 30.10.97 to 2.11.97 to attend Ist Annual Int. Conference of the IEEE Engineering.

48. Dr. B.S. Mathur, Sci. G visited Australia during 1.12.97 to 11.12.97 to attend the 13th meeting of Asia Pacific Metrology Programme.

49. Dr. S.C. Prasanna Kumar, Sci. F visited Denmark from 19-21 Nov. 97 to attend the 4th European Conference on Energy Efficient Lightening

50. Dr. P.K. Gupta, Sci. EI was deputed to Thailand from 24-26th Jan. 97 to attend the Annual Review Workshop at the Asian Instt. of Technology.

51. Dr. O.P. Bahl, Sci. F visited France for 39 days w.e.f. 27.11.97 to undertake characterization of Carbon Composites under IFCPAR Sponsored Project.

52. Dr. Krishan Lal Sci. (Director's Grade) visited South Korea during 25-26 Nov. 97 to attend 8th COSPAR Task Group meeting and workshop survey of data sources in Asian Ocean Countries.

53. Prof. A.K. Raychaudhuri, Director visited Australia from 1.12.97 to 16.12.97 to participate in the 13th meeting of Asia Pacific metrology programme (APMP) and visit NML a CSIRO Lab.

54. Dr. Sanjay R. Dhakate, Sci. B presently visiting Japan to attend training on advanced materials from 19.1.98 - 20.6.98.

55. Dr. S.C. Jain, Sci F visited USA from 12-21 Jan 98 for research work under collaborative projects with Naval Research Lab.

56. Dr. K.S. Zalpuri, Sci. EII & Sh Prabhat Kumar, EI were deputed to Maldives & Mauritius to carry out Indian Ocean Experiment (INDOEX) from 17th Feb. to 31st March 98.

57. Prof. A.K. Ray Chaudhuri visited France & Germany from 22nd Feb. 98 to 28th Feb. 98 to attend BIPM meeting & Sign MOU with PTB.

58. Dr. Mansha Ram Sci EI and Dr. Y.P. Singh, Sci EI were deputed to Germany from March 2-27, 98 under NPL-PTB Technical Cooperation Programme.

59. Dr. V. Mohanan, Sci. EII was deputed to UK from 10-13 March, 98 to attend the CPM working meeting on Acoustics Ultrasound and Vibration and to visit NPL Teddington.

60. Dr. Rina Sharma, Sci B is presently visiting Germany under BOYCAST fellowship in Research Project "Investigation and Development of highly sensitive methods for high resolution spectroscopy of weak over tone transitions and the practical realisation of wavelength stds.

61. Dr. B.K. Roy, TOC is presently visiting Saudi Arabia for six months from 1.3.98 to work in the area "Dimensional Metrology using laser under SASO Exchange Programme".

62. Dr. Ranjit Singh, Sci. EI is presently visiting Japan to avail AIST Japan Fellowship as a guest researcher to work in the area of microwave attenuation stds. for one year w.e.f. 25-3.98.

Special Lectures

Date	Speaker	Topic
23-4-97	Dr. Leong Ying Project Manager Cryo-Industries of America, USA	Open Cycle cryogenic systems ultralow temperature cryogenic system, closed cycle refrigerator and superconducting magnet systems design considerations and cryogen free systems
25-5-97	Dr. K.L. Chopra Ex-Director I.I.T., Khargpur, India	Plasma processing of thin film materials
09-6-97	Prof. U. Balachandran Director Argonee National Laboratory Supercond, Technol Programme U.S.A.	Development of ceramic superconductors for electrical power applications
09-7-97	Prof. Om Prakash IIT, Madras, India	Electronic and local structures of electron doped T superconductors
14-7-97	Prof Medved Alexander Institute of radio Engineering of Russian Academy of Sciences Russia	The present state of art and future of SAW Science and Technology
15-7-97	Prof Paras N Prasad Director Photonics Research Laboratory State University of Newyork USA	New Photorefractive plastics for photonics applications
6-8-97	Sh. T. Viswanathan Director Microtorr Vacuum System Pvt. Ltd.	High vacuum system, furnaces & components

20-11-97	Prof. Asit Datta Deptt. of Applied Physics Calcutta University, India	Neural Network and its Applications
15-12-97	Prof. M. Matsumoto Shinshu University, Japan	Evolution of Information Storage Media
17-12-97	Prof. Dr M Groll Institute for Nuclear Technology & Energy System University of Stutgart, Germany	Application of Heat Pipes/Closed two phase Thermosyphons in Energy Technology and for Precision Measurement Techniques.
22-12-97	Prof. Y Tomokiyo High Voltage Electron Microscope Laboratory Kyusho University Fukuoka, Japan	Analysis of local Lattice Strain near impurites, Gettering sinks in silicon wafers by convergent beam electron diffraction
8-1-98	Prof. John H Marsh Glasgow University, UK	Quantum will intermixing in materials systems for 850 nm and 1.5 Microns
8-1-97	Prof A.K. Mulchandani College of Engineering University of California, USA	Biosensors for organophosphorous nerve Agents
9-1-98	Prof Jong-Jing Kim Korea Advanced Institute of Science and Technology Taejon, Korea	Dipolar Relaxation in Dipole Glass
13-1-98	Dr A.K. Singh Deputy Director NAL, Bangalore, India	Pressure Metrology in the Megabar Range
14-1-98	Prof A C D Chakladar British Columbia University, Canada	Advanced Structural Ceramics : Problems and Prospects
28-1-98	Dr Bruce P Gaber Senior Biomolecular NRL, USA	Writing Biomolecules on surface
28-1-98	Dr Chris J Gibbins Rutherford Appleton Laboratory, Oxfordshire, UK	The Exploitation of mm-wave for future Communications systems
12-2-98	Dr R.L. Mossbauer Noble Lauret Fakultat fur physik	Neutrino Physics at Nuclear Energies

	technische universitat muenchen, Germany	
2-3-98	Dr B.D. Inglis Director National Measurement Laboratory, CSIRO, Australia	The role of APMP in international Metrology
9-3-98	Dr Juergen Helmcke Head, Div Length & Time PTB, Germany	Realization of the Length unit by Optical Frequency Standard
28-1-98	Dr H.H. Weetall National Institute of Standard & Technology Gaithersburg, USA	New Approaches to Biosensor Technology
19-3-98	Prof. R Schindler, FRG Germany	Silicon solar cells using imperfect Substrates
20-3-98	Dr G Bhaskaran Institute of Mathematical Sciences, Madras, India	New Development in the theory of High temperature Superconductors

Krishnan Memorial Lecture

XVIII Krishnan Memorial Lecture was delivered by Prof. R. Mossbauer, Nobel Lauret in Physics, on 12-2-98 at NPL.

A Sandalwood Momento was presented to speaker by Prof. A.K. Raichaudhuri Director, NPL for delivering the Lecture. Large number of Scientists, Research Scholars and other staff members from NPL attended the Lecture.

XVIII Krishnan Memorial Lecture delivered on 12-2-98 by Prof. R. Mossbauer

Research/Management Council

Research Council

Name	Position
Dr. R. Chidambaram Chairman AEC & Secretary Department of Atomic Energy Anushakti Bhawan Chatrapati Shivaji Marg Mumbai-400 039 (MS)	Chairperson
Prof. V.S. Ramamurthy Secretary Department of Science & Technology Technology Bhawan New Mehrauli Road, New Delhi-- 110 016	Member
Dr. R.R. Kelkar Director General Indian Metrological Department Mausam Bhavan Lodi Road, New Delhi-110 003	Member
Mr. P.S. Das Director General Bureau of Indian Standards Manak Bhawan 9, Bahadur Shah Zafar Marg New Delhi - 110 002	Member
Prof. Dipankar Chakravarty Director Indian Association for Cultivation of Science 2A & B Raja S.C. Mullick Road Jadavpur, Calcutta - 700 032	Member
Dr. N. Srinivasan Deputy Director General Confederaton of Indian Industry Gate No. 31, North Block Jawahar Lal Nehru Stadium Lodi Road, New Delhi-110 003	Member
Mr. M.K. Mittal Director (E & RD) BHEL BHEL Headquarter Sirifort, New Delhi-110 049	Member
Prof. R.N. Biswas Director Central Electrical & Electronics Research Institute (CEERI) Pilani-333 031 (Rajasthan)	Member Sister Laboratory
Dr. S.P. Vassi Reddy CMD Vimta Laboratories Limited 142, IDA Phase II Cherlapally Hyderabad-500 051 (AP)	Member DG's Nominee
Dr. A.K. Raychaudhuri Director, NPL	Member
Mr. T.K. Chakravarty Scientist 'EI' P&C Group	Non-Member Secretary
Dr. H.R. Bhojwani Head Research Planning & Business Development (RPBD)	

Council of Scientific & Industrial
Research (CSIR)
Anusandhan Bhawan
Rafi Marg, New Delhi-110 001

Management Council

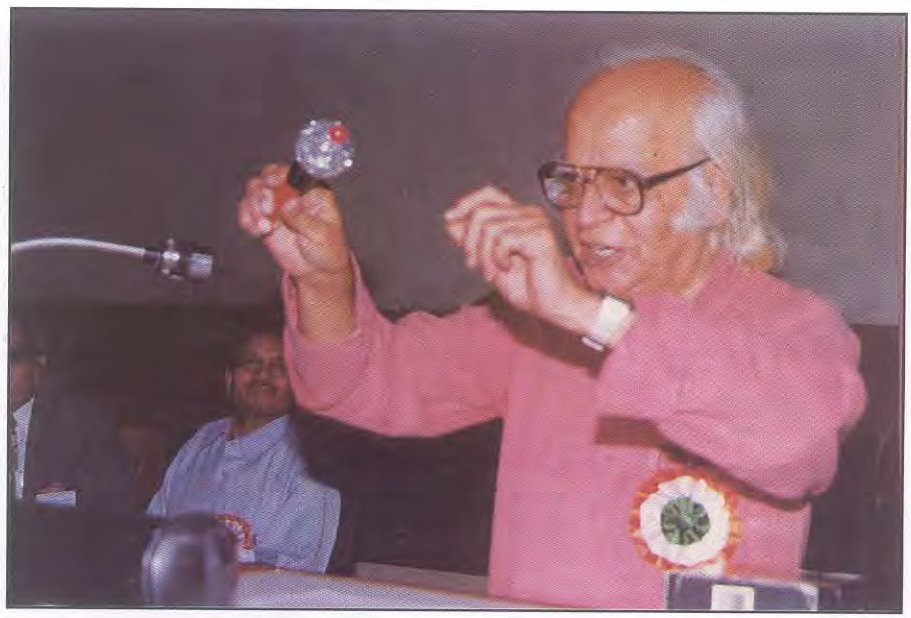
Name	Position
Dr Raychoudhary Director National Physical Laboratory New Delhi-110 012	Chairman
Dr. A.K. Srivastava Scientist National Physical Laboratory New Delhi-110 012	Member
Dr. Gopal Bhatia Scientist National Physical Laboratory New Delhi-110 012	Member
Dr. R.P. Singhal Scientist National Physical Laboratory New Delhi-110 012	Member
Dr. B.S. Mathur Scientist National Physical Laboratory New Delhi-110 012	Member
Dr. S. Mallick Head HRDG CSIR Complex New Delhi-110 012	Member
DG or his Nominee	Permanent Invitee
Sr. FAO National Physical Laboratory New Delhi-110 012	Member
COA National Physical Laboratory New Delhi-110 012	Member Secty.

Training Provided

1. A training course code No. 043 on Dimensional Metrology held at NPL for four persons from Industries from 21st to 25th April, 97.
2. A one week familiarisation programme was arranged at NPL for SC/ST student from 2nd to 6th June, 97.
3. Twenty six students from different Engineering Institute carried out project work at NPL towards fulfilment of the course work.
4. Inhouse Training Programme for scientist of Std. Group Marketing of NPL Service.
5. A training course code No. 103 on Dimensions Metrology held at NPL for four persons from Industry from 13th to 17th
6. 4 students from various Engineering Institutes carried out their project work at NPL towards fulfilment of their course work.
7. A training course code No. 033 on Precision Microwave Measurements held at NPL for three persons from Industry on 19th & 20th March, 1998.
8. A training course code No. 022 on calibration of RTD's with Pt-100 prelos etc. (0-650 °C & 200 °C to Room Temperature) held at NPL for two persons from Industry on 2nd to 6th Feb., 1998.

Seminar/Symposia/Workshop

1. Seminar on Saw Devices Physics Technology and Applications held at New Delhi on 7th to 11 July, 1997.
2. Symposium on Accoustical Signal Processing held at New Delhi on 21st to 22nd August, 1997.
3. Workshop on Characterisation of Advanced Materials Environmental Issues (WCME) held at National Physical Laboratory, New Delhi on 21st and 22nd Aug., 1997.
4. Workshop on Calibration Services was held at NPL on 26th July, 97.
5. Symposium on Accoustical Signal Processing at NPL on 21-22nd Aug., 98.



National Symposium on Instrumentation, 22nd to 25th October, 1997

6. National Symposium on Accoustic NSA 97 held on 6th to 8th Oct. 98 at Vishakapatnam.
7. National Symposium on Instrumentation held on

22nd to 25th October, 97 at New Delhi.

8. VIIIth National Symposium on Ultrasonic (VIII-NSU) held at Amritsar on 6th & 7th Nov., 97.
9. DAE Solid State Physics Symposium-97 held at Koshi on 27th to 31st Dec. 97.
10. Ninth International Workshop on Physics of semiconductor Devices held at Delhi from 16th to 20th Dec., 1997.
11. National Symposium on Instrumentation 22 to 25 Oct. 97 (NSE-22).
12. Seminar/Workshop on Metrology Introduction Course. Introduction, 13th-15th Nov. 97 to Key users from Industries.
13. International Conference on Computer Device for Communication held at Hyderabad on 3rd to 7th Jan., 1998.
14. IUPAC International Symposium on Advances in Polymer Science and Technology (MACPO 98) held at Chennai on 5th to 9th Jan., 1998.