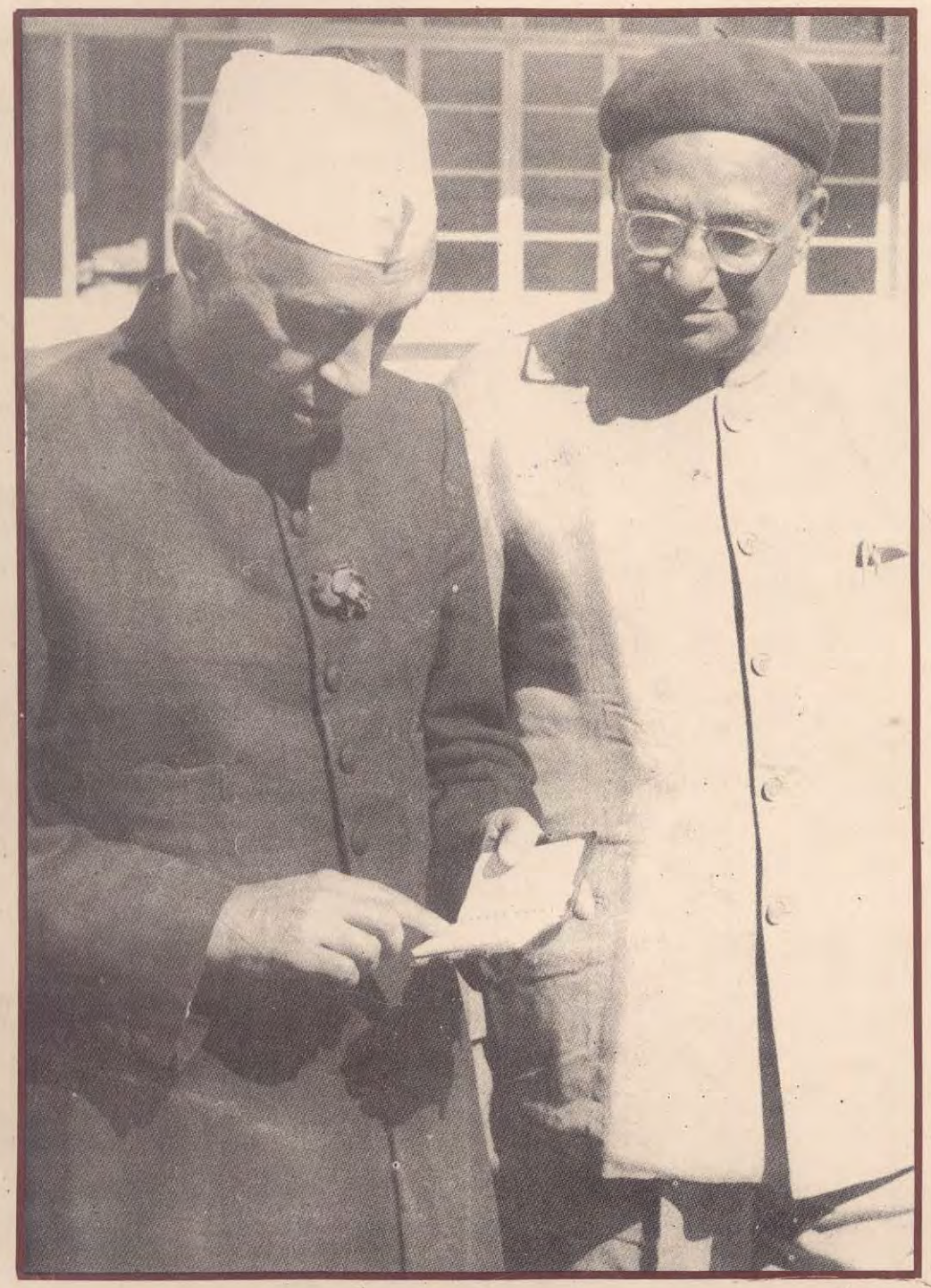
ANNUAL REPORT
1988 - 89



NATIONAL PHYSICAL LABORATORY

NEW DELHI

I am quite certain that this large programme of building fine national laboratories would never have gone as far ahead as it has, if Dr. Bhatnagar had not been in charge of them. Well, Sir, we all now-a-days, talk of science in terms of praise. In a sense, we all worship at the altar of science and yet I often wonder if science is not going to meet the same fate as religion did in older times. Science is not a matter of merely looking at test tubes and mixing this and that and producing things big or small; science, ultimately, is way of training the minds and of the whole life functioning according to the ways and methods of science, that is, the whole structure, social or otherwise, functioning in the spirit of science... As I look at this fine building and think of the large number of young men and young women working in it, dreaming sometimes and producing results which will flow out and benefit our people in this country and the world, for the matter of that, because the frontiers of Science cannot be limited—as I think of those tremendous advances that science has made in the past and the great advances that I hope is going to make in the future, I am so fascinated by them that I feel how much better it would have been for me to be the Director of this laboratory, if I had the competence, than to be the Prime Minister.

Extract of Pt. Nehru's speech—inauguration of NPL (21.1.1950)

COVER PHOTOGRAPH

Pt. Jawaharlal Nehru with Dr. K.S. Krishnan, the first Director of NPL

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NATIONAL PHYSICAL LABORATORY

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(June 1989)

CONTENTS

Director's Report

This report presents the progress of work done at the National Physical Laboratory during the year 1988-89. In 1989 the nation is celebrating the birth centenary of Pt. Jawaharlal Nehru, the architect of modern India, under whose leadership the science and technology took root and got immediate support. NPL community pays tribute to him while remembering the day, Jan. 4, 1947, when he laid the foundation stone of this laboratory. The thrusts of research & development work at NPL have been in Measurement, Standards and Calibration; Materials and Material Characterization and Atmospheric Sciences.

In the area of Standards and Calibration Services our aim is to reach the industry and improve the quality of its products. We have not only improved by research the accuracies of our primary standards but have served a large number of industries through calibration of the measuring instruments. This report would provide information on the improvements in primary standards. We are now transmitting regularly the standard time and frequency signals through INSAT. In order to ensure international traceability, international intercomparisons were done for a number of standards. A new addition to our activities has been the establishment of a Commonwealth India Metrology Centre (CIMET) at NPL. The Centre will provide training to metrologists from the commonwealth countries.

In the area of Materials the efforts were continued in research and development of electronic and engineering materials. A plasma enhanced chemical vapour deposition system was commissioned and the growth kinetics of silicon oxide grown-over silicon by plasma oxidation technique was studied. A new procedure based on electro deposition from organic electrolytes was developed to produce single crystal Cd Te films for solar cells. There has been significant progress in improving the efficiency of hydrogenated amorphous silicon photovoltaic solar cells. A parametric acoustic system of source level 155 dB, beam width 3.6° was developed and used for detection of metallic targets obscured behind sand sediments and rubber sheets.

Quantitative measurements of stress induced by multilayer metallizations in semi-insulating and n-type gallium arsenide crystals were carried out by using high resolution X-ray diffraction methods. As a part of standard reference materials programme, standard solutions of lead in high purity water with concentration in the range 1-2 ppm were prepared.

The basic research on high Tc superconductors like La-based, Y-based and Bi-based superconductors was continued with emphasis on substitutional studies. In the field of applications of high Tc superconductors, different processing techniques for production of superconducting powders were evaluated. A multi-laboratory project of development of high temperature SQUID was formulated. Theoretical studies of high temperature superconductivity and heavy fermion superconductivity were continued.

Special interference filters were fabricated for INSAT payload and were supplied to the Space Application Centre, Ahmedabad for tests. The cryo-cooler of length 38 mm was developed and demonstrated at Instrument Research and Development Establishment, Dehradun. An electronic timer for achieving conservation of

energy in the lighting sector was developed.

The Retarding Potential Analyser (RPA) was selected by Indian Space Research Organization (ISRO) as the only aeronomy payload to be launched in SROSS-C satellite. Special short and medium-term forecasts were provided to ISRO and Physical Research Laboratory, Ahmedabad. New communication prediction techniques were developed and the frequency band of microwave radiometry extended to the mm region.

Various technical services were provided to the industry and public sector. The process know-how of a number of products/instruments was released to the industry for the transfer of technology. This included Silver Impregnated Graphite Contact, Liquid Nitrogen Container and INSAT-STFS Decoder. Consultancy was provided to the industry in the field of acoustical treatment of auditoria, thin film technology and instrumentation.

NPL maintained active collaboration with other CSIR laboratories, government agencies, universities, scientific institutions and international laboratories. A number of seminars/workshops were arranged during the year for exchange of results of scientific and developmental work. More than 50 lectures were delivered by eminent scientists and engineers from the country and abroad on topics related to the activities of NPL. Amongst the lecturers were Prof. H.J. Queisser, Dr. R.A. Smith, Sir. A. Laughton, Dr. P. Aigrian, Prof. C.N.R. Rao and Prof. M.M. Sharma. Prof. A. Hewish, NL, of Cambridge University delivered the Krishnan Memorial Lecture entitled "Pulsar Era".

Our scientists won recognitions and our congratulations to them. Dr. Ravi Mehrotra was given CSIR Young Scientist Award. Dr. A. Sengupta was chosen as the leader of the eighth Indian Scientific Expedition to Antarctica. Dr. V.N. Bindal and Dr. Ashok Kumar won the NRDC Award for their development of calibration block for characterization for non-destructive testing of metals. About 110 papers were published by the scientists of NPL in reputed national and international journals and about 30 research reports were produced during the year.

The laboratory is quite concerned about the development of human resources. A number of training programmes were arranged, including Vocational Training Course and in-house computer training courses for scientific and administrative staff. A number of scientists were deputed abroad to get acquainted with developments in their areas of research. The activities of Solar Thermal Devices and Carbon Plant were phased out and the manpower there utilized for other projects.

Our laboratory was very fortunate to have a number of outstanding and distinguished scientists as members of new Research Council which is chaired by Dr. Raja Ramanna. The laboratory wishes to acknowledge its collaboration with many institutions as well as funding it received from various agencies like Deptt. of Science & Technology, Deptt. of Electronics, Deptt. of Ocean Development, Deptt. of Non-conventional Energy Sources, Deptt. of Space, Bureau of Indian Standards, National Science Academy and the University Grants Commission.

S. K. Joshi

(S.K. JOSHI)

STANDARDS

LENGTH & DIMENSIONS

1. LENGTH

The iodine stabilised He-Ne laser was used to determine the frequencies of stabilised He-Ne lasers used in calculable capacitor and length measurement systems. More than ten He-Ne laser tubes were got fabricated making certain improvements in the life of the laser upto 5,000 hours. Some of them were given to the universities and laboratories such as Burdwan, Sagar and CBRI, Roorkee for field trials. The laser mirrors were coated and other optical components were made in the optical workshop of the section.

The work on microdimensional metrology, as applied to multilevel automatic mask aligner was carried out. The developments made in the electronic servocontrol circuits based on Moire Technique, enabled to attain a high alignment sensitivity.

Optical fibre sensors were developed for measurement of vibration amplitude and small displacements. With these sensors vibration amplitudes can be measured to the range of 2 mm to 0.01 μ m with a wide frequency range of 0.5 Hz to 100 kHz. A speckle shearing interferometery with constant radial and azimuthal shears, was developed. This was successfully applied to obtain radial and rotational slope counters of a spherical surface by dual refractive index immersion methods.

2. DIMENSIONAL METROLOGY

A mechanical comparator for calibration of precision linear scales was designed. An experimental investigation was successfully made for the calibration of long length bars by employing noncontact electro-optical sensors and laser interferometer.

The uncertainties involved in the calibration of slip gauges by interferometric method and in the calibration of angle gauges, polygon and rotary table by comparison with Moore Index Table were experimentally investigated and evaluated. The performance of Angle Goniometer was studied and its accuracy was found to be 10 secs. of arc. A system for calibration of measuring tapes using laser interferometer was designed.

Technical service was provided to India Government Mint, Bombay, on the repair of their Linear Dividing Machine & Transverse Comparator.

MASS, VOLUME DENSITY & VISCOSITY

Several sets of weights from 100 g to 1 mg and a few weights of 2 kg, 1 kg and 500 g were recalibrated. Mass values of all the standards agreed well within the stipulated accuracy assigned earlier. An immersible rotating system for intercomparison of volumes of four solid objects, at a time, by hydrostatic weighing was fabricated by incorporating a few modifications. The recalibration of two sets of reference standard alcoholometers, from 50° onwards, was completed.

Another 25 dm^3 automatic pipette was fabricated and calibrated. One 50 dm^3 automatic pipette was also fabricated and was being calibrated. These pipettes would be used as NPL primary standard for calibration in flow measurements. A one litre measure for calibrating fuel flow meters was designed and supplied to the Vehicle Research & Development Organization, Ministry of Defence, Ahmednagar. The work relating to the establishment of viscosity

scale starting from the primary standard, double distilled water, was continued and the scale was established upto 240 mm^2/s. In the process, five master viscometers were standardized.

FORCE & HARDNESS

In order to be able to calibrate devices of higher capacity than the available standard facility, 'built up' technique is used. Three identical load cells were developed to study the techniques. A strain-gauge torque transducer of capacity 2500 Nm was developed for calibration of torque meter.

PRESSURE VACUUM

1. Pressure

The investigations were carried out by crossfloating the two laboratory secondary standards against primary standards upto 4 MPa using nitrogen as pressure transmitting fluid. NPL-4 was crossfloated against NPL-8 using different pressure media having widely different kinematic viscosity. All the data of the NPL-4 obtained using nitrogen was used to normalise the results for other gases. These studies clearly indicated a difference of about 34 ppm in the area of the NPL-4 by changing the pressure media from argon to hydrogen. The uncertainty in the NPL-4 was only 27 ppm and the observed uncertainty of the order of 34 ppm in its effective area value may be due to the effect of kinematic viscosity of the fluid used. These secondary standards were calibrated against the laboratory/standard used in the international intercomparison with PTB (FRG) upto 4 MPa. An agreement in the effective area better than 1 ppm and 5.8 was obtained for these respective standards.

The detailed investigations were undertaken to further reduce the uncertainty in the pressure measured by the primary standard upto 500 MPa in the hydraulic hydrostatic region. The jacket pressure coefficient was computed theoretically and compared to that of the value determined experimentally. The measurement uncertainty was reduced to 74 ppm.

An international intercomparison exercise of static pressure in the range 20-100 MPa in fluid media was undertaken by BIPM (France). About 13 leading metrological laboratories from the different parts of the world, including NIST(USA), NRLM (Japan), IMGC (Italy), PTB (FRG), NPL(UK), VNIIFTRI (USSR) participated. The NPL had already completed the comparison of BIPM transfer standard against laboratory transfer standards. The pressure standards having the full scale pressure of 500 MPa, 280MPa, 140 MPa and 100 MPa were used. Their accuracies are traceable to the NPL primary standard. A confidence level was built up when the A_o^{Tr} and the distortion coefficient of the BIPM transfer standard was determined experimentally by crossfloarting it against NPL transfer standards. The agreement in the value of BIPM standard as derived by using these two NPL standards was better than 2 ppm.

2. Vacuum

Further improvement in the performance and accuracy of the Ultrasonic Interferometer Manometer (UIM) was incorporated using a new set of four frequencies 9.36, 9.42, 9.86 and 10.6 MHz. the working programme was modified by introducing subroutines for the measurement of temperatures of the mercury column and piston gauge. The new values of the effective area measured with the new set of frequencies were found in agreement with the earlier measured values. The values of effective area (at 23°C) determined for nitrogen at 40, 70, 100 and 130 kPa were found within 1-2 ppm of the values determined at the NIST, U.S.A.

The effect of thermal transpiration on the

measurement of low pressure in the MKS capacitance gauges was determined. The temperature difference between the system and the gauge caused the pressure gradient between the two. This was studied for 1 torr (310 series) and two 10 torr (310 and 398 series) using argon, nitrogen and helium gases. The results obtained were compared with the different theoretical models and found in good agreement with the empirical model.

The influence of the electric power input on the pumping properties was investigated for a Diffstak 100/300 diffusion pump for the nitrogen and helium gases. A detailed study of the compression ratio for different heater voltages was made and it was observed that the compression ratio had an exponential decay with respect to the decrease of the heater voltages. This break down point value of heater wattage showed an increasing trend at the lower input pressures.

A comparison of low pressure measurements between NPL and PTB (FRG) over the range 10^{-3}-2 Pa was performed. Both the laboratories used the static expansion system for pressure generation. The values of the tangential momentum transfer coefficient of the two gauges for Ar agreed within $\pm$ 0.5% for the two laboratories.

3. Surface Physics

The work to study the electronic structure of Ti, $TiSi_2$ was continued. The changes in the Auger and Loss spectra of chemical binding of Ti with Si and oxygen was understood as manifestations of the changes in the electronic participation. AES spectra showed distinct changes in line shapes of transitions involving the Ti valence electrons. The SEELS spectra provided information regarding shallow core levels, valence band and the collective excitation energies of the volume and surface plasmons. By monitoring the changes in the Auger peak at 387 eVand the 3p-3d quasiatomic transition (at 45 eV), the role of d-orbital occupancies were studied in Ti and its compounds. Computer programmes for interactive graphics, to transfer spectra from derivative mode to integrated mode were developed.

Stoichiometry and depth profile experiments were performed on thin films of approx. 200 nm of mangnetic materials, as a part of the collaboration between NPL and CNRS, France. In the Tb-Fe-Co_2 sample carbon was seen to be near the substrate, which could be due to insufficient substrate cleaning procedure. The Co (92)–Yb (8) sample showed lesser Co than expected (75%), while oxygen was an impurity.

Depth profiling experiements were performed on three samples of the high Tc 1-2-3 compound films on different substrates, prepared by Dr. Milan Jergel, of Bratislava, Czechoslovakia, as a part of their collaboration with NPL. The $YBa_2Cu_3O_7$ films were deposited on three substrates viz. silicon, Al_2O_3 and $SrTiO_3$, to see the stoichiometry and the substrate-films interaction. The stoichiometrics measured were observed not to be in the 1-2-3 configuration, but had excess barium and less of copper and oxygen. The film material diffused strongly into the strontium titanate substrate, while the film/Si interface was relatively sharp. The insulating substrates posed charging problems at the interface.

TEMPERATURE

The construction of Photoelectric Pyrometer was completed. The Pyrometer was hooked on to PC/XT through Solartron DVM. The current signal from the silicon diode was converted to voltage signal by home made circuitory. Automation in generation of calibration report of thermocouples was completed.

Triple point of Argon was realized with a reproducibility of $\pm$ 1 mK. Triple point of mer-

cury cell was designed and fabricated to serve as secondary fixed point of IPTS.

OPTICAL RADIATION

The intercomparison of optical radiation standards between India & USSR was continued. Under the first phase of the programme the luminous intensity standards, as maintained by the two countries at 2042 and 2353 K colour temperatures, were inter-compared. In the second phase of the programme a scientist from VNIIOFI visited NPL in Nov. 1988. The intercomparison of luminous intensity standards at 2800 K colour temperature and that of illuminance scale were made. The values assigned to the intensity and illuminance scales by the two laboratories were found to agree within 1.1 and 0.2% respectively.

INFRARED RADIATION

In order to extend the range of irradiance/radiance measurement upto 14 microns, spectral irradiance of a Black Body source was calculated for various temperatures and wavelength intervals. The radiation from Black Body—cavity was matched with the optics of SOPRA make monochromator by getting essential mounts made. A few spectra in the spectral range of 0.8 to 14 microns were recorded and the alignment of Black Body was checked and redone to optimize the out-put. The calibration of detector, evaluation of various other parameters of monochromator, and modifications in the computer programme are in progress

The specular reflectance values from measurements at near normal, incidence performed on several films (aluminium, gold on optically flat surfaces) and silicon, one surface polished, were compared with their theoretically calculated values. The uncertainties were calculated and the entire study was repeated by aging the films. Thus, the radiometeric scale of Perkin Elmer, model 399, IR spectrophotometer was calibrated at various wavelengths. The feasibility of establishment of transmittane standard was explored and further work in this direction is in progress. The photoacoustic spectroscopic facilities were provided to various sections of the laboratory and outside institutions.

The design of optical set-up for absolute measurement of specular reflectance and transmittance at normal incidence in the spectral range of 0.8 to 2.8 microns was proposed. A few private firms have shown interest in the commercial exploitation of hot axle box detection system developed for Indian Railways.

ACOUSTIC

A noise and vibration survey was carried out in Calcutta Metro to identify the major noise and vibration sources and to suggest remedial measures. The results were interpreted in the light of available data of metro operation, the comfort levels achieved by other agencies in various parts of the world and the safe limits set by various international bodies.

Certain system refinements were done to suppress conducted and radiated electrical noise interference in the Doppler Sodar. In this respect steps were also taken to activate another antenna located slightly differently.

The work on climatological studies of sea breeze at Tarapur was undertaken. Also the observed sodar structures were correlated with the stack plume dispersion under various conditions of stability. The monostatic system was operated regularly and the set up at Mukherji Nagar was repaired.

ULTRASONIC

Investigations were completed on determi-

nation of effective radiating area of transducers, by obtaining best fit between experimental and theoretical axial distribution. For the parametric transducer studied, it was observed that in some cases effective area can be different than the physical area, the maximum variation being 20%. An intercomparison study was carried using a Medisonics PVDF probe hydrophone. The average sensitivity measured by the reciprocity method was 0.189/ μv/Pa in the frequency range 1 MHz to 10 MHz.

Ultrasonic beam calibrator was procured under the British Council project. The BECA system was set up successfully and measurements were taken on the acoustic wave form and beam profiles of parametric transducer and NDT probe. The beam calibrator was used to investigate the acoustic output and field characteristics of Linear Array Scanners (Hitachi & Siemens make) in M mode. The measurements were conducted in various hospitals at Delhi. Peak positive and negative pressure, spatial peak temporal average intensity, beam width and profiles etc. were studied. Studies on the design of float were carried out.

FLUID FLOW MEASUREMENTS

The setting up of primary standards of Fluid Flow Measurements, under the Indo-FRG Technical Co-operation programme, was initiated. The scientist visited the fluid mechanic laboratories at PTB and finalised the primary standards measurement rig for water flow measurements in the flow range of 0.4 m^3/h to 1000 m^3/h.

The development of the national flow measurement system and identification of traceability linkages to the national standards of measurements at NPL was also studied. The study of the volumetric and gravimetric measurement techniques, sources of errors and linkages to the primary standards of volume measurements based on delivery type over-flow pipettes was conducted.

TIME AND FREQUENCY

NPL disseminated Standard Time and Frequency Signals (STFS) regularly through Indian Domestic Satellite INSAT. These signals carry the coded information of Indian Standard Time and instantanious Satellite position coordinates. The uplink is at 6 GHz and the down link at 2.5 GHz. At the user's end, a dish antenna with a front end converter and FM demodulator recovers the signal upto base band. This demodulated signal is fed to NPL developed decoder to recover the entire information and also to generate clock pulses synchronous with NPL clock. With the availability of these systems commercially, a user any where in the country can obtain time information corrected upto ± 20 micro seconds with a jitter of 1-2 microseconds and can use the system for performing frequency calibration also.

The scheme of utilization of TV signal directly from INSAT-1B for precise time comparison was analysed. An automatic recording system to facilitate the measurements was developed and tested. The exchange of data from the user's end to NPL is being tried through interlinking of computer via MODEM and P & T telephone line. Necessary software for the same was developed. The data from GPS satellite was monitored and sent to BIH for incorporation in their circulars.

DC STANDARDS

New values were assignated to the decade multiple standard risistors of 10 Ω ,100 Ω ,1 k Ω ,10 k Ω , 100 k Ω , 1 M Ω and 10 M Ω for establishing the full scale of resistance. The stability of the Zener based electronic voltage standard, housed in a heavy metallic shielded box, was studied.

LF AND HF IMPEDANCE

The calculable capacitor was completely overhauled and the fault was rectified and the optical system was realigned. The Transfer Standard of 10pF silica capacitor was reassigned value against the calculable capacitor with an uncertainty of 2 parts in 10^7.

The thermostatted 1 k Ω ac (1592 Hz) resistance was reassigned value against the 10 pF silica capacitor using the four terminal pair capacitance comparison, quadrature and equal power 100:1 resistance bridges. The ac-dc difference of the 1 k Ω resistor has also been determined. Williams Twin-T dual admittance bridge for extending the range of impedance measurements upto 100 MHz was commissioned and evaluated. A method to measure quality factor, "Q" of inductors was set up and evaluated. The accuracy in the measurement was of the order of 2%.

International intercomparison of 10 mH Standards of Inductance was carried out with VNIIM, USSR. The standards of two countries agree to within 15 ppm.

AC AND LF

The constant temperature oil bath was further improved by incorporating thermo-electric heat pumps. The temperature stability achieved was 3-5 m.C° over a range 20°-30°C with ambient temperature 2°C above and below the oil bath temperature.

Calibration facilities for phase meters with a phase accuracy of 5 m deg to 100 m deg within frequency range 1 Hz to 100 KHz were established. Three phase power and energy calibration system (based on electronic multiplication.) was commissioned after removing some faults.

HF AND MICROWAVE

Primay standard of microwave power measurement in waveguide system, was established in the frequency band of 18 to 26 GHz. The total uncertainty in power measurement in this frequency range lies within ± 0.2%.

A thin film barretter mount in Ku band was developed and calibrated for its effective efficiency at 14.3 GHz using microcalorimetric technique. Its intercomparison with earlier established pure calorimeter load type primary standard gave a consistency of ±0.15% which is well within the uncertainty limits of our primary standard.

International intercomparisons of rf voltage at 30 MHz were carried out under the auspices of BIPM:

a) 100 volt at 30 MHz

Three laboratories NPL-India, NBS-USA and PTB-FRG participated in the comparison with PTB acting as pilot laboratory. NPL received the travelling standards from PTB and NBS and completed the measurements. The results of measurements were sent to pilot laboratory for further analysis.

b) 1 mV 30 MHz

Eight laboratories namely, NPL, NBS, PTB, NIM-China, PTF-Finland, OMH-Hungary, ASMW-GDR, VSL-Netherlands with PTB acting as pilot laboratory participated. NPL India received the travelling standards from PTB, in the month of December, 1988 and completed the measurements in the month of February, 1989. The results were sent to the pilot laboratory for final analysis.

Quarterwave short circuits to be used as re-

flection coefficient standard at 8 spot frequencies in K-band (18.0 to 26.0 GHz) were fabricated for electroforming. These short circuits and low VSWR terminations would be used in the tuned reflectometer set-up for K-band.

CALIBRATION SERVICE PROGRAMME

The Calibration Service Programme under the NCTCF scheme of DST, is co-ordinated by NPL. Director, NPL as the chairman of the steering committee, is the co-ordinator of this programme. Six documents entitled "General guidelines and specific criteria for accreditation of Calibration Laboratories" in the areas of Electrical Measurements, Electronic Measurements, Mechanical Measurements, Thermal & Optical Measurements, Fluid Flow Measurements and Radiological Measurements were finalised and printed. A user's guide giving brief description of calibration laboratories and their areas of work in different fields of measurement throughout the country was prepared.

Two detailed documents regarding the present status of National Standards of Measurement & Calibration facilities at NPL were prepared and presented to the IECQ team. NPL has been recogaised as the calibration service element in the IECQ system in respect of electronic components and these would now be able to find unrestricted acceptability in the EEC market.

About 500 industrial units were approached under the CSP for surveying the existing and required calibration facilities so that an integrated view in respect of development of such facilities in the country could be undertaken.

MATERIALS

SILICON AND SILICON DEVICES

1.1 Crystalline

The main objective was the study of silicon material and the processes for fabrication of devices on silicon.

Under the NPL-CEL joint project for growing 10 cm × 10 cm area ingots, the NPL team carried out the required modifications in the Hamco CG-800 crystal puller of CEL. A completely redesigned heater of graphite, fabricated at NPL, was installed in the said equipment.

Computer simulation of phosphorous diffusion into silica under non-oxidising ambient was done solving parabolic partial differential equation. The calculated diffusion profile was matched with the experimental data.

A plasma enhanced chemical vapour deposition system (Model Vacutec VPS 1530S) was installed and commissioned. Initial experiments, to deposit uniform films of Si_3N_4 on silicon wafers were carried out. The growth kinetics of silicon oxide grown over silicon by plasma oxidation technique was studied.

Ti and Si films on silicon wafers, deposited by electron beam evaporation (sequential and coevaporation) were anealed in Ar and analysed for their sheet resistance behaviour. The samples were given various types of anneal treatment and the observed sheet resistance varied between 6 ohm. cm^{-2} to 1.2 ohm. cm^{-2}. These studies are useful in the development of microelectronic devices.

Metal-Oxide superconductor interfaces were studied. The contact interface properties were observed to depend on contact metal-oxygen interaction parameter. Several other interfaces such as semiconductor-semiconductor, semiconductor-metal were also studied. A new procedure based on electrodeposition from organic electrolytes was developed to produce single crystal CdTe films. Exploratory studies of the interfacial phase equilibrium in Ti/Si system was also carried out.

1.2 Amorphous

The development work of fabrication of thin film amorphous silicon solar cells was continued. An improved plasma CVD system was designed and fabricated, specifically to grow device quality a—Si:H films at higher rate of deposition. Extensive characterization of high rate deposited films was carried out and efforts were directed to fabricate complete p-i-n structure solar cells using the new system and to grow films suitable for electrophotography. The panels of size 100 × 100 mm, involving such cells, were developed and demostrated at CEL, Sahibabad and IACS, Calcutta.

LUMINESCENT MATERIALS

The objective was to develop fluorescent screens coated with phosphors for use in the real time X-ray imaging. The work was continued and experiments were done by varying the firing atmosphere from air to nitrogen using the open boat configuration and by increasing the flux proportions. Firing in covered crucible for 3 hours at 1100°C increased the average particle size from 5.48 μ to 7.47 μ This material was prepared using the purer quality sulphur. Cathodoluminescence output studies of the samples were made. The films of the phosphor were prepared by a different technique, in PVC binder so as to make it independent of substrate. It was programmed to put up these films

tungsten sheets of varying thicknesses for obtaining best resolution on a specified dose of X-rays. These films were tested on 70 KeV X-ray unit for light output. The maximum output obtained was for a film of 120 μ, using a coating density of 40.0 mg of phosphor per sq.cm. Gd202S:Tb phosphors prepared under different conditions were studied and found to reveal the influence of structural disorders such as vacancies on luminescence.

Regarding simulation studies, the study on gas-liquid reaction for absorption of hydrogen sulfide in ammoniacal solution of zinc chloride was concluded. Simulation work of spray reaction and drying was extended from monodisperse system to a more practical situation of polydisperse spray. Experiments were done keeping polydispersity of spray in view.

LIQUID CRYSTALS

The studies regarding the use of newer liquid-crystalline display materials including ferroelectric, supertwisted birefringent liquid crystals, polymer dispersed nematic liquid crystals and non-linear optic materials, were continued.

1. Liquid Crystals

Polarization reversal current response for parallel and antiparallel rubbed samples of a 3μm thick sample of DOBAMBC were studied. It was found that the selective pretilt angles with the surface resulted intotilted or bent smectic layers to give the multipeak response of the polarization reversal current. The zig-zag type of defects were eliminated by applying an alternating electric field of suitable frequency. The sample showed uniform contrast, remained defects free and exhibited the characteristic of fast switching bistable SSFLC displays. The current response of (SSFLC bistable) cells was studied to different square pulses and (the SSFLC's) showed a peculiar behaviour forasymmetric and time delayed positive and negative square pulses for bistable SSFLC cells and the comparative studies of optical transmission of the associated molecular reorientation processes for these pulses were done.

Systematic experimental investigations were carried out to study the effect of various device fabrication parameters such as the total twist angle, the ratio of cell thickness versus pitch, the surface tilt angle on the performance characteristics of SBE cells. Fig. shows one set of electro-optical transmission curves of SBE cell with different twist angles for high tilt angle devices. It was found that in SBE cell for LaRoche LC mixture 3010, the twist angle $\theta_o \sim 240$ for surface tilt angle $\simeq 25$–$30°$ was optimum to get extremely sharp transmission characteristics with very little bistability. Following Alt and Pleshko's criterion, some of these samples could be used for 200:1 multiplexed scheme.

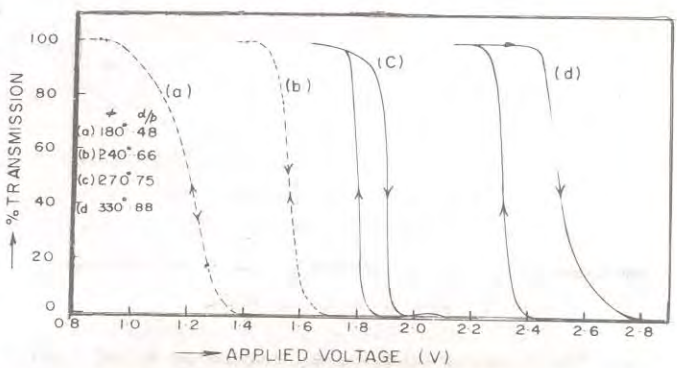

Fig. Set of normalized transmission curves of SBE cells with different twist angles.

1.1 Conducting Polymers

Some new conducting polymers such as polyanilines, polyaniline-polystyrene sulfonate, polyparaphenylene, polynitrophenylene and poly-aminophenylenes were generated using chemical and electro-chemical methods. Measurements carried out on poly-α-naphthalene oxidepyrole indicated that it could

store upto 18% of the available charge. An important observation was made that the composite of polyaniline/polystyrene-sulfonate exhibited interesting rubbery characteristics. The precolation threshold of this conducting polymer was found to occur at 11.6% of the weight of the polyaniline contained within the polystyrene sulfonic acid. The electrical conductivity of the chemically prepared polyparaphenylene could be raised by ten orders of magnitude when electrochemically doped with BF_4^- and ClO_4^- ions.

ULTRASONIC SYSTEMS FOR OCEANOGRAPHIC STUDIES

The development and characterization of acoustic transducers and parametric systems for oceanographic applications was continued.

1. High Power Ultrasonic Systems

Transducers for pingers were developed using NPLZT-4 having a loss factor of 0.004. The peak acoustic output was comparable to the output of the ITC transducer. The resonant frequency and workable bandwidth was 18kHz and 6kHz respectively. The measurements were also made under conditions existing in sea at Bombay. The pinger transducers were tested at hydrostatic pressures upto 3000 psi in the Benthos pressure chamber, which was installed. There was no appreciable change in the impedance of transducers with only a marginal change in capacitance and the resonant frequency. A tone burst generating circuit was developed as a part of the circuitry for exciting the pinger.

Aging studies were undertaken on receiving hydrophones fabricated using piezoelectric ceramic tubes of OD 25.4mm, ID 19mm and length 22mm, inserted in neoprene encapsulation. The decrease in sensitivity, over a period of six months, was observed from 200dB to 197 dB. The Coupler block was fabricated and tested for pressures upto 300psi. Termination transducer for noise free response at low frequencies was also fabricated.

The dielectric loss factor tan δ as a function of electric field was studied in samples of piezoelectric ceramic fabricated indigeously and imported from Vernitron. It was observed that tan δ was less than 0.03 upto a field of 3KV/cm. For low fields upto 1KV/cm, the behaviour was similar in both the samples. For high fields, the indigneous sample showed a slight increase.

1.1 Development of Parametric System

In addition to the 16 element transducer for 300kHz, transducers were constructed of 36 elements for 300kHz and using 9 elements for 185kHz. The radiating face was coated with polyurethane which was obtained free from bubble nuclei by degassing during curing. The transducers were found to work well during continuous immersion in water for several days. Parametric arrays were generated by driving the 36 element 300kHz transducer, with carrier suppressed double side band excitation, at a drive voltage of 360 VP-P. The frequency of the parametric signal could be varied by varying the modulation frequency from 1.5 to 5kHz. The propagation characteristics were studied upto 15 metres.

Measurements were repeated at the NPOL, Cochin in November 1988. It was observed that there was fine agreement between the values of source level and directivity measured at NPL and at NPOL. Measurements were carried at U.A.R.F. Kulamavu Idduki, where in a frame work containing rigidly fixed transducer, hydrophone, butyl rubber and mild steel reflector was suspended into water. It was observed that the reflections could not be detected by primary beam of 300KHz and the parametric signal as well. The above difficulty was sorted out in subsequent testing. The source level of parametric acoustic arrays was increased by driving

the transducer harder and by decreasing the primary frequency, keeping the parametric frequency same. Attempt was made to detect the target using both primary and parametric beams. The studies showed that the parametric beam has an edge over the primary beam in detecting the target.

The experiments were thereafter repeated at NPL in the horizontal configuration, using the hoist for submerging the sheets and the high precision translation facility. Studies were also made using sand in a rectangular frame giving strata thickness of 0.5 metres. In this case, the primary level was cut down by 40dB. Whereas the parametric level was reduced by 12dB. Transducer for operation at 1.2 kHz was successfully tested in air previously. For determination of source level in water, a team went to Bombay for conducting measurements at the required depth at sea. The acoustic signal was marked by electromagnetic pick up. Transducer insulation was also not proper for use in sea water.

The high precision XYZ translation system with stepof 1mm in X and Y and 0.01mm in Z has been installed and positioned over X-Y trolley. The structure for operating electric hoist was created and a 2 ton hoist was commissioned for lowering or raising heavy objects.

1.2 Piezoelectric Ceramics

Elements of O.D. (62mm) I.D. (50m), tan δ (.005) and K (1050) were produced for application as underwater projectors. Sufficient consistency in properties was achieved. Large size discs (100mm diameter) were fabricated for application in OATS. A large number of PZT rings were produced and supplied to several firms.

CARBON PRODUCTS

1. Carbon Fibres

Successful runs were carried out in the experimental pilot plant for carbon fibres. Benzoic acid modified PAN fibres were carbonised. A new technique was evolved to evaluate the crystallinity of PAN fibres by X-ray diffraction. Continuous experimentations have resulted in bringing down considerably the cost of flexible graphite foil. Intercalation of natural graphite flakes was carried out in liquid phase and X-ray and calorimetric studies were carried out to understand the phase transition and desorption kinetics.

A process was developed for making a low quinoline insoluble special pitch. This pitch was subjected to heat treatment for various periods of heating so as to study its effect on the resulting pitch characteristics, namely, softening point, quinoline and toluene insolubles, B-resins, coking value and specific gravity. It was found that the B-resin contents of the resulting pitch increased to about 44% upon heating at 400°C for 20 hours.

1.1 Carbon-Carbon Composites

The technology was developed for 3 dimenional weaving of carbon fibres of different sizes. Orthogonal weaving was carried out for a big size (40 cmsx40 cmsx20 cms) nose tip.
Carbon-Carbon (C/C) composites were coated with SiC by chemical vapour deposition (CVD) tecnique and the conditions of deposition were optimised. The microstructure of the coated composite was studied by optical microscope and scanning electron microscope. Oxidation behaviour of SiC coated C/C composites was studied upto 1650°C and weight loss was found to be about 25%. Due to difference in thermal behaviour of SiC and composite, cracks were found to arise in SiC coatings. These cracks were subsequently filled with glasses such as B_2O_3. Weight loss in air, when heated upto 1000°C for 3 minutes, came down to about 1-2% as compared to 4% at 1650°C.

1.2 Glassy Carbons

Glassy carbon plates of size 200 mmx20 mmx2

mm were made and supplied to BHEL, Hyderabad for the development of fuel cell. Carbon resistor plates and crucibles were made. The fixation of glassy carbon dental implants onto animals at Dental College, Trivandrum was taken up for substituting titanium plates used presently.

2. Impregnating Pitch

The work of development of impregnating pitch was continued. The solvent fractionisation process was modified to reduce the cost of the pitch by avoiding use of quinoline. The fractions were reduced and the cost of the pitch brought down. The isotropic pitch was separated out and the low ash carbon residue examined for its physical properties for making carbon products.

HIGH PRESSURE PHYSICS AND TECHNOLOGY

The investigations about the diamond compacts were continued. In the synthesis of cubic boron nitride the effect of the degree of crystallinity of the raw material on the process parameters and the percentage conversion was studied. It was observed that the PT values for phase transformation were lower and the percentage conversion higher with the starting material of higher graphitisation index. Studies on the genesis of garnets, particularly the Al bearing and Cr bearing varieties, were pursued in order to characterize the diamond bearing kimberlites.

Exploratory work on hot extrusion of rods, produced by vertical retort process, was initiated jointly with SAIL R&D. The work on the prototype development of strategic component using warm forging technology was continued. The development of corrosion resistent composite tubes by shear spinning was continued. A new process for self gasketing flanged pipe joints was developed to check the corrosive liquid from coming in contact with the outer corrodable shell.

CHARACTERIZATION

The research investigations regarding various aspects of materials characterization including purity, composition, structural and crystalline perfection were carried out. Standard solutions were prepared as a part of standard reference materials.

1. PURITY AND COMPOSITION

1.1 Chemical Methods

The work of development of a new method for the determination of non-stoichiometry oxygen in high Tc superconductors was carried out. Only few mgs of material was required for the insitu analysis. The accuracy of the method was better than 3%. A highly sensitive method was developed for the determination of moisture in gases or atmospheric samples using gas chromatographic technique. Stainless steel gas sampler was developed to collect air samples under pressure without any contamination. Spectrophotometric methods were developed for the determination of boron in high purity materials and silicon in copper and its alloys at sub-ppm levels. The characterization of different samples from various industries, government agencies (26 reports) and internal projects was done.

Surface area measurements were carried out on silica and silica powder samples of carbon powder bound in teflon suspension for Delhi University. Activated carbon granules received from NTPC were tested for surface area, real and apparent density.

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1.2 FTIR Absorption and UV-Visible Emission Spectroscopy

FTIR spectroscopic studies in the range of 400 to 1500 cm^{-1} of high Tc superconducting materials were carried out. The presence of unusual carbonate could be detected by measuring $BaCO_3$ characteristic bands at 1435, 856 and 694 cm^{-1}. The stretching and bending vibrations of CuO in the range 400 to 650 cm^{-1} were studied at different temperatures from 6 K to 290 K. The band at 436 cm^{-1} was found to reduce its absorptance with lowering of temperature. Far infrared absorptance measurements were also done at temperatures above and below Tc. Screening of certain phonons due to free charge carriers below Tc was demonstrated experimentally.

Far infrared absorptance studies were carried out of phosphorus doped silicon having different doping concentration. Sharp absorption bands were observed in the far infrared range below 400 cm^{-1}. The fifth group impurity phosphorus in silicon acts as a solid state homologue of hydrogen atom. Elemental analysis of some samples was carried out.

1.3 X-ray Fluoroscence Spectrometry

Efforts were continued to make strong pellets of sample for X-ray fluoroscence analysis. It was found that the thin film smear technique, requiring only 5 to 10 mg of the sample, was successful in characterization of odd shaped samples. The standard sample holder of the equipment was modified and fabricated to get a fully stretched Mylar sheet for preparing thin film smears. The characterization facility was provided to the Directorate of Revenue and Intelligence and Ministry of Defence. Semi-quantitative elemental analysis was done for high Tc superconducting thin films, steel shaft bush, gold and silicon wafers. In the X-ray fluoroscence of single crystal wafers/ingots it was found that many extra weak reflections also appeared and could not be traced to any impurity present in the sample.

1.4 Electron Paramagnetic Resonance Spectroscopy

EPR investigations were continued for defects/impurities present in synthetic diamonds. Traces of copper ions were also observed in diamonds synthesised by using monel as the catalyst solvent. Detailed investigations have shown that the width of EPR lines of nitrogen present in the specimen are quite sensitive to the nature of the catalyst employed. EPR investigations were done on as-deposited and air heat treated CdTe thin films.EPR signal was obtained only for CdTe films which were heated in air at or above 300°C. Line intensity of thin signal increases from 300°C and reaches maximum at 500°C beyond which it decreases.

2. STRUCTURAL CHARACTERIZATION

2.1 X-ray Diffraction

The oxidation characteristics, annealing effects, copper incorporation and effects of compaction in high temperature superconducting compounds were studied. The correlation of the above effects on X-ray parameters and phase transformations at different cooling rates were also studied. X-ray diffraction profiles of completely amorphous PAN were obtained in order to measure accurately the crystallinity of various PAN precursors. The angle of orientation and degree of crystallinity of PAN fibres, obtained by different modification techniques, were determined.

For the study of influence of deposition parameters and growth conditions for achieving oriented acoustic quality ZnO films, the crystallite orientation, size distribution and lattice strain measurements were done in collaboration with IIT, Delhi. Studies on the chalcogenide

system Ga_2Te_3 were continued. It was concluded that the zincblende phase of Ga_2Te_3 was metastable and slowly transformed to hexagonal form at room temperature. Solid solutions $Cu\ Ga_xIn_{1-x}\ Se_{2(0<x<1)}$ were studied for elemental composition, particle size and crystallite size measurements. Investigation on the stacking faults and defect parameters in the tellurium-selenium alloys were completed. Theoretical studies on vapour obsorption on porous materials were continued and the separation factor of a binary gas mixture was calculated.

X-ray diffraction studies of samples from the projects of carbon fibre and carbon materials; superconducting materials and synthetic diamond were carried out. Characterization assistance was provided to various laboratories, departments and industry.

2.2 Electron Microscopy and Diffraction Techniques

High Tc superconducting materials were investigated by TEM and SEM. In certain samples lattice planes were resolved by using TEM. The superconducting and non-superconducting phases formed under different conditions of treatment were detected and analysed for their elemental composition. The uniformity of material was also studied by determining elemental analysis at a large number of points on the surface of materials. The thin films of superconducting materials prepared by sputtering, spray, flash evaporation and screen printing techniques were also investigated. The films grown on silicon glass, poly and mono $SrTiO_3$, MgO, YSZ, Al_2O_3 and Cu were studied for their surface morphology, elemental composition and the uniformity of composition.

The black nickel coating prepared by dipping process on zinc coated aluminium substrate was studied for optical performance. The optical reflectance vis-a-vis the morphology of the coatings after each predeposition treatment were investigated. The studies showed that the emissivity of the final black coating on electropolished aluminium sheets had low values. The coatings also showed little degradation on thermal annealing up to 200°C. A number of samples of black Ni and Ni-Co layers were examined by SEM to study their surface morphology. The optical reflectance of these coatings was also studied. It was observed that the surface morphology of these coatings affected the solar absorptance of the coatings and the surface morphology could enhance the solar absorptance.

A new facility of *"Ion Mill"* for preparing specimens suitable for TEM examination was acquired, installed and tested for its performance and specifications. Samples from various projects of the laboratory and other R & D institutions including universities were investigated by TEM. The samples consisted of chalcogenides, TiSi films, Si powder, channel black, CdS/Se layers, ZnCdS/Si, foils of Pb, Al and Sn etc. Surface structure and morphology of samples were examined by SEM. Using electron probe microanalyser samples were examined for their point to point elemental analysis. The samples included superconducting materials CdTe, B-Alumina, failed steel samples of turbine and heater tube and mangnetic/non-magnetic dust particles of colour T.V. picture tubes. The various institutions/organisations assisted were IIT, Delhi; Delhi University; N.T.P.C.; Uptron; CEERI; and IACS Calcutta.

3. CRYSTALLINE PERFECTION

3.1 High resolution X-ray Diffractometric, Topographic and Diffuse X-ray Scattering Techniques

Stress measurements were made on 100 mm diameter (001) Si wafers with polysilicon film on silox film, in collaboration with M/s Semiconductor Complex Ltd. SAS Nagar. X-ray

diffractometers were used for recording diffraction curves and for radius of curvature measurements from (004) and (220) diffracting planes. The half width of the diffraction curves were in range 13-21 arc seconds. Determination of crystallographic orientation of surface for 100 mm dia silicon single crystals was also done using (400) planes and triple crystal X-ray diffractometers.

High resolution X-ray diffractometry, topography and curvature measurements were used for evaluation of crystalline perfection and for determination of strain in semi-insulating gallium arsenide single crystal substrates with and without metallization. The value of strain in the wafers was determined from the experimentally measured radius of curvature of planes. The quadruple crystal X-ray diffractometer was used in (+,–,+,–) (+,–,+) as well as in standard topographic (one crystal) mode. The specimens were generally 10 × 10 × 0.1 mm^3 wafers. The metallization deposits were five layers of different materials of thicknesses: Ge–20 nm, Au–5 nm; Ni–10nm; WSi_2–100 nm; Au-100 nm (total thickness = 235 nm).

The half widths of the diffraction curves of reference specimen (without deposits) were in the range (15-22) arc seconds. Their radii of curvature, R, were around 6 m. The topographs showed low density of line defects. Deposits of contacts led to a considerable decrease in the degree of perfection of the specimen and increase in the level of strain. Deffraction curves became quite broad with half widths in the range 40-180 arc seconds. Topographs showed the presence of strain field and bands which appear to be linked with the deposits. A remarkable decrease in the radius of curvature was observed showing the presence of strain. The values of R were in the range 1.2-2.5 m. There was an anisotropy in the strain distribution which was investigated experimentally. With n-type GaAs crystals the following two types of metallization were used: (i) Ge/Ni/WSi_2/Au and (ii) Ge/Au/Ni/WSi_2/Au. The strain in wafers with the second type of deposit was higher than that in wafers with the first type of deposit (In collaboration with Technical University, Darmstadt FRG).

Experimental data of diffuse X-ray scattering (DXS) measurements made on Czochralski and float zone grown silicon single crystals was analysed by using a theoretical model. The variation of the experimentally observed DXS intensity with scattering vector K* could be explained. From this correlation the sizes of the point defect clusters and the number of point defects in each cluster could be obtained. Experiments on crystal growth of lithium niobate and barium fluoride were carried out by Czochralski method. Different gas atmosphere was used in the experiment.

4. STANDARD REFERENCE MATERIALS

Standards of lead solutions in the range of 1-2 ppm were prepared in high purity water obtained after deionization and sub-boiling distillation. The stability of these solutions and contamination due to leaching from container material was measured. It was found that quartz and pyrex containers have minimum effect on the stability of the solutions of lead. Quantitative estimation of lead was carried out by different analytical techniques like atomic absorption spectrophotometry, ICP emission spectrometry and ICP mass spectrometry. The values of lead obtained from these three techniques were compared and values for lead concentration were assigned.

Analar grade nitric acid was purified by sub boiling distillation method. An evaluation of trace impurities before and after distillation was carried out by inductively coupled plasma emission spectrometric method. It was found that most of the impurities were reduced by a factor of 5 to 10 in the purified material. Constituents like Fe, SiO_2, Al_2O_3, TiO_2, S and P were

analysed in iron ore provided by NML Jamshedpur. In plain carbon steel carbon, sulphur, silicon, phosphorus and manganese were analysed and provided.

CONDENSED MATTER PHYSICS

1. HIGH TEMPERATURE SUPERCONDUCTORS

1.1 Basic Studies

Basic research on superconductors with emphasis on La-based 2-1-4, Y-based 1-2-3 and Bi-based 2-1-2-2 and other related systems was continued. These systems were subjected to various cation and anion substitutions and resulting effects and superconducting characteristics were investigated. The studies led to collaborative efforts with other laboratories, in particular, TIFR, Bombay; IIT's of Kanpur, Bombay, Madras, and Delhi; Universities of Rajasthan, Udaipur, Shivaji and Pune.

Amongst all substitutions partial replacements of Zn for Cu in 2-1-4 and 1-2-3 systems proved very rewarding. Unusually large Tc depression was observed with Zn substitution, free from constraints of O-T transformation and changes in oxygen stoichiometry and lattice parameters. Close similarities suggest that the mechanism of superconductivity in the 30K and 90K systems are unlikely to be radically different. XANES studies on the above samples at the University of Rajasthan showed a diminished d-p hybridization with Zn substitution. Zn substitution in 2-1-2-2 Bi-based system had much less deliterious effect, however. Indications are that Zn possibly goes to Ca-site. Unlike Zn, partial substitution of Fe for Cu had a pronounced effect in lowering Tc of 2-1-2-2- Bi system. Mossbauer absorption of Fe in the above samples, studied at the University of Udaipur, suggested Fe to go to Cu-sites. Also these studies indicated that apart 2-1-2-2 phase, Fe went also to the two Cu-sites of 2-2-2-3 phase. The Mossbauer lines showed marked quadrupole splitting in conformity with the above contention.

Hf substitution in small concentration in 1-2-3 had little effect on Tc but it helped in reducing the grain size and compaction of the sample. Low field Microwave absorption studies carried out in collaboration with IIT, Kanpur showed that weak-links were diminished with Hf substitution and it was possible to study the effect of H_{c1} of weak-links and hysteresis characteristics of the substituted samples. All these cuprates have their superconducting properties sensitively affected by oxygen stoichiometry. Oxygen vacancies could serve as host lattice defects in these materials and gave rise to various phenomenons of luminescence. Electroluminescence of the samples was studied in collaboration with Shivaji University while fluorescence was investigated at IIT, Kanpur.

The measurements on the thermoelectric power on a series of $Y_1 Ba_2 Cu_3 O_{7-x}$ specimens with varying amount of oxygen deficiency, obtained by changing the cooling rate of the sintered specimens, were carried out between 77 and 300K. The specimens were characterized by X-ray diffraction measurements, electrical resistivity and oxygen contents. The thermopower variation with temperature revealed a peak (8-10 μv/K) above the superconducting transition temperature Tc. The most interesting result of the studies was that the quenched specimen (1200K to 77K) showed a metallic behaviour down to 77K but no superconducting transition and yet the TEP dropped to zero around 85K similar to slow cooled specimens. X-ray diffration measurements indicated that the specimen, though tetragonal, nevertheless had a small quantity of orthorhombic phase. The peak in TEP above Tc was attributed to the pair fluctuations in the normal state close to but

above Tc. TEP measurements were also carried out on a large number of quenched condensed films of Cu-Sn alloys with a view to understand the anomalous TEP in terms of structural and electronic behaviour of these highly disordered systems.

An electron-beam evaporation technique was developed for fabrication of SC films of Bi-Sr-Ca-Cu-O system. The special feature of this simpler technique was the use of a *"single sintered pellet"* as an evaporation source. The films deposited by this technique on MgO and $SrTiO_3$ and annealed later in slow oxygen showed superconductivity with onset temperature Tc (ON)~85K and zero resistance temperature Tc° = 73K respectively. Characterization of the films with XRD and electron microscopy showed strong preferred orientation of the films and agreement between the compositions of the film annealed under appropriate conditions and the source.

1.2 Processing Studies

The processing technique for large scale production of the 1-2-3 superconducting powders was further studied. Through TG/DTA studies, the oxidation characteristics, decomposition temperature and the anneal treatment necessary for appropriate oxidation of the tetragonal phase into the superconducting orthorhombic phase was formulated. The chemical homogeneity (or phase homogeneity) of the material is reflected in the width of the transition zone (ΔTc). Through a systematic study of the densification and microstructure growth, considerable undestanding was developed of the linkage between the grain shape and sizes, sample porosity etc. on one hand and Jc and Δ Tc on the other. Jc of more than 350 A/cm^2 (1 μV/cm, 77K, OT) was obtained in ceramic samples. Some additives in the form of oxides of tungston, vanadium silver etc were studied for modulating grain growth and densification of the sintered samples.

Effect of pressure induced stress on Tc of superconducting La-Sr-Cu-O and Bi-Ca-Sr-Cu-O systems was studied in 20-58 kbar range establishing that the effect of pressure within this range would decrease the value of Tc.

1.3 Superconducting Wire

The superconducting powder of Y-Ba-Cu-O (calcined and milled) mixed with binder and plasticizer was used to fabricate fine wires (50 μm-250 μm dia.) by wet spinning technique. By giving proper heat treatment, the effect of binder on Jc in these wire samples was minimised. The development of Ag-clad superconducting wire was continued. Preliminary work on the Bi based superconductors yielded single phase, high Tc (zero resistance at 104 K) samples of 2-2-2-3 composition.

1.4 High Temperature SQUID

This is a multi-laboratory project of CSIR involving four laboratories, NPL; CEERI, Pilani; CGCRI, Calcutta and RRL, Trivandrum. This is being coordinated by Dr. A.K. Gupta of NPL. The objectives are: study of grain boundary Josephson junctions and development of high quality thin films of high Tc materials; fabrication and study of thin film SQUID devices.

The primary objective is to fabricate SQUID devices. Various types of junctions such as point contacts, break junctions and inter-grain junctions were fabricated and studied. Inverse AC Josephson effect in these materials was observed due to the presence of inter-grain Josephson junctions. Both DC and AC Josephson effects, due to grain boundary Josephson junction, were observed in constricted samples of Y BaCU O and Bi Sr Ca Cu O. Superconducting Quantum interference effects were observed in a DC SQUID like geometry consisting of a pair of constrictions carved out of a bulk Y Ba Cu O superconductor.

The work of development of good quality

thin/thick films of high Tc superconductors was initiated. Various techniques for fabrication of thin films were studied. Thick films of Y Ba Cu O using screen printing technique having a superconducting onset temperature around 90K and zero resistance around 82 K were fabricated. JC of these films was of the order of 15A/cm^2 at 77 K. About 5-10 μm thick films of both Y Ba Cu O and Bi Sr Ca Cu O superconductors were also fabricated by spray pyrolysis technique and zero resistance at about 84 K and 83 K was achieved respectively. Jc 5×10^3 A/cm^2 at 4.2 K and zero field was obtained in thick films of Bi Sr Ca Cu O. DC SQUID like structures were manually fabricated on these films and oscillations in V-I curves due to superconducting quantum interference effects were observed at 4.2 K.

Preliminary work on development of low resistivity Ag contact pads on superconducting bulk samples was done. Contact resistivity $\sim 9 \times 10^{-6}$ ohm cm^2 was obtained at 77 K. The work on fabrication of thin films by RF sputtering technique using a single composite target was initiated and superconducting films with Tc (zero) around 50 K were fabricated. Patterning of these films using photolithography is being attempted to fabricate microbridges and SQUID structures.

For the development of superconducting thin films for SQUID applications, thin films of Y-Ba-Cu-O were sequentially deposited on a (111) Silicon substrate with an e-beam evaporated over layer of ZrO_2. Various types of precursors such as acetyl acetonates, hexonoates etc of Y, Ba, Cu were investigated and studied.

2. LOW TEMPERATURE PHYSICS

An rf shielded metal room was got ready and tested to house a dilution refrigerator to conduct experiments at temperatures as low as 5 mK. The dilution refrigerator was also installed and will be tested soon.

3. THEORETICAL STUDIES

A new mechanism of reduction of effective mass of peroxiton bonds responsible for high Tc superconductivity in Chakraverty's bipolaronic model was suggested. The changes in the O-O bond length due to the presence or absence of a hole on each of these two oxygen atoms induced a dynamic ligand field potential, which caused a substantial reduction in the effective mass of peroxiton. The mechanism was also used to explain the unusual ESR result on $YBa_2Cu_3O_{7-x}$. The fast motion of peroxiton bond and the associated dynamic ligand field satisfied the condition of fast vibronic relaxation. This caused a motion averaging and narrowing effects in ESR spectra of the neighbouring Cu-holes resulting in nearly isotropic and temperature dependent g-values.

A method was developed to study the low temperature ordering in heavy fermion systems by combining lattice vibrations with coulomb and exchange interactions. The method provided an understanding of the nature and strength of superconductivity in various heavy fermion systems.

DEVELOPMENTAL PROJECTS

THIN FILM

Special visible channel multicavity interference filters for INSAT-II-VHRR payload were fabricated as per specifications received from Space Application Centre, Ahmedabad. The optical characteristics have been fully achieved and a batch of four filters was sent for tests and evaluation. A large number of narrow-band interference filters having a band width of 8-12 mm were fabricated and supplied to the standards section.

BETA ALUMINA TUBES

The toughening of beta alumina tubes by the addition of partially stabilized zirconia (PSZ) was studied in detail. It was observed that the addition of 10.0 wt% PSZ improved the fracture strength of the beta alumina tubes from 150-200 MPa to 250-350 MPa. However, the ionic resistivity (at 300°C) in these tubes increased undesirably to 7-10 ohm. cm and the wetability of the sealing glass was less. These difficulties were overcome by adjusting the heat treatment schedules. For the fabrication of 50 mm dia PSZ-beta alumina tubes, necessary moulds, jigs and tools were prepared and a few tubes were pressed.

About 30 tubes were supplied to CECRI, Karaikudi and IGCAR, Kalpakkam for actual applications. Na-Na cell performance of these tubes was encouraging.

XERORADIOGRAPHY

The development of prototype of Xeroradiographic machine was continued. After the first phase of hospital trials, the efforts were continued for further improvements. The work of development of photoreceptors having polymer/selenium combination was done. One additional vacuum coating setup is being assembled. Thermally stimulated discharge current studies on amorphous selenium films were carried out to understand the behaviour of the photoreceptor. Various types of toners for cloud chamber development were characterized for their particle size & triboelectric properties.

CRYOGENIC SYSTEMS

Various studies were undertaken to find out the rate of production of liquid nitrogen by feeding pure nitrogen gas from the PSA generator to the liquefier at different pressures and flow rates. It was observed that by using PSA, the liquid nitrogen production rate increased to 4-4.5 lit/hr as compared to liquid air production rate of 3.75 lit./hr. without PSA. About 22,000 litres of liquid nitrogen was supplied during the year including outside agencies.

A PSA oxygen generator and moisture separator was being developed. Various subsystems were tested in situ as well as independently. In the initial phase, indigenous zeolite molecular sieves from ACC were used as the adsorbent material. It was observed that the compressed air with -1.2° C dew point (5500 ppm) could be dried to -41° C dew point (corresponding to about 110 ppm). This generator would be useful for R & D work in the division. A chemical based system of determining the oxygen content in the mixture of gases was developed. The samples from the PSA O_2 generator were checked along with the standard air sample. The accuracy of the system was about 0.1%.

A new series of miniature cryo-coolers with smaller length of 25 mm and having a cooling time of about 2 minutes were developed. The cryo-coolers of 38 mm length were successfully demonstrated at Instrument Research and Development Establishment, Dehradun. Preliminary studies with the critical adjustment of bellow and the orifice showed good results. A high pressure bottle of 30 $1N^3$. capacity (6000 psi) was designed and fabricated. A pneumatically operated high pressure booster was designed.

A simple, compact, inexpensive liquid nitrogen level indicator, based upon thermodynamic principle, was developed. The device is easy to fabricate and does not require electricity for its operation. This unit can sense liquid levels within 5 cms. A refrigerator, for storing medicines and vaccines in remote villages for the large scale immunization programme, was being developed based on vapour compression cycles. The refrigerator was tested and results were encouraging.

RADIO SCIENCE

INDIAN MIDDLE ATMOSPHERE PROGRAMME

In the final phase of IMAP a number of planned rocket and balloon campaigns and ground based measurements were continued.

1. Rocket and Balloon experiments

The data obtained from two M-100 rocket flights carried out as a part of the second phase of Indo-USSR ozone campaign was analysed and the ozone density profiles were intercompared with those obtained by other groups and were found to be in fairly good agreement. A centaure rocket was successfully launched from Thumba on May 4, 1988 under NPL-UTK, Japan collaboration programme. NPL's contribution to the payload for this flight was propagation experiment operating on two frequencies viz 1865 & 2610 KHz, Langmuir probe, ozone (255 & 290nm) and Lyman-alpha experiments. The data obtained from this flight was analysed and electron density, electron and ion currents, ozone and nitric oxide density profiles were obtained.

Ozone experiment operating on three wavelengths namely 255,290 and 310 nm was also successfully flown on a M-100 rocket on Sept. 10, 1988 from Thumba. The main objective of this flight was to study the seasonal change in ozone concentration. The data obtained from all the sensors was scaled and is being analysed. Fabrication, testing and calibration of nitric oxide, propagation experiment, Langmuirprobe and Gerdian condensor payloads were undertaken. These are scheduled to be flown in 1989 as part of IMAP-C campaign. A new method of validating the Langmuir probe data on electron densities over Thumba in the D-region via the solar cycle dependence was worked out. The theoretically calculated production rates and the experimentally measured electron densities by Langmuir probe in the D-region were not consistent with each other.

1.1 Laser heterodyne system

The laser heterodyne system was successfully extended to measure vertical distribution of water vapour and nitrogen dioxide. The ozone profiles obtained by the laser heterodyne system were compared with those obtained by balloon ozone sonde of IMD, New Delhi on all possible days when both profiles were obtained on the same day. The available ozone data was used to get a mean profile for ozone over Delhi. The LHS ozone mean profile was compared with the mean profiles obtained by balloon ozone sonde data at IMD, Aya Nagar, New Delhi and also over Thumba by rocket and balloon ozone sondes. The mean profile at Delhi by laser heterodyne system and balloon ozone sonde compared fairly well but the ozone mixing ratio values over Thumba were slightly less below the peak and higher above the peak (32km)

The laser heterodyne system was used to get water vapour profiles upto 25 km using 924.9883 cm^{-1} line which is near the P(40) line of CO_2 laser. A mean profile for water vapour over Delhi was obtained using the available data and compared well with that obtained by rocket, balloon and LIMS measurements. The hygropause, was confirmed by satellite results which showed that minimum water vapour in the stratosphere extended from 30° N to 30° S upto 40 mb (22km). In the present case minimum water vapour mixing ratio was found to be 3.5 ppmv around 19 km. Efforts were made to extend LHS measurements to get nitrogen dioxide profiles using 932.9214 cm^{-1} absorption line which is close to P(32) line of the CO_2 laser. The profiles so obtained were compared

with those obtained by LIMS satellite data. It was noted that profiles obtained by LHS do not match well with those of LIMS.

1.2 Solar radiation measurement

Solar UV-B radiation measurement were continued to monitor long term effects of ozone variability. The data collected during last eight years were carefully examined to see any trend of the depletion of stratospheric ozone. However, no conclusive evidence was available for ozone depletion except the variability of UV-B radiation reaching at ground due to changes in total ozone contents in the atmosphere.

Aerosol optical depth measurement was carried out regularly on clear days to estimate the aerosol pattern over Delhi. It was observed that the aerosol size distribution was entirely different than the coastal region measured by similar set up at Trivandrum. The mean optical depths obtained in March, 87 (pre-monsoon) was compared with the Oct., 1988 (post-monsoon) values, Fig. The variation of optical depth at different wavelengths shown in figure is near representative of annual mean values. However, the optical depths at 750, 800, 935 and 1025 nm have contribution due to absorption of water vapour in these wavelength regions.

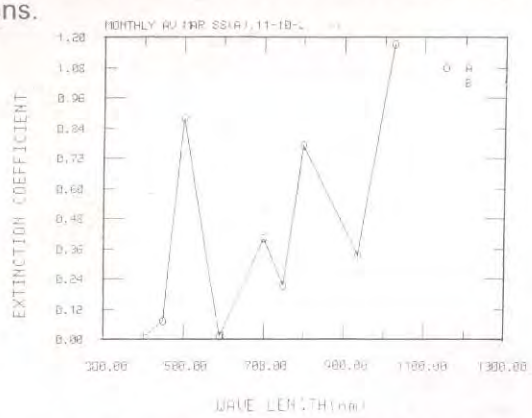


Fig. Variation of combined extinction coefficient with wavelength due to water vapour and aerosols, (A) monthly average for March 1988 (a premonsoon period) and (B) 11th October 1988 (a post monsoon period)

The low values of measured ozone at the French Antarctic Station, Dumond Durville during spring 1958 were compared with those obtained at the Japanese station Syowa during the recent hole phenomenon of year 1987 and they appeared to agree very well. It was concluded that most probably the solar cycle variation was responsible for the initial conditions for production of the Ozone Hole. Ozone data from Nimbus 4 and 7 satellites were analysed. Satellite total ozone values were compared with the ground based Dobson values. It was seen that the departure of the satellite and Dobson data was marginally dependent on the latitude even within the Indian sub-continents.

SROSS AERONOMY SATELLITE

For real time testing, performance evaluation and calibration of RPA satellite payload during various phases of payload integration with the satellite, an IBM compatible PC based Ground Checkout System (GCS) was developed. GCS interfaced with the payload through a hardware-interfaced which was directly connected to the PC bus. All control and data handling signals coming from different satellite interfaces to the payload, were simulated in this system. The data transmitted from the payload in a specified format was received, decoded, processed and analysed in real time to generate a graphic display of the results. The system performance was checked on the laboratory model of the RPA payload.

ISRO has decided to launch a simpler satellite on next ASLV in 1990 with reduced power and weight capabilities. The satellite would carry aeronomy payload of RPA, developed by NPL. The work towards making the engineering version of the RPA payload was intiated. Separate data acquisition and T/M interface for EPS was designed using conventional logic circuits. Remote multiplexing unit and power supplies were separated from RPA. Separate

stair case generators for the two channels namely E + P and E were designed, fabricated and tested. The mechanical design of the EPS detector mount and the electronic box was finalised. Fabrication of detector mount and electronic box was done at workshop. Three low electron energy sources were procured. The calibration of the silicon surface barrier detectors was carried out at Gujarat University, Ahmedabad using the three different sources.

RADIO COMMUNICATIONS

1. Longterm Ionospheric and Solar Predictions

Routine ionospheric predictions were prepared and sent to the user organisations. On the basis of the recent data received, the 22nd solar cycle was expected having a very high peak value. This prediction was based on the method in which previous peak was used as a reference point to obtain an average predicted cycle and then using multivariate analysis on the deviations, the complete cycle was built up. Studies on atmospheric radio noise levels were measured at serveral HF frequencies and the analysis of this data revealed certain major discrepencies that existed between actual radio noise levels and the predictions of International Radio Consultative Committee (CCIR). These results have an important bearing on the transmitter requirements of HF radio systems operating in India.

1.1 Field strength measurements in HF bands

HF broadcasts transmissions at several frequencies originating within India and abroad were monitored at New Delhi as a part of CCIR study programme 1WP6/14. A comparative study of various methods for estimation of ionospheric absorption was made using these field strength measurements and a final recommendation based on the results regarding the suitability of these methods to low latitudes would be made to CCIR. Fading characteristics of these HF transmissions received at Delhi were also studied. Dependence of fading rates and fading depth on local time, season and frequency were some of the aspects which were studied in detail.

1.2 Ionospheric modelling and ARWC

A comparative study of variation in ionospheric parameters such as foF2, TEC, slab thickness etc. with different solar indices including EUV radiations was made. It revealed that EUV index has an advantage over sunspot number and 10.7 cm flux for modelling ionosphere for short and mediumterm forecasting; foF2 and TEC also showed varying trends in their variations with EUV especially in winter. Special short and medium-term forecasts were provided to ISRO to aid in their computations of orbital parameters of 'Indian Remote Sensing' satellite. Special forecasts on solar and magnetic activities were provided to PRL, Ahmedabad for their Fabry-perot interferometer experiment. Activity of daily forecasts on solar-geophysical conditions was continued.

2. Microwave Refractometer

At the request of Indian Navy microwave refractometer was mounted on a Naval aircraft in order to study the anomalous propagation phenomena over the oceans. Radio refractivity fine structure information was collected over the oceans and a good amount of information on sub/super refractions and ducting occurrence was identified. The ship-borne radiosonde data and refractometer could not identify the existence of various layers of sub/super refraction and ducting (trap) conditions at various heights. This information acts as an aid in determining the optimum flight profiles for an aircraft to avoid detection.

2.1 Rain rate statistics

Rapid response rain gauges of 10 sec in-

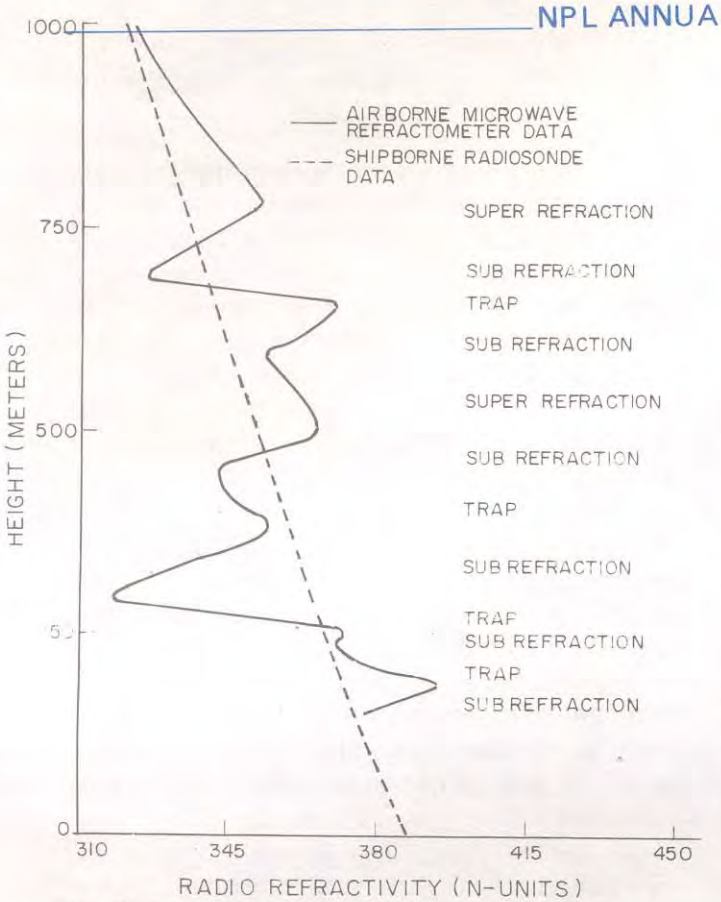


Fig.2 RRI PROFILE OVER THE OCEAN UNDER NORMAL CONDITIONS.

tegration time were installed at different locations in India to raise the rain statistics. Simultaneous measurements of 15 mt integration time rain rate data was also obtained from India Meteorological Department to derive conversion factors. The worst month statistics were deduced for different geographical regions of India which are shown in Table . It is seen that rain rates of the order of 130 mm/hr are observed over high altitude regions. It is also observed that for rain rates of around 50 mm/hr and below the equivalent path length is of the order of 10 to 13 km while it is about 8 km for heavy rain intensities.

3. Influence on obstacles of VHF TV signal propagation

The existing prediction methods of trans-

Distribution of rain rate during worst months (mm/hr)

Regions	Percentage of time rain rate exceeded							
	1	0.8	0.5	0.2	0.1	0.05	0.02	0.01
Northern Plains	14	20	30	51	69	85	102	122
North-East Region	20	22	31	45	66	88	120	128
High Altitude Region	13	18	25	43	62	85	120	130
Eastern Plains	22	25	32	62	92	107	124	130
Central Plains	16	21	31	52	69	84	109	118
Indian Desert	-	-	12	30	41	62	85	101
East Coast	19	21	31	58	81	107	125	130

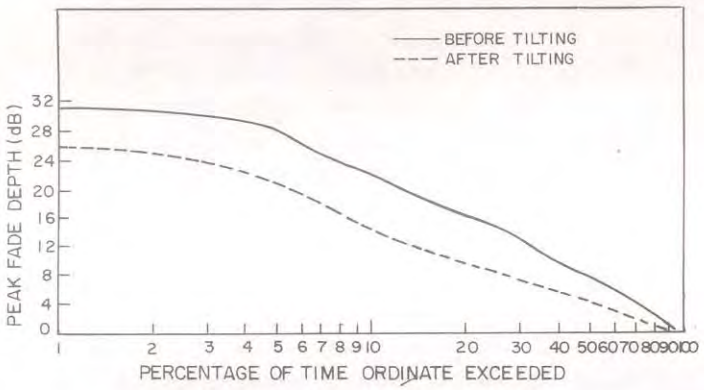
mission loss over the irregular terrain are not tested with propagation measurements in this country. The propagation measurements were conducted over 13 paths mostly in Western India. All the paths were chosen in such a way that they constitute single knife edge diffraction propagation paths. The field strength data was collected using Bombay, Poona and Srinagar TV transmitters. The observed fieldstrength values were converted into path loss values and compared with those obtained from different prediction techniques. In semi-urban and rural areas, the methods of Deygout, Epstein-Peterson and CCIR were used to give realistic estimates whereas in the case of urban paths an additional urban loss was added for realistic predictions. An empirical formula for calculating the urban loss was developed.

Systematic monitoring of anomalous long distance TV signals and their field strength measurements were carried out on channels 2,3 and 4 of Band I and channels of 5 to 12 of Band III on strip chart recorder from the output of spectrum analyser. Field strength of coloured TV signals received on various channels was found to be much higher than black and white TV signals. Various Ionospheric and Tropospheric modes of propagation were identified.

3.1 Multipath fading

The 56 km link operated by VSNL at 2149.5 MHz between Delhi-Meerut was subjected to severe fading and NPL was approached for advice. By

using specially developed path loss techniques, it was concluded that nighttime fading was due to ground-based layers. The remedial measures were suggested. Among the remedial measures, upward tilting of the antenna was implemented and it was found that it reduced the peak fade depth, average fade depth appreciably at all probability levels. This method may not be useful when the fading is due to elevated layers and useful in links where the fading is due to surface based layers. The cumulative distribution of peak fade depth before and after tilting is shown in Fig.



The Bombay-Matheran digital link of VSNL was installed by NEC Japan and after installation it was exhibiting high BER'S frequently leading to link outages. The path length of the link is 48 km, operating at a frequency of 8 GHz with 8-PSK modulation and transmits a data rate of 68 Mb/s. Most of the time BER's were observed during early morning hours or late evening hours indicating that nighttime superrefractive conditions were responsible for high BER's. The analysis of the data showed that fade depth had no correlation with BER. To improve the link performance, on our suggestion the antenna at Matheran was raised and fixed at a point where Linear amplitude dispersion (LAD) was minimum. This work was completed and the link was functioning satisfactorily.

Microwave amplitude measurements were carried on round the clock basis using a line-of-sight link in Northern India on both polarisations. Based on the analysis of 3 months of data empirical relations were developed between fade depth number of fades, average duration of fade and the fraction of time.

3.2 Computation of microwave signal levels in evaporation ducts.

A computer programme was developed for the estimation of extended ranges and signal levels in an evaporation duct. The input parameters were duct and radar characteristics. The output included radar coverage diagrams for different duct thicknesses, refractivity gradients, signal levels under ducting conditions, target heights as a function of detection ranges etc. It was observed that (1) the contribution of rays with negative elevation angles was greater than positive rays to the signal level at any point, (2) the detection range increased with duct thickness for a given gradient, (3) the detection range under ducting conditions was greater than free space conditions, (4) when the refractivity gradient changed from-200 to-300 N/Km, spatial increase in radio hole region occurred.

RADIO AND ATMOSPHERIC PHYSICS

1. Atmospheric studies of other Planets

In-situ measurements from Pioneer Venus Orbiter were analysed to test a recent hypothesis that, the solar wind interacts directly with the neutral atmosphere during high solar wind dynamic pressures. The neutral species behaviour during the Disappearing Ionosphere episodes

on the nightside of Venus were studied for any possible evidence of such an interaction. Certain disturbances were observed in the height profiles of oxygen, for most of these disappearing ionosphere episodes which might be a plausibe signature of this interaction. A comprehensive review was also prepared summarising our present state of knowledge regarding the ionospheres of Venus, Mars, Jupiter, Saturn and Uranus.

1.1 Wave Generation and Wave-Particle Interaction Studies

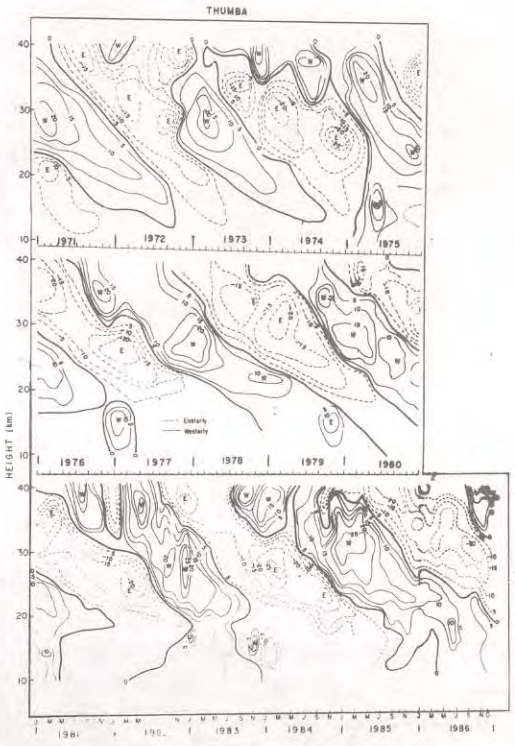
Considering a mixture of cold and dense plasma of ionospheric origin and hot and tenuous plasma of plasma-sheet origin, the emission of electrostatic emission was studied. The diffusion coefficients of charged particles interacting reasonably with emitted electrostatic spectrum were computed. It was found that charged particles in the vicinity of loss cone interacted resonantly with the electrostatic spectrum in a narrow latitudinal range around the equator and diffused into the loss cone to precipitate down into the lower atmosphere. Using wave and particle data observed on board GEOS 2, a theoretical model for equatorial pitch angle distribution function was developed. Taking these distributions as initial data, the pitch angle distribution all along the auroral field line was also computed. Considering the externally excited ULF wave as a slow perturbation of the ambient plasma the modification in VLF spectrum and precipitating flux were estimated.

1.2 MST Radar

NPL was closely associated with all the aspects related to the development of this national facility. ST mode will be operational by mid 1990. The total system is likely to become operational by 1991.

1.3 Long period oscillations over Thumba

A model for mean seasonal winds at middle atmospheric heights (1 to 60 km) at Thumba (9°N) was reported earlier. The Rocket Sonde and Radio Sonde data for period from 1971-1986 was used to develop a model of long period oscillations such as quasi biennial oscillation (QBO), annual and semi-annual oscillations in the horizontal wind components. This is the first climatological model of these oscillations for the equatorial latitudes in Indian longitude zone. Fig. shows the behaviour of QBO in zonal wind at Thumba over seven cycles.



1.4 F-layer dynamo polarization fields

The ionsonde data was studied for equatorial station, Thumba, to delineate various features of

the evening height rise of F layer. Sharp increases of h'F and h_pF2 were observed in the post-sunset period for high solar activity. Seasonal variation was observed in this increase of h'F and it was maximum for equinox months. For summer months, there was a delay of about an hour in the time of occurrence of h'F (peak) as compared to winter and equinox months. This delay was shown to be associated with the delay in sunset times in the conjugate E regions. As for magnetic activity dependence, it was found that this height increase was less pronounced for disturbed days for winter and equinox whereas for summer it was marginally higher over the quiet day values. Experimental observations of both the neutral winds and ionospheric conductivities were examined for their variation with solar activity, season and magnetic activity as both these factors would contribute for the various observed features of height rise.

1.5 Satellite radio Beacon Studies

The geostationary satellite ETS-II was continuously monitored at VHF for amplitude scintillations and Faraday rotation studies. A carefull analysis of Faraday rotation data obtained at Delhi Kurukshetra, Hyderabad, Bangalore, Waltair, Nagpur and Calcutta of Feb. 16, 1980 and at Delhi on July 31, 1981 provided positive evidence that gravity waves may be generated by a total solar eclipse. An analysis of amplitude scintillations data of geostationary satellites ETS-II and symphonie II showed that during high solar activity, magnetic activity inhibits growth of instability and hence of scintillations. Further during low solar activity simultaneous scintillation observations of ETS-II and Marisat signals showed that severe magnetic storms increased the scintillations perhaps due to the triggering of large scale instabilities. Meteor showers like Geminid Leonid, Orionid and Perseid were observed to give rise to considerable enhancement in TEC during high solar activity period as compared to quiet sun period.

1.6 GHz Scintillation

GHz (4GHz) scintillation experiment initiated in 1983 generated very interesting data. While the data in 83-84 indicated low amplitude scintillations (2-3 dB peak to peak) with occurrence peaking in summer, the present observation (with high solar activity) showed very high level of amplitude (12 dB peak-to-peak) fluctuations with faster fading rates (13-14 fades/min. as against 3-4 fades/min in 84-85). These observations have far-reaching consequences on earth–space communication links using small earth station terminals. Recently 15 dB peak-to-peak amplitude scintillations were observed at L-Band continuously for 75 minutes. Power spectrum analysis for 4 GHz scintillations has shown a temporal slope of 2.5 to 3.0 corresponding to irregularity spectral slope p $= -3.5$ to -4.0. Average estimated irregularity drift was observed to be 75 m/s from the power spectrum. Average irregularity size was found to be 322 m which is thought to be responsible for causing 4 GHz scintillations. Therefore, a minimum antenna seperation of 300-400 m. was required to achieve usable diversity operation.

1.7 Microwave/millimetre wave radiometry

Microwave radiometry research facilities at NPL currently available upto 22.2 GHz were now extended to the millimetre region. A prototype 37 GHz total power radiometer was developed and tested. The radiometer has a detection sensitivity of better than I K in one second integration time. Efforts were continuing to make this system portable so that it could be easily transported to any site for rain attenuation and other related scientific investigations. Attenuation measurements involved simultaneous and instant measurement of rainfall rate by 10 seconds upto electronic fast response raingauge and attenuation by microwave radiometer. The attenuation results obtained showed that for 10mm/hr rainfall rate attenation was around

0.75 dB for 9.6 GHz and 2.1 dB for 18 GHz.

1.8 Theoretical ionograms

Using the overlay technique and the latest model of recombination coefficient and model atmosphere the Delhi ionograms were analysed. The values of production rates, loss rates, scale weights and neutral gas temperatures in F1-F2 transition region evaluated using this technique agreed well with the values found with lastest sophisticated techniques.

1.9 Antarctic measurements

An attempt was made to infer the ionospheric environment over the Indo-Antarctic region from the published radio observations carried out during the last Indian Expeditions to Antarctica. The diurnal phase variation was more of a trapzoidal nature for the low latitude VLF path crossing the equator whereas it was more of a cosine form for the high latitude path. The depth of night to day phase change for the low latitude path was consistent with the previous results available in the literature but was half of the expected value for the high latitude path. An equation involving non-linear perameters was postulated to model the IRI vertical profile of electron density in the ionosphere. The non-linear parameters were estimated using iteration based and computer-oriented optimization techniques. Judicial choice of the initial parameters has shown that the number of non-linear parameters necessary for the emperical IRI model description could be reduced considerably.

TECHNICAL SERVICES

INSTRUMENTATION

Regarding development of precision electronic instruments, the circuits for input stage, multiplexing, logic controls, ADC, display drives and digital displays for a simple $5\frac{1}{2}$ digit DVM were completed. Complete circuit for microprocessor based $5\frac{1}{2}$ digit DVM was designed. The unit and controls were fabricated and tested. The input circuits for AC Volts and DC Volts were fabricated. The study of microprocessor 8085, its programming language and hardware was made. Complete circuit for the $6\frac{1}{2}$ digit DVM was designed, the display unit along with the drives was fabricated and tested.

A quartz crystal with 10 MHz frequency was tested for its long-term and short-term stability for use in the temperature controlled frequency oscillator. An oven, was designed and the fabrication is in progress. A microprocessor-based frequency counter (1×10^{-8}) for Echelon III level laboratories was designed and fabricated. Special power supplies and input circuits were made.

Several instruments received from different departments of the laboratory were repaired and made functional. Some of the major instruments repaired were: Universal Bridge ITL Power supply, Multimeters (digital and analog), Microtest Klystron Power Supply, Temperature controller, TGA unit, Counters, etc. A number of special electronic circuits and gadgets were designed and fabricated for other activities of the laboratory. Different types of instruments were tested for being sent to Central Stores as unserviceable. Technical assistance and consultancy were also rendered to outside parties.

Regarding biomedical ultrasonic instrumentation a sonic bone fracture diagnostic instrument was developed for the detection of a fracture and its rate of healing. The instrument was tested on invitro animal bones in the laboratory and showed satisfactory results. A new piezoelectric bone hydrophone and a new vibration sensor were developed and characterized for the frequency response and other parameters. The renal calculi (kidney stones) and gall bladder stones were studied for different ultrasonic parameters like propagation velocity, acoustic impedance, attenuation and dynamic modulus of elasticity. Miniature type ultrasonic opthalmic probe and biometric unit were developed. Safety studies of the use of low level ultrasound for diagnostic applications were made. The radiation pressure of such source was measured with a strain gauge transducer system in terms of calibrated ultrasonic power output. Effect of ultrasonic stress on the performance characteristics of various digital devices was studied. A novel transducer with changeable focusing lenses to five different frequencies and intensities was developed.

COMPUTER FACILITY

The central computer facility with VAX-11/780 computer system with a number of peripherals and terminals was in regular operation and computational facilities were provided to the staff. These facilities were also utilised by outside scientists belonging to educational and research institutes on payment basis. An amount of Rs. 2,414 was realised. A software package with a large number of subroutines on mathematical and statistical work called IMSL (International mathematical and statistical library) was installed on the system and made available to the users. In-house training courses on (1) Numerical techniques (2) FORTRAN language (3) PASCAL language and (4) WORDSTAR and d-base were conducted for the benefit of NPL staff.

LIBRARY

The library continued to provide library, documentation, and reprographic services to the scientists. The focus of library activity was mainly on library computerisation and collection development. Serials control software and acquisition control software were further refined to incorporate features such as data processing using multiple files, indexed searching. Besides these two softwares, circulation control software was developed.

The library acquired 583 titles for its book collection, 550 standard specifications for the standards collection. For its journal collection it subscribed 325 journals on payment and 40 journals on gratis. The library continued to receive Indian patent specifications from the Indian Patent Office, Calcutta.

In library services the library provided 5623 items on loan to scientists. It borrowed 107 items but gave 617 on inter library loan. The institutions included INSA, IIT Delhi, University of Delhi, Defence Science Centre, Indian Oil Corporation. In documentation services the library served as many as 34 subject profiles providing 2720 relevant references to scientists, provided 10 bibliographies on demand. About two lakh copies were turned out on the photocopying machine. In stock maintenance 200 books and 1679 periodicals were got bound.

GLASS WORKSHOP

Various projects of the laboratory were assisted in the fabrication of glass, silica and glass-to-metal sealing apparatus. Laser tubes were fabricated for the Length Standards section. Similar jobs from the industry and research organisations were undertaken.

The units of compact double distillation apparatus were fabricated and supplied to various institutions and universities including IARI; Jamia Milia Islamia; C.S. Azad university of Agriculture, Mathura; IDPL, Rishikesh; L.N.J.P. Hospital etc. Dewar & RB flasks were fabricated and supplied to various research and educational institutes. Solvent extractor and sand clocks of different sizes were also made and supplied. The jobs worth Rs. 2.52 lakhs approximately were completed during the year.

PHOTOGRAPHY

Assistance was proveded to the scientific and technical staff regarding taking of B & W as well as coloured photographs for publication work. The section covered visits of distinguished scientists, lectures and symposia, workshops and training courses. During the year about 10,000 prints and slides were made.

RAJ BHASHA

Rajbhasha unit was engaged in the progressive usage of Hindi in NPL. *"Sameeksha Rashtriya Bhotik Prayogshala"*, the quarterly bulletin of NPL was brought out. Besides this, two more publications, namely, *"Rashtriya Bhotik Prayogshala–Ek Jhalak"* and a pamphlet containg the present status of uncertainty related to various standards and calibration activities of NPL were brought out. The unit also conducted classes of Hindi for the staff. Most of the proformas of NPL were translated into Hindi. In addition, to help various sections of NPL, day to day translation work, was done.

ENERGY CONSERVATION

In the lighting sector, energy conservation is achieved by switching off lights automatically when not required. The street lights in any city or town, are switched on manually in the evening and are switched off in the morning. It

would be worthwhile to switch off some or alternate lights at or after 11 PM providing illumination for security purposes only.

An electronic timer for achieving this was developed. Its advantages are total solid state design, cheaper, smaller size, better realiability and less weight. This device will be useful for automatic dust ON/dawn OFF of individual or group lights; mid-night switch OFF timers for mercury, sodium vapour lamps etc; timers for cyclic ON/OFF of room air-conditioner, medical purposes and railways.

NPL—TWENTY YEARS BACK

Manpower

Scientists and technical officers	110
Total staff	904
Expenditure	Rs. 87.52 Lakhs

Scientific highlights

The project on C.R. Tube was started. The microwave components were batch produced. Ferrite memorycores were produced in the pilot plant. A universal testing machine was developed. The know-how of semi-conductor grade silicon was improved. Prof. Kathleen Lonsdale of university of London delivered Krishnan Memorial Lecture.

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PATENTS

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2. Bhawalkar, R.H.—A device for attachment to a box type solar cooker for efficient heat transfer—No. 163554, accepted, Oct. 8, 1988.
3. Rastogi, A.C., Balakrishnan, K.S. and Salkalachen, S.—An integrated thin film Cd S solar cell fabrication and encapsulation technology—filed, Jan. 89.

RESEARCH REPORTS

STANDARDS

1. Standard time and frequency signal dissemination service via Indian domestic satellite Insat-1B—A. Sen Gupta, A.K. Hanjura, P. Banerjee & B.S. Mathur, No. 88-27.
2. Calibration of 1 kg. Mauritius standard of mass using NPL 1 kg. interchangeable pan balance—Tripurari Lal, S.V. Gupta & Ashwani Kumar, No. 88-34.
3. Development of standards for measurements of specular reflectance at near normal incidence in the spectral region of 2.5 to 25μm—D. Gupta & S.P. Varma, No. 88-38.
4. Design and development of broad band standard mismatches of VSWR 1.10, 1.20 and 1.30 for Ku-band microwave frequencies—P.S. Negi, R.S. Yadav, Ram Swarup & K. Chandra, No. 89-02.
5. The realization of the triple point of Argon (83 798 K) as defining temperature standard on the international practical temperature scale,—Ram Kishan, J.K. Gupta, V.P. Sharma & K.D. Baveja, No. 89-03.
6. The gold *vs* platinum thermocouple—V.P. Wasan, N.K. Srivastava & Mansha Ram, No. 89-04.
7. Establishment of reference standard of luminance—K.C. Joshi, J.S. Vaishya & H.C. Kandpal, No. 89-05.

MATERIALS

1. Sintering & resistivity studies of various compositions of Nasicon compounds—B.K. Das, H.S. Kalsi, Balbir Singh, S.K. Sharda, R.C. Goel & S.U.M. Rao, No. 88-13.
2. Advanced Ceramics—A perspective—B.K. Das, No. 88-22.
3. Growth of polycrystalline silicon ingots for photovoltaic application—P.K. Singh, Ram Kishore, S.N. Singh & B.K. Das, No. 88-31.
4. Technology of Xeroradiography—D.C. Sharma, M.N. Kamalasanan, Suresh Chand, R.C. Bhatheja, S.C.K. Misra, Krishan Lal, Jaikaran Singh, G.D. Sharma, Surat Singh, J.R. Anand & H.N.P. Poddar, No. 88-32.
5. Density of gap states in Si:H films grown in cascaded glow discharge reactors—O.S. Panwar, P.N. Dixit, R. Bhattacharya & V.V. Shah, No. 88-35.
6. Electrical properties of boron doped hydrogenated amorphous silicon films prepared by glow discharge decomposition in diluted silane—O.S. Panwar, P.N. Dixit, Ajay Tyagi, Tanay Seth, B.S. Satyanarayan, R. Bhattacharya & V.V. Shah, No. 88-36.
7. Study of high Tc superconductor metal interfaces and contacts—A.C. Rastogi & S.T. Lakshmi Kumar, No. 88-37.
8. Investigation of the Si-Ti interface during initial stages of silicidation—S.T. Lakshmi Kumar & A.C. Rastogi, No. 89-01.

CHARACTERIZATION OF MATERIALS

1. A quantitative study of diffracted X-ray intensities from natural diamond crystals using multicrystal X-ray Diffractometers and comparison with silicon crystals-Part I—Krishan Lal, S.N. N. Goswami & Ajit Ram Verma, No. 88-14.
2. Role of EPR & related techniques in the study of amorphous silicon—S.K. Gupta, No. 88-18.

CRYOGENICS

Liquid nitrogen level indicator—Harikishan, S.K. Mahajan, S.K. Aggarwal & A.P. Jain, No. 88-15.

RADIO SCIENCE

1. Anomalous VHF propagation observed at New Delhi—M.V.S.N. Prasad, S.K. Sarkar, R.C. Saxena & B.M. Reddy, No. 88-16.
2. Reference atmosphere for Indian sub-continent from 90 to 1000 km—V.N. Laxmi, R. Kohli & K.K. Mahajan, No. 88-17.
3. A multi-station Satellite Radio Beacon study of the ionospheric variations during solar eclipse—Lakha Singh, T.R. Tyagi, Y.V. Somayajulu, P.N. Vijaya Kumar, R.S. Dabas, B. Lokanadham, S. Ramakrishna, P.V.S. Rama Rao, A. Dasgupta, G. Navneeth, J.A. Klobuchar & G.K. Hartmann, No. 88-19.
4. Ozone perturbations in a middle atmosphere radiation model—K. Bhattacharya, No. 88-21.
5. Inversion technique for ozone profile using laser heterodyne radiometer-limb sensing—S.L. Jain, No. 88-24.

6. Computation of microwave signal levels and extended ranges in evaporation ducts over the sea—P.K. Pasricha, M.V.S.N. Prasad, A.B. Ghosh & B.M. Reddy, No. 88-25.

7. Zonal and meridional wind over Thumba-Part I: Reference wind model from 1 to 60 km.—A.R. Jain, V. Mathew & O.P. Nagpal, No. 88-26.

8. Zonal and meridional wind over Thumba-Part II: Study of long period atmospheric oscillations—O.P. Nagpal & A.R. Jain, No. 88-28.

9. Net improvement in detect ability due to averaging (coherent and incoherent integration) in the signal processor of the planned Indian MST radar—A.R. Jain, No. 88-29.

10. Intercomparison of plasma densities measured by ionospheric experiments abroad pioneer venus and effect of solar zenith angle—K.K. Mahajan, J. Kar, D.V. Srilakshmi, R. Paul & R. Kohli, No. 88-30.

11. Atmospheric radio noise measurements in India—D.R. Lakshmi, M.M. Gupta, Raksha Marwah & Mangal Sain, No. 88-33.

12. Morphological study of travelling ionospheric disturbances over Delhi during the period 1976-80—Lakha Singh, J.K. Gupta & T.R. Tyagi, No. 88-39.

13. Spatial estimates of Rayleigh-Taylor instability at geomagnetic equator from satellite observations at Delhi—P.N. Vijayakumar, J.K. Gupta, T.R. Tyagi, Lakha Singh & Y.V. Somayajulu, No. 89-06.

TECHNICAL SERVICES

An analysis of the NPL Research Reports during the Years 1985-87—R.S. Khanduja, No. 88-20.

APPENDICES

SPONSORED/SUPPORTED PROJECTS

Sl. No.	Title	Agency	Fund received during the year Rs. (lakhs)
	NEW PROJECTS		
1.	Development of sodium sulphur batteries for electric vehicles	DNES	12.000
2.	Hydrogenated amorphous silicon films (Phase II)	-do-	20.000
3.	Development of oxidation resistant carbon-carbon composites	DRDL	2.000
4.	Weaving of 3-D carbon-carbon composites	-do-	7.500
5.	Characterization of electronic materials	DOE	50.000
6.	Growth of nearly perfect crystals of oxides like Lithium Niobates (ILTP)	DST (Indo/U.S.)	1.500
7.	Data base on electronic materials (ILTP)	-do-	1.800
8.	Volatile metal organic compounds (ILTP)	-do-	5.000
9.	Ionospheric modelling for radio communication including effects of the artificial modification of ionosphere (ILTP)	-do-	1.600
10.	Study of electrical conductivity of mentle forming rocks.	DST	11.000
	CONTINUING PROJECTS		
1.	Augmentation of Primary Electronic Standards	DOE	-
2.	Improving the quality and reliability of standard Time & Frequency signals in Echelon II laboratories	-do-	-
3.	Monitoring of solar ultra violet radiation at the ground in UV-B region	ISRO	0.500
4.	Development of fluorescent screens for real time x-ray imaging	ISRO	0.909
5	Multi-crystalline silicon for solar cells	CEL	2.200
6.	Tropospheric and Ionospheric Communications in HF and microwave bands	Defence	2.900
7.	Calibration Service Programme under NCTCF	DST	7.000
8.	A study of degassing characteristics of Materials in ultrahigh vacuum	DST	1.000
9.	Preparation, characterization and precision measurements of semi-conducting materials	DST (Indo/U.S.)	1.582
10.	Development of gas chromatographic facilities for measurement of minor constituents in the atmosphere	DST	-
11.	Development of thin film Josephson junction and Planar DC Squids	-do-	-
12.	Development & characterization of acoustic transducer materials for application in ocean engineering	DOD	2.888
13.	Development of big size carbon-carbon composites	DRDL	-
14.	Low dimensional coulomb systems.	DST	-
	PROJECTS COMPLETED		
1.	Development of process know-how for Aviation Grade Brushes	HAL	-
2.	Development of parametric system for detection of objects embedded in sea-bed	DOE	2.300
3.	Study of defect structure in nearly perfect single crystal	DST	-

PROCESSES RELEASED

Sl. No.	Process	Party	Terms
1.	Silver Impregnated Graphite Contacts	M/s. Tilak International, A-107, Jhandewalan Flatted Factories, New Delhi.	Premium—Rs. 55,000 Royalty—5%
2.	Liquid Nitrogen Containers	M/s Prestige Fabricators (P) Ltd., 30 Jaora Compound, M.Y.H. Road, Indore.	Premium—Rs. 15,000 Royalty—Rs. 60 per unit
3.	INSAT-STFS Decoder	M/s Shyam Antenna Electronics (P) Ltd., Community Centre, Narain Vihar New Delhi.	Premium—Rs. 50,000 Royalty—Nil

CONSULTANCY

Sl. No.	Title	Party	Amount (Rs.)
	ACOUSTIC STANDARDS		
1.	Acoustical treatment of auditorium at the Forest Research Centre, Meghalaya.	C.P.W.D., Gauhati	12,500
2.	Acoustical treatment of the committee hall.	Harijan Avam Nirbal Varg Avas Nigam, Ltd., Lucknow.	10,000
3.	Acoustical treatment of the hall.	Central Polytechnic, Chandigarh.	11,500
4.	Acoustical treatment of conference hall.	Tourist Complex, Mussoorie.	10,500
5.	Design & fabrication of Tone Burst Generator.	Defence Inst. of Physiology & Allied Sciences, Delhi Cantt.	13,720
6.	Acoustic design of Marine Aquarium cum Research at Digha, West Bengal.	C.P.W.D. Calcutta.	12,750
	INSTRUMENTATION		
	Characterization of anti-glare screens for electrical/electronic parameter of CRT.	M/s Neelam Plastics, Model Basti, New Delhi.	5,000
	THIN FILMS		
	Metallisation of plastic frames used in all clocks.	M/s Vega Clocks, Malviya Nagar, New Delhi.	38,000

RECEIPTS OF CALIBRATION/TESTING AND OTHER CHARGES REALISED DURING 1988-89.

ACTIVITY	AMOUNT (Rs.)	REPORTS
CALIBRATION		
Force & Hardness Standards	7,65,702	552
Dimensional Metrology	4,19,775	424
Temperature Standards	2,57,000	236
Optical Radiation Standards	2,31,793	98
Mass Standards	2,21,850	316
DC Standards	98,000	98
AC & LF Standards	81,000	25
LF & HF Impedance Standards	79,000	110
HF & Microwave Standards	72,000	59
Pressure & Vacumm Standards	68,750	33
Acoustic Standards	39,800	21
Time & Frequency Standards	8,750	5
Length Standards	7,000	2
HF & MW Attenuation and Impedance Standards	4,500	2
MATERIALS CHARACTERIZATION		
Chem. Methods	28,900	26
Others	51,450	18
Total	24,35,270	2025

OTHER CHARGES	
Glass Fabrication	2,51,729
PZT Materials	44,867
Silver Paint	984
Carbon Products	2,832
Interference Filters	42,000
Kcl Crystals	800
TOTAL	3,43,212

PREMIA & ROYALTIES

(ending 31.12.87)

Process	Party	Lab. Share (40%) (Rs.)
Cinema Arc Carbon	M/s Advani Oerlikon Ltd., Bombay.	1,68,400
	M/s Beni Ltd., Calcutta.	4,000
Indelible Ink	M/s Mysore Lac & Paints Ltd., Mysore.	32,000
Silver Impregnated Graphite Contacts.	M/s Jyoti Refinery, Bombay.	10,024
Distillation Apparatus	M/s Scientronic Instruments, New Delhi.	3,000
Film Thickness Monitor & Controller	M/s Shakti Vacuum Products, Bombay.	2,000
Zinc Oxide Paper	M/s Tokushu Menon Mfg. Co. Ltd., Madras.	2,000
Ultrasonic Interfero-meter	M/s Bharat Electromech. Engineers, New Delhi.	1,200
	M/s Electronics Inds.	1,200
Silver Tungstan Tablets	M/s Compact Contracts (P) Ltd., Delhi.	1,200
Ultrasonic Probes for NDT beams.	M/s Technotronics Indus., New Delhi.	1,122
Broad Band Ferrites	M/s K.L.B. Electronics, New Delhi.	1,000
Nitrogen Dewars	M/s Refrigeration and Cryogenics, New Delhi.	800
Ceramic Rods for Carbon Resistors.	M/s Techno Ceramics, Khurja.	614
Reconditioning of Picture Tubes.	M/s Videotronics	400
Sequencial Switching Device.	M/s Becon Enterprises, Delhi.	400
Peizoelectric Materials	M/s Servo System & Devices	400

CALIBRATION AND TESTING

The calibration and testing service was provided to the industry by the various sections of the Standards Divion as usual. This included calibration of measuring instruments and testing of materials, equipment and glassware etc. The characterization service was provided by the Materials Characterization Division regarding chemical composition, crystalline structure and perfection of materials. The T&C section coordinated the service and the issue of test reports.

Various calibrated lengths were supplied to industry for maintaining their standards. The calibration work pertaining to reference and secondary standards of mass, analytical weights and volume was carried out for the state departments and industry. Calibration of 3—coordinate machine and optical flats regarding flatness and parallelism was also done. Calibration of temperature measuring instruments was done for the industry. The life tests of GLS lamps & tube lights were continued. The proven rings & dynometers were also calibrated and evaluated alongwith acoustical products and electro-acoustic devices.

Coaxical attenuators and microwave equipment were calibrated for laboratories of DOE. The calibration of capcitance, inductance and ac resistance standards, dc sources and impedance bridges were done for public and private sector industries and Govt. and Defence Departments.

COLLABORATION WITH OTHER INSTITUTIONS

NPL had active collaboration with scientific institutions, universities, CSIR laboratories, Govt. Deptts. and international laboratories regarding scientific projects and studies in the areas of Standards, Superconductivity, Materials including Characterization and Radio Sciences.

In the area of Standards, NPL collaborated with NIST, USA, regarding the project on stability of mass standards of stainless steel; the Institute of Fundamental Technological Research, Poland, about the ultrasonic methods of investigation; and VNIIOFI, USSR, regarding optical radiation standards. The international intercompasisons of standards were continued with various laboratories of the world which included PTB (FRG), BIPM (France), NPL (UK), NRLM (Japan), IMGC (Italy), and NIM (China). The NPL scientists were represented in various subcommittees of Bureau of Indian Standards.

In the field of high temperature Superconductivity collaborative studies were initiated with TIFR Bombay; IIT's of Kanpur, Bombay, Madras and Delhi and universities of Rajasthan, Udaipur, Shivaji and Pune. The CSIR laboratories, CEERI, Pilani; CGCRI, Calcutta and RRL, Trivandrum, along with NPL are participating in the project of fabrication of SQUID using high temperature superconducting material.

In the area of electronic materials the programme with CECRI, Karaikudi and IGCAR, Kalpakkam regarding Beta Alumina for Na-S battery is continuing. The project of multicrystalline silicon for solar cells, sponsored by Central Electronics Ltd., Sahibabad, was continued. The project of development of acoustic transducers for oceanographic studies is being pursued in collaboration with NIO, Goa. The interference filters were developed for Space Application Centre, Ahmedabad.

There was active participation by universities of Patiala, Calcutta and Tirupati in the activities of Radio Scinece Divion, in the areas of anamolous VHF propagation, monitoring of a boundary layer with acoustic radar, radio climatology, radar and microwave propagation.

COLLOQIA LECTURES

Speaker	Topic & Date
Prof. Arun Varshnaya, Alfred University, USA	Synthesis of High Tc superconducting materials—April 13
Prof. Y. Vohra, Cornell University, USA	Static high pressure research at multi Mega Bar pressure range—May 2
Prof. R. Schollhorn, Technical University, Berlin	From Electronic ' ionic conductors to high Tc superconductors—May 9
Dr. A.P. Mitra, DG, CSIR, New Delhi	Ozone holes—May 10
Prof. K. Moorjani, Johns Hopking University, Maryland	Investigation of bulk and thin film of high Tc superconducting oxides—May 11
Prof. Carl. M. Lampert, Berkley University, USA	Advance materials for solar energy—June 22
Dr. Atit Bhargava, New York State College of Ceramics, NY	High Tc superconductivity glass ceramic approach—Aug. 2
Dr. M.P. Das, International Centre for Theoretical Phys., Trieste, Italy	High Tc superconductivity from Macroscopic to Microscopic Theory—Aug. 3
Prof. C.V. Suryanaryana, Alagappa College of Tech., Anna University, Madras	Physico-chemical environment of the oceans—Aug. 4
	Corrosion and associated problems in protection of equipments/systems in oceanography, Aug. 5
Dr. S.M. Bhattacharjee, AT & T Bell Labs. New Jersey, USA	Molecular weight dependence of polymer interfacial tension and density profile—Aug. 8
Dr. K. Venkatasubramanian, CSMCRI, Bhavnagar	Crystal structures of some organic and inorganic molecules, Aug. 12
Dr. K. Muraleedharan, IIT, Bombay	Microwave absorption in high Tc oxide materials—Sep. 13
Mr. Rene Dacheer, Meyer & Burger AG, Switzerland	Special slicing machines from Switzerland for optical glass—Sep. 23
Prof. C.N.R. Rao, Director, IISc., Bangalore	Novel metal oxides of Perovskites and related structures—Oct., 13
Dr. Gupta Sarma, NGRI Hyderabad	Very long base line interferometry science and applications—Oct. 17
Dr. N.S. Sundaresan, Fritzhaber Inst., DER MPG FRG	Self-doped conducting Polymers—A new approach to optimization of device properties.—Oct. 21.
Dr. Dannis Flood, NASA, Lewis Research Centre, Cleveland, USA.	Photovoltaics for space applications—Oct. 25.
Dr. R.S. Rao, Phys. Deptt., TTKK Tampere, Finland	Fermi surface in YBa Cu O—Oct. 27.
Prof. M.M. Sharma, Deptt. of Chem. Tech., Bombay	Innovation in chemical industry—Nov. 3.
Dr. Sushil Chandra, NASA Space Flight Centre, Goddard, USA	Recent trend in ozone depletion "Ozone Hole" story—Nov. 7.
Dr. R.K. Pachauri, Tata Energy Res. Inst., New Delhi	Energy resources and their management—Nov. 24.
Prof. G.T. Russell, Heriot Watt University, UK	Sub-sea automation—Nov. 28.
Mr. Richard Drinkwater, CVC Scientific Product Ltd., UK	Thin film technology—Nov. 29.
Dr. M. Jergel, Electrotechnical Inst. Slovak Academy of Science, Bratislava.	Research & development of superconducting materials at Electro Technical Institute Bratislava, Czechoslovakia—Dec. 6.
Prof. Volker Heine, University of Cambridge, UK	A Microscopic understanding of some incommensurate structure and polytypes—Dec. 9.
Prof. G. Nimitz, Physics Department, Koln University, FRG	Size induced metal insulator transition mesascopic conductor co-existence of insulating and superconducting state—Dec. 12.
Prof. Herbal, CNRS, Grenoble, France	Recent results & applications in heat transfer in Milli Kelvin range.—Dec. 12.
Dr. (Mrs.) Maria Farkas, Research Institute for Technical Physics, Budapest	Polytypism in crystals.—Dec. 13.
Prof. Marko V. Jaric, Texas A & M University, Texas	Quasicrystals—Dec. 14.

Dr. R.N. Bhargava, Phillips Lab., USA	Materials engineering of semi-conductors, insulators and superconductors—Dec. 14.
Dr. J. Shapira, President, Israel National Committee for Radio Science	Terrain scattering of microwave signals—Dec. 16.
Prof. A.K. Ramdas, Purdue University, Indiana, USA	Diluted magnetic semiconductors—Dec. 15.
Prof. V.L. Chopra, IARI New Delhi	Biotechnology in the services of man—Dec. 17.
Emeritus Prof. Philip Morrison, MIT. USA.	Means, methods and implications of search for intelligent life beyond our planet—Dec. 20.
Sir Edmund Hillary, High Commissioner of Newzealand, New Delhi	Himalayan Adventure—Dec. 22
Prof. Arun Bansil, Northeastern University, Boston, Massachusetts, USA	Is there a fermi surface in YBa Cu O—Dec. 23.
Dr. Rejendra K. Arora, College of Engineering, Tallahassee, Florida, USA.	Optical and superconducting VLSI interconnects—Dec. 28
Dr. (Mrs.) Rama Bansil, Boston University, USA	Diffusion in gels—Jan. 3
Prof. A. Hewish, NL, Cavendish Laboratory, Cambridge University, UK	XIX Krishnan Memorial Lecture "Pulsar Era"—Jan. 5
Prof. Noboru Ichinose, Waseda University, Japan	Superconductivity—Jan. 6
Dr. Pierre Aigrain, Scientific Adviser, President of Thomson Group, France	How to succeed in high technology—Jan. 12
Dr. Charles R. Tilford, National Institute of Standards and Technology, USA	Aircraft altimetry: life and death metrology—Jan. 23
Sir Anthony Laughton, FRS Institute of Oceanographic Science, Surrey, UK	Nehru centenary celebration lecture "The shape of the ocean floor"—Jan. 24
Dr. P. Samoilov, Inst. of Inorganic Chemistry, USSR	Some Studies on high temperature superconductors—Jan. 25
Dr. Brahm Bhardwaj, Expert on Photodetectors, USA	Physics & Technology of silicon photodiodes—Jan. 30
Prof. A.K. Rajagopal, Naval Research Lab., Washington	Slow relaxation in complex condensed matter systems—Jan. 31
	Neutron scattering from novel condensed matter systems—Feb. 2.
Prof. Sukumar Biswas, Sr. Prof. TIFR, Bombay	Cosmic rays, heliosphere and the interstellar medium: results from spacelab-3 Anuradha experiment—Feb. 8
Prof. Walther Fuhs, Philips Universitat, Marburg, FRG	Hydrogenated amorphous silicon (a:Si:H)—a new material for solar cells—Feb. 8
	Structural and electronic properties of amorphous alloys a-$Si_{1-x}C_x$:H and a-Si_{1-x}—Feb. 10
	Recombination and defects in amorphous silicon (a-Si—H)—Feb. 22
Prof. E. Gmelin, Max Planck-Inst., Stuttgart, FRG	Low temperature calorimetry for solid state research—Feb. 23
Prof. Doris Wilsdorf, University of Virginia, Charlottesville	Mechanical strength and workhardening of metals and other crystalline materials—Mar. 9
Prof. H.G.F. Wilsdorf, University of Virginia, Charlottesville	Ultra-high strength iron whiskers—Mar. 10
Dr. D.K. Ray, C.N.R.S., France	Some recent developments in the theory of high Tc superconductivity—Mar. 14 & 15
Dr. P.N. Sen, Schlumberger—Doll Research Centre, USA	Electrical properties of porous media—Mar. 16
Dr. A.K. Singh, N.A.L., Bangalore	Kinetics of pressure induced solid-solid structural transitions—Mar. 21

DISTINGUISHED VISITORS/SCIENTISTS

(Visited NPL between 1.4.88 to 31.3.89)

Name	Institute/Country	Date
Mr. Aboel Hamid Eazz	Minister of State, Scientific Research, Egypt	April 18
Ms Ann Choi, Mr. K. Churchill Mr. S. Kachru, Mr. Jay Koh Ms P. Krahl, Mr. S. Lumetta Mr. J. Miller, Mr. M. Mitzenmachar Mr. S. Strong & Mr. Al Wicker and Ms Digennaro	Indo-US Exchange Programme Students	Aug. 5
Dr. K. Seitz	President, Centre for Excellence, USA.	
Prof. H.J. Queisser	Ambassador of FRG.	Aug. 18
Dr. John H. Moore	Director, Max Planck Institute, Stuttgart, FRG.	
Dr. Wilmot N. Hess	US Delegation Director, NSF	Oct. 4
Dr. Melvin N.A. Peterson	Associate Director, Office of High Energy and Nuclear Physics.	
Dr. P. Heydemann	Chief Scientist, National Oceaenic and Atmospheric Administration.	
Col. A.D. Etukudo	Scientific Attache Embassy of USA, New Delhi.	
Mr. J. Switkowski	Chief Executive, Standards Organisation of Nigeria.	Oct. 26
Prof. G.T. Russell	Polish Ambassador, New Delhi.	Nov. 22
Dr. K.H. Klinger	Heriot Watt University U.K.	Nov. 19-Dec. 2
Dr. Michael Einke	Dy. Minister, S&T GDR.	Dec. 6
Dr. R.A. Smith	Ministry of Science and Technology, GDR.	
Dr. Pawlikowski	NPL, Teddington, U.K.	Nov. 19-Dec. 11
Mr. H. Xiangsong, Mr. X. Tiaolu Mr. Z. Rujian, Mr. Q. Zuosheng, Mr. Wu Haiying	Technical University, Poland. Science & Technology Commission of the Peoples Republic of China.	Dec. 19 Jan. 3
Prof. A. Hewish, N.L.	Cambridge University, U.K.	Jan. 5
Mr. Marek Bogucki	Deputy Minister, Science & Technology, Poland.	Jan. 12
Dr. Pierre Aigrain	Sc. Adviser President of Thomsons Group, France.	Jan. 12
Prof. Hubert Curien	Minister, Scientific Research & Technology, France.	Feb. 2
Mr. Shridath S. Ramphal	Commonwealth Secretary General, UK.	Feb. 23
Madam Zhu Lilan	Vice Chairmen, State S&T Commission, China with ten members	Mar. 28

HUMAN RESOURCES TRAINING

SCIENTISTS OFFICERS

(as on 1.4.89)

DIRECTOR
JOSHI, S.K., Ph.D

STANDARDS

LENGTH & DIMENSIONS

Aggarwal, N.K., B.Sc.
Chitnis, V.T., Ph.D.
Dahiya, H.S., Ph.D.
Dandavate, V.D., Ph.D.
Jain, P.C., Ph.D.
Kanjilal, A.K., B.Sc.
Karfa, M., M.Sc.
Kathuria, Y.P., Ph.D.
Khanna, R.K., B.Sc.
Kulkarni, V.G., Ph.D.
Ram Narain, I.T.I.
Ram Prasad, M.Sc.
Roonwal, V. (Mrs.), M.Sc.
Roy, B.K., B.Sc.
Sharma, V.D., M.A.
Singhal, R.P., B.E.
Tanwar, L.S., M.Tech.
Vardhan, Kowsalya. (Mrs.), M.E.

MASS

Das, M.L., M.Sc.
Gupta, S.V., Ph.D.
Kohli, N.K., B.A.
Mathur, B.G., B.Sc.
Mohinder Nath, B.Sc.
Nangia, S.N., AMIE.
Tripurari Lal, M.Sc.
Verma, S. (Mrs.), B.Sc.

FORCE & HARDNESS

Anil Kumar, B.Sc., Engg.
Chaudhury, M.K., AMIE.
Dasgupta, M.K., B.Sc., Engg.
Dhawan, J.K., B.E. Tech.
Sharma, R.S., M.Sc.

PRESSURE & VACUUM

Bandopadhyay, A.K., Ph.D.
Chakraborty, B.R., Ph.D.
Gupta, A.C., M.Sc.
Jain, K.K., Ph.D.
Pradeep Mohan, M.Sc.
Sharma, D.R., Ph.D.
Sharma, J.K.N., Ph.D.
Siva Prasad, S.M., Ph.D

TEMPERATURE

Bhatnagar, K.N., AMIE.
Luthra, R.K., M.Sc.
Mansha Ram, M.Sc.
Saksena, T.K., Ph.D.
Singh, Y.P., M.Sc.
Srivastava, N.K., M.Sc.
Wasan, V.P., AMIE.
Ojha, V.N., Ph.D.

OPTICAL RADIATION

Bhola, O.P., B.Sc.
Jai Bhagwan, B.Sc.
Joshi, K.C., Ph.D.
Kailash Chand, M.Sc.
Kandpal, H.C., Ph.D.
Mahesh Chander, Ph.D.
Manrai, S. (Mrs.), M.A.
Vaishya, J.S. Ph.D.

INFRARED RADIATION

Gupta, Devendra, Ph.D.
Joginder Singh, M.Sc.
Om Prakash, M.Sc.
Ram, R.S., Ph.D.
Varma, S.P., Ph.D.

ACOUSTIC

Bhaskar, H.L.B., B.Sc., Engg.
Gera, B.S., Ph.D.
Gautam, C.B.L., B.Sc.
John, P.C., Gd. IETE.
Khanna, R.M., DMIT,
Mohanan, V., Ph.D.
Pahwa, D.R., M.Sc.
Sharma, Omkar, M.Sc.
Singal, S.P., Ph.D.

TIME & FREQUENCY

Bahadur, Harish, Ph.D.
Banerjee, P., Ph.D.
Chatterjee, A. (Mrs.), M.Tech.
Goel, G.K., B.Sc.
Gurdial Singh, Matric
Hanjura, A.K., Ph.D.
Mathur, B.S., Ph.D.
Saxena, G.M., Ph.D.
Saxena, M. (Mrs.), Gd. IETE.
Sengupta, A., Ph.D.
Shakdhar, M.L., B.Sc.
Taneja, P.N., Matric

D.C. STANDARDS

Batra, V.K., M.Sc.
Ganapathy, T.V., B.Sc.
Mahajan, S.K., Ph.D.
Mittal, P.K., B.Sc.
Sircar, B., B.Sc.

L.F. & H.F. IMPEDANCE

Dahake, S.L., Ph.D.
Dhar, R.N., Ph.D.
Kailash Chandra, Ph.D.
Kaushik, A.R. (Mrs.), Dip. Engg.
Kewal Krishan, Gd. IETE
Nagar, M.R., Gd. IETE
Naib Singh, AMIE.
Omkar Nath, Ph.D.
Saxena, A.K., B.E.

A.C. & L.F.

Arora, T.R., ITI
Gupta, S.R., M.Sc.
Gurmej Ram., B.Sc. Engg.
Inder Bhan, Dip. Engg.
Joginder Singh, Gd. IETE
Mittal, M.K., M.Tech.
Surinder Singh, ITI

H.F. & MICROWAVE

Aggarwal, Ritander, AMIE
Aggrawal, V.K., Ph.D.
Bhatnagar, H.M., M.SC.
Govil, A.K., M.Sc.
Kothari, P.C., Ph.D.
Rustagi, V.K., B.Tech.

MICROWAVE ATTENUATION

Negi, P.S., M.Tech.
Ram Swarup, M.Tech.
Ranjit Singh, M.Tech.
Yadav, R.S., Ph.D.

FLOW MEASUREMENT & C.S. PROGRAMME

Bahl, S.D., ITI
Dwivedi, S., M.Sc.
Govindarajan, M.Tech.
Raj Singh, AMIE
Sharwan Kumar, Ph.D.

TESTING & CALIBRATION

Ghosh, A.K. Dip. Engg.
Mathur, S.P. (Mrs.), B.A.
Singh, C.P., H.School
Thadani, H.K., Gd. Brit. IRE

MATERIALS

SILICON, BETA ALUMINA & SUPERCONDUCTORS

Arora, N.K., Ph.D.
Ashwini Kumar, P.K., Ph.D.
Awasthy, B.R., M.Sc.
Balbir Singh, AMIE
Bangari, N.S., B.Sc.
Chakravarty, B.C., Ph.D.
Das, B.K., Ph.D.
Goel, R.C., B.Sc.
Gupta, H.P., B.Sc.
Jain, Kiran (Mrs.), M.Tech.
Kalsi, H.S., B.Sc.
Khullar, S.M., AIC
Khurana, B.S., B.Sc.
Kotnala, R.K., Ph.D.
Lakshmi Kumar, S.T., Ph.D.
Manmohanan, S.B., M.Sc.
Mithan Lal, M.Sc.
Mohan Lal, Ph.D.
Prem Prakash, AIC
Ramanathan, P.V.N., DIISC
Ram Kishore, Ph.D.
Rastogi, A.C., Ph.D.
Reddi, B.V., Ph.D.
Sarkar, S.K., Ph.D.
Sastri, V.D.P., Ph.D.
Satbir Singh, Ph.D.
Sharda, S.K., B.Sc.
Singh, P.K., Ph.D.
Singh, S.N., Ph.D.
Tripathi, R.B., Ph.D.
Vijay Kumar, M.Sc.

THIN FILM & AMORPHOUS MATERIALS

Anandan, C*., M. Tech.
Basu, A., Ph.D.
Bhattacharya, R., Ph.D.
Devindra Singh, M.Sc.
Dixit, P.N., Ph.D.
Kar, M. (Mrs.), Ph.D.
Panwar, O.S., Ph.D.
Shah, V.V., Ph.D.
Thind, S.L., Dip. Engg.
Verma, B.S., Ph.D.

LUMINESCENT MATERIALS

Ghosh, P.K., Ph.D.
Harish Chander, B.Sc., Engg.
Narang, H.P., M.Tech.
Shankar, V., Ph.D.

LIQUID CRYSTAL & XERORADIOGRAPHY

Agnihotri, B.A. (Mrs.), Ph.D.
Bawa, S.S., Ph.D.
Bhateja, R.C., ITI
Biradar, A.M., Ph.D.
Ekbote, S.N., Ph.D.
Jain, S.C., Ph.D.
Kamalasanan, M.N., Ph.D.
Malhotra, B.D., Ph.D.
Misra, S.C.K., Ph.D.
Panwar, V.S., Ph.D.
Ramadhar Singh, Ph.D.
Saini, K.K., Ph.D.
Sharma, C.P., Ph.D.
Sharma, D.C., M.Sc.
Sharma, R.K., Ph.D.
Subhash Chandra, Ph.D.
Suresh Chand, Ph.D.
Verma, N.S., M.Sc.

ULTRASONICS & ELECTROCERAMICS

Ashok Kumar, Ph.D.
Bindal, V.N., Ph.D.
Gupta, S.C., Gd. IETE
Jain, S.K., Ph.D.
Janardan Singh, Ph.D.
Mukesh Chandra, M.Sc.
Narayanaswamy, N., B.Sc.
Saksena, T.K., Ph.D.
Som, J.N., Ph.D.
Subhash Chandra, B.Sc.
Tandon, R.P., Ph.D.

CARBON FIBRE, COMPOSITES & PRODUCTS

Aggarwal, R.K., Ph.D.
Bahl, O.P., Ph.D.
Bhatia, Gopal, Ph.D.
Chhote Lal, Ph.D.
Dhami, T.L., Ph.D.
Hanspal, S.S., Gd. IETE
Kulshreshtha, R.K., B.E.
Manocha, L.M., Ph.D.
Mathur, R.B., Ph.D.
Ramanathan, S., ITI
Seth, R.L., Ph.D.
Siva Ram, P., M.Tech.
Verma, C.L., B.Sc.

HIGH PRESSURE PHYSICS

Bindal, M.M., Ph.D.
Chakraborty, T.K., AMIE
Chopra, Rajeev, B.E.
Dhar, Ajay, Ph.D.
Nayar, R.K., Dip. Engg.
Sharma, S.L., ITI
Singh, B.P., Ph.D.
Singhal, S.K., Ph.D.
Verma, S.S., B.E.
Virendra Babu, B.Sc.

CHARACTERIZATION

CHEMICAL METHODS

Aggarwal, A.K., Ph.D.
Amar, V.K., M.Sc.
Bohra, J.N., Ph.D.
Gupta, P.K., Ph.D.
Gupta, Prabhat Kumar, M.Sc.
Jitendra Rai, M.A.

GLASS WORKSHOP

Biswas, M.K., Middle
Chandan Singh, W/man Ist cl.
Hans, G.S., Matric
Jusht, M.C., Matric
Kani Ram, Matric
Karnail Singh, Matric
Razdan, D.N., Prajna
Sen, S.S., Middle
Sengupta, S.K., Hr. sec.
Shashi Bhushan, F.Sc.
Vashisht, J.P., Matric
Verma, M.L., Matric
Verma, V.P., Matric

INSTRUMENTATION

Aftab Ahmed, M.A.
Banaudha, Inderjeet, B.Sc.
Prabhakar, A.C., Dip. Engg.
Sachdeva, D.S., Gd. IETE
Singh, V.R., Ph.D.

LIBRARY

Ashok Kumar, Ph.D.
Dhawan, S.M., M.Lib.Sc.
Phull, S.K., M.Lib.Sc.
Sudarshan Kumar, M.Sc.

COMPUTER

Jain, V.C., M.A.
Raizada, Sanjay, M.C.A.
Sethi, N.K., M.Phil.

PLANNING, LIAISON MONITORING

Arora, G.K., M.Sc.
Bhakri, S.S., M.A.
Govindaswamy, G., M.B.A.
Kapur, S.K., B.Ch.E.
Khanduja, R.S., M.Sc. Engg.
Khullar, F.C., M.A.
Kohli, P.K., M.A.
Mandal, S. (Mrs.), M.Sc.
Sharma, S.K., M.Sc.
Tewari, Indra (Mrs.), M.Sc.
Tomar, T.R., M.A.

SERVICES

Dhama, J.S., M.A.
Dhawan, R.C., B.Sc.
Kapur, S.S., Dip. Engg.
Krishnamurty, K.V., Dip. Engg.
Kumar, C.S.P., M.E.
Sharma, J.C., AMIE
Singh, R.S., B.Sc.
Tagra, O.P., ITI

EMERITUS SCIENTISTS

Das, S.R., Ph.D.
Sen, D., Ph.D.
Verma, A.R., Ph.D.

RESEARCH ASSOCIATES/ POOL OFFICERS

Choubey, D.R., Ph.D.
Hazara, Ishani (Mrs.), M.Tech.
Murugasan, T., Ph.D.
Murty, G.S.N., Ph.D.
Padam, G.K. (Ms), Ph.D.
Prasad, R., Ph.D.
Rao, C.V.N., Ph.D.
Reddy, G.S., Ph.D.

ADMINISTRATION/ ACCOUNTS

Anil Kumar, B.Sc.
Bhasin, R.K., B.A.
Chopra, B.B., Matric
Dewan Singh, Inter
Gaira, B.S., B.A.
Gupta, S.L., B.A.
Jitender Parasar, M.A.
Joseph, S.A. (Mrs.), H.Sec.
Joshi, B.C., B.A.
Meni, O.P., H.Sec.
Nirmal Singh, B.A.
Pran Nath, Inter
Sardana, J.M., Inter
Santosh Kumar, M.Com.
Sharma, M.M., B.A.
Sharma, R.K., M.A.
Soni, S.S., Prabhakar
Thakur, Dr. Arvind, MBBS
Vijay Kumar, P.G. Dip.

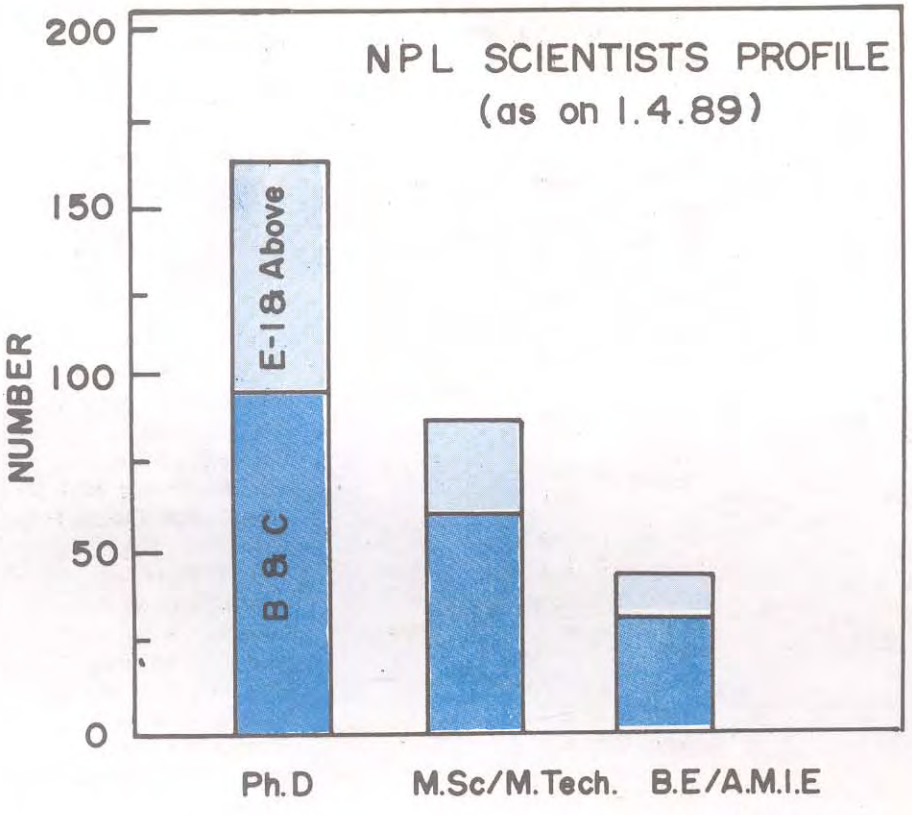
RETIRED

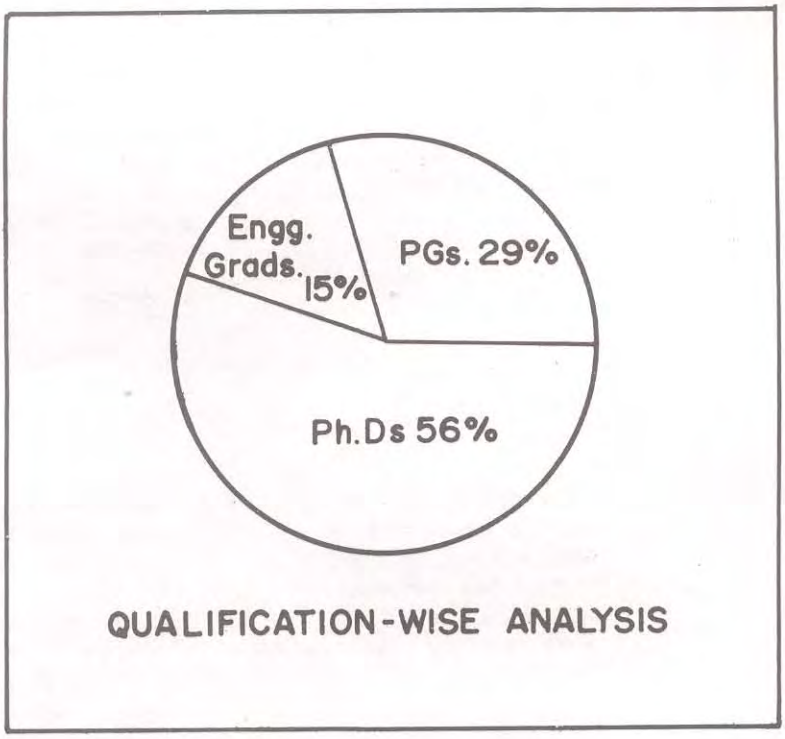
Bachan Singh
Balchandani, M.K.
Choudhary, J.N.
Dutta, K.K.
Ojha, J.N.
Sarin, C. Kanta (Mrs.)
Srivastava, G.S.

*Abroad

Non-Officers retired

Babu Lal, Tech. VI
Chawla, R.P., Tech. VIII
Giri, Mewa, Tech. VI
Kartar Singh, Tech. VIII
Kaul, N.N., STA
Kochhar, T.R., Tech. VI
Lal, D.B., Sr. Store Asstt.
Malkiat Singh, Tech. VIII
Mangat Ram, S.P. Asstt.
Matu Ram, Mali I
Mool Shanker, Sr. Stenographer
Nair, K.P.S., STA
Nanu Ram, Tech. VIII
Padam Bahadur, Sec. Guard
Partap Singh, Tech. VIII
Pritam Singh, W/S Asstt.
Ram Saran, STA
Ram Singh, Tech. VI
Sethi, P.R., Tech. VI
Sohan Lal, W/S Asstt.
Umrao Singh, Tech. VI


NPL SCIENTISTS PROFILE
(as on 1.4.89)
NUMBER
200
150
100
50
0
E-1& Above
B & C
Ph.D
M.Sc/M.Tech.
B.E/A.M.I.E


Engg. Grads. 15%
PGs. 29%
Ph.Ds 56%
QUALIFICATION-WISE ANALYSIS

STAFF STRENGTH

(As on 1.4.1989)

Category	Grade	Number
SCIENTIFIC		
Group IV	Scientist B to Director	301
TECHNICAL		
Group III	Scientist A & Technical Officers A to C	93
Group III & II	Technician (II) to S.T.A.	467
Group I	Helper A to Workshop Asstt.	143
		1004
ADMINISTRATIVE		
	Officers	17
	Establishment	159
	Group B	89
		265
	TOTAL	1269

SYMPOSIA TRAINING COURSES

* Three trainees from Zambia and one from Cuba had undergone training for six weeks in Length Metrology, Mass and Temperature Standards. They were sponsored by the Department of Weights & Measures.

* Nine M.Sc. students from IIT-Delhi, IIT-Kanpur, BHU, Varanassi and Jamia Millia Islamia, Delhi, were provided training at NPL from June 1 to July 15, 1988 under the stipend scheme of the CSIR.

* A workshop on Fabrication Testing & Calibration of Electronic Components was held under IECQ System from Oct. 26-28, 1988. This was collaborated by Metrology Society of India and ERTL (DOE).

* A seminar cum workshop on Technological Nursery for optical research & development was held from Nov. 19-25,1988.

* A national seminar on Non-destructive Testing and Inspection was organized jointly with NDT Society of India from Feb. 9-10 1989.

* A national symposium on Metrology & Exposition of Metrological Instruments was organized jointly with Metrology Society of India at NPL from Feb. 15-17, 1989.

VOCATIONAL TRAINING COURSE

The written examination and the practical tests of the Vocational Training Course were conducted in the respective trades. The duration of the course was two years including three months inplant training. Fourteen trainees qualified and were awarded the certificates. They are:

Electrician Trade
Anil Kumar
Magha Nand Sharma
Mange Ram
M.S. Negi
Sri Krishan
J.P. Sharma

Fitter Trade
Chandan Singh Manral
Laxmi Narain
Hawa Singh
Ramesh Kumar
M.L. Sharma

Carpenter Trade
Bhola Thakur
Jhuther Singh
Sukhpal Singh

COMMONWEALTH INDIA METROLOGY CENTRE

The Commonwalth India Metrology Centre (CIMET) was established at NPL, New Delhi. This was inaugurated by Shri K.R. Narayanan, Minister of State for Science & Technology and Vice President, CSIR, on Feb. 23, 1989. Mr. Shridath. S. Ramphal Commonwealth Secty. Gen. was the cheif guest.

This Centre will provide "Group" as well as "Individual" training to metrologists from the commonwealth countries with full financial support from Commonwealth Fund for Technical Cooperation (CFTC). The infrastructural facilities for training and secretariat for the centre would be provided by NPL.

CIMET will operate under the guidance of an international Advisory Committee, chaired by Dr. A.P. Mitra, DG, CSIR. Other members are:

1. Dr. S.K. Joshi *(India)*
2. Dr. K. Chandra *(India)*
3. Dr. Dudley Rhynd *(Barbados)*
4. Dr. L.T. Danso *(Ghana)*
5. Mr. T.P. Jones *(Australia)*
6. Mr. Y. Xiaren *(China)*

OBITUARY

1. Shri T.V. Ramamurthy, former Deputy Director, NPL passed away on May 22, 1988. He was associated with the R&D and pilot plant production of electronic components. He was awarded Moudgil award of ISI in 1961 and Padmashri in 1971. He retired from NPL in 1972.

2. Members of staff expired during the year.

Mai Chand	Workshop Assistant
Misri Lal	Technician
Noor Mohd.	Workshop Assistant
Ram Sohawan	Helper B
Vijender Kumar	Tech. Assistant

VISITS ABROAD

(1.4.88 to 31.3.89)

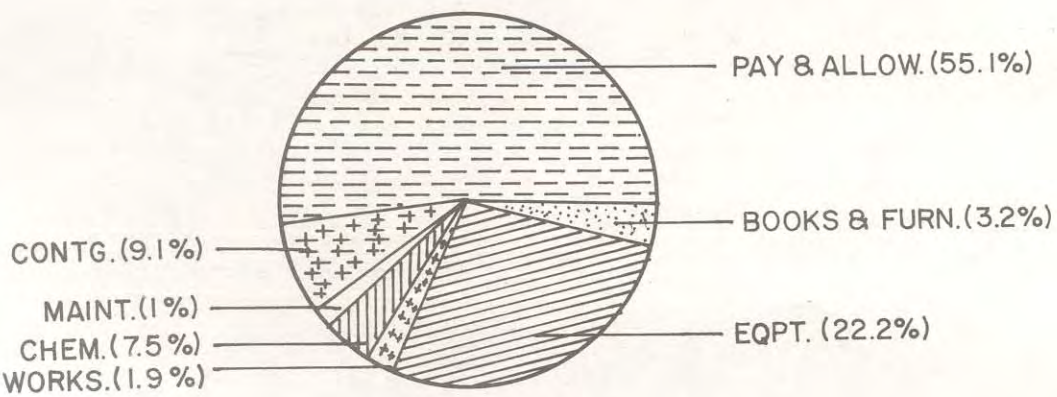
Name of Scientist	Country	Month	Purpose
Dr. Ashok Kumar	UK	April-Dec.	Post doctoral training at NPL Teddington.
Dr. B. Jayaram	UK	April	South Hampton University, post doctoral fellowship.
Dr. Vijay Kumar	Japan	May	For training at M/s Rigaku Corporation.
Dr. Krishan Lal	Bulgaria	May	To visit Optics Research Instt., Sofia Physics Centre and Bulgarian Academy of Sciences.
	USA	Jan.	Under Indo-US collaborative project "Preparation, Characterization and precision measurements of semiconducting materials".
Dr. D.R. Lakshmi	Japan	May	INSA/JSPS Exchange Programe in the field of Ionospheric Physics.
Dr. R.G. Sharma	UK	May	To attend the international meeting on critical currents in high Tc superconductors at the University of Birmingham
	FRG	Sept.-Dec.	To work in superconductivity under CSIR-DAAD Programme.
Dr. T.R. Tyagi	USSR	May	A member of delegation to IV Meeting of joint Indo-Soviet working group in space metrology aeronomy
Dr. S.K. Joshi	France	June	To attend 2nd meeting of Science Council and governing body of the Indo-French Centre for Promotion of advanced research (IFCPAR).
	Czechoslovakia	Sept.-Oct.	For discussions on "High temperature superconductivity & disordered alloys" under INSA-CSAV Programme.
Dr. B.K. Das & Dr. A.K. Gupta	USSR	June	In the area of electronic materials investigations on high temperature superconductivity.
Dr. V.K. Agarwal	Japan	June	To attend the biennial conference on CPEM 88 at Tasukube Science Centre and to visit Electro-technical Laboratory.
Dr. Kailash Chandra	Bhutan	Aug.	To take up UNESCO consultancy assignment
	S.Koria	Nov.	To attend 88 ASCA Post Workshop in "Measurement Technology for International Development" and to attend 10th ASCA meeting at Seoul.
	China	Nov.	To attend 4th review meeting of Asia Pacific Metrology Programme.
Dr. (Mrs.) N. Kundu Dr. K.S. Zalpuri	FRG	Aug.	To present a paper at the Quadrennial Ozone Symp. 1988 at Gottingen.
Dr. S.C. Jain	FRG	Aug.	To present a paper at the 12th Intl. Liquid Crystal Conference at University of Freiburg.
Dr. M.M. Pradhan	Switzerland	Aug.	To attend the 4th Intl. Conference on Infrared Physics at Zurich.
Dr. B.M. Reddy	USSR	Sept.	Under Indo-USSR S & T Programme.
	USA	Nov.	To attend SUNDIAL Workshop and to visit NRC in Washington.
	Italy	Feb.	To deliver lectures at Workshop on "Theoretical and Experimental Radio Propagation Physics" at Trieste.
Mrs Santosh Agarwal	USSR & UK	Sept.	Under Indo-USSR S & T Programme and to visit Rutherford Appleton Lab. near London

contd.

Name of Scientist	Country	Month	Purpose
Dr. B.S. Gera	Japan	Oct.	To present a paper at the 2nd Intl. Conference on Atmospheric Science
Dr. Harish Bhadur	Brazil & USA		To present a paper at the 4th Intl. Symp. on Radiation Physics at Sao Paulo and one month study/training at Oklahama State University
Dr. P.K. Ghosh & Dr. Virendra Shankar	Japan	Oct.	To attend the 4th Intl. Workshop on Electro-luminescence, at Tottori
Dr. V.N. Bindal	USA & UK	Oct.-Nov.	To visit WFUMB at Falmouth, Boston, National Inst. Standards, Gaithesburg & University of Bath
Dr. V.R. Singh	USA & Canada	Oct.-Nov.	To attend & present a paper at WFUMB meeting and to deliver a lecture at the University of Toronto
Sh. Subhas Chandra	Poland	Oct.	Under the PAS-CSIR exchange programme
Dr. Sharwan Kumar	Denmark, France, Belgium & FRG	Nov.-Feb.	To study accreditation systems for calibration labs. in EEC countries and training in fluid flow measurements under NPL-PTB Tech. Cooperation
Mr. Ravi Kumar	France	Nov.	For training in operation and maintenance of ultra high vacuum system
Dr. M.V.S.N. Prasad	Itaky	Jan.-Feb.	To participate in course on radio propagation Physics
Shri H.N.P. Poddar	Italy	Jan.	For training in the field of pressure standards under UNDP
Dr. S.D. Sharma	USSR	Jan.-June	Under Indo-USSR integrated long term cooperation in S & T in the area of growth of perfect crystals of oxides
Dr. B.V. Reddi	USSR	Jan.-July	To study rate of stoichiometry impurities and microstructure on superconducting properties under ILTP
Dr. S.V. Gupta	USA	Jan.	Indo-US collaborative project in the area of measurements
Mr. Mukesh Chandra	UK	Feb.-July	For studies in the area of under water acoustics at the University of Bath
Dr. Ram Kishore	Australia	Feb.	To present a paper at the 4th Intl. conference on Photovoltaic Science & Engineering at Sydney
Dr. K.C. Joshi	Malaysia	March	To attend a group meeting of Association for Science Cooperation in Asia (ASCA) held at Kaulalumpur
Dr. B.S. Mathur	USSR	March	Under Indo-USSR S & T Programme

ACTUAL EXPENDITURE

Budget Head	Rs. (Lakhs)
Pay & Allowances (P1, 2, 3)	489.998
Contigencies (P4)	81.501
Maintenance (P6)	8.482
Chemicals (P7)	66.519
Total Recurring	646.500
Works (P5-1 & 2)	16.763
Equipment (P5-3)	197.844
Books & Furniture (P5-4)	28.502
Total Capital	243.109
Grand Total	889.609
Actual Expenditure of sponsored projects	75.398



RESEARCH COUNCIL

Dr. R. Ramanna 402, 9th Cross, R.N. Nagar, Bangalore-560032	Chairman
Prof. R. Vijayaraghawan, Physics Faculty, TIFR, Bombay-400 005.	Member
Prof. A.B. Bhattacharya, IIT, New Delhi-110016.	Member
Prof. M.K. Dasgupta, Instt. of Radio Physics & Electronics, Acharya P.C. Road, Calcutta-700027.	Member
Prof. D. Chakravorty, IACS, Jadavpur, Calcutta-700027.	Member
Prof. R. Narasimha, Director, NAL, Bangalore-560017.	Member
Shri K.P.P. Nambiar, Secty. DOE, New Delhi-110003.	Member
Shri K.R. Parameswar DG, BIS, New Delhi-110002.	Member
DG, CSIR or his nominee	Member
Dr. S.K. Joshi, Director, NPL, New Delhi-110012.	Member

MANAGEMENT COUNCIL

Dr. S.K. Joshi, Director, National Physical Laborotory, New Delhi-110 012.	Chairman
Dr. K. Chandra, Scientist (Dir. Gd.), NPL, New Delhi.	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.S.S. Agarwala, Scientist, CEERI, Pilani-333 031.	Member
Sr. Finance & Accounts Officer, NPL, New Delhi.	Member
Director General, CSIR, New Delhi-110 001. Or, his nominee.	Permanent Invitee
Controller of Administration, NPL, New Delhi.	Member Secretary

Dr. S.S. Ramphal addressing at the inauguration ceremony of Commonwealth India Metrology Centre, at NPL. Seated from left to right are Dr. K. Chandra, Dr. S.K. Joshi, Mr. Moni Malhotra, Mr. K.R. Narayanan, Dr. A.P. Mitra, Dr. A.R. Verma, Dr. G. Thyagarajan and Mr. K.N. Johry.

Prof. A. Hewish, NL, delivered the Krishnan Memorial Lecture on Jan. 5, 1989. The speaker with Dr. R. Ramanna and Dr. S.K. Joshi before the portrait of Dr. K.S. Krishnan.

Open Day at NPL.

A view of Dr. K.N. Mathur Vatika of NPL Colony.

The newly constructed Indian Antarctic Station 'Maitri', about 80km south of Dakshin Gangotri.

HONOURS AND AWARDS

Dr. Ravi Mehrotra was awarded the CSIR Young Scientist Award in Physical Sciences for the year 1988 for his work on low dimensional systems of electrons floating on a helium surface, experiment on the Quantum Hall Effect and studies of chaos in two dimensional arrays of Josephson junctions.

Dr. V.N. Bindal and Dr. Ashok Kumar were awarded Rs. 20,000 jointly by NRDC on their invention for the development of calibration block for characterization and standardization of ultrasonic surface wave probes for NDT of metals.

Dr. A. Sen Gupta was chosen as the Leader of the VIIIth Indian Antarctic Expedition.

Sh. Prabhat Kumar Gupta was a member of the VIIIth Indian Antarctic Expedition.

OPEN DAY

The Foundation Day of CSIR was celebrated at NPL by observing an Open Day on Sept. 26, 1988. The students of various schools and colleges of Delhi visited the laboratory. Special audio-visual programmes were shown on this day. An exhibition and display of various activities of NPL was arranged. This included High Temperature Superconductivity; Laser Holography; Standards of Volume, Density, Angle Measurement, Force, Time and Frequency, Temperature; Electronic and Engineering Materials; Materials Characterization; SROSS, Satellite Model, Satellite Signal and Glass apparatus.

The students were exposed to the scientific achievements and applications. The meritorious science students were provided special attention. Mementoes were presented to the employees who had compeleted 30 years of service in the CSIR on that day. CSIR Foundation Day studentship awards, essay competition and science subject awards were also presented.

EXPEDITION TO ANTARCTICA

Dr. A. Sengupta of NPL was the leader of the VIII Indian Scientific Expedition to Antarctica. The expedition consisting of 100 members including Shri Prabhat Kumar Gupta of NPL, sailed on Nov. 29, 1988.

The objectives of the expedition were: maintenance of the station at Dakshin Gangotri; completion of the construction of new station at Maitri; scientific studies in the areas of Geology, Geophysics, Meteorlogy, Upper Atmosphere Physics, Ozone Depletion, Oceanography, Geomagnetism and measurements and collection of samples.

The scientific studies made by the scientists of NPL were: direct UV radiation measurements made every half an hour using spectroradiometer; collection of air samples for study of minor constituents of atmosphere; setting up of phase tracking equipment at Maitri. The data of phase and amplitude are being recorded on strip chart.

NATIONAL SCIENCE DAY

The National Science Day was celebrated at NPL on Feb. 28, 1989 by organizing a special lecture by Prof. D.S. Kothari, Chancellor, J.L. Nehru University. The topic of the lecture was "Pt. Nehru and Indian Science".

Prof. Kothari highlighted the role of Pt.Nehru in the development of science in India after independence. He recalled about his personal meeting & interaction with Pt. Nehru in 1947 regarding the Science Congress at Delhi. He stated that Pt. Nehru was the architect of modern science in India and was instrumental in establishing scientific institutions and departments. He also quoted Pt. Nehru's sentiments about Einstein and also Einstein's views about Pt. Nehru.

KRISHNAN MEMORIAL LECTURE

The XIX Krishnan Memorial Lecture was delivered by Prof. A. Hewish, NL, of Cavendish Laboratory, Cambridge University, UK, at NPL on Jan. 5, 1989. The topic of the lecture was *"Pulsar Era"*. Dr. Raja Ramanna presided over the function.

The audience included physicists, scientists, research students and others. Dr. S.K. Joshi, Director, NPL presented a memento to Prof. Hewish on the occasion.

EXHIBITION

NPL participated in the exhibition organised on the eve of 76th Indian Science Congress held at Madurai from Jan. 6 to 18, 1989. The charts, photographs and demonstrations of instruments/set-up of activities of NPL, which included Time & Frequency dissemination via INSAT, high temperature Superconductivity, air borne microwave refractometer, and liquid crystal, were displayed. The rain gauges, Kytoon experiment and amorphous silicon solar cell panel were demonstrated by NPL scientists.

NPL also participated in the exhibition "Science towards Villages" held at Gauriganj, (U.P.) from March 4 to 15, 1989, organised by CSIR in collaboration with National Wasteland Development Board. The activities displayed included carbon-carbon composites, amorphous silicon solar cell panel and electronic energy saver.

Shri Rajiv Gandhi, Prime Minister of India visited both the exhibitions.

DR. K.N. MATHUR VATIKA

The central park of the NPL Colony was developed during the year. The vatika was inaugurated by Dr. K.N. Mathur, former Deputy Director of NPL, on Mar. 19, 1989 in the presence of Dr. S.K. Joshi, Director, and residents of NPL Colony. The vatika has been named after Dr. K.N. Mathur.

BIRTH CENTENARY PROF. C.V. RAMAN

The birth centenary of Prof. C.V. Raman was celebrated at NPL and a function was organized. A special issue of NPL Technical Bulletin was released on the occasion by Prof. D.S. Kothari, Chancellor, Jawaharlal Nehru University, who also presided over the function. Prof. D.D. Pant and Prof. Roop Kishore spoke about their experiences as students of Prof. Raman and threw light on unique personality that Prof. Raman was. Prof. Kothari also recalled the contributions made by Prof. Raman regarding the development of science in India.

NPL CLUB

NPL Club organised its Annual Sports Tournament during April 1988 in which about 200 members including senior scientists participated. To mark the birth centenary of a great mathematician, Srinivasa Ramanujan Memorial General Knowledge Contest was organised on May 27, 1988 at NPL and prizes were given away by Dr. S.K. Joshi, Director.

Sixth Dr. K.S. Krishnan Memorial Bridge Trophy Tournament was also organised in May 1988 at NPL, in which prominent players from Delhi and adjoining states participated and the prizes were distributed by Mrs. Hema Joshi. NPL also participated in the S.S. Bhatnagar Memorial Tournament held at NAL, Bangalore and NPL cricket team was placed in III position. Shri V.D. Arora & Shri Prem Chand were members of CSIR National teams in cricket and volley ball respectively. NPL club also took part in 2nd CSIR Atheletics at CMERI, Durgapur. The Club organised a trip to Suraj Kund Crafts Mela in Aug. 1988.

जवाहरलाल नेहरू
जन्मशती

JAWAHARLAL NEHRU
CENTENARY

1889 1989