ANNUAL REPORT 1990—91

NATIONAL PHYSICAL LABORATORY
NEW DELHI

CONTENTS

Director's Report

It is a pleasure to present a brief account of the achievements of the National Physical Laboratory during 1990-91. The laboratory actively contributed in the National Scientific and Technological Programmes : (i) SROSS Aeronomy Satellite Project, (ii) Superconductivity; (iii) International Geosphere-Biosphere Programme and (iv) Standardization, Metrology and Quality System.

R&D work was carried out in the CSIR mission programmes : (i) New Materials, (ii) Microelectronics ; and (iii) Advanced Ceramics. Laboratory thrust area programmes were : (i) Characterization of Materials ; (ii) Amorphous and Crystalline Silicon and (iii) Modern Communication Systems-Media Characterization.

In the area of Standards and Metrology, efforts were continued to improve levels of accuracy in measurements on base units as well as derived units. The laboratory participated in international intercomparisons in several areas. Calibration and testing facilities were provided to users in different sectors.

The laboratory continued to coordinate calibration activities in the country under the NCTCF programme. Two units of methane stabilized He-Ne lasers were developed with frequency stability of a few parts in 10^{11}. Volume of a solid glass cylinder was established in terms of density of water with an uncertainty of a few parts per million. Results of international intercomparison involving five laboratories including NPL in pressure standard showed agreement within 140 into 10^{-6} in the measurements of effective area at zero pressure. Jointly with VNIIFTRI, USSR calibration of standard condenser microphones was carried out. Transfer standard of single phase ac power and energy was realised in terms of dc voltage and current standards. In collaboration with VNIIM, USSR intercomparisons of 10 pF silica and 1 nF—100 nF mica capacitance standards were carried out.

Fundamental as well as applied research was continued on high temperature super conductors. Basic investigations on La-214, Bi-2122 and Y-123 systems were concerned with introduction of selected rare-earth and 3d transition metal ions into these and their effect on superconducting properties. A superconducting magnet for magnetic separation of ores and other materials was successfully developed and tested in close association with BHEL. It was designed to produce a maximum field of 5T in a room temperature bore of 100 mm. Preparation and studies of thick and thin films as well as tapes of high Tc materials were continued by using a variety of techniques. Rf SQUIDs based on thick films of Y Ba Cu O and Bi Sr Ca Cu O systems were developed and operated in flux locked loop mode which enabled measurement of flux values ranging from a fraction of a flux quantum to several flux quanta with same high sensitivity. Coulomb interaction in cuprates was studied on the basis of a time dependent multiple scattering theory.

Research and development work on electronic and engineering materials was continued. A single crystal silicon solar cell with 13.5% efficiency was fabricated. Two thin film amorphous silicon solar cells could be combined in tandem and the efficiency of the structure could be increased by optimization of film thicknesses. A total internal microoptic switch using high-tilt-angle materials was developed for photonics applications. Conducting polymers, leucomeraldine and pernigraniline

were prepared. A systematic study helped in reduction of time taken for pyrolysis of stabilized fibres. For development of oxidation resistant ceramics, silica and silica based materials were synthesised by sol-gel process in collaboration with IIT, Delhi.

An NPL-DOE Centre for Characterization of Materials for Electronics has become functional which provides service, undertakes consultancy assignments, trains manpower and carries out fundamental research. Significant research investigations include study of electronic and structural defects generated by implantation in silicon crystals relevant to shallow junction formation, structural studies of high Tc superconductors, study of biaxial stress at the interface of GaAs substrates with multilevel metallizations and investigation of methane emission from paddy fields. A five crystal X-ray diffractometer was developed in the laboratory with state-of-the art level resolution. Single crystals of lithium niobate were grown on a system developed in NPL. Three Indian Reference Materials (Bharatiya Nirdeshak Dravayas) prepared through a joint effort of seven laboratories were released and supplied to users.

The Radio Science group contributed significantly in nationally coordinated and laboratory projects. Under the IGBP, UV-Bradiation received at the ground in 1991 was less than that observed in the preceding three years even though there was appreciable increase in ozone level. Flight packages of the sensors and electronic hardware for the payloads for the SROSS were space qualified. A new computerized method for predicting sun spot cycle was developed and tested. High solar activity during the year caused disturbances for communications and ARWC issued several special warnings to the agencies. An acoustic sounding system was developed in collaboration with SV University and IIT Kanpur. Detailed comparison of neutral atomosphere, ionosphere and solar wind interaction of Venus and Mars was made.

Collaborative research with several R&D institutions, universities and scientific departments was continued. These include BHEL, ISRO, DST, DOE, DOD, CEL and CEERI. The amount realised from other agencies for the sponsored projects during the year was over Rs. 230 lakhs. Consultancy services were provided to the Government departments and industry in the areas of acoustic treatment, materials characterization and instrumentation. The processes for preparation of TV picture tube phosphors, rear view prisms for aircraft, glassy carbon and oxidised PAN fibre were released to the industry for the first time.

Professor J.N. Thomas, Director, The Royal Institution of Great Britain, delivered Krishnan Memorial Lecture on "The Genius of Michael Faraday". A number of our scientists were recipients of awards and honours at national level. Dr. H.C. Kandpal received the CSIR Young Scientist Award. Dr. P.K. Ghosh and his team were awarded Rs. 50,000/- by NRDC for the development of a process for the manufacture of phosphors. The team working on the development of high Tc SQUIDs was awarded by the Indian Cryogenics Council. Dr. A.K. Hanjura led the tenth Antarctic Expedition.

A number of distinguished scientists from India and abroad visited the laboratory and delivered lectures. They included Prof. G.B. Donaldson, Sir. Herman Bondi, Dr. T.Spurling, Prof. Markl Habert, Dr. U.R. Rao, Prof. Theodor Berchem and Dr. S.Z. Qasim. About 140 papers were published in national and international journals and 10 research reports were produced.

Krishan Lal

(KRISHAN LAL)

STANDARDS

LENGTH & DIMENSIONS

1. LENGTH

The primary standard of length, in the form of an iodine stabilised He-Ne laser, was maintained. Two portable units of such lasers were made. A laser based refractometer was developed with a capacity to determine the refractive index of air with an accuracy of $\pm$ 2 parts in 10^7. With these facilities line gauges can be calibrated with an uncertainty of $\pm$ 1.5 µm per metre.

Two units of 3.39 µm methane stabilised He-Ne laser, one with hardware of FIAN, Moscow and another with NPL hardware, were built using laser tubes and methane absorption cells of NPL. The narrow absorption feature of methane, was detected in the frequency band width laser gain curve and the laser frequency was servolocked to the methane absorption line. An estimate of the frequency stability of this prototype laser is a few parts in 10^{11}.

Improvements were made in the fibre optic displacement sensor by incorporating an analog switch and a twin photodetector. The sensor response was linear over a range of $\pm$ 400 µm with minimum detectibility of 0.02µm. The progress on sponsored project of a photolithographic mask aligner was made, by achieving x-y alignment, gap control and angular alignment between the mask and wafer using the technique of Moire interferometry. Advice was rendered to the National Airport Authority, New Delhi in setting up their laser auto-tracker in order

2. DIMENSIONAL METROLOGY

A system for speedy calibration of precision spirit levels was designed. A computer programme was developed for computation of errors in the slip gauges, calibrated by interferometric method. The effect of various design parameters on the performance of electro-optical sensor for displacement measurement, was studied. The project engineering work regarding the installation of new coordinate measuring machine, was done.

The calibration of dimensional measuring instruments, standards including slip gauges, length bars, ring gauges, measuring tapes, inclinometer, vernier calipers, etc., for the industrial laboratories, was continuted. The calibration of heavy items was done at site.

MASS

Two sets of weights from 200 g to 1 mg and some 1 kg and 500 g weights were recalibrated. Four weights 1kg, 500 g, 200 g and 100 g, fabricated at NPL, were adjusted, calibrated and supplied to the Regional Reference Standard Laboratory, Bangalore. To study the water absorption by silicon weights, experimental work was conducted using three circular discs of polycrystalline silicon. Automation of mearurement and recording of temperature, pressure and humidity inside HK 1000 Mass Comparator was completed. The study of the variation of temperature with time and horizontal temperature gradient along the beam and vertical temperature gradient along the pan suspension assembly of the comparator was carried out.

Under the Indo-US project, two finished weights obtained from NIST, were calibrated against NPL transfer standards and four weights of 1kg from three samples of stainless steel were fabricated and machine finished. Measurement capability of comparing the two masses at 1kg level was updated to $\pm$ 10 µg. A complete hydrostatic measurement system was established. The volume of a solid glass cylinder was established in terms of density of water within an uncertainty of a few parts per million. Initial observations for volume/density determination of silicon cylinder from NIST was carried out.

Calibration work pertaining to reference and secondary standards of mass volumetric measures like pipettes, burettes, hydrometers and viscometers was done for the state departments and industry. A firm was advised regarding the calibraion and fabrication of automatic pipettes.

FORCE

As per the collaboration with F.I.E. Research Institute, Ichalkaranji, for the development of 1 meganewton hydraulic multiplication system, two machines were produced. One machine was installed at the Institute and the other one was received at NPL free of cost and was under installation. The calibration of force measuring devices was done for the industry.

PRESSURE VACUUM

1. PRESSURE

The 35mm air piston gauge, calibrated against the Guildner manometer at NIST, was brought to NPL for intercomparison. The absolute uncertainty of this gas thermometer was 1.5 ppm and was calibrated with ultrasonic interferometer manometer to further reduce the uncertainty of measurements. The present undertainty at 1 kbar was 53 ppm.

Under NPL-PTB (Phase-II) programme the determination of the triple point pressure of argon was carried out at PTB. The pressure and temperature of the plateau at the various fractions of solid and liquid phases of argon were measured. This method enabled to determine the triple point pressure within an uncertainty of 10ppm. The hydrostatic head correction of the gas column was also carried out for argon together with the result of temperature measurements at various points of the capillary. The triple point pressure obtained was 68.8905 k Pa $\pm$ 0.5 Pa, while the temperature studies of these points showed the triple point temperature as 83. 8058 K.

The results of the international comparison in pressure showed agreement between five laboratories within 140×10^{-6} for the measurement of the effective area at zero pressure. All uncertainties were evaluated on the basis of three times the standard deviations. The results also agreed for the pressure distortion coefficient, within the combined uncertainties for three labs. The results confirmed that the changes in area measured during the two first phases disappeared after about three years.

2. VACUUM

The work on the effect of zero shift in the capacitance diaphragm gauges (CDG) due to change of line pressure, was continued. The experimental results were analysed and the effect of the gas media on the zero shift was explained. The effect of the change of line pressure on the zero stability in a quartz spiral gauge was studied. The experimental results obtained earlier were reconfirmed for different gases under different experimental conditions. The experimental results obtained for different gases showed that the shift in zero value, with respect to time for different gases obtained in one case, followed exactly the reverse cycle in another case.

The volume ratio was redetermined by means of the method of successive expansion while measuring the initial pressure by a quartzbourdon spiral gauge and the final pressure by means of a 1-Torr (CDG). After that a 10-Torr (CDG) was calibrated on the static expansion system and compared with the corresponding values obtained by calibration against ultrasonic interferometer manometer.

3. SURFACE PHYSICS

A study of ion-induced chemical bonding of Ta with carbon was carried out on Ta and Ta_2O_5 film surface. It was observed that Ta had a high tendency of carbide formation during sputter cleaning due to its unfilled d-orbital electrons and free electrons of the graphitic carbon released due to ion bombardment.

In order to understand the absorption and desorption phenomena in stainless steel, used as vacuum vessel materials, the experiments were carried out. It was visualized that electrons and ions could do different things to the surface contaminants of stainless steel. A study on a Ta/Si multilayer thin film structure was carried out during depth profiling, at Max Planck Inst., FRG.

TEMPERATURE

Intercomparison of Pt/Pd, Pt/Au and type S thermocouples were carried out for new fixed points and

black bodies were fabricated. The comparison was made with linear pyrometer above 1064°c. An oxygen point cryostat was developed for calibration of platinum resistance thermometers. A new apparatus for determination of thermal conductivity of 12 IN samples was fabricated.

Software was developed to analyse data of temperature measuring instruments and to prepare calibration reports as per ITS-90. Inter-face circuitry and software programmes were developed for control of instruments and data acquisition, plotting and preparation of tables from raw data.

OPTICAL RADIATION

The measurement of absolute spectral responsivity of photodetectors was done. Photometric and radiometric calibration services were provided to the lamp and lighting industry. In addition, testing of sources, detectors and luminaires was also done in a limited manner. The accuracy of measurements was improved.

INFRARED RADIATION

The spectral calibration of the detector was carried out by using a variable temperature black body as source and the irradiance measurement set-up. The irradiance of black body at other temperatures was experimentally determined and compared with the computed values and uncertainties were determined.

The absolute values of reflectance, from surface of a variety of samples, were measured at He-Ne laser wave length. The work on the establishement of the transmittance standard in 2 to 25 μm spectral region was continued. A number of samples from other projects were analysed by using photoacoustic and infrared spectrophotometers.

ACOUSTICS

Ground vibration studies were undertaken at site of SCL, Chandigarh, for selecting a suitable location. The acoustical evaluation of the auditorium at Jamia Millia Islamia University, New Delhi, was carried out. The results showed that all the design objectives were achieved. Acoustic evaluation of renovated NPL auditorium was undertaken.

Inter laboratory calibration of standard condenser microphones (Echelon 1) was carried out in collaboration with VNIIFTRI, USSR. Two Russian specialists visited NPL and exchanged methodology of calibration techniques and data.

A monostatic sodar system was fabricated, installed and operated at CAZRI, Jodhpur for Monsoon Boundary Layer experiments. The results were compiled on a floppy and deposited in the national data bank as a part of the MONTBLEX programme. The sodar data collected at the IPCL, Nagothane site was processed and the report was submitted. A mobile sodar antenna of light weight was designed and fabricated. A new model of the sodar facsimile recorder was developed and fabricated.

A feasibility experiment was conducted with a polarisation interferometer for vibration amplitude measurement for calibration of standard accelerometers. Secondary standards from regional laboratories including microphones, accelerometers, tachometers, distortion meters and sound level meters were calibrated.

UNDERWATER ACOUSTICS

Development work was carried on a minipinger system, for applications in fisheries research and the driving circuit was assembled. Measurements of the receiving sensitivity, of lead titanate piezoceramic elements, were carried out, for the study of hydrostatic constant. The high pressure tube installed for acoustic calibration of underwater transducers was tested upto 2000 psi. Wide band hydrophones, to be used at low frequency in this system, were developed and electrical feed thru arrangement was made.
Calibration of echo sounder transducers of frequencies 30 kHz and 210 kHz from Port Trust, Kandla, was carried out. The testing of transducer elements from a sonar transducer array was done. Calibration service was provided to hospitals for evaluating

ultrasonic exposure parameters of scanners. Pulse echo overlap method was established for the measurement of ultrasonic velocity in solids and liquids using the Matec equipment procured under the British Council Projects. A facility for ultrasonic flaw detections with colour C scan and signal waveform analysis was set up. The studies of measurement of uncertainty in reciprocity technique for calibration of ultrasonic hydrophone, were carried out.

FLUID FLOW MEASUREMENT

Calibration of 50 litre automatic over-flow pipette, which will eventually act as a primary standard, was completed at PTB and the results were studied. The detailed technical specifications and design details for setting up of water flow measurements facility at primary standard level were finalised. Some civil works for setting up the facility were in progress. Designs of OH tank and sump tank were prepared and being scrutinized.

TIME AND FREQUENCY

Standard time and frequency signal (STFS) dissemmination via INSAT I was being continued with an accuracy of + 10 microseconds with the help of newly developed more accurate software for predictions of satellite coordinates. INSAT-TV network was being utilised in a common view mode for time transfer.S&T service was provided to the department of Light House and Lightships, Ministry of Surface Transport, by way of reconditioning the physics package of their HP Rb atomic frequency standard. Theoretical studies on the application of squeezed light to diode laser pumped Rb atomic clock were made.

DC STANDARDS

The maintenance of the emf values of group of saturated standard cells and soil state zener based electronic voltage standards was continued. The dc standards of resistance and scale of resistance were maintained. The calibration of dc measuring instruments including standard resistors, standard cells, electronic voltage standards, digital multimeters and calibrators was continued.

The quantum standard of resistance was established using Ga As sample and 6 Tesla super conducting magnet. The Hall plateaus were obtained with 20 - 30 μA source - drain current at 4.2K. The system was hooked up to a computer controller and the inter comparison of Hall plateau resistance against Klitzing standard resistor was also done to establish transfer standard facility. The precision of measurement was in the order of 10 ppm.

HF IMPEDANCE, AC AND LF

1. *LF & HF Impedance*

The reference standards of inductance were reassigned values against the standards of capacitance realized through the calculable capacitor, using Maxwell - Wien bridge technique.

For the automatic precision capacitance bridge being developed in collaboration with Jadavpur University, the transformer unit of the NPL was coupled with the processor unit developed at Jadavpur. The evaluation of the bridge was carried out at NPL. In order to extend the range of measurements of impedance standards upto100MHz,computer programmes were redeveloped.

International intercomparison of 10 pF silica and 1nF - 100 nF mica standards of capacitance, was carried out with VNIIM, USSR. The values of two countires agreed within 3 parts in 10 at 1 kHz. The mica capacitance standards agreed within ± 0.01% in the frequency range 1 kHz - 1 MHz.

2. *AC & LF Standards*

Single - phase transfer standard of ac power and energy was realized in terms of the standards of dc

voltage and current. The 3 - phase power and energy calibration source was evaluated and found to conform to the stated accuracy of 0.05%. The phase standard was established in the frequency range from 1.0 kHz with an accuracy of 0.05°. The calibration of power factor meter, energy meter, phase meter, current transformer and high voltage voltmeter were done for the industry.

HF & MW VOLTAGE, CURRENT POWER, FREQUENCY & NOISE

Waveguide transfer standards in X (8.2 to 12.4GHz) and Ku (12.4 - 18.0 GHz) bands were recalibrated for their calibration factors against our waveguide primary standards at 1 GHz frequency interval. The total uncertainty in the calibration factor was within ± 1.0.

The calibration of coaxial power transfer standards for their calibration factor values was done. The loss of coaxial to wave guide adapters was measured by two different techniques in three different bands (XN, X, Ku) as a number of frequencies in each band. The adapter loss was assigned with an uncertainty of ± 0.01 dB. Periodic inhouse calibration of transfer standards of LF & HF voltage was carried out. The scientists assisted various laboratories in assessing for electrical and electronic parameters under NCTCF programme. They also rendered advice to BEL, Ghaziabad for improvements in their calibration facilities. A number of standards and precision instruments of various user organisations were calibrated.

HF AND MW ATTENUATION AND IMPEDANCE

Three standard mismatches of VSWR 1.10, 1.20 and 1.30 alongwith their precision terminations were fabricated for K-band microwave frequencies. The reflection coefficients of K- band quarterwave short circuits were computed at spot microwave frequencies. The evaluation of the standard mismatches showed the variation of VSWR about the nominal value as ± 0.02 throughout the K-band microwave frequencies. Calibration of attenuators matched terminations and mismatches was carried out for various government departments and undertakings.

CALIBRATION SERVICE PROGRAMME

The Calibration Service Programme under NCTCF scheme of DST is coordinated by NPL. 114 laboratories, in the areas of electrical, electronic, fluid flow, radiological, mechanical, thermal and optical measurements, have applied for under this programme. 75 labs. were assessed and 18 labs. were awarded the Accreditation Certification for a period of 3 years effective from March 1, 1991 to provide authorized calibration service under the scheme. Half of these laboratories belonged to industrial sector, public as well as private. Six meetings of the expert panels and steering committee for calibration were held during the year.

MATERIALS

SILICON AND DEVICES

1.1. *Crystalline*

Computer modelling of diffusion of B,P, As and Sb into silicon was carried out and a diffusion module was developed and incorporated into a 1-D VLSI Process Simulator STEPS. The project was funded by DOE, New Delhi.

A single crystalline silicon solar cell of 13.5% efficiency was fabricated and a realistic theoretical model of solar cell was developed to analyse functioning of low-moderate or high efficiency silicon solar cells. Studies were made to deposit and optimise PECVD Si_4N_3 antireflection film on 100 mm dia single and polycrystalline silicon solar cells. A single graphite crucible was used for more than 4 times to grow multicrystalline silicon ingots in it.

1.2 *Amorphous*

The development work of thin film amorphous silicon cells was continued. Two cells could be combined in a tandem fashion and efficiency of the tandem structure could be increased by optimisation of thicknesses. Through a process of optimisation of layer thicknesses involved in the constituent cells of the tandem structure, the cells of about 9.3% efficiency were fabricated.

INTERFACES AND MICROSTRUCTURE

The investigations on the electronic behaviour of extrinsic, dielectric (yttrium oxide) silicon crystal interfaces were continued. The studies, of dependence of the current voltage characteristics of metal yttrium oxide semiconductor and metal yttrium oxide metal structures, both at room and low temperatures, were undertaken.

The rf plasma deposition system was used to deposit good quality films using benzene as the source material and structural studies were performed. The work on the use of semiconductor semiconductor interfaces in solar cell configurations was continued and new experiments were conducted.

LUMINESCENT MATERIALS

The development of rare earth oxysulfide phosphors was continued. Required quantities of the activated gadolinium oxysulfide phosphor was produced for coating screen layers of varying thicknesses which were tested at SHAR. The presence of impurities in the starting materials degraded the luminescent properties of the phosphor. This problem was studied by systematically investigating the effect by preparing samples using purer materials with intentional addition of known amounts of impurities. The development of Eu activated yttrium oxysulfide, red emitting phosphor used in the CTV tube was started and samples tested.

A multilayer screen on 1.25 mm tungsten sheet was made by coating seven successive layers of thickness ranging from 50 to 320μ on the substrate. The layers were clearly observed on the varian image monitor while testing. In the second screen, six layers of phosphors (two standard and four indigenously developed) were coated and tested. The NPL phosphor compared with the standard phosphor in resolution, but the image was less sharp as the brightness under X-ray was less.

DISPLAY DEVICES

1.1 *Liquid crystals and photonics*

A total internal micro-optic switch using high-tilt-angle materials was developed for photonics applications. The device showed excellent temperature independent electro-optic characteristics and exploited the maximum contribution of ferroelectric liquid crystal (FLC) birefringence. The switch showed

asymmetric response and interesting non-linear behaviour had a switching response of about 20 microseconds and showed a beam attenuation of ~ 5 x 10^7 in the off-state. A larger value of birefringence and higher extra-ordinary index of FLC than the refractive index of glass was chosen.

Extensive research investigations were carried out on the electro-optic, dielectric and refractive index properties of various polymer dispersed liquid crystal (PDLC) films prepared by solvent induced and thermal induced phase separation techniques. Low frequency dielectric studies showed that due to the difference in the conductivities of LC mixture and polymer matrix there was a charge accumulation at the LC-polymer interface resulting in a Maxwell-Wagner polarization. This led to an apparent increase in the dielectric permitivity of the PDLC film which inturn shielded a major portion of the electric field to appear across the LC droplets. The studies predicted a strong frequency dependence of the threshold voltage of film which was experimentally verified subsequently.

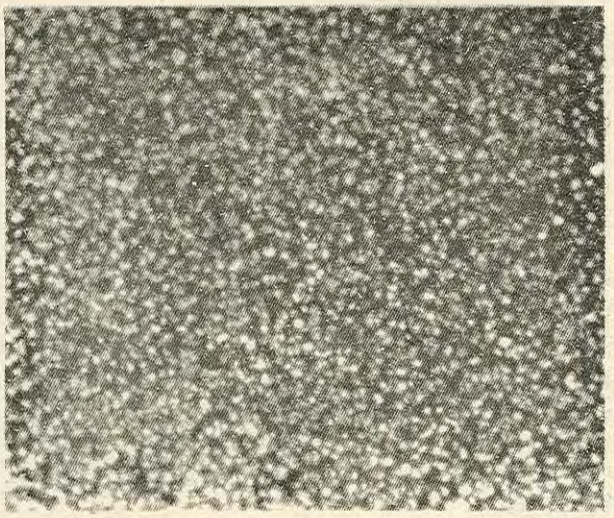


Fig. Optical micrograph of a polymer dispersed liquid crystal film under a polarizing microscope (x 400 magnification); LC droplets size ≈ 5 μm

Refractive index studies of PDLC mixtures with varying concentration of liquid crystal in the polymer matrix showed that for the low concentration (≤20%) of liquid crystal in the polymer, there was very little phase separation of it from the polymer matrix. With high content there was always a large amount of LC-mixtures that did not phase separate out from the polymer matrix and resulted in plasticizing of the polymer which modified the electro-optic performance characteristics of PDLCs very significantly.

Ferroelectric thin films of $BaTiO_3$ and Bi_4 Ti_3O_{12} were fabricated on a variety of substrates including quartz, steel plates and tin-oxide coated glass slides, by solgel technique. Through optimization of process parameters it was possible to obtain crystalline, transparent and crack free films of ~5000 A° thickness by spinning and post-deposition annealing in the temperature range of 550-600C°. Ferroelectric properties were confirmed by P-E hystersis loops. The dielectric constant and optical transmission were also measured.

The measurements on ac conducutivity of lightly doped polypyrrole films suggested that two relaxation mechanisms should be considered to explain the temperature dependence of ac conductivity. An elegant model was proposed which qualitatively explained the temperature and frequency dependence of ac conduction in polypyrrole films; one relaxation mechanism may be associated with hopping near the Fermi level and the other was the hopping of the carriers excited to the localized band tails. The origin of the dc conduction and dielectric relaxation was investigated and found the same.

1.2 *Development of biosensors*

The work was started in the sponsored project for the development of biosensors in collaboration with the CSIR Centre for Biochemicals, New Delhi and the Indian Association for the Cultivation of Science, Calcutta. The technological development of enzyme electrode involved the development of polymeric supports required for the immobilization of glucose oxidase and urease. In this context conducting polypyrrole and polyaniline chloride synthesized electrochemically and chemically were utilized for immobilization of the desired enzymes. A composite electronic circuit, both for potentiometric (urea) and amperometric (glucose) measurements, was developed. The precise measurement of blood glucose was greatly facilitated using an amperometric device.

1.3 *Conducting polymers*

The sysnthesis of fully reduced polyaniline i.e. leucomeraldine was carried out by oxidation and reduction of half oxidized polyaniline. The conductivity of pernigraniline and also of leucomeraldine measured, using four points probe method, was found to be 10^{-11}—10^{-10}. S.cm^{-1} respectively. The formation of polypernigraniline was confirmed from infra-red measurements. The shift of 3.0 eV to 2.6 eV observed in the UV visible spectra of polypernigraniline confirmed the formation of this important conducting polymer. Copolymer of aniline and anisidine was another conducting material that was chemically synthesized. The electrical conductivity of this conducting copolymer was found to be 10^{-2}—10^{-3} S. cm^{-1}. The FTIR spectra of this polyaniline-anisidine was recorded using Nicolet 510 P, which was installed at the polymers laboratory. The cyclicvoltametric studies carried out revealed the electrochromic response time of 25 m sec. on switching from oxidized to reduced state. Interesting space charge phenomena was observed in these films of polypyrrole. The analysis of dielectric relaxation studies conducted on metal-polypyrrole-metal capacitors revealed the presence of mobile free carriers. The mobility of charge carriers increased with decrease in temperature indicating that the transport properties in this conducting polymer strongly depended on mechanism such as scattering and trapping by defects. Polyaniline/metal Schottky junctions were fabricated. The estimation of various electronic parameters (Table) such as work function, barrier height, and ideality factor were determined through I-V measurements. The relative concentrations and moieties in a copolymer were estimated using theoretical models and experimental data. The electronic structure of the constituent monomers and the copolymer were computed with the experimental estimates. The workfunction of polyaniline was found to be between 4.10eV and 4.28eV. Excellent rectification was observed for indium/polyaniline junctions.

TABLE

Metal	Workfunction (eV)	Barrier height (V)	Ideality factor
In	4.12	0.4	1.9
Sn	4.11	0.4	4.9
Pb	4.02	0.5	6.9
Al	3.74	0.4	2.8

1.4 *Xeroradiograply*

The infra-structure was created for the development and precise characterization of the xeroradiography photoreceptors. The position of the deep intrinsic and photostructural defect levels in a-Se xeroradiographic photoreceptor films was indentified both for electrons and holes. The photoreceptors of Se doped with dopants such as chlorine and arsenic and also incorporating interfacial barrier layers of suitable polymeric materials were developed. These have shown about 50% reduction in their X-ray dosage requirements.

CARBON PRODUCTS

1.1 *Carbon fibres and composites*

A systematic study was undertaken to decode the courtille PAN precursor in terms of crystallinity, mechanical and thermal properties. A model was proposed for such stabilized fibres. The carbonization speed was enhanced and the total time taken for pyrolysis of stabilized fibres was reduced to only 10-15 minutes, as compared to 6 hours taken previously. Ceramic composites using silica and carbon fibres as reinforcements and glasses as matrix were developed. The processing parameters such as temperature, pressure, residence time, were varied and their effect on the mechanical properties was evaluated. The composites were characterized for microstructure, thermal and mechanical properties and fracture behaviour.

The work of synthesis and characterization of oxidation resistant ceramics viz. silica, titania, zirconia, silicon, oxynitride and silicon nitride, was carried out in collaboration with IIT, Delhi. Silica and silica based materials were synthesised employing sol-gel process. The alkoxides of silicon Si $(OR)_4$ were used as precursors for synthesis. The effect of certain organic constituents as drying control/chemical additive

to obtain a crack free silica monolith was investigated. The gels prepared under different pH conditions were characterized using physico-chemical techniques. The gels, prepared with silicon alkoxides were sintered in air and also in a mixture of nitrogen and ammonia atmosphere. The nitrides and oxynitrides of silica were obtained as suitable material for oxidation resistant coatings. The doped silica gels prepared by sol-gel techniques were also studied. Gels containing analytical reagents for nitride/nitrogen dioxide, sulphur dioxide/sulphite were prepared.

1.2 *Speciality carbons and pitches*

A simple process was developed for making impregnating pitches for carbon-carbon composites. The work was done on the development of high density high strength isotropic graphite from mesophase (liquid-crystalline) spherules with an average size around 10-15 microns. These spherules were moulded into a product which was carbonised to 950°C to obtain the isotropic carbon having special properties. The work of development of machineable glassy carbon plate for the fuel cell, was initiated.

The polymeric raw materials from solvent extracted pitch were made using a 5Kg. batch of coal tar. The material was drawn into a single filament pitch fibre which was stabilized and carbonized. Two samples of carbon brushes, for airforce helicopter, were made and sent for performance evaluation.

HIGH PRESSURE TECHNOLOGY

The synthesis of single crystals of cBN, using Mg as the calalyst-solvent material, was studied. The degree of three dimensional ordering and the purity of the starting hBN were investigated. It was observed that under the favourable P.T conditions, a reaction time of about 10 minutes was sufficient to bring out a complete hBN-cBN transformation and the longer duration was detrimental. The data on the percentage yield as a function of pressure, temperature and duration was generated in BN-Mg system.

The studies were conducted on quartz, limestone, sandstone and basaltic rocks, obtained from different sources of the Indian sub-continent and made under high pressure alone. The engineering design with drawings, of two-axis tracking mechanism for focussing of sunlight in paraboloid type solar collectors, was supplied to DNES, New Delhi.

CHARACTERIZATION

PURITY AND COMPOSITION

1.1. *Chemical Methods*

The work of development of rapid and accurate spectro photometric method for the determination of traces of silicon in alloys of copper and aluminium was done. A new method was developed for the determination of phosphorus in copper alloys by indirect atomic absorption spectrophotmeter and for the determination of sulphur dioxide (sulphite). New facilities were established for the ultra trace determination of metallic impurities in materials for electronics.

The measurement of methane emission from rice paddy fields and a rough estimate of toal emission from the fields was worked out. A number of samples received from different organizations were analysed for impurity concentrations.

A number of samples from the NPL projects and NTPC were tested for BET surface area and porosity. These included silica, activated carbon and carbon fibre.

1.2 *Standard Reference Materials*

Seven different laboratories participated in the programme and the data obtained on three reference solutions of lead and cadmium was compiled, analysed and certified values were assigned. The solutions were supplied to user organisations. The preparation of Indian reference solutions of arsenic and chromium was undertaken. The report on the examination of boiler tube was prepared.

1.3 *FTIR Spectroscopy*

A large number of samples from NPL projects and outside organizations, including CEERI, Pilani, were characterized using FTIR measurement facilities at ambient and at low temperatures. This included IR measurements, computation of the results, plotting of the spectra and interpretation of the observed bands. The samples included silicon, nitrite films, silicate and silica gel, amorphous silicon, germanium, KBr single crystals and quartz. Research investigations were also carried out.

1.4 *EPR Spectroscopy*

The implanted silicon wafers were studied in collaboration with CEERI, Pilani. The spin density of dangling bonds was found to decrease considerably on annealing these samples in inert atmosphere showing recrystallization of amorphous state during the process.

EPR studies of Cu In Se_2, during annealing, were continued. In vacuum annealing, the In_{Cu} donors were formed whereas V_{Cu} acceptors were dominant in air annealed samples. The properties of $CuInSe_2$ were governed mainly by these defects. Air annealng decreased the resistivity of these samples. A number of samples from NPL and outside organizations were analysed.

1.5 *X-ray Fluorescence*

The analysis of samples from M/s. Gujarat Heavy Chemicals Ltd. was continued. Relative variation of different elements in the sample was compared by using peak intensities of characteristic lines of the elements. Laterite ore samples from Orissa were studied further using addition method. The amount of platinum determined was again found to lie within the experimental error.

A singnificant shift from the theoretical position of computer peak was observed in graphite samples using RhK radiation. The magnitude of the shift was found to depend on both the thickness of graphite sample and the X-ray beam diaphragm used.

STRUCTURAL CHARACTERIZATION

1.1 *X-ray Diffraction*

X-ray diffraction techniques were used for the characterization of materials of various projects and outside organisations. A few hundred samples were

analysed. The elemental and structural analysis of boiler tubes was done. The structural and impurity analysis of certain catalysts from M/s. Indian Oil Corporation., R&D centre, was done on consultancy basis.

X-ray diffraction analysis was carried out on high Tc superconductor materials and the results were correlated with the observed Tc and microstructural properties. The effect on the properties of Y Ba Cu 0 screen printed thick films, as a function of silver content, was carried out. A small addition of silver (Ag or Ag_2O) helped in enhancing the superconducting properties and large amounts led to formation of 211 phase as the decomposed product and thereby deteriorated the quality of the superconductor. The densification and microsturctural studies on Bi Pb Sr Cu 0 indicated the decrease of density with the increase of sintering time, though the high Tc (110K) phase content showed increase through XRD analysis. To increase the volume fraction of high Tc phases (2223), mixed samples with Pb + Sb doping in a Bi superconducting system were studied systematically by XRD analysis. Extensive studies on TlBaCaCuO superconducting compounds were carried out. Three different starting compositions (2201, 1201 & 2202) were studied extensively with varying conditions of preparation. In collaboration with CEERI, Pilani, XRD studies on silicides of nickel and cobalt were carried out. The layered configuration increased the thermal stability of the silicides as confirmed by XRD. The optical constants of CuGaInSe thin films were determined in the wavelength range 400 - 1200 nm and were found to be independent of substrate temperature.

1.2 *Electron Microscopy and Electron Diffraction Techniques*

Characterization regarding microstructure and phase identification using transmission electron microscopy and diffraction techniques was carried out for about 200 samples of materials including polymer layers, film couples, films etc. A variety of powders were also examined for the determination of particle shape, size distribution and phase identification. Using scanning electron microscope and electron probe micro-analyser about 500 different types of samples were characterized regarding surface structure morphology and elemental analysis of a variety of materials including superconductors, composites and boiler tubes.

High Tc superconductors of Pb doped Bi Sr Ca Cu 0 system were prepared by varying the sintering parameters and the Tc was measured. The surface morphology of these samples was examined and the composition of the different phases was determined by electron probe microanalysis. The microstructure of these samples was investigated by transmission electron microscopy by using lattice imaging technique. The study led to the detection of isolated dislocations and intergrowth at certain regions.

Thin film couples of Au/Sn were prepared by varying the concentration of Au from 12 at % to 88 at % and annealed to different temperatures for different periods. The structure of the couples was investigated and different phases identified by electron diffraction. The study revealed that inter diffusion of Au and Sn was appreciable and this was rapid when annealed around 100°C and the alloy formation took place in few minutes. The crystallite size of the alloy increased several folds on annealing. The thin film couples of Sn/Air/Au were also studied. It showed the reflections of Au and Sn and no formation of alloy. On annealing these films around 110°C for a short period, intermetallic alloy formation was observed by electron diffraction.

The edges of shaving blades of a firm were examined by SEM for the surface structure and the results revealed that the width of the coating material on the edges varied. The corrosion/ erosion at different regions of the edges of the moisture affected blades was observed which damaged the smoothnes and the sharpness. The catalysts, provided by M/s. Indian Oil Corporation, Faridabad, were characterized for the particle size, shape and size distribution.

CRYSTAL GROWTH AND PERFECTION

1.1 *Five Crystal X—ray Diffractometer*

A five crystal X - ray diffractometer, developed and fabricated in the laboratory, was thoroughly tested and the maximum resolution evaluated. Diffraction

curves in Bragg geometry with (+, -, +, -, +) settings of the diffractometer were recorded using nearly perfect dislocation free silicon single crystals. The curves had shapes nearly the same as predicted by the dynamical theory of diffraction of X - rays. Hundred percent reflectivity was obtained with (III) diffracting planes. This diffractometer can be used for diffractometry, topography, stress measurements, lattice parameter measurements and for study of anomalous transmission of X - rays through crystals near diffraction maxima. It can be used in one-crystal, two - crystal, three - crystal, four - crystal and five - crystal configurations.

1.2 *Crystalline perfection and biaxial stress studies.*

Semi-insulating gallium arsenide single crystals grown by horizontal Bridgman and liquid encapsulated Czochralski method were investigated. The total thickness of the composite was 145 nm. Interesting differences between defect structure in crystals grown by above methods were observed. Depositions of multilayers produced biaxial stress which led to bending of the substrates. Bending of the blank wafers was such that the film produced bending in opposite direction and therefore film deposition led to a decrease in observed bending. This rather unusual feature was observed in these experiments. Annealing at lower temperatures led to relaxation of stress and the crystal regained original curvature. Preliminary experiments on anomalous transmission of X-rays through gallium arsenide crystals revealed that this was quite sensitive to stress. A part of this work was carried out during the visit of Dr. J. Wurfl from Technical University, Darmstadt, FRG, under collaborative project.

1.3 *High resolution X-ray diffraction studies*

Type II diamond crystals from late Prof. C.V. Raman's collection were investigated further. Slip line like features were clearly observed. Some dynamical features, typically of very perfect crystals, were observed for the first time though these showed very broad diffraction curves with half widths of about 200 arc sec.

Employing high resolution diffuse X-ray scattering (DXS) measurement technique and multicrystal X-ray diffractometer, structural defects produced by BF_2^+ ion implantations were carried out at room temperature on a NV-3204 Eaton Implantor at CEERI. DXS measurements were made along $\pm$ [100] directions around 400 reciprocal lattice point. The half widths of the diffraction curves increased slightly from 6 arc sec to 7 arc sec due to implantation. Isolated point defects of interstitial nature were observed on unimplanted regions in the observed volume of the reciprocal space. The distribution of DXS intensity showed that implantation produced point defect clusters. Experimental data was analysed by using a curve fitting method based on function minimization. Values of loops size, volume of the loops and number of defects per loop were determined. This work was carried out with collaboration of CEERI, Pilani.

1.4 *Crystal growth and data base development*

Single crystals of lithium niobate were grown on an indigenously developed crystal growth system. Niobium pentoxide and lithium carbonate were used as the starting materials. Experiments were performed to optimise ratios of lithium and niobate crystals. Some crystals were subjected to treatment in oxygen for determination of certain point defects.

Single crystals of K_2ZnCl_4 were successfully grown by Czochralski technique using idigenously developed polishing machine. The dielectric and ferroelectric properties of materials were evaluated. It was observed that these exhibited pronounced memory effects.

CONDENSED MATTER PHYSICS

HIGH TEMPERATURE SUPERCONDUCTORS

1.1 Basic Studies

The research on high temperature superconductors carried out related to the investigation of La-214, Bi-2122 and Y-123 systems. The samples studied were mainly polycrystalline bulk type. Systematic studies of transport properties of La_{2-x} Sr_x CuO_4 carried out over a wide range of composition with .02<x<0.4 and large temperature range of 4.2K <T <300K provided evidence for a transition from the metallic behaviour at higher temperatures to the variable range hopping (VRH) regime at low temperatures. A crossover from 3D-VRH to 2D-VRH was also observed as the system moved from the semiconducting nonsuperconducting regime to semiconducting-superconducting one. In the hopping regime localization length and the electron mean free path of the system were estimated and compared. With increasing Sr content, the former decreased while the latter increased. The above samples were further doped with Zn at the Cu-site in varying concentrations and their low temperature resistivity was systematically explored. There was an increase in the hole concentration with Sr addition while their localization occurring due to Zn doping. As the hole concentration became progressively larger owing to Sr substitution, a higher level of Zn doping was found to be needed to observe localization.

The effects arising from substitution of the rare-earth (RE) cations, namely, Eu, Dy and Tm at the Ca-site of Bi-2122 were processed under varying conditions. Under identical conditions, the aforesaid substitutions gave rise to near identical effect on resistivity temperature curves and Tc (R=O) as well as Tc-onset values. For dopant concentrations in excess of 50% a variable range hopping occurred at low temperatures. The results of the above study indicated that there was an optimum carrier concentration for superconductivity below which the insulating behaviour was depicted. The effects of substituting various d-band cations namely, Ni, Fe, Co as well as Zn and Ga at the Cu-site of Bi-2122 were characterized using XRD which confirmed their single phase nature for the low doping levels of 4 to 5%. The result corroborated earlier contentions that the mechanism of superconductivity in all the cuprates must essentially be the same. Samples prepared with substituting Dy^{3+} at the Ca^{2+}

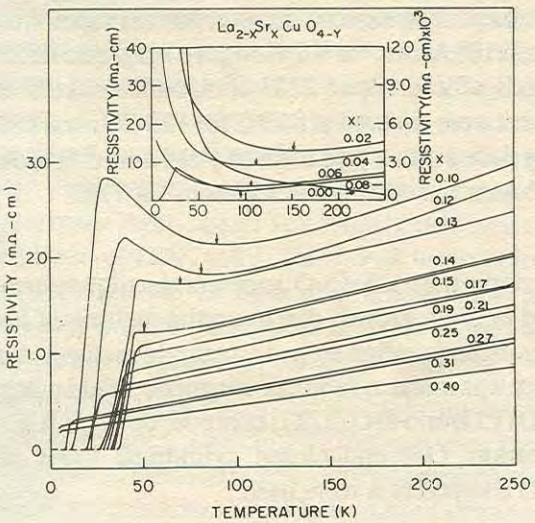


Fig. Resistivity - Temperature behaviour of La_{2-x} Sr_x CuO_4 system.

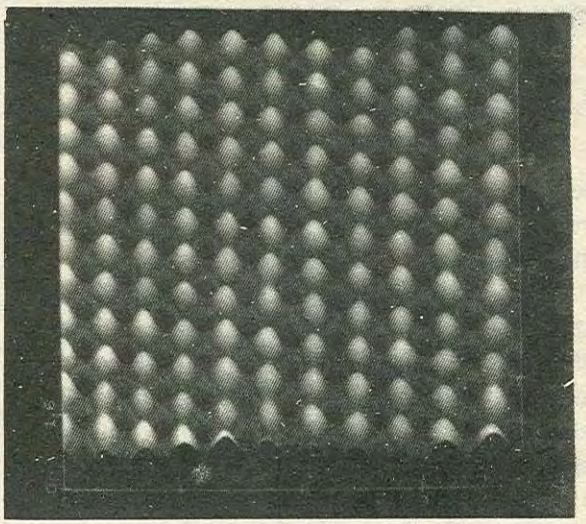


Fig. 4.0 nm x 4.0 nm STM 3-D image of the a-b plane of Bi-2122 sample. The atomically resolved image shows an average separation between 0-0 (Bi-Bi) atoms to be 0.38 nm at a bias voltage of -0.9 mV and low pass filtered.

site were systematically explored. The substituting gave rise to excess oxygen which got intercalated in Bi-O layers and made the Bi-O layers more insulating. It was concluded that for Tc enhancement the layer should be more metallic and free from excess oxygen.

Flexible tapes of superconducting Bi-2122 were prepared on a Ni substrate. Thick films formed by doctor blade technique on a Ni-tape showed an optimum Tc of 76K and the composite tape was found to be flexible. The estimated critical current density at 4.2 was 2000 Acm^{-2}. Under the Indo-French EEC Cooperation, the studies on Hall effect of Zn doped samples of $YBa_2Cu_3O_7$ were conducted to explore the drastic Tc depression due to Zn in spite of its non magnetic character. The carrier density at 300K was seen to be nearly independent of the Zn doping. The normal state resistivity behaviour change-over from matallic to semiconducting like was compared with that of La_{2-x} Sr_xCuO_4 and Zn doped La Sr Cu O systems. Extensive studies carried out on laser ablated epitaxial thin films of YBaCuO through magnetization and transport studies indicated significant results on these films when irradiated with He^+ ions. Contrary to neutron irradiation studies Jc was seen to drop by a factor of about 3 initially accompanied by a slower decrease later. Critical current density studies were made on Zn doped Er BaCu O and Bi Ca Sr Cu O systems.

Chemical vapour deposition technique was also invoked to develop good quality YBaCuO films on various substrates. Superconducting thin film with Tc of 90K and transition width of less than IKwas successfully developed. The morphology and structure of these films were also studied. These were found to be highly c-axis oriented with the pole figures showing a very good in-plane orientation with the substrate. The zero field Jc as deduced from the remnant magnetization or from the screening properties of the films was found to be strong function of the substrate. Jc at 10K and zero field inthe case of $SrTiO_3$ substrate was seen to be $1.2x10^7 Acm^{-2}$, a value close to the very best films obtained through laser ablation so far.

With collaboration of KfK group at Karlsruhe, FRG, flux line decoration studies were initiated on good quality single crystals prepared with different crucibles. The observed vortex patterns and the magnetic measurements were used to establish the correlation between crystal defect sturcture and the vortex pattern.

1.2 Processing studies

The inherent limitation of Pb-doped 2223 Bi Sr CaCu O superconductor was the high volatality of lead during the different processing steps. This difficulty was overcome upto a certain extent by utilising spray-drying of nitrate solutions. The samples thus obtained showed reproducible results in terms of homogeneity of the constituents and uniform reaction of lead with other constituents. Samples of nominal composition $Bi_{1.72}Pb_{0.32}Sr_2Ca_2Cu_3O_x$ were synthesized as a single phase 2223 in open containers. These samples showed a Tc of about 110 K by the AC susceptibility measurement.

Textured tapes of $Bi_2Sr_2CaCu_2O_x$ with Tc of 90K were prepared using screen printing technique on silver sheet. The current density, for the tapes was about $2x10^4$ A cm^{-2} at 4.2 K in zero magnetic field. The rods of lead doped 2223 compound encased in Ag sheet were sintered at 845°C for 120-240 hrs. and finally rolled into a tape form to yield a zero field Jc of 10^4 Acm^{-2} at 4.2K and 1500 Acm^{-2} at 77K.

Lead doping in YBaCuO superconducting system helped in grain growth due to partial melting of Pb during its preparation steps by ceramic method. An attempt was made to fabricate magnetic shield using YBCO (123) and BiO (2223) compounds for SQUID application. One end closed cylindrical tubes of YBCO composition were used.

Thin films of YB CuO approximatey one micron

were deposited by conventional thermal evaporation technique on different substrates. Different annealing schedules were tried to obtain a high Tc superconducting thin film,. X-ray diffraction analysis confirmed the presence of 123 phase without any peak for the non superconducting 211 phase but still some peaks remained unidentified. A glass apparatus was fabricated to deposit thin superconducting films of 123 compound by chemical vapour deposition technique using the volatile metallo-organic chelates, B- diketonate of copper,barium and yttrium were synthesized and purified. Theexperiments were performed to deposit metal films on different substrates and subsequently to oxidize them. The metallo-organic compounds of copper, barium and yttrium 2 ethyl hexanates were synthesized', purified and characterized.

RF. sputtering facility was created and cerium substituted barium ferrite magneto-optically active thin films were grown. The sputtering targetof130 mm was prepared by using standard ceramic technique. Three reasonably well characterized series of thallium based superconducting compounds with Tc ranging from 70K to 125K were synthesized. The effect of high temperature sintering (970±5°C) on the $TlBa_2Ca_{n-1}Cu_nO_x$ systems where n varied from 1 to 5, was studied. It was found that under optimized conditions of preparation, the final phase composition obtained could vary considerably from the starting or nominal composition. The calcium free $Tl_2Ba_2Cu_1O_x$ systems (2202)were also synthesized by the method of rapid cooling and flash sintering and it was shown that in 2201 system having no calcium and only one copper oxide layer, higher Tc's could be achieved and a Tc (onset) of 115K and Tc (zero) 96K was reported. The optimization of sintering temperature and formation of 2201 phase with no other phases and reproducibility confirmed the above findings.

The effectiveness of Pb doping on stabilising the high temperature superconducting 2223 phase was clearly brought out by synthesis of Pb-doped systems both in the bulk and thin film form. Optimization of various process parameters was towards achieving the highest volume fraction of 2223 phase and for the highest value of Tc. This was achievable after prolonged annealing of about 250 hours for the bulk and about 20 hours for the film. In one approach Bi was partially replaced by Pb+Sb, rather than Pb-alone. The best superconducting properties (Tc=111K and more than 80% 2223 phase) for this system were obtained in just half the annealing time required for system doped with Pb alone. No superconductivity above 77K was shown by this phase. In the second approach, addition of excess of Ca and Cu than the ideal composition of the high Tc phase was found to bring down a drastic decrease in the annealing time leading to best superconducting properties Tc>100K and more than 75% of the 2223 phase resulted in just 35 hours of annealing.

1.3. Superconducting magnet applications

The wide bore 7T magnet was wound using a wet winding process. The magnet can accommodate another magnet insert for producing higher field. The work on the sponsored project of superconducting high gradient magnetic separator was continued. The magnet was designed to produce a maximum field of 5T in a room temperature bore of 100mm. High magnetic gradient was produced by magnetic stainless steel wool packed at low density in a non-magnetic canister located at the centre of the field. The filtration of number of ores was carried out up to a field of 4-5T. This will be the first industrial application of a superconducting magnet in the industry.

1.4 High temperature SQUIDs

The multi-laboratory project on development of SQUIDs was successfully completed. RF SQUIDs based on screen printed thick films of YBaCuO and Bi Sr Ca Cu O superconductors were developed. The geometry of the SQUID consisted of hole of about 1mm diameter which was shunted with a microbridge of approximate dimension 0.2X 0.5 mm^2. The SQUIDs were also successfully operated in the flux-locked-loop mode which made it possible to measure external flux with values ranging from a fraction of a flux quantum to severalflux quanta with same high

sensitivity. The rf SQUID behaviour was observed upto 85K in YBaCuO films and upto 96K in BiSrCaCu-O films.

Thick films of $YBa_2Cu_3O_{7-x}$ superconductor were prepared on YSZ (100) substrate by screen printing technique followed by two step heat treatment in air. Tc of the films was 86K. Thick films of BiSrCaCuO superconductor were also prepared by this technique on MgO (100) substrate using calcined powder of nominal composition 1112. The annealing conditions were optimised so as to get a highest possible fraction of high Tc (2223) phase. The best films showed a Tc (R=0) 104K. Similarly $Bi_2Sr_2CaCu_2O_{8+x}$ films were also prepared using calcined powder of nominal composition 2212. However, when films were quenched after the second step heat treatment, they showed an enhancement in Tc (R=0) to 96K. The enhancement in Tc was attributed to favourable oxygenation of low-Tc (2212) phase.

The temperature dependence of the critical current of the microbridges showed that the grain boundary weaklinks behaved like either S-N-S or S-N-I-S Josephson junctions. A modified MBE system was established for deposition of thin films of high Tc superconductors by coevaporation technique. The system consisted of three interconnected ultra high vaccum (UHV) chambers. The ultimate achievable vaccum in the preparation and Auger chambers was 10^{-10} Torr while that in the load-lock chamber was 10^{-8} Torr. The substrates with films grown in the preparation chamber could be directly transferred into the Auger chamber under UHV conditions using another transfer rod. The preparation chamber had facility for simultaneous evaporation upto a maximum of five materials using two electron guns and three Knudsen cells. The chamber also contained three quartz crystal thickness monitors, a beam flux monitor, quadruple mass gas analyser, a reflected eletron diffraction facility, substrate rotation and heating facilities.

LOW TEMPERATURE PHYSICS

The computer simulation studies were conducted further on vortex turbulence in two-dimensional arrays of current driven Josephson junction arrays. In the phase space of these two control parameters various regions showing steady state, periodic, quasiperiodic and chaotic behaviour were found. The vortices were found to be the appropriate collective variables for this many-body problem. In particular the transition from quasiperiodicity to chaos was found to result from a deadsorption of the vortices from the drive edge into the bulk of the array and mixing of positive and negative vortices. The idea of vortices as collective variables may find applications else where in hydrodynamical problems.

Experiments were designed and conducted to study the superfluid transition of liquid helium contained in silica aerogels. The superfluid density in the helium aerogel system was measured by heat pulse propagation as a function of temperature at various pressures. A pressure independent exponent was found for the superfluid density and the superfluid transition remained sharp as close as 50μK away from the transition. This work was done under the Raman Research fellowship programme of the CSIR.

THEORETICAL STUDIES

The Coulomb interaction in cuprates was treated using a time dependent multiple scattering theory. This pairing mechanism was analysed to learn the nature of superconductivity in cuprates. A biopolaronic model of high Tc superconductivity, with idea that a doped oxygen hole reduced the separation between the d_{x2-y2} and d_{3z2-r2} levels of the neighbouring Cu-ion causing a Jahn-Teller mixing between the two levels was suggested. The model was consistent with the X-ray absorption spectroscopy results.

Relativistic electronic structure studies were carried out on catalytically important random alloys. Various relativistic effects in electronic structure of Au-Pd and Cu-Pt were analyzed and the catalytic reactivity suggested to be partly electronic in origin. A study of structural and electronic properties of some important biological molecules resulted in good estimates of their bond orders, valence indices and the net atomic charges.

DEVELOPMENTAL PROJECTS

THIN FILM

Attempts were made to develop narrow band interference filters in the UV region, having peak transmission wavelength anywhere from 340 nm down to 200 nm. The problem of monitoring of quarter and half wave thicknesses, was solved by choosing a suitable monitoring wavelength in the visible region and chopping the vapour beam during deposition. A few filters, made with this technique, exhibited band widths in the range of 15 to 25 nm and transmission 20-25%. Special narrow band interference filter in the near IR region, was designed and fabricated for Defence Department for their night vision system. Theoretical computation were carried out to design an all dielectric multilayer stack using "effective index" concept to antireflect low index substrates (1.25 to 1.35).

The development of diamond like carbon (DLC) films (sponsored by IRDE), was continued. Preliminary experiments were carried out in the home made plasma CVD reactor, showing encouraging results. DLC films coated on both the surfaces of a polycrystalline germanium substrate (50mm dia x 8 mm thick) enhanced its transmission from 46% to 87% at 10.0 micron wavelength with residual reflection only 5%.

CERAMICS

1.1 *Beta-Alumina tubes for Na-S battery*

An attrition mill of 10 litre capacity was procured to aid the grinding of beta-alumina powders for large scale production. Moulding jigs, flexible moulds and pressing jigs were fabricated for isopressing of tubes of size 36 mm O.D and 300 mm long. The tubes were sintered in V-grooved alumina plates to maintain the straightness. These plates were fabricated and were deformed after few sintering runs.

An effort was initiated to polish the tubes chemically to enhance the surface wettability of liquid sodium filled in it. Fifteen tubes each of 50 mm dia and 10 mm dia, complete with headers, were sent to CECRI, Karaikudi for making Na-S batteries.

1.2. *Piezoelectric Ceramics*

Transducer elements of different sizes and shapes were fabricated for use in parametric transducer, pinger transducer, minipingers and hydrophones. The development of $Zr_{0.75}$ Ti $Sr_{0.25}$ based system, having dielectric of 8000 and dielectric constant 40, was carried out.Electroacoustic parameters relating to barium titanate elements, from a sonar transducer array, were measured and studied for the changes produced by subsequent repolings.

CRYOGENIC SYSTEMS

The liquid nitrogen plant was maintained during the year and about 26, 000 litres of liquid nitrogen was produced and distributed in the laboratory. Miniature cryo-coolers were tested at SSPL, New Delhi. A prototype self-regulating cryo-cooler was designed and fabricated.

A high pressure gas accumulator for mini-cooler assembly of titanium alloy in 0.5 litre capacity, was fabricated and tested upto 6000 psi. A thermodynamic design computer code was developed for the stirling engine for power production. An efficient liquid expansion and transfer system was designed and fabricated. A modified version of the refrigerator for immunisation programme, was fabricated. A pressure swing nitrogen oxygen generator was developed which generated oxygen of 42% and nitrogen of 95% purity.

RADIO SCIENCE

INTERNATIONAL GEOSPHERE BIOSPHERE PROGRAMME

1.1. *Solar UV - B radiation measurements.*

Solar UV- B radiation measurement was continued with international light spectrometer from 290 - 400 nm wavelength for direct as well as global radiation at fixed solar zenith angles. Also total erythema was measured by a sensor peaking at 297nm. The global measurement, by automatic integrating type photometer, was continued for full day observation. The data of spectroradiometer was analysed for direct, diffuse and global variation of UV - B radiation for different days. Global UV - B radiation measurements made at Pune, Mysore, Waltair and direct UV - B radiation measurements at Trivandrum were analysed. It was observed that UV - B radiation received at ground in the year 1991 was less in comparison to previous three years, although there was appreciable increase in ozone values. This decrease could be due to increase in particulate matter and turbidity of the atmosphere.

1.2. *Aerosol measurements:*

Data sets pertaining to last four years (1987-1991) were analysed for monthly mean extinction co-efficient. Measurements were taken at 9 discreet wavel engths in 400 - 1025 nm range. Measurement of last two filters at 935 nm and 1025 nm also provided the estimate of water vapour in the atmosphere. A steady increase in extinction coefficient was observed at all the wave lengths from 1989 to 1991. The increase during January 1991 for the first four filters, from 400 - 590 nm was quite appreciable compared to remaining filters, while in February 1991, the increase was in the entire region. This abnormal high extinction coefficient may be due to increase of particulate matter, especially carbon and sulphur dioxide compounds drifting from the gulf region.

1.3 *Solar infrared measurement*

The solar spectroradiometer was calibrated using a 200 watt quartz halogen tungsten coiled - coil filament lamp standard traceable to NBS spectral irradiance scale. Line of sight water vapour measurements were made and using an inversion technique, water vapour content was evaluated. Measurement of solar infrared radiation in 2.5 to 14.5 μm range usingsunphotometer was continued. A few well defined absorption lines of water vapur carbondioxide, ozone etc were identified. The data obtained was used to estimate total ozone content in the vertical column.

1.4 *Rocket measurement of minor species.*

Data obtained from the flight carried out in 1989 was analysed and the nitric oxide concentration was derived as a function of altitude. Theoretical simulation of nitric oxide in the mesosphere and thermosphere was also undertaken and profiles were generated for all rocket flight conditions. The theoretical and experimental profiles showed fairly good agreement above 90 Km. Ozone concentration profiles were also derived from the data obtained from the two rocket flights carried out in March, 1991 under DYANA Campaign of IMAP. These profiles were also compared with the profiles obtained by other groups around the same time under this campaign and were found to be in fairly good agreement.

1.5 *Ozone studies.*

A systematic analysis of global ozone data was made using satellite and ground based observations. An important result was a missing peak in the Quasi Bienniel Oscillation (Q.B.O) in ozone during 1983. It was also seen that there was a reversal in the oscillatory peak above 34Km. The missing Q.B.O was attributed to EI Chichon volcanic eruption which contributed to aerosol loading. Studies of ionospheric absorption and total ozone data at a few stations showed low frequency oscillations. Fast fourier transform spectra indicated peaks with 20,30 and 50

day (a broad band between one to two months) periods. An attempt was made to see whether a mechanism existed between tropospheric, stratospheric and mesospheric levels.

SROSS AERONOMY SATELLITE

Flight packages of the sensors and electronic hardware of satellite payload were fabricated, tested and space qualified. The payload consisted of four packages named as RPA 11, RPA 12, RPA 13 and RPA 20. The fabrication of sensors was done in a dustfree controlled environment at the mechanical QA laboratory of ISAC, Bangalore. The packages were handed over to ISRO for spacecraft integration. The testing and qualification of the payload was done at the test and evaluation laboratory of ISRO Satellite Centre, Bangalore. The payload passed successfully all the environmental tests for flight acceptance.

The testing of RPA payload, during bench and other environmental tests, was done with the help of a payload checkout console (PCC) developed at NPL. The complete operation of the RPA payload was controlled with PCC. The data coming out of the payload was also stored in the PCC memory and was analysed in near real time to have the tabular or graphic display of results. Simultaneous to the activity of payload integration with the spacecraft, the work on the development of software, compatible to VAX as well as to the IBM PC was started for data recording and near real time analysis, after the satellite is being launched.

Preparations were going on for the launching of two high altitude RH - 560 rockets from SHAR coinciding with the overhead passess of the SROSS aeronomy satellite, to be sent into orbit towards the end of 1991. The rockets will be launched two or three months after the launching of satellite.

RADIO COMMUNICATIONS

1.1 *Long term solar and ionospheric predictions*

A new computerized method for predicting sunspot cycle was developed and the declining part of the current cycle No. 22 which peaked during July 1989, was predicted. Comparisons made between predicted values of smoothed sunspot number and those obtained from observations for the year 1990 were found to be satisfactory. A draft atlas of ionospheric communication parameters over the Indian sub-continent was prepared. The atlas contained characteristics along with error analysis on monthly basis for different stations in this region. A report entitled "Performance analysis of an HF radio link between India and Antarctica" was compiled for the Department of Ocean Development. It presents an analysis of the performane of the HF radio link between Delhi and the Indian Antarctic station Dakshin Gangotri.

1.2 *Studies on HF field strength.*

The study of field strength measurements of several HF broadcast transmissions yielded some important results. It was observed that transmission losses in HF bands arising due to random and short term ionospheric phenomena at low latitudes were particularly large during equinoctial methods. A provision of 4 dB towards transmission losses, other than free space and ionospheric absorption losses, seemed to bring the predicted values closer to measured field strength values for single - hop circuits in about 50% of cases in the Indian region and 8 dB about 90% of cases. These results were of great relevance in planning of HF circuits in India.

1.3 *Line of sight propagation*

A detailed study was made on the effects of path inclination on fading based on the experimental measurements carried out on various LOS links situated in different geographical locations of India. In regions, where super refractive and ducting layers prevailed for a considerable percentage of time, the design of LOS links should incorporate the concept of path inclination for minimizing the fading. It was also found that the rising layer in the morning hours reflected the electromagnetic signals to far off distances and acted as a source of interference. The

electromagnetic interference potential has shown that the range of an LOS transmitter for a normal reception could be as large as 110 Km.

1.4 *Rain rate characterization*

The characteristics of rain rate were studied using rain gauges having different integration time (10 secs, 15 mins. and 1 hour) over Delhi. The results on the relationship between rain intensity measured with different integration times were studied. The rain rate durations and return periods of the specific rain rate occurring within continuous rain events were also studied.

1.5 *VHF propagation*

Influence of obstacles such as mountains, ridges on VHF TV signal propagation was studied over 13 single knife-edge diffraction propagation paths in India. It was observed that in urban areas additional loss should be added to the predicted path loss to explain the observed values while the predicted path-losses obtained using Epstein - Peterson, Deygout and CCIR methods were found to be comparable to the observed values in the rural zone.

1.6 *Airborne microwave refractometer*

Airborne microwave refractometer data was used for collecting information (on near - real-time basis) in convective conditions. The analysis of data obtained during 9 June, 1983, flight revealed layer movement due to convection and the observed convection field growth rate was in agreement with the vertical wind velocity prevailing during the observational period. The observations showed excellent agreement, with the data collected using remote sensing systems.

In order to assess the atmospheric refraction anomalies and their bearing on low angle radar tracking problems, airborne microwave refractometer data was utilized. Path of the airborne radar rays was derived using a three - dimensional computer stimulated ray tracing technique combined with the radio refractivity profiles from refractometer observations.

1.7 *ARWC and consultancy services*

The period 1990-91 continued to experience high level of solar activity. ARWC issued several special warnings and forecasts on solar and geophysical conditions to aid a number of users, including ISRO, Bangalore. Consultancy services, related to HF, VHF and radio communications, were rendered to a number of organizations including CEERI, Defence Deptt. and Rajasthan Communication Ltd, Jaipur.

1.8 *Propagation of TV signals*

The diurnal variations of anomalous longdistance TV signals at Delhi were studied. As the peaks occurred both in 1978 and 1991 (solar activity peaks) this indicated to be a solar activity related effect. The operating frequencies of high power short wave radio transmitters were found to be closer to the plasma frequencies of F - region during high solar activity on several occasions especially during night.

INDIAN ANTARCTIC RESEARCH PROGRAMME

An acoustic sounding system was designed and developed in collaboration with the S V University, Tirupati and IIT, Kanpur. The system has a unique acousic shield designed to survive a wind velocity of 300 Km/hr. The system was established in Antarctica by the NPL team in December, 1990. A microbarograph and an automatic weather station were also established to study the planetary boundary layer effectively.

UV spectroradiometer and sunphotometer were used for taking observations during the 10th expedition. The data collected on solar UV - B measurements from 6th expedition onwards was analysed and compared with the satellite data for anti-correlation. Aerosol measurements taken enroute and at Maitri station during the period 1988-1990, were analysed for solar zenith angle dependence and were compared from year to year. It showed slight increase in the aerosol loading from 1988 to 1990.

The air samples brought form Maitri station in April 1990 by the antarctic expedition were analysed for green house molecules viz. methane, carbon dioxide and nitrous oxide. The concentration of methane over the year showed an interesting variation with a minimum during April - May and a maximum in December - January. Mean concentration of methane, carbon dioxide and nitrous oxide were found to be 1. 73 + 0.02, 373 + 10 and 0.359 + 0.01 ppm respectively.

The development and fabrication of the laser heterodyne system in collaboration with France was in progress. 1 GHz acousto-optic spectrometer was developed and tested. The system will act as aback end of laser heterodyne system to be sent to Antarctica. The absorption / emission lines of the atmospheric minor constituents will be resolved with a high spectral resolution to obtain vertical profiles of various trace species using inversion techniques.

RADIO AND ATMOSPHERIC PHYSICS

1.1 *Aeronomy of Venus & Mars - ionopause and electron temperature*

Inspite of the long Venus night there was a remarkable abundance of ions on the nightside, featuring the same constituents as on the dayside. The height of the near terminator ionopause was very crucial, since it determined the strength of the source. It was generally accepted that during solar maximum at times, when solar wind dynamic pressure (PSW) was high and during solar minimum at all the times, the terminator ionopause came down to very low altitudes (250-300 km). It was shown from the pioneer Venus spacecraft measurements that the terminator ionopause always remained above about 500 Km, there by providing a large reservoir for plasma transport from dayside to nightside all the time. The ionopause definition applicable to transport studies, was the altitude where the ions *pause* and that was used in the analysis.

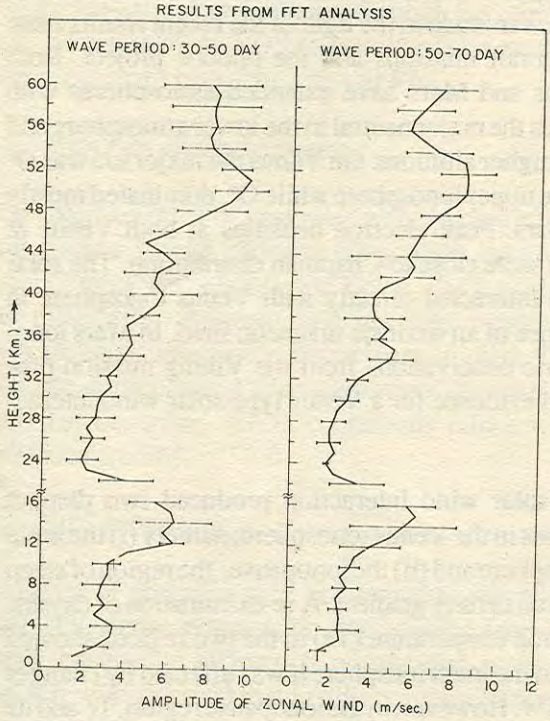
A detailed comparison of the neutral atmosphere, ionosphere and solar wind interaction of Venus & Mars was made in the light of the recent results from spacecraft missions and the phobos project. Both Venus and Mars have extended atmospheres with CO_2 as the major neutral in the lower atmosphere and O at higher altitudes. On Venus the major ion was O^+ in the upper ionosphere while O^+_2 dominated mostly in Mars. Peak electron densities at both Venus & Mars were close to Chapman distribution. The solar wind interacted directly with Venus ionosphere in absence of an intrinsic magnetic field. In Mars ionospheric observations from the Viking mission provided evidence for a Venus type solar wind interaction.

The solar wind interaction produced two distinct regions in the Venus ionosphere, namely (i) the main ionosphere and (ii) the ionopause, the region of steep electron density gradient. A re-examination of dayside electron temperature (Te) in the two regions showed that in the main ionsphere it was affected by changes in PSW. However, in the ionopause region, Te and its height gradient were grossly affected by changes.

1.2 *MST Radar spectra and atmospheric waves*

A quick fit algorithm, following an approach followed at Poker Flat, was developed and tested for validity using the available spectral data. The agreement between the moments from the present algorithm and those given by Poker Flat was found to be satisfactory, suggesting that it can be used for quick fit algorithm of the data from India MST Radar.

Long series of wind data from regular radiosonde and rocketsonde flights were analysed using Fast Fourier Transformation and Maximum Entropy Method techniques to study atmospheric waves of 30-70 days period. Data of zonal wind over near-equatorial station Thumba, collected by M-100 rockets and radiosonde balloons, was used for the purpose. These atmospheric waves were not confined to south-westerly monsoon season but also noticed to be equally strong in north-easterly monsoon season. The waves were observed at tropospheric as well as stratospheric heights. The phases of both 30-50 days and 50-70



days waves were noticed to be advancing downward. The analysis of meridional wind suggested that waves did not conform to Kelvin waves.

1.3 *Incoherent scatter radar studies*

The incoherent scatter measurements at Arecibo were used to deduce width and depth of the EF valley. These parameters were compared with those calculated from Gulyaeva's empirical relation. The incoherent scatter measurements did not show any significant valley during daytime, these confirmed the occurrence of significant valley during night. The width of the valley calculated from Gulyaeva's relation was larger during the day but smaller during the night, as compared to the observed values. However, the depth of the valley calculated from Gulyaeva's relation was lower during the day but much higher during the night, as compared to the observed values.

1.4 *Satellite beacon studies*

The VHF signals of the geostationary satellite ETS-2 and L-band signals of the geostationary satellite INMARSAT for amplitude scintillations were monitored. The signals of the ETS-2 were terminated on Dec. 14, 1990, because of the reallocation of the 136 MHz band for mobile communication. Since then 244 MHz signals of the geostationary satellite MARISAT were recorded for amplitude scintillation studies. Data from three station network- Delhi, Meerut and Panipat was recorded during Jul.-Aug. 1990 and from the network-Hyderabad, Shadnagar and Vikarabad was recorded during Nov. 6-28, 1990 for TID studies. An algorithm which detected all the travelling ionospheric disturbances and determined their various parameters viz. amplitude, period, speed, direction and wavelength was developed.

A study of IEC at Hyderabad during 1979-87 showed that IEC increased with solar activity, post sunset secondary maximum was observed during high solar activity and diurnal maximum in summer months showed saturation after 170 units of 10cm solar flux. An analysis of post sunset secondary maximum, scintillations and Faraday polarisation fluctuations at Hyderabad showed that Faraday polarisation fluctuations were observed only on those days when both amplitude scintillations and post sunset secondary maximum were present. Computer simulation studies of the effect of geometry on satellite Faraday polarisation fluctuations showed that during high solar activity depolarisation effects were comparatively less at Hyderabad than at Delhi.

1.5 *Ionospheric effects*

The ionospheric effects observed during the great storm of 13 March 1989 were studied in detail using ionosonde observations for some equatorial and low latitude stations. Significant longitudinal differences in the stormtime responses were observed both during day and night. The dramatic night time ionization collapse observed at Kodaikanal was not seen at Manila located 45°E of Kodaikanal. The collapse of Kodaikanal could be accounted only partly as due to increased loss rates caused by lowering of layer heights and increased neutral temperature. The presence of a localized heat source was suggested to

account for the observed decay in ionization.

1.6 *Electric and dynamo fields*

The storm time electric fields at equatorial latitudes were studied from the F region height variation during the high solar activity period. This study revealed that the increase in these electric fields observed during the first day of the storm on certain occasions could be attributed to the penetration of magnetospheric electric fields and the decrease observed during the second day on many occasions could be due to the disturbance dynamo electric fields generated by the thermospheric wind system driven by heating in the polar regions.

The design of the rocket experiment for studying the F-layer dynamo fields, was worked out. It consisted of specifying the time, location and extent of modification to be made in the E region conductivity in the post sunset period and observing its dynamical effect on the F region at Thumba connected by the geomagnetic field line.

1.7 *Microwave/millimeter wave radiometry*

Microwave propagation studies for slant path attenuation distribution and instant measurement of rainfall rate were evaluated. It was shown from the scatter plot that the attenuation against rainfall rate varied between 0.04 + 0.08 R and 0.04 + 0.11 R. It was observed that for 0.1 % of time, the attenuation exceeded for slant path was of the order of 6 dB corresponding to the rainfall rate of 60 mm/h.

An inversion technique for evaluating water vapour content over land and sea from SAMEER on board satellite platform Bhaskara was evaluated and compared with the radiosonde measurements. The integrated water vapour content for different latitude-longitude range over Indian subcontinent was plotted in the form of contours for 0900 and 1400 hrs. Indian Standard Time averaged over the months of July-August 1979. The value of water vapour content was found to be less over the Arabian sea than over the Bay of Bengal. A large cross-equatorial water vapour flux existed in the eastern part of the Indian ocean and brought moisture in the Bay of Bengal.

1.8 *Ionospheric time delays*

A detailed study of excess time delays recorded in Global Positioning Satellite measurements at 1.57542 GHz following the solar flare events of 12-17 August, 1989, period was made. The delays were of the order of 1280 nano secs. during normal days and increased by about 100-120 nano secs. following the X-20 flare on 16 Aug. 89. The excess time delays showed good correlation with increases seen in N_mF_2 values at Ahmedabad, corresponding to sub-ionospheric point of the satellite.

1.9 *Equatorial plasma bubble dynamics*

The equatorial bubble dynamics was studied using scintillation observations at 4 GHz from two satellites, INSAT-1B (74°E) recorded simultaneously at two earth stations, Sikandarabad and Chenglepet during 1989 along the same geomagnetic meridian. The characteristics and occurrence pattern of the scintillations suggested that these were equatorial plasma bubble-induced events. The east-west plasma bubble irregularity motion was also estimated from the systematic onset time differences observed between the equatorial and low latitude station. The difference in the magnitude observed between the present results and those reported by other techniques were interpreted in terms of the vertical shears in the plasma zonal flow over the equator.

INFRASTRUCTURAL FACILITIES

LIBRARY

The library continued to provide documentation and reprographic services to the scientists of the laboratory. The transaction of acquisition, subscription of journals, circulation and information retrieval were done on the computer. The library added 476 books in the areas of physics and related subjects, raising the collection to 89,110. About 70 titles in Hindi were also added. It subscribed 290 journals on payment basis and received 42 on gratis. It continued to receive patent specifications from the Indian patent office. The library continued to provide services of document-loan, inter library loan, bibliography and literature search to the scientists and research students. More than one thousand outsiders visited the library for their use. The library added another xerox machine for the use of scientists on self-service basis.

COMPUTER FACILITY

VAX-11/780 and Zenith SC computer system were in regular operation during the year. Computers were utilized by the scientists for their computational work as well as for documentation and bibliographical applications. The administrative staff utilized the facility for monthly payroll and allied activities. An IBM PC compatible computer system based on Intel 80386 was acquired to develop software and provide consultation service to PC users of NPL and for transferring files from VAX system to PC floppies and vice versa.

The computer staff provided consultation services to users and developed special subroutines and programmes for scientists working in the laboratory. The jobs regarding software design and its execution on VAX system were done for outside organisations realizing an amount of about Rs. 1.5 lakhs.

WORKSHOP

The workshop assisted the scientists of various projects of the laboratory regarding the fabrication and repair jobs. The *Drawing Section* served scientists for their design work and for making of drawings, graphs and charts.

The *Mechanical Processing Activity* section provided assistanee in the fabrication of jobs. The developmental work, regarding the sponsored project of DMRL, Hyderabad, was completed and a report submitted. The work of development of secondary processing of metal-matrix composites was done and the billets having improved properties were produced. The extrusion studies of billets were also undertaken.

GLASS WORKSHOP

The unit provided assistance in the fabrication of glass and silica apparatus, to various R & D projects of the laboratory and outside parties. The jobs worth Rs. 3.086 lakhs approximately were completed during the year. The fabrication of special glassware apparatus was done for various universities, R&D institutions and industry. These included universities of Rajasthan, Delhi, Punjab, Himachal Pradesh and Jawaharlal Nehru; IARI, New Delhi; ONGC, Dehradun; NBRI, Lucknow; RRL' Jorhat; DNES, New Delhi; BHEL, Haridwar; IOL, Faridabad, Modi Rubber Ltd., Modipuram; JCT Ltd., New Delhi and Industrial Carbon, Calcutta.

The various items fabricated included BET spectrometer apparatus, Dewar flasks, double distillation apparatus, mercury diffusion pump, UV transmitable flasks, air sampler, solar collector tubes, microtest oxidation apparatus, decompostion and reaction tubes, vacustat and Soxhlet apparatus.

INSTRUMENTATION

Complete electronic circuitry was designed and developed for a temperature controlled crystal oscillator to be utilised in a precision digital frequency counter. A constant voltage float charger was fabricated. Highly stable and regulated power supplies were made. A frequency converter was also developed and proto-type model was under fabrication. Complete circuit of 5 1/2 digit voltmeter was designed, fabricated and tested. A PCB was designed

and fabricated to accommodate all such circuits. A simple 5 digit voltmeter was made for microprocessor hardware and softwares were completed. A precision acoustic power meter for the measurement of power of therapeutic ultrasonic sources was designed and fabricated. Radiation pressure due to ultrasound source was monitored with the help of semiconductor strain gauge transducer. The bone fracture diagnostic instrument was studied on patients at Adya Orthopaedic Hospital, Bareilly, to diagnose bone disorders and their rate of healing.

The work on the development of an ultrasonic kidney stone disintegrator was continued. A focussed ultrasound disintegrator was developed with seven individually focussed transducers having a common focal point. The ultrasonic parameters of kidney and gall bladder stones were determined by using a doubleprobe through-transmission technique. The elastic parameters such as crushing load, crushing strength and hardness were studied by using Instron universal testing instrument. The results obtained were correlated with ultrasonic parameters and chemical composition. Electrical and dielectric properties of human kidney stones were studied as a function of frequencies from 10 kHz to 1.5 MHz. The dielectric loss factor, dielectric constant, resistivity, charge constant and voltage constant were also determined.

The work on development of ultrasonic transducers for scientific and medical applications was continued. A rectangular array of thirty six elements was made and tested for layer by layer of materials. Ultrasonic techniques were studied for developing an instrument to detect adulteration. A number of instruments from other projects were analysed and repaired. Electronic components and devices were tested and certified on regular basis for acceptance by the central stores of the laboratory.

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PATENTS

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2. Rastogi AC, Balakrishnan K & Salkalechen-An intregrated thin film CdS Colar fabrication and encapsulation technology, accepted, 1990.

3. Bhatia Gopal & Aggarwal RK-An improved process for the production of glassy carbon, sealed, 1990.

APPENDICES

SPONSORED / SUPPORTED PROJECTS

Title	Agency	Amount received during the year Rs. (lakhs)
COMPLETED		
A study of degassing characteristics of materials in ultrahigh vaccum.	DST	—
Compendium of R & D activities in the area of fibre reinforced composites in the country.	ARDB	0.300
Printing of a report on polycrystalline thin film technology for solar cell application.	DNES	0.120
Development of motor body component on prototype scale.	DMRL	—
Development of process simulator diffusion modelling	DOE	—
Tropospheric and ionospheric communications in HF and microwave bands.	Defence	0.710
Monitorning of solar ultraviolet radiation at the ground in the UV - B region (completed last year)	ISRO	0.500
CONTINUING		
Development & Characterization of acoustic tranducers & materials for applications in ocean engineering	DOD	0.136
Augmentation of primary electronic standards.	DOE	—
Improving the quality and reliability of standard Time & Frequency signals (STFS) to Echelon - II laboratories.	DOE	—
Photolithographic mask aligner using modified moire technique	DOE	—
Development of expert optical system	DOE	—
Calibration service programme under the National Coordination of Testing & Calibration Facilities Programmes NCTCF.	DST	—
Study of the tropical boundary layer meteorology at Jodhpur using monostatic acoustic sounder and instrumented tower.	DST	—
Metrological studies on standards of measurements.	DST (INDO - US)	—
Interaction of small gas molecules with semiconductors metal interfaces as studied by surface analytical techniques.	DST (INDO - US)	—
Establishment of transfer leak standards in vaccum metrology.	DST (INDO-US)	—
R & D in Laser frequency standards	DST (INDO - USSR)	—
Development of technology of indigenous manufacture of retro - reflective sheeting / tape.	SUR TRANSPORT	2.500
Development of Laser resistant carbon fibre compositis	ARDB	—
Hot extrusion & cold forging.	British Council	—
Multicrystalline silicon ingot technology.	CEL	—
Thinfilm polycrystalline interface cells	CEL	—
Development of Sodium - Sulphur batteries for electric vehicle.	DNES	—

Hydrogenated amorphous silicon films (Phase-II)	DNES	6.000
Study of electrical conductivity of mantle forming rock minerals under high temprature environment.	DST	—
Technical feasibility and concept proving in the area of biomolecular devices - technical development of biomass.	DST	29.480
Bench scale experimental studies on impregnating pitch.	DST	—
Synthesis, characterization & application of some conducting polymers.	DST (INDO-EEC)	3.679
Volatile metal organic compounds.	DST (INDO - USSR)	7.890
DOE-NPL Centre for characterization of materials for electronics.	DOE	60.00
Growth of nearly perfect crystals of oxides like lithium niobate.	DST (INDO-USSR)	17.340
Data base on electronic materials.	DST (INDO - USSR)	3.000
Low dimensional coulomb system	DST	—
National superconductivity fellows (National Superconductivity Programme)	DST	1.673
Superconducting magnetic separator	DST	—
Studies of polycrystalline bulk, thin films and single crystals of high temperature superconductor	DST (INDO-EEC)	—
Perparation, characterization and precision measurements of semiconducting materials.	DST (INDO-US)	2.850
Studies on high temperature superconductivity.	DST (INDO-USSR)	—
Development of Stirling engines for power production	DNES	—
Laser heterodyne system for the study of ozone and other minor constituents in Antarctica.	DOD	17.500
A ground based millimeter wave technique for ozone observations at Antarctica.	DOD	22.000
To monitor solar infrared radiation for studying minor constituents in atmosphere using infrared spectrophotometer.	DST	—
Development & decay of scintillation producing irregularities and gravity wave propagation in low latitudes.	DST	—
Ionospheric modelling for radio communication including effects of the artificial modification of ionosphere.	DST (INDO - USSR)	3.900
Very long baseline interferometry	NGRI	20.000
NEW		
Development and supply of pressure vessels and storage tanks.	DRDL	21.455
Development of high X-ray sensitive photo receptors for dose reduction in xerography.	DOE	6.140
Synthesis of high Tc superconductive materials through eutectic melt.	DST	0.800
Acoustic sounding system at Antarctica.	DOD	4.580

PREMIA & ROYALTIES

(ending 31.12. 89)

PROCESS	PARTY	TOTAL AMOUNT (Rs.)	LA B SHARE (Rs.) (40%)
Silver Impregnated Graphite Contacts	Jyoti Refinery, Bombay	2,09,513	83,805
Cinema Arc Carbons	Britelite Carbons Ltd., Baroda.	1,44,000	57,600
Indelible Ink	Mysore Lac & Paint Works Ltd.,Mysore.	25,000	10,000
Hard Ferrites	Ferrites & Electronics Components Pvt., Ltd., Lucknow.	13,377	4,551
Ceramic Capacitors	Southern Electronics (India), Cochin.	4,551	1,821
Reconditioning of Picture Tubes	Videotronics, New Delhi	1,802	721
Ultrasonic Probes	Technotronics Indus. New Delhi	1,738	695
Film Thickness Monitor	Vaccum Instruments Co, New Delhi	833	333
Ceramic Rods for Carbon Resistors	Micro Ceramics (P) Ltd., Hyderabad.	273	109

PROCESSES RELEASED

PROCESS	PARTY	TERMS
Electronic & capacitive ballast, voltage regulatorand timer	M/s. Energy Conservation Devices, 20/181D,W. Patel Nagar. New Delhi	Premium - Rs. 40,000 Royalty- NIL
Manufacture of glassy carbon	M/s. Graphite India Ltd., 407 Ashoka Estate, Barakhamba Road, New Delhi.	Premium - Rs. 50,000 Royalty-NIL
Oxidised PAN fibre	M/s. Jagjiwan Enchem, Udyog Ltd., Shreeji House, Ahmedabad	Premium-Rs. 50,000 Royalty - NIL
Mono-chrome T.V. picture tube phosphors.	M/s. Hindustan Hi-Tech, Industries Ltd. Flat No. 102, Madangir, New Dalhi.	Premium -Rs. 10 Lakh Royalty-2.5%
Recovery of silver from waste hypo-solution	M/s. B. Rajeshwari Devi Prayag, Althana Road,Trivandrum.	Premium - Rs 10,000 Royalty-NIL
Rear view prism	M/s. Indtrument Design Development & Facilities Centre, Ambala Cantt.	Premium - Rs 35,000 Royalty- NIL
Flexible graphite tapes & sheets.	M/s. Stoplik Services (India) Pvt. Ltd., Bombay.	Premium - Rs 55,000 Royalty-2%
Thermal stabilisation of PAN fibre.	- do -	Premium - Rs 50,000 Royalty-2%

CONSULTANCY

Sl. No.	TITLE	PARTY	AMOUNT (Rs.)
	ACOUSTIC STANDARDS		
1.	Acoustic treatment of Vidhan Sabha Mandap, Lucknow	Ex-Engineer Anurakshan Khand, No-1, PWD, Lucknow	30,000
2.	Acoustic treatment of walls & ceiling of hall of Govt. Degree College, Ramnagar, Nainital.	PWD, Ramnagar, Nainital.	20,000
3.	Acoustic treatment of assembly hall of Indira Gandhi National Forest Academy, Dehradun.	CPWD, R.K. Puram, New Delhi	20,000
	MATERIALS CHARACTERIZATION		
1.	Detailed structure & impurity analysis of certain catalysts.	Indian Oil Corpn, R&D Centre, Faridabad.	60,000
2.	Advice on water descaling system.	Amrit Aqua Equipment (P) Ltd; New Delhi.	1,200
	DEVELOPMENTAL PROJECTS		
1.	Replacement of present vaccum system by a more efficient system.	Hindustan Vaccùm Glass Ltd., Faridabad.	22,450
	INSTRUMENTATION		
1.	Upgradation, standardisation & calibration of vehicular exhaust smoke density instrument.	Envirotech Instruments (P) Ltd, A-271, Okhla Industrial Complex, New Delhi.	52,000
2.	Digital electronic security lock.	Aakrity Plastic Products (P) Ltd, Karol Bagh, New Delhi.	7,700
3.	Improvement in the circuitry of axle weighing indicator.	Central Road Research Inst; New Delhi.	7,200
4.	Consultancy on electronic 3-way buzzer.	Energetics Innovative Electronic System, Green Park, New Delhi.	4,500
5.	Optimisation of electronics & performance of cordless remote control for air-conditioners.	Touch System, Janak Puri, New Delhi.	1,600

RECEIPTS OF CALIBRATION/TESTING AND OTHER CHARGES
(realised during 1990-91)

ACTIVITY		AMOUNT (Rs.)	REPORTS (No.)
STANDARDS			
	Force & Hardness.	9,38,075	546
	Optical Radiation	5,38,625	93
	Dimensional Metrology	4,82,750	379
	Temperature	4,16,700	253
	Mass, Density & Viscosity	2,94,425	440
	HF & MW Voltage, Current Power, Freq. & Noise	2,02,250	33
	D C	2,01,250	131
	Pressure & Vacuum	1,83,750	55
	AC & LF	1,38,500	35
	LF & HF Impedance	95,500	89
	Acoustic	83,150	28
	Time & Frequency	27,000	15
	HF, MW Attenuation & Impedance	26,500	13
	Length	9,000	5
	Ultrasonic	7,000	5
	Materials Characterization	99,500	29
	TOTAL	**37,43,975**	**2149**
OTHERS			
	Glass Fabrication	3,08,625	
	PZT Materials	24,110	
	TOTAL	**3,32,735**	

R & D LINKS COLLABORATION

The laboratory continued to maintain active scientific liaison and collaboration with other institutions, CSIR laboratories, universities, Government departments and international laboratories regarding projects and studies. The names of the organisations and the areas of collaboration are listed below:-

INDIA

Agra University (Instrumentation)
Anna University, Madras (Superconductivity)
Banaras Hindu University, Varanasi (Superconductivity, Theoretical Studies)
Bharat Heavy Electricals Ltd, Hyderabad (Superconductivity, Carbon)
Bureau of Indian Standards (Standarads)
Central Electrochemical Research Institute, Karaikudi (Ceramics)
Central Electronics Engineering Research Institute, Pilani (Superconductivity, Characterization)
Central Electronics Ltd., Sahibabad (Silicon)
Central Glass & Ceramic Research Institute, Calcutta (Superconductivity)
CSIR Centre for Biochemicals, Delhi (Display Devices)
Defence Metallurgical Research Laboratory, Hyderabad (Mechanical-Processing Activity)
Delhi University (Characterization, Instrumentation)
Department of Non-Conventional Energy Sources, New Delhi (Thin Film, Materials)
Department of Ocean Developmen New Delhi (Radio Science)
Department of Electronics New Delhi (Silicon, Characterization)
Electronic Regional Test Laboratories (Standards)
F.I.E. Research Institute, Ganga Nagar, (Force Standard)
Indian Assocition for Cultivation of Science, Calcutta (Display Devices)
Indian Institutes of Technology, Bombay (Superconductivity)
Indian Institute of Technology, Kanpur (Radio Science)
Indian Institute of Technology, New Delhi (Carbon, Characterization)
Indian Space Application Centre, Bangalore (Radio Science)
Indian Space Research Organistion, Bangalore (SROSS Satellite, Radio Science)

Jadavpur University Culcutta (Impedance Standard)

Poona University (superconductivity)

Rajasthan Communication Ltd, Jaipur (Radio Science)

Rajasthan University (Superconductivity)

Regional Research Laboratory, Trivandrum (Superconductivity)

Shriram Institute for Industrial Research, Delhi (Superconductivity)

S.V. University, Tirupati (Radio Science)

OVERSEAS

Asia Pacific Metrology Programme (Standards)

Commonwealth India Metrolgy Centre (Standards)

FRANCE

Centre de Recherche Paul Pascal, BODEAUX (Carbon)

National Centre for Scientific Research, CNRS Meudon, Grenoble (Superconductivity)

Meudon-de Observatoire, Paris (Radio Science)

FRG

Institute fur Hochfrequenztechnik Technische Hochschule, Darmstadt.

KfK Group, Karlsruhe (Superconductivity)

Max Planck Institute, Stuttgart (Superconductivity)

Physikalisch Technische Bundesanstalt, Braunschweig, (Standards)

JAPAN

Gunma University, Kiryu Gunma, (Carbon)

UK

Oxford University (Conducting Polymers)

USA

National Institute for Standards Technology, Washington (Standards)

University of Arizona (Characterization)

University of Cincinatti (Superconductivity)

USSR

Institute of Inorganic Chemistry, Novosibirsk (Electronic Materials, Crystal Growth)

Institute of Metal Physics, Sverdlovsk (Materials)

P.N. Lebedev Institute, Moscow, (Standards)

VNIIFTRI MOSCOW (Standards)

VNIIM D.I. Mendeleyev Institute Metrology (Standards)

SPECIAL LECTURES

SPEAKER	*TOPIC & DATE*
Dr. Sergey A. Degterjov, Moscow State University, Moscow	Thermodynamic properties and stability of phases in Y-Ba-Cu-O systems, April 2.
Dr. S. K. Saha, Visiting Scientist from USA	Applications of non-linear optics in science & technology, June 15.
Prof. P.S. Gill, former Director, CSIO, Chandigarh	Science of chaos, June 19.
Dr. Cedric Powell, NIST, USA	Accuracy & precision of quantitative surface analysis by AES & XPS, June 21.
	Attenuation lengths and inelastic mean free paths for low-energy electrons in solids, June 21.
	Reference materials and reference data for quantitative surface analysis, June 22.
Dr. P. Ganguly, National Chemical Laboratory, Pune	Materials problems in high Tc superconductors, June 26.
Dr. U.N. Singh, University of Maryland, USA	Laser remote sensing of the atmosphere, July 10.
Prof. S.D. Mahanti, Michigan State University USA	Structural properties of high Tc superconductors and their relationship with electron-phonon interaction, July 19.
Dr. U. Balachandran, Argonne National Laboratory, Illinois, USA	Improved processing of ceramic superconductors , I, Aug. 8.
	Fabrication of ceramic superconductors for practical applications, Aug. 13.
	Development of monolithic solid oxide fuel cells, Aug. 17.
Prof. Knowbloch, University of California, Berkeley.	Introduction to bifurcation problems,Aug. 16
Prof. P. Boolchand, University of Cincinatti, USA	Metal doping effects in 1 2 4 system, Aug. 24.
	Metal doping effects in Bi 2 1 2 2, Aug. 28.

	Use of close cycle refrigerator for low temperature research Sept..5.
Mr. R. B. Mitson, Fisheries Lab. Lowestoft, UK.	Acoustic tags for fish, Sept. 12.
	Observation of fish behaviour, Sept. 19
Prof. J. Wurfl, Inst. fur Hochfrequenztechnik, Darmstadt, FRG.	Enhancing the reliability of Ga As devices requirement and solutions, Sept. 13.
Prof. A.A. Balchin, Brighton Polytechnic, UK.	Application of X-ray diffraction in industry Oct. 30.
Prof. M.A. Kallistratova, Inst. of Atmospheric Physics, USSR.	Remote sounding investigation, Nov. 1.
Prof. A. Kon, USSR.	Studies of anisotropic irregularties in the atmosphere, Nov. 1.
Dr. I.V. Petenko, USSR	Development of Doppler Sodar technique and its use in atmospheric researches, Nov. 1.
Prof. Ronald W. Armstrong, University of Maryland, USA	X-ray diffraction topography for materials characterization, Nov. 7.
Prof. C. Schlenker, LEPES, Grenoble, France.	Magnetic properties of YBa CuO thin films, Dec. 12.
Dr. P.K. Roy, Bell Labs, USA.	Thin gate oxide technology of 1990's, Dec. 13
	Silicon/silicon dioxide interface: where do we stand in understanding it, Dec. 28.
Prof. P. Vashishta, Louisiana State University, USA	Classical and quantum simulations, Dec. 17&18
	Intermediate range order in glasses-A molecular dynamic simulation, Jan. 4.
	Phonons and superconductivity in $K_x Ba_{1-x} BiO_3$ materials, Jan 11.
Prof. E. Wolf, University of Rochester, USA.	The red shift controversy & a new mechanism for generating frequency shifts of special lines, Jan. 11
Dr. P. Cambell, University of New South Wales, Australia.	Light trapping in single crystalline silicon solar cells, Jan. 23.

Prof. C. R. Hill, University of Surrey, UK.	R & D in ultrasonic diagnostic physics and tumour ablation at Institute of Cancer Research, Jan. 25.
Dr. J.R. Jha, Consulting Services, Los Angeles, USA.	High temperature superconductors for microwave applications Jan. 28.
Dr. T.S. Radhakrishnan, Indira Gandhi Centre for Atomic Research Kalpakkam.	Oxygen ordering in high temperature superconductor, Feb. 14.
Dr. C. Gough, Birmingham University, U.K.	Recent highlights in the scinece and applications of high Tc superconductors, Feb, 14.
Prof. G. B. Donaldson, University of Strathclyde, Glasgow, U.K.	The prospects for small scale electronic applications of superconductivity, Feb. 18.
Dr. Brahm Dev, University of Groningen, Holland.	Statistics of secondary electron emission induced by low energy He^+ ions and neutrals, Feb. 26.
Prof. T. Venkatesan, University of Maryland, USA	Perspective in high Tc superconducting electronics, Feb. 26.
Prof. E. Gmelin Max Planck Inst., FRG.	Specific heat measurement at low temperature: a particular branch of thermalanalysis, Feb. 27.
	Heat capacity experiment, Feb. 28
	Heat capacity experiment cluster compounds, magnetic phase transitions, ferro-electrics, March 4.
	Heat conductivity of High temperature superconductors, March 5.
	Practical cryogenics: Part I, March 6.
	Practical cryogenics-Part II, March 7.
	Semiconducting micro-contacts: a new way to submicron physics, March 8.
	Correct and accurate calibration of differential scanning calorimeters, March 13.

VISITS ABROAD

(1. 4. 90 to 31. 3. 91)

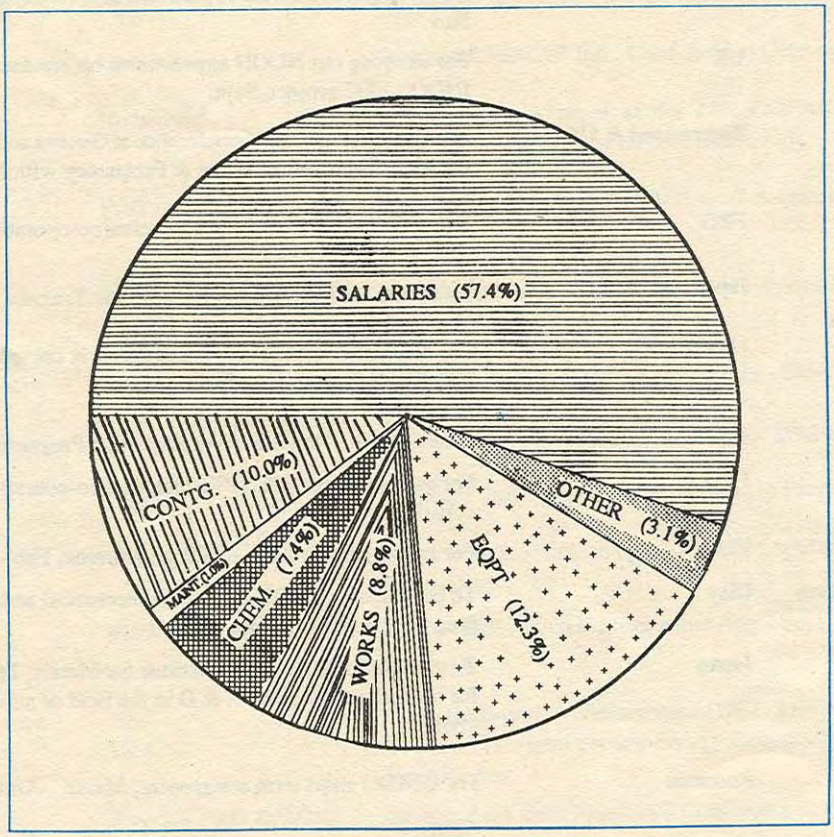
Scientist & Country		Purpose & Month
Dr. D R Lakshmi & Dr. Lakha Singh	USSR	Under INDO- USSR long term programme in the area of Radio Physics & Astrophysics, Feb-May.
Dr B M Reddy	USA	To deliver the invited lectures at SUNDIAL workshop at New Orleans, April
	Czechoslovakia	To attend 23rd General Assembly of URSI, Aug-Sept.
	Italy	To give invited lectures and to attend special meeting regarding URSI handbook, Jan.
Dr. Ajay Dhar	Canada	To take up post-doctoral fellowship for 2 yrs. at Queens University, April.
Dr. S.K. Aggarwal	France	Under CSIR-CNRS Exchange Programme, April-May.
Dr. A K Bandopadhyay	FRG	Under NPL-PTB (Phase-II) technical co-operation programme, April-July.
Dr. K C Joshi	USSR	Under S & T Programme of comparison in the area of Standards and Metrology, April.
	FRG	Under NPL-PTB (Phase II) technical co-operation programme, May-June.
Dr. K K Jain,	USA	As a visiting Scientist to NIST for one year, May
Dr Krishan Lal	Spain	To deliver lectures in the Intl. School of Crystal Growth and Crystallographic Assessment of Industrial Materials, Barcelona, May
	USA	To attend CODATA Conference & General Assembly at Columbus, July.
	S.Korea	To attend fourth meeting on Survey of Data Sources in East Asian countries and to visit Korea Standards Research Inst. Jan-Feb.
Dr. L S Tanwar	FRG	Under NPL - PTB (Phase - II) technical co-operation programme, June - May - 91.
Dr Ashok Kumar	U K	Under INDO -UK Project on ultrasonic standards -June.
Dr V N Ojha,	FRG	Under NPL-PTB (Phase - II) technical co-operation programme, June - Sept. 91
Dr A C Rastogi	USA & Canada	To attend the IEEE Photovoltaic Specialists Conference, May

	Japan	Under INSA-JSPS Exchange Programme, Jan-June, 91
Sri. Pardeep Mohan	USA	For training at NIST under INDO-US collaborative project, June-Nov.
Dr S K Joshi	USSR, UK, Poland & Hungary	Under Bilateral Exchange Programme of INSA, May-June.
	S. Korea & Malayasia	Visited Korean Science & Engg. formulation to review collaboration programme between INSA-KOSEF and attended annual meeting of Federation of Asian Scientific Academicians & Societies. July.
	France	Attended the meeting of CIPM committee at Paris, Sept.
	France	Attended 6th Scientific Council Meeting of IFCPAR at Sopnia Antopole, Oct.
	USA	Attended meeting of scientists , arranged by INSA, and the meeting of International Materials Research Committee at Boston, Nov.
P Banerjee	USSR	Under S & T Cooperation between INDO-USSR in the area Standards and Metrology, May - June.
Dr A K Gupta	USSR	Under INDO-USSR long term training programme, May-June.
Sri Mukul Sharma	Japan	For equipment training, June.
Mrs. A Chatterjee	Canada	To attend CPEM-90 Intl . Conf. held at Ottawa, June
Dr. J Kar	Netherland	For presenting a paper at the 28th COPAR plenary meeting & associated symp. held at Hague, June - July.
Sri V K Batra	FRG	Under NPL - PTB (Phase - II) technical co-operation programme, June - Aug.
Sri B C Arya	Italy	For participation in the Intl. School of Physics, Enrico Fermi summer course, June - July
Dr B R Chakraborty	FRG	Under CSIR - DAAD programme, July - Sept.
Dr Neeraj Khare	UK	Under CSIR - British Council exchange programme July - Dec.
Dr R B Mathur	France	To attend Intl. Conference on Carbon at Paris, July
Dr V T Chitnis	USA	To attend Intl. Symp, on opto-eletronics, applied science & engg. held at San Diego, July.
Dr Ramadevi Ramachandran	FRG	Under CSIR - DAAD programme Aug - Sept.
Dr S M Sivaprasad	USA	Under the Boys Cast Fellowship of DST., to New Jersey, Aug - July 91.
Sri R B Saxena	USA	To attend 25th Inter Society Energy Commission Engg. Conference at Nevada, Aug.
Dr S P Singal	Sweden, FRG & GDR	To attend the Inter Noise - 90 Conference at Gothenburg, Aug.

Sri M V S N Prasad	Czeckoslovakia	To attend 23rd General Assembly of URSI at Prague and to visit some CSIR Labs, Aug - Sept.
Dr. S L Dahake	Czeckoslovakia & FRG	To attend URSI General Assembly and NPL - PTB (Phase - II) Programme Aug- Oct.
Dr A P Jain	USA	Visited various institutions, universities for technical scienctific discussions in the field of Stirling Engines, Aug.
Dr. D. C Parashar	Malaysia	To attend Commonwealth Council meeting on Chemical Research and Environment Needs, Aug.
	FRG	Visited Max Planck Inst. under INSA - DFG Exchange Programme Nov - Dec.
	France	To attend international experts meeting on the estimation of green house gas emission and sinks, Feb
Sri J K Dhawan	FRG	Under NPL - PTB (Phase - II) technical co-operation programme, Sept - Dec.
Sri P K Dutta	USSR	Under INDO - USSR programme of co-operation in the area of Stdds. and metrology, Sept.
Dr. Suresh Chand	France	Under CSIR - CNRS exchange programme, Sept.- Nov.
Dr B S Gera	FRG	To participate in a field experiment at University of Hamburg, Sept - Nov.
Dr B D Malhotra	UK	For carrying out NUON experiments on conducting polymers under INDO - EEC project, Sept.
Dr B S Mathur	Switzerland & USA	To attend world climate conference at Geneva and discuss the ongoing INDO - US project on Time & Frequency with NIST, Oct.
Dr H C Kandpal	FRG	Under NPL-PTB (Phase - II)I technical co-operation programme, Nov.
Dr O P Bahl & Dr L M Manocha	Japan	To attend 3rd Intl. Symp. on Carbon at Tsukuba, Nov.
Dr A K Gupta	UK	For discussion in processing metal matrix composites under INDO - UK, MOU Project, Nov-Dec.
Dr P K Ghosh	UK	Under INSA - Royal Society Exchange Programme, Jan - Mar.
Sri R K Luthra	FRG	For training under NPL - PTB technical co-operation programme, Feb. - April, 91
Sri A K Saxena	FRG	For training under NPL - PTB programme, Feb - Oct 91.
Dr Mahendra Mohan	Itlay	To participate in ICTP Course on theoretical and experimental radio propagation physics, Jan.
Dr R G Sharma	Japan	To visit National Research Institute for Metals, Tsukuba Laboratories for mutual exchange on R & D in the field of superconductivity. Feb - March.
Dr O P Bahl.	Romania	For UNIDO short term assignment, March - April 91.

ACTUAL EXPENDITURE
(1990-91)

Budget Head	Rs. (Lakhs)
Salaries	587. 591
Contigencies	102.263
Maintenance	10.172
Chemicals	74.824
Works etc.	88.900
Equipment	131.140
Other	30.999
Total	**1025.889**
Sponsored Projects	258.072



HUMAN RESOURCES

SCIENTISTS OFFICERS

(in order of Gp.IV to Gp III as on 1.4.91)

DIRECTOR
S.K.JOSHI

STANDARDS

LENGTH & DIMENSIONS

P C Jain
V T Chitnis
V D Dandawate
R P Singhal
H S Dahiya
V G Kulkarni
Om Prakash
L S Tanwar
K Vardhan
M Karfa
V Roonwal
N K Aggarwal
A K Kanjilal
B K Roy
Ram Narain
V D Sharma
S L Thind

MASS

S V Gupta
D C Sharma
M L Das
S N Nangia
Tripurari Lal
N K Kohli
B G Mathur
S Verma

FORCE

M K Dasgupta
Anil Kumar
M K Chaudhury
J K Dhawan
R S Sharma

PRESSURE & VACCUM

J K N Sharma
A C Gupta
K K Jain
A K Bandopadhyay
B R Chakraborty
Pardeep Mohan
D R Sharma
S M Sivaprasad
S P Sharma

TEMPERATURE

V P Wasan
K N Bhatnagar
R K Luthra
T K Saksena
Y P Singh
N K Srivastava
Mansha Ram
S K Nijhawan

OPTICAL RADIATION

K C Joshi
Mahesh Chandra
J S Vaishya
T K Chakraborty
Kailash Chand
H C Kandpal
S Manrai
O P Bhola
Jai Bhagwan

INFRARED RADIATION

S P Verma
Joginder Singh
D Gupta
R S Ram

ACOUSTICS

S P Singal
D R Pahwa
V Mohanan
B S Gera
R M Khanna
Omkar Sharma
H L B Bhaskar
P C John
C B L Gautam

UNDERWATER ACOUSTICS

T K Saksena
S C Gupta
Janardan Singh
Ashok Kumar
S K Jain
Mukesh Chandra
J N Som
R P Tandon
Ved Singh
N Narayanaswamy
Subhash Chandra
Jagdish Lal

FLOW MEASUREMENT & C. S PROGRAMME

Sharwan Kumar
Raj Singh
Sudarshan Kumar
S. Govindarajan
Virendra Babu

TIME & FREQUENCY

B S Mathur
P Banerjee
A Chatterjee
A K Hanjura
Harish Bahadur
G M Saxena
M Saxena
A Sengupta*
G K Goel
M L Shakdhar
Gurdial Singh

D C STANDARDS

V K Batra
S K Mahajan
P K Mittal
B Sircar

H F IMPEDANCE & AC LF

SL Dahake
SR Gupta
Gurmej Ram
Kewal Krishan
MK Mittal
M R Nagar
Omkar Nath
A K Saxena
T R Arora

A R Kaushik
Naib Singh
Surinder Singh

H F, MICROWAVE, ATTENUATION

V K Agrawal
R S Yadav
P C Kothari
Ram Swarup
Ritander Aggarwal
H M Bhatnagar
A K Govil
P S Negi
V K Rustagi
Ranjit Singh
R L Mendiratta

TESTING & CALIBRATION

H K Thadani
C P Singh
S D Bahl
S P Mathur
A K Ghosh

MATERIALS

SILICON, CERAMICS & SUPER-CONDUCTORS

B K Das
S N Singh
R B Tripathi
N K Arora
B R Awasthy
Balbir Singh
B C Chakravarty
Kiran Jain
R K Kotnala
S B Manmohanan
Mohan Lal
Ram Kishore
B V Reddi
Satbir Singh
P K Singh
N S Bangari
S S Hanspal
H S Kalsi
S M Khullar
R C Goel
B S Khurana
S K Sharda
M K Banerjee
H P Gupta
T Podikunju
Prem Prakash
T R Pushpangadan
Ravi Kumar

INTERFACES & MICROSTRUCTURE

A C Rastogi
S T Lakshmi Kumar
K S Balakrishnan

LUMINESCENT MATERIALS

P K Ghosh
H P Narang
Harish Chander
V Shankar

DISPLAY DEVICES

Subhas Chandra
S S Bawa
S C Jain
S A Agnihotri
A M Biradar
S N Ekbote
M N Kamalasanan
K K Saini
C P Sharma
Suresh Chand
R K Sharma
N S Verma
R C Bhateja

CONDUCTING POLYMER

B D Malhotra
S C K Misra
V S Panwar
Ramadhar Singh

CARBON PRODUCTS

O P Bahl
R L Seth
Gopal Bhatia
R K Aggarwal
Chhote Lal
T L Dhami
R K Kulshrestha
R B Mathur
P Siva Ram
Vasantha Raman
CL Verma
S Ramanathan

HIGH PRESSURE TECHNOLOGY

M M Bindal
A K Aggarwal
B P Singh
Rajeev Chopra
S K Singhal
R K Nayar

CHARACTERIZATION

CHEMICAL METHODS

D C Parashar
P K Gupta
V K Amar
J N Bohra
J C Trehan
A K Aggarwal
P K Gupta
Mewa Singh
R Ramachandran
A K Sarkar
Jitendra Rai

I R & EP R SPECTROSCOPY

M M Pradhan
R K Garg
S K Gupta
S Parthasarathy

X-RAY MEASUREMENTS

K C Nagpal
K D Kundra
R H Bhawalkar
U Dhawan
Rashmi
D K Suri

ELECTRON MICROSCOPY

S K Sharma
G L Malhotra
Narendra Kumar
SUM Rao

CRYSTAL GROWTH & PERFECTION

Krishan Lal

R V Ananthamurthy
G Bhagavannarayana
S K Haldar
S D Sharma
Vijay Kumar
K S Bartwal
S K Gupta (UGC)

CONDENSED MATTER PHYSICS

HIGH TEMPERATURE SUPERCONDUCTORS

A V Narlikar
S K Sarkar
A K Gupta
M S Hegde
R G Sharma
V S Tomar
P K Ashwini Kumar
P K Dutta
V K Gumber
B V Kumaraswami
Manmohan Krishan
N S Natrajan
V N Ojha
Y S Reddy
M L Sharma
U C Upreti
S K Aggarwal
Neeraj Khare
P L Upadhyay
S B Samantha
V S Yadav

THEORY & LT PHYSICS

S K Joshi
Ravi Mehrotra
Ramji Rai
Ratan Lal
R S Rao
V. Soni (UGC)

DEVELOPMENTAL PROJECTS

THIN FILMS & AMORPHOUS MATERIALS

V V Shah
R Bhattacharya
Devindra Singh
C Anandan
A Basu
P N Dixit
M Kar
O S Panwar
B S Verma

CRYOGENIC SYSTEMS

A P Jain
S C Gera
N K Babbar
Ganga Parshad
Hari Kishan
Kasturi Lal
R B Saxena
S S Verma
R S Khandekar

RADIO SCIENCE

B M Reddy
K K Mahajan
B C N Rao
M N M Rao
S C Garg
S B S S Sarma
B N Srivastava
T R Tyagi
S Aggarwal
R S Arora
P K Banerjee
H N Dutta
A B Ghosh
S L Jain
D R Lakshmi
M K Raina
Y V Ramanamurthy
R C Saksena
G S Uppal
B C Arya
Madhu Bahl
P Chopra
R S Dabas
M K Goel
J K Gupta
P N Vijaya Kumar
N Kundu
Lakha Singh
Mahendra Mohan
H K Maini
P L Malhotra
D R Nakra
V K Pandey
P K Pasricha
M V S N Prasad
S S Rajput
V P Sachdeva
S K Sarkar
M C Sharma
S K Singhal
P Subrahmanyam
C B Tandel
D K Tewari
R Venkatachari
V K Vohra
K S Zalpuri
J Kar
Risal Singh
John Thomas
R S Tanwar
SK Shastri
Abdul Hamid
S R Bakshi
Didar Singh
K L Gulati
Raksha Marwah
A R S Vashisht

INFRASTRUCTURAL FACILITIES

PLANNING, LIAISON, MONITORING, PUBLICATION

G K Arora
G Govindaswamy
S K Kapur
R S Khanduja
F C Khullar
Shikha Mandal
S K Sharma
Indra Tewari
P K Kohli
S S Bhakri
T R Tomer
S C Verma

LIBRARY

S M Dhawan
S K Phull
Sawanti Lal

COMPUTER

VC Jain
NK Sethi

Sanjay Raizada

WORKSHOP & MECH. PROC. ACTIVITY

J R Anand
A K Gupta
H N P Poddar
R C Anandani
M L Sarkar
I A Malik
M K Chibber
Harish Chand
R Khanna
M L Nagpal
M G Sehgal
Dharam Chand
Ganpat Singh
H B Singh
Kewal Krishan
T R Marwah
Ram Swarup
Rajiv Sikand

GLASS WORKSHOP

S S Sen
V P Verma
Chandan Singh
M C Jusht
Shashi Bhushan
J P Vashisht
M L Verma
G S Hans
Kani Ram
Kamail Singh

INSTRUMENTATION

V R Singh
Aftab Ahmad
I Banaudha
D S Sachdeva
Y P S Negi

SERVICES

C S P Kumar (Electrical)
S Dwivedi (Rajbhasha)
J C Sharma (Electrical)
R C Dhawan (Photography)
O P Tagra (Transport)
P K Garg (Civil)
K V Krishnamurthy (Civil)
R S Singh (Hort).
J S Dhama (Photography)
S S Kapur (Civil)
P L Sharma (Air Conditioning)
S L Sharma (Electrical)
Arvind Thakur (Part time MO)

EMERITUS SCIENTISTS

S R Das
A R Verma

ON DEPUTATION

Ajay Dhar
A R Jain
Kailash Chandra
N D Kataria
L M Manocha

ADMINISTRATION
ACCOUNTS

M M Sharma, Sr. COA
B C Joshi, SFAO
B S Gaira, AO
J M Sardana, SPO
O P Kakkar, FAO
Anil Kumar, SO
O P Meni, SO
Jitendar Parasar, SO
Sardara Singh, SO
R K Sharma, SO
Sarla Sonsi, SO
S K Vohra, SO (F & A)
Prem Singh, Dy SPO
U N Thakur, Dy SPO
R K Bhasin, SPA
B B Chopra, SPA
Jagdish Kumar, SPA
S A Joseph, SPA
Pran Nath, SPA
D V Sharma, SPA
Vijay Kumar, Sec. Offr.

RESEARCH ASSOCIATES
POOL OFFICERS

Anil Kumar
Annapoorni
B P Singh
D R Chaubey
S N N Goswami
Keshav Kumar
G K Padam
Arun Pandya
G S Reddy
D K Rout
Nirupa Sen
Rina Sharma
S K Sharma
J S Thakur
Pushpa Upadhyay

*Abroad

RETIRED

V N Bindal Sc.
V D P Sastri, Sc.
Mohinder Nath, Sc.
Ram Prasad, Sc.
P V N Ramanathan, Sc.
M K Biswas, TO
R K Khanna, TO
A C Prabhakar, TO
D N Razdan, TO
Ajit Singh, Tech.
Budhai Ram, Tech.
Krishan Lal, Tech.
Mohinder Singh, Tech
Sahib Singh, Tech.
Ajay Ram, W/S Asstt.
Ram Swarup, W/S Asstt.
Tabi Ram, W/S Asstt.
Nathu Singh, Mali
S S Soni, SO
Basant Bihari, Asstt.
L M Franklin, Asstt.
R P Jaidka, Asstt.
Radhey Shyam, Asstt.
KP Bhattacharya, Rec Keeper,
Pahlad Singh, Sec. Gd.

OBITUARIES

Makan Singh, Sec. Asstt.
Raj Rani, Helper,
Surat Singh, Rec. Keeper.

ANALYSIS OF NPL TECHNICIANS (GP II) (NO.)

(as on 1.4.91)

QUALIFICATION-WISE

Gp & Gd. \ Q	Literate(Hindi)/ Illiterate	Middle	Matric/Inter/Hr. Sec.	Graduate	ITI	Total
II (1) (Tech.II)	6	5	28	9	80	128
II (2) (Tech.VII)	31	40	25	3	74	173
II (3) (Tech. VIII)	4	15	20	2	50	91
TOTAL	**41**	**60**	**73**	**14**	**204**	**392**

- In the case of Tech. II, 91% were qualified as Matric/Inter/Hr. Sec./ Grad. or ITI.
- 59%of Tech. VII were qualifed as above, whereas 23% were Middle and 18% were literate (Hindi) or illiterate.
- Regarding Tech. VIII, 79% were qualified and 16% were middle.
- Considering entire technicians, 74% were qualified, 15% were only Middle and 11% were illiterate or knowing Hindi.

AGE-WISE

Gp & Gd \ Age (Ys)	20 - 30	30 - 40	40 - 50	50 - 60	Total
II (1) (Tech. . II)	28	78	16	6	128
II (2) (Tech. VII)	2	25	69	77	173
II (3) (Tech. VIII)	--	9	33	49	91
TOTAL	**30**	**112**	**118**	**132**	**392**

- There were 392 technicians in NPL as on 1.4. 91; Gd II - 128 (33%), Gd VII - 173 (44%) and Gd VIII - 91 (23%)
- In the case of Tech. II, 61% were in the range of 30-40 years.
- Regarding Tech. VII, 40% were in the range of 40-50 years and 45% were in the range of 50 - 60 years.
- Regarding Tech. VIII, 36% were in the range of 40-50 years and 54% were above 50 years
- Considering total technicians, 29% were in the range of 30-40 years, 30% were in the range of 40-50 years, 34% were above the age of 50 years, 16% of technicians will be retiring during the next 5 years.

STAFF STRENGTH

(as on 1. 4 . 91)

Category	Grade	Number
SCIENTIFIC		
Group IV	IV (1) to Director (Scientist)	290
TECHNICAL		
Group III	III (3) to III (5) (Tech. Officer)	105
Group III	III (1) to III (2) (Tech. Asstt.)	103
Group II	II (1) to II (3) (Technician)	392
Group I	I (1) to I (3) (Helper)	125
		1015
ADMINISTRATIVE		
	Officer	21
	Establishment	143
	Group D	108
		272
	TOTAL	**1287**

Ph.D's AWARDED

Name	Title	University	Guides
1. Ravinder Agarwal	Ultrasonic studies in renal calculi and gall bladder stones.	HP	Dr.S.P.Sud, H.P. University. Dr. V.R. Singh, NPL.
2. Harish Chander	Studies in gas- liquid reaction & development of reactor.	IIT, Delhi	Dr. K.K.Baveja & Dr. S.C. Dhingra, IIT, Delhi Dr. P.K. Ghosh, NPL.
3. Om Pradash	Photoacoustic studies of solids, liquids and surfaces.	Meerut	Dr. A.N. Pandey, Meerut University. Dr. R.S. Ram NPL
4. M.V.S.N. Parasad	Some aspects of VHF and microwave propagation over selected regions of India and their application to communication systems.	S.V.	Dr. D.N. Rao, S.V. University, Dr. B.M. Reddy, NPL.
5. S.K. Sharma	Growth kinetics and electrical properties of thin oxide layers on silicon.	Delhi	Dr. P. K. Bhatnagar, Delhi University, Dr. B. K. Das, NPL
6. D.K. Suri	Investigation of the semiconducting chalcopyrite solid solutions and crystal structure and thin film studies.	Delhi	Dr. G.K. Chadha Delhi University, Dr. K.C. Nagpal, NPL
7. Sanjay Yadav	Research contributions to the develoment and analysis of ultrasonic instrumentation in forensic, medicine, engineering and allied sciences.	Meerut	Dr. A.S. Yadav, Meerut, University. Dr. V.R. Singh, NPL

HONOURS AWARDS

Dr. S.K. Joshi was recipient of Republic Day National Award of Padma Shri.

Dr. Kailash Chandra was elected Fellow of Indian National Academy of Engineering.

Dr. K.K. Mahajan was elected Fellow of the Indian Academy of Sciences, Bangalore.

Dr. H.C. Kandpal was awarded the CSIR Young Scientist Award in Physical Sciences for the year 1990. Dr. Kandpal has demonstrated through experiments that the Wolf effect is responsible for the considerable dispersion that exists in the spectroradiometric standards maintained by national laboratories.

Dr. M.V.S.N. Prasad was awarded URSI Young Scientist Award.

S/Sri. P.K. Ghosh, H.P. Narang, Harish Chander and V.Shanker were jointly awarded Rs. 50,000 by NRDC on the development of a process for the manufacture of Monochrome Television Tubes - Phosphor.

Dr.(Mrs.) S.A. Agnihotry was awarded Bharat Nirman Award for the Year 1990 for outstanding contribution in the field of science.

The Indian Cryogencis Council awarded A.N. Chatterjee memorial medal to Dr. A.K. Gupta and a merit scroll each to the members of team (37 in all) for the development of high Tc SQUIDs.

Dr. O.P Bahl was awarded a medal by the Materials Research Society of India for work in the area of materials.

Dr. V.R. Singh was elected a Fellow both of the Institution of Electronic & Telecommunication Engineers India and the Institution of Engineers, India.

Dr. A.K. Gupta was elected a Fellow of the Institution of Engineers, India.

KRISHNAN MEMORIAL LECTURE

The 21st Krishnan Memorial Lecture was delivered by Prof. J.M. Thomas, FRS, Director, The Royal Institution of Great Britain, London, on Jan. 14, 1991. The title of the lecture was "***The genius of Michael Faraday***".

Dr. Thomas informed that the story of Faraday's electrical experiments at the Royal Instn. has become almost legendary in character. The precise nature of his experiments showed the orginality and persistence, the initiative, the skill, in a word, the genius of a man who was one of the greatest experimentors.

The detailed information regarding Faraday's researches was provided in Faraday's diary. Faraday experimented for the discovery of electromagnetic induction. The ring experiment proved successful on Aug. 29, 1831. This was the first occasion when a galvanometer was used in an experiment. He discovered diamagnetism and paramagnetism. He used to deliver Christmas lectures in 1855.

Faraday worked as an assistant to Sir Humphry Davy. He used to work for 10 to 12 hours a day. He was known for his honesty and simplicity and devotion to work. The Royal Society is celebrating the bi-centenary of birth of M. Faraday.

Prof. B.V. Sreekantan, INSA Srinivasa Ramanujan Professor, presided over the function. Dr. S.K.Joshi, Director, NPL, presented a memento to Prof. Thomas on the occasion. The lecture was attended by scientists, engineers, research students and others.

RESEARCH COUNCIL

Prof. B.V. Sreekantan, INSA Srinivasa Ramanujan Professor, Tata Instt. of Fundamental Research, Bombay - 400 005	Chairman
Prof. R. Vijayaraghavan, Physics Faculty, Tata Instt. of Fundamental Research, Bombay - 400 005	Member
Prof. A.B. Bhattacharya, Centre for Applied Research in Electronics, Indian Instt. of Technology, New Delhi - 110016.	Member
Prof. M.K. Dasgupta, Instt. of Radio Physics & Electronics, Acharya P.C. Road Calcutta - 700 027.	Member
Prof. D. Chakravorty, Indian Association for the Cultivation of Science Jadavpur, Calcutta - 700 032.	Member
Prof. R. Narasimha, Director, National Aeronautical Laboratory, Bangalore - 560017.	Member
Dr. S.G. Patil, Director, Deptt, of Electronics, New Delhi-110 003.	Member
Lt. Gen. H.Lal(Retd) Director General, Bureau of Indian Standards, New Delhi-110002	Member
Sri K R Parameswar Pkt. II Sector B, Vasant Kunj, New Delhi-110 030	Member
Director General CSIR or his nominee	Member
Dr. S.K Joshi, Director, National Physical Laboratory, New Delhi - 110 012	Member
Sri G K Arora, Scientist, NPL	Non-Member Secty.

MANAGEMENT COUNCIL

Dr. S.K. Joshi, Director, National Physical Laboratory, New Delhi - 110 012.	Chairman
Dr. B.K. Sarkar, Director, Central Glass & Ceramic Research Instt, Calcutta - 700 032	Member
Dr. B.M. Reddy, Scientist, NPL, New Delhi.	Member
Dr. B.K. Das, Scientist, NPL, New Delhi -	Member
Dr. (Mrs) D.R. Lakshmi, Scientist, NPL, New Delhi	Member
Dr. A Sengupta, Scientist, NPL, New Delhi	Member
Dr. S Ahmad Scientist, Central Electronics Engineering Research Institute, Pilani - 333 031	Member
Sr. Finance & Accounts Officer, NPL , New Delhi	Member
Director General CSIR, or his nominee	Permanent Invitee
Sri M. M. Sharma, Sr. COA, NPL, New Delhi.	Member Secty.

SYMPOSIA

A short course on Particle Size Measurement of Powders & its Importance to Industry was held on Sept 26.

An International Symposium on Optical &Remote Sensing of the Atmospheric Environment was held from Oct.24to26.

An International Congress on Ultrasonics was organised from Dec. 12 to 14.It was sponsored by CSIR, DOD, CSIO, ICMR and USI

An Asian Workshop on International Geosphere Biosphere Programme was organised from Feb. 11to 15. It was inaugurated by the Prime Minister Sri Chandra Shekhar.

TRAINING

The training programmes were organised in the field of legal metrology for one to five weeks for trainees from Mauritius, Egypt. Malaysia, Vietnam, Bangladesh, Uganda, Tanzania and Nepal. The trainees were sponsored by the Deptt. of Weights and Measures, Ministry of Food & Cuvil Supplies. Some of the trainees were trained in some areas of standards including electrical.

The scientific and technical personnel of licensees of projects of thin films, glassy carbon and flexible graphite were provided training for one to three weeks.

A student of M. Sc of Meerut university completed the summer training course in the growth and characterization of crystals. A number of M.Sc students and scientists of CSIR were given training on FTIR spectroscopy.

Two engineers from the industry were trained in the use of X-ray fluorescence equipment for one week.

A student of M.Phil completed his thesis in the project of preparation and characterization of thick superconducting films.

Under the stipend training scheme for talented students, 8 students of IIT's of Kanpur and Varanasi completed training and project work for six weeks.

Four students from BITS, Pilani completed their M. Tech project reports in the areas of Materials, Characterization and Radio Science.

VISITORS

1. Markl Habert Prof.; President DFE, FRG with delegation, April. 2
2. Simeon Elena Rosa Dr.(Mrs.); Minister, Science & Technology, Cuba, April.4
3. AI-Madani Nauri A1-Fitouri Mr., Minister, Science & Technology Libya, August.10
4. Munk Walter H. Prof.; University of California, USA, November.16
5. Bondi Herman Sir; Cambridge, UK, November.19
6. Berchem Theodor Prof; President, DAAD, FRG, November.20
7. Thomas J.M. Prof; Director, Davy Faraday Research Laboratory and the Royal Institution of Great Britain, Jan.14.
8. Spurling T. Dr., President and Noller Barry Dr., Secretary General Federation of Asian Chemical Society of Australia; Feb.1
9. Donaldson G.B. Prof; University of Strathclyde, Glasgow, UK Feb.18
10. Quisser, Prof; Director, Max Planck Instt. FRG, Feb.28

NPL-TWENTY YEARS BACK
(from the Annual Report 1970-71)

MANPOWER

Scientists and Technical Officers	125
Total staff	963
EXPENDITURE	Rs. 104.92 Lakhs
Director	Dr. A.R. Verma

SCIENTIFIC HIGHLIGHTS

As per the recommendations of the Executive Council, the laboratory was reorganised into the following groups:

Standards and Testing; Test and Evaluation Centre; Specialised Techniques; Materials and Carbon;Developmental Projects; Oriented Basic Research; Radio Sciense and Pilot Plants.

The laboratory continued to maintain the primary standards for base and derived units to internationally accepted accuracy. The laboratory also supplied secondary standards to the industries, research laboratories and various Government organisations for use at their premises.

The new processes released to the industry included:-

1. Electrostatic Photocopying Machine.
2. Cinema Arc Carbons.
3. Microwave Components.

Mossbauer studies on ferroelectrics and anti-ferroelectrics were pursued. Investigations were carried out in aeronomy, ionospheric physics and solar terrestrial physics.

The laboratory observed Open Day in March, 1971. Prof. S.N. Bose, F.R.S., delivered the Krishnan Memorial Lecture on the topic "History of development of scientific research in India specially at IACS, Calcutta".

ABBREVIATIONS USED

ARDB	- Aeronautical Research Development Board
ARWC	- Associate Regional Warning Centre
BHEL	- Bharat Heavy Electricals Ltd.
BIS	- Bureau of Indian Standards
BITS	- Birla Institute of Science & Technology
CAZRI	- Central Arid Zone Research Institute
CCIR	- International Radio Consultative Committee
CECRI	- Central Electrochemical Research Institute
CEERI	- Central Electronics Engineering Research Institute
CEL	- Central Electronics Ltd.
CGCRI	- Central Glass & Ceramic Research Institute
CSIO	- Central Scientific Instruments Organisation
CSIR	- Council of Scientific and Industrial Research
DAAD	- German Academic Exchange Service
DMRL	-Defence Metallurgical Research Laboratory
DNES	- Department of Non-Conventional Energy Sources
DOD	- Department of Ocean Development
DOE	- Department of Electronics
DRDL	- Defence Research Development Laboratory
DST	- Department of Science & Technology
DXS	- Diffuse X-ray Scattering
EPR	- Electron Paramagnetic Resonance
FIAN	- Lebedev Physics Institute, Moscow
FTIR	- Fourier Transform Infrared Spectrophotometer
IACS	- Indian Association for Cultivation of Science
IARI	- Indian Agricultural Research Institute
ICMR	- Indian Council of Medical Research
IMAP	- Indian Middle Atmosphere Programme
INMARSAT	- International Maritime Satellite
INSA	- Indian National Science Academy
IPCL	- Indian Petrochemicals Corporation Ltd.
IRDE	- Instrument Research Development Establishment
ISRO	- Indian Space Research Organisation
LOS	- Line Off Site
MARISAT	- Maritime Satellite
MST	- Mesospheric Stratospheric & Tropospheric
NBRI	- National Botanical Reaserch Institute
NCTCF	- National Coordination of Testing Calibration Facilities
NGRI	- National Geophysical Research Institute
NIST	- National Institute for Standards & Technology
NTPC	- National Thermal Power Corporation
ONGC	- Oil and Natural Gas Commission.
PTB	- Physikalisch Technische Bundesanstalt, Braunschweig
SAMEER	-Society for Applied Microwave Electronics Engineering Research
SEM	- Scanning Electron Microscope
SHAR	- Shriharikota Rocket Launching Station
TID	- Travelling Ionospheric Disturbance.
URSI	- International Union of Radio Science
USI	- Ultrasonic Society of India
VNIIM	- D.I. Mendeleyev Institute of Metrology