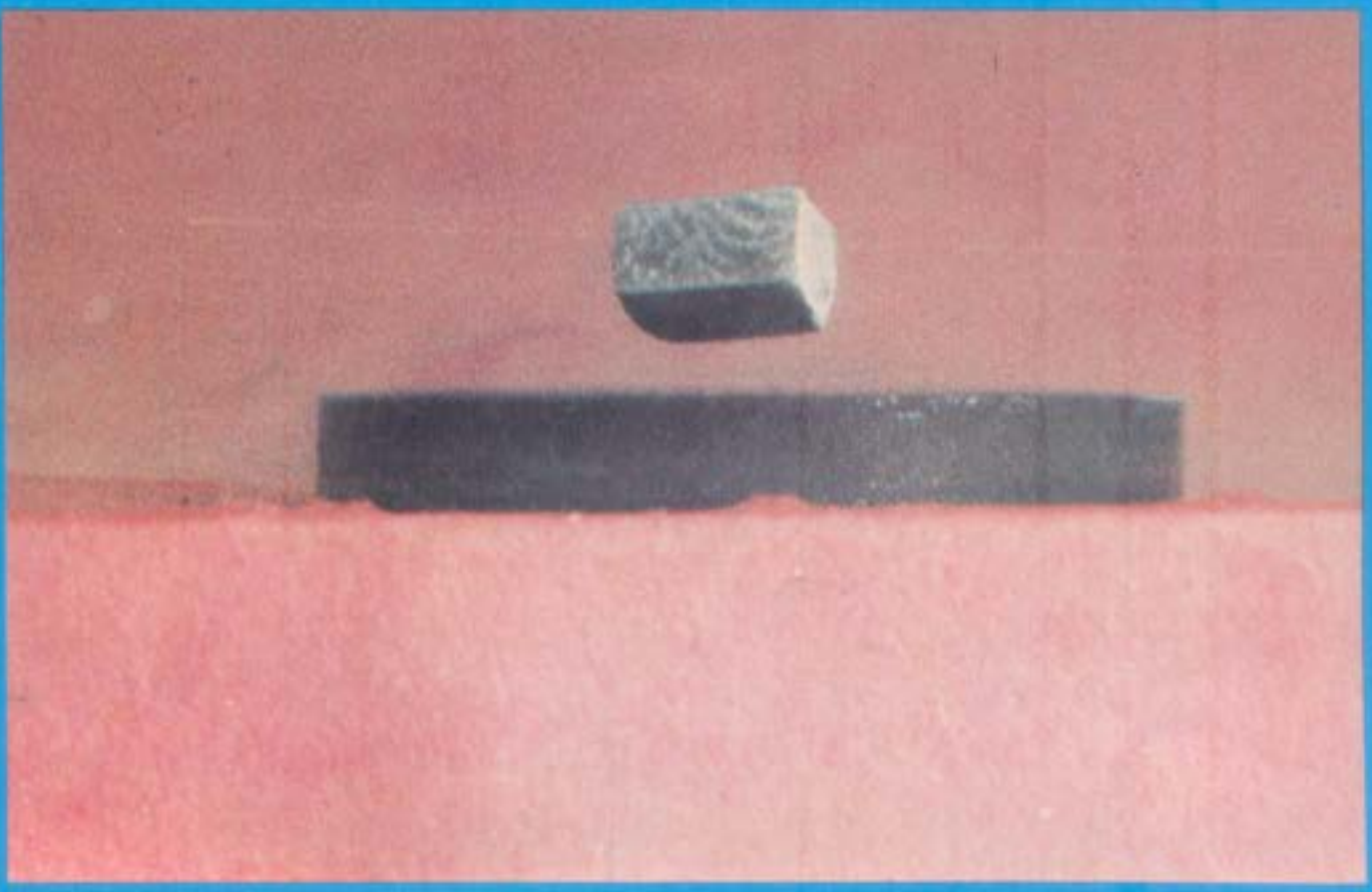
ANNUAL REPORT 1986-87



N P L

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Preface

NPL has had another successful year of growth. This Report gives the summary of the progress of the activities at NPL during the period April 1986 to March 1987. The major areas of activities were: Standards, Materials Development and Characterization, Radio & Atmospheric Sciences, Cryogenics and Superconductivity.

The efforts in the area of Standards were continued towards further improvements in the accuracies:

* The accuracy of the Josephson voltage standard has been improved to 0.8 ppm.
* A GPS receiver was installed and this has improved the time keeping accuracy to 100 nanoseconds.
* By the addition of a programmable mass comparator, measurement upto 1 microgram can be made.
* Fabrication of standard Rockwell Hardness Machine and thermal voltage convertors was completed.
* Facility for intercomparison of Industrial Platinum Resistance Thermometers for low temperature range was established.
* Uncertainty of 26 ppm in the pressure generated by piston gauge has been achieved.
* The Intercomparison & Calibration, under the Indo-USSR Programme, was carried out for luminous intensity, slip and angle gauges, DC voltage, capacitance standard and thermal voltage convertors.
* A CSIR-Industry Get-together on Measurement Standards, Calibration, and Quality Assurance was held at NPL.

A number of sets of reference and secondary standards of mass for Departments of Weights & Measures of various states were calibrated. The calibration of a large number of reference standards and measuring instruments from outside agencies was done and 1933 test reports were issued during the year.

In the area of Characterization of Materials the facilities were strengthened by the commissioning of a Perkin Elmer gas chromatograph for analysis of traces. Rigaku X-ray fluorescence spectrometer was also installed:

* A small but measurable electron lattice interaction has been observed in silicon MOSFETs using multicrystal X-ray diffractometers.
* High resolution diffuse X-ray scattering measurements have been carried out around four different reciprocal lattice points of the same specimen in eight planar sections of the reciprocal space.

In the field of Materials the activities were concentrated on the development & batch production of products:

* A multizone system for preparation of amorphous silicon solar cells was commissioned and an apparatus for the measurement of spectral responsivity of the cells was assembled & tested.
* Batches of glassy carbon dental implants and carbon brushes were processed and supplied for tests. 3D carbon-carbon composites were also developed.
* A novel technique of making coloured liquid crystal displays, without using external polarizer, was developed.
* Evaluation of transducer performance at high electric drives was studied. An ultrasonic atomizer was developed for Physical Research Laboratory, Ahmedabad.
* The sponsored work regarding the development of space qualified interference filters for Space Application Centre, Ahmedabad was completed. The first prototype of xeroradiographic machine was constructed.

The Cryogenics & Superconductivity group had an active programme:

- 1-2-3 compound was synthesized which exhibited superconductivity at 90 k.
- A multistage purification system was developed with output of less than 12 ppm of hydrocarbon.

In the area of Radio & Atmospheric Sciences the major tasks accomplished were:

- Satellite measurements of EUV flux were successfully used for the first time to develop ionospheric prediction techniques.
- Fabrication and testing of pre-engineering models of payloads for SROSS-3 satellite was completed.
- A comprehensive programme on ozone took new shape and inputs included UV-B photometers, laser heterodyne system, balloon and rocket experiments and analytical studies using data from Nimbus satellites.
- Infrared and visible sensors for aerosols under IMAP were flown aboard a rocket over Thumba on Oct. 2, 1986. NPL-UTK (Japan) nitric oxide rocket payloads were fabricated.
- Co-ordinated rain rate measurements were initiated by establishing a chain of fast-response rain gauges.
- Air-borne microwave refractometer data and LOS link data were combined to optimise tropo-link design.
- The pioneer venus orbiter magnetometer data analysis show a continuous rather than time-evolving mechanism for generation of ionospheric magnetic fields of venus.

The XVI Krishnan Memorial Lecture was delivered by Prof. P.W. Anderson, Nobel Laureate on Jan. 12, 1987. The topic of the lecture was "Puzzles & Surprises in Condensed Matter Physics". Prof. D.S. Kothari presided.

A large number of distinguished scientists from other countries visited the laboratory and some of them gave lectures also.

Dr. A.K. Hanjura and Dr. S.D. Sharma, participated in the VI Expedition to Antarctica and performed various experiments. Dr. Ravi Mehrotra was given INSA Young Scientist Award. The processes of Cinema Arc Carbons, Carbon Thrust Bearings, SIG Contacts and Piezoelectric Materials & Bimorph Elements were released to industry.

The computer system VAX-11/780 was installed & commissioned. More than 125 papers were published in reputed national and international journals and about 120 research reports were produced during the year.

The 60th Birthday of Dr. A.P. Mitra, D.G. CSIR, was celebrated on Feb. 20, 1987, at NPL.

S.K. Joshi

(S.K. JOSHI)
Director

PHYSICO MECHANICAL STANDARDS

LENGTH STANDARDS

1. Portable I_2 Stabilised He-Ne Laser

Encouraged by the performance of the 633nm iodine stabilised He-Ne laser, a programme was taken to build a portable unit of such a stabilised laser. Such a unit has been made and is under performance evaluation. It is planned to get this laser intercompared with that of BIPM, France.

1.1 Development of Methane Stabilised Laser.

Work has been started on the development of 3.39 μm methane stabilised He-Ne laser. This laser has been chosen because of its higher values of frequency stability and repruducibility, and also because its radiation is one of the recommended radiations for realisation of metre as per CGPM'83.

Lasing action has been achieved at this wavelength and work is in progress to make a stable laser cavity, a methane absorption cell and an electronic control system.

1.2 Linkage of Metre with Second

To realise the metre as per its new definition, it is necessary that one should know the frequency of the stabilised laser radiation, in terms of the Cs clock frequency. A study of the different available methods was made and a method which is comparatively simple and less expensive has been chosen. Some of the essential components like 300 mm long stable Fabry Perot interferometer have been made and others are being purchased.

1.3. Laser Measurement Systems.

Two laser-interferometric length measurement systems are under development. In the end-gauge interferometer, the length of end-gauge is determined in terms of the wavelength of a frequency stabilised laser. The system gives an accuracy of 0.2 μm. Effective steps were being taken to minimise the influence of the temperature variation so as to improve the accuracy of the system. In the line-gauge interferometer the graduation-intervals of a line-gauge standard, a metre bar, are calibrated in terms of the wavelength of frequency stabilised laser. A one metre linear dividing machine was being used as a bed for getting a uniform movement to the metre bar. The mechanical system for the movement of the bed was modified and the bed can now be moved smoothly using electrical signals from a microprocessor. Work is in progress to improve the electronic control system and provide better thermal isolation to the whole system.

1.4 Research Activity.

Studies on the polarisation properties of internal mirror He-Ne laser at 633 nm were carried out and improvements were made in the sensitivity of the laser-polarimeter.

Considering the developments of application of optical fibres as sensors for determining certain parameters, work was started in this direction. In one application a microdisplacement system, capable of measuring a displacement of the order of 0.1 μm, has been developed. It can be used for measurement of several displacement related parameters like an extremely small amplitude ($\simeq$ 50 Å) of vibration. In another application, the optical fibre along with the technique of holographic interferometry was used to detect phase changes. In a specific case, the phase change was introduced by heating the fibre and the phase sensitivity achieved was 94 rad $m^{-1}K^{-1}$. A grazing incidence lateral shearing interferometer has also been developed. This interferometer is useful for testing groundglass blanks, surface plates, machine-tool guide-ways and for similar other industrial measurements.

DIMENSIONAL METROLOGY

1. Calibration

Calibration facilities have been utilised by in

dustry and other organisations for a variety of measuring instruments or gauges. Calibration of slip gauges, angle gauges and a polygon was carried out under INDO-USSR Intercomparison Programme. The polygon was calibrated using the method of two autocollimators. The uncertainty of calibration was found to be ± 3 seconds of arc at 99.7% confidence level.

Specific criteria for approval of Echelon I, II and III calibration laboratories in the area of dimensional measurements were prepared and the accuracies of standards and measurement uncertainties for these laboratories were laid down.

2. Developmental Work

Preliminary studies have been carried out for using a laser interferometer on the existing three-coordinate measuring machine so that dimensional measurements in three-coordinates could be carried out in terms of laser wavelength.

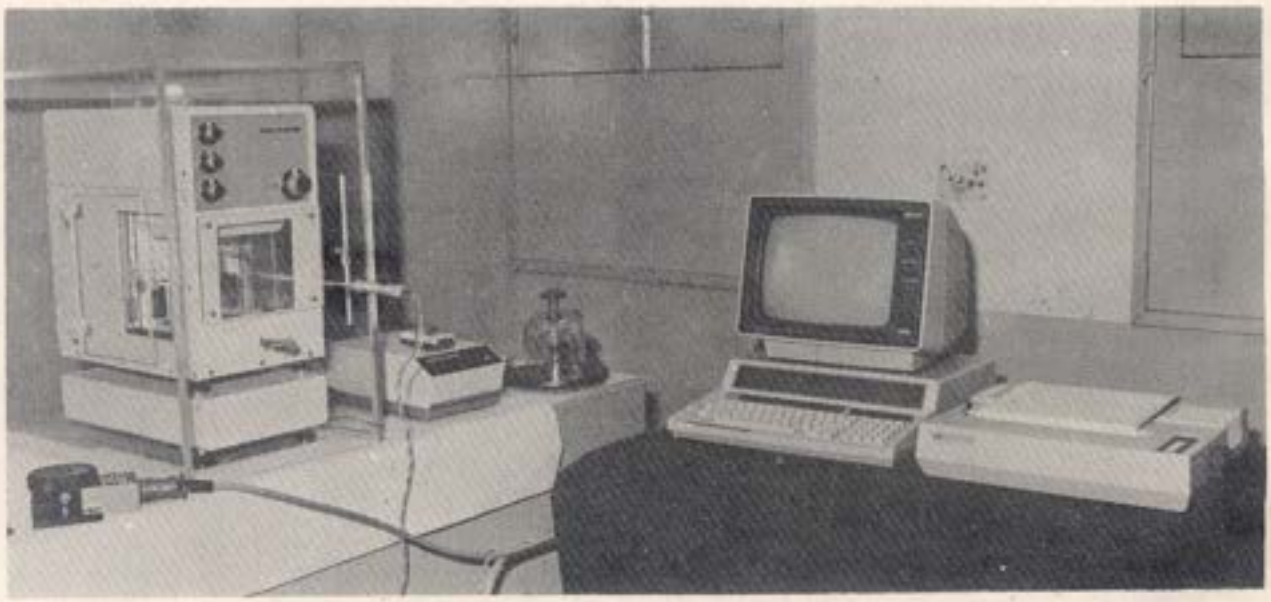
A non-contact electro-optical sensor for microdisplacement measurement has been developed. With this system, a resolution of 0.1 nm in the linear range of about 10 μm is possible. An Angle Goniometer incorporating Moire radial gratings has been designed.

MASS, VOLUME & DENSITY STANDARDS

1. Mass

A programmable 1 kg mass comparator with computer controlled weight handler was installed in a separate chamber. The balance can read upto 1 microgram. To filter out undue vibrations, the balance has been placed on a special concrete block resting on a resiliant material, partly isolated from the main floor of the chamber. System for measurement of pressure, temperature and relative humidity using remote sensors was set up. Pressure, temperature and relative humidity can be measured within 0.02 mm of Hg, 0.001°C and 0.2 percent respectively.

Two 1 kg weights of same material were inter compared, on four different occasions. Each time ten sets of mean of 10 differences in their mass value were taken. Combined standard deviation of the mean of differences has been found to be 1.2 μg giving the total random uncertainty of 3.0 μg at



1 Kg Mass Comparator with computer controlled weight handler

99 percent confidence level. As the mean value of the mass differences was obtained by taking quite a few sets of observations, it was necessary to estimate variability within the set σw^2 and in-between the sets σb^2. Typical values of σw^2 and σb^2 for a day have been calculated as 38.4 and 2.6 respectively showing thereby that there was no significant variation in-between the sets.

1.1 Density

Solid base density standards whose volume and density were established in terms of the density of triple distilled water, were used to determine the density of weights received from Bhabha Atomic Research Centre, Trombay and for calibration of NPL density hydrometers.

1.2 Viscosity

Using water as primary standard of kinematic viscosity, the viscosity scale upto 9 mm^2/s has been established.

1.3 Calibration and Testing

A number of sets of reference and secondary standards of mass for State Weights & Measures Departments were calibrated. The prototype testing of several weighing machines from the manufacturers were carried out.

FORCE AND HARDNESS STANDARDS

The fabrication of standard Rockwell Hardness Machine was done. A dead weight machine of 100 kN capacity for calibration was being fabricated. Some straingauge type load cells have been fabricated.

The calibration of force measuring devices for various public and private organisations was done.

PRESSURE STANDARDS

1. Pneumatic Pressure Range

The controlled clearance platon gauge, primary standard for the pneumatic pressure region, has been characterized to optimise certain parameters in order to have the minimum overall uncertainty in the pressure generated at the reference level of the piston gauge by measuring its fall rate as a function of the jacket pressure, temperature, rate of rotation of the piston and finally the most important parameter i.e. the pressure transmitting fluid like nitrogen, argon, helium, hydrogen etc. having different kinematic viscosity values at ambient temperature and atmospheric pressure. After incorporating all the necessary corrections for different parameters the computed uncertainty of 26 ppm in the pressure generated by the piston gauge at 5 MPa has been achieved using nitrogen as working fluid. However, an improved reproducibility in the pressure measured by the piston gauge can be obtained if hydrogen is used instead of nitrogen as working fluid. The use of helium is suggested instead of hydrogen due to the latter being inflamable and hazardous.

1.1 International Intercomparison between NPL and PTB, West Germany

Apart from the different parameters which contribute some finite value of uncertainty in the pressure generated by the piston gauge, the correction term $(1 + bP)$ is the leading cause of introducing the uncertainty in the pressure generated by these gauges. In order to promote the uniformity in the high pressure measurements and to study the pressure dependent phenomenon it was all the more essential to know the values of the uncertainty associated with the generated pressure by the piston gauge of any particular metrological laboratory. With this aim in view, the bilateral comparison between NPL, India and PTB, West Germany using the piston gauge as transfer pressure standard upto 4 MPa in the pneumatic pressure region was carried out during October, 1986. An agreement in the value of effective area was within $\pm$ 1 ppm and the 18 ppm uncertainty was achieved in the pressure measured by the transfer standard.

1.2 Hydrostatic Pressure Region

The characterization of the controlled clearance piston gauge upto 1 GPa i.e. primary pressure standard in this region was being done in order to improve the overall uncertainty in the measured

pressure by this standard by measuring its fall rate as a function of pressure transmitting fluid, temperature and piston rotational frequency etc.

1.3 Fixed Points

In order to establish a reliable and reproducible first fixed points on the international practical pressure scale i.e. the mercury melting line, the work is in progress.

VACUUM STANDARDS

1. Ultrasonic Interferometer Manometer : A Manobarometer

The Ultrasonic Interferometer Manometer (UIM), a primary standard for the accurate measurement of barometric pressure, has been developed in collaboration with National Bureau of Standards, USA. It is a microcomputer based system used for precise and accurate measurement of pressure in the barometric region i.e. 0.1 MPa to 1.0 Pa. Its performance has been evaluated for its zero pressure stability, pressure resolution and temperature stability for the memory columns. The measurement accuracy of the manometer is 2×10^{-2} Pa $\pm$ 20 ppm of the reading and its stability is 1 ppm of the reading. It has the pressure resoiution of about 10^{-3} Pa and automatically makes the complete measurement in two seconds without disturbing the mechanical and thermal stability of the manometer. The temperature stability of the manometer is within 5×10^{-3} K. Ultrasonic Interferometer Manometer would be used for the calibration of aircraft altimeters, secondary vacuum standards and other precise pressure transducers, etc.

1.1 Conductance of a Porous Plug and Flow Measurement

A permeation type flowmeter was designed and assembled. Using this flowmeter, a method was evolved to study the conductance of a porous plug as a function of pressure in the range 0–1000 mbar and above. In case of He, the best fit for the pressure range 67-1284 mbar is expressed by an 8th degree polynomial, while for nitrogen, the best fit for the range 60-930 mbar is obtained by a 9th degree polynomial. The conductance of the plug is shown to be constant for pressures below 20 mbar in case of N_2 while for greater pressures, it is found to vary linearly with pressure. The corresponding pressure value of helium has been found to be 53 mbar. The conductance of the plug for He in the transition flow range has been shown to be expressible in terms of the nitrogen conductance and molecular weights of the two gases. The conductance of the plug thus determined has been used for measuring the flowrates of gases admitted into the calibration chamber of our dynamic flow system.

One spinning rotor gauge (VM 210) and two ionization gauges were calibrated using the above-mentioned constant volume flowmeter in the range varying from 10^{-3} mbar to 8×10^{-8} mbar, with errors not exceeding $\pm$ 3%. The work has been extended to argon also and the slopes of the respective K vs P lines for He, N_2 and Ar when multiplied by corresponding viscosities have been shown to be constant, as expected from theory.

1.2 Pressure Distribution in the Axial Direction

A theoretical analysis of pressure distribution along the axial direction in a dynamic vacuum system with oil diffusion pump was studied in detail. Theoretical relationships between the measured pressure and different orientations of the gauge openings have been derived by taking into account the gas beaming effect, inside a test dome, connected to the same diameter oil diffusion pump. A precise experimental study to verify the theoretical relationships between the measured pressure and the three orientations of the tubulated gauge was carried out by using a 104 mm diameter test dome connected on top of the same diameter oil diffusion pump. Experimental results obtained on the pressure distribution in axial direction at the four tubulated gauge positions were presented and discussed. The pumping probability factor for the four positions of the test dome was experimentally measured and compared with the theoretical values. The value of throughput measured by a flowmeter is found to agree with the experimentally computed throughputs. The axial characteristics of pressure values

were measured hydrodynamically and it was observed that the gauge orientation opposite to the direction of flow of gas would measure the total pressure while the gauge opening at right angles to the flow would measure the static pressure and should be preferred to measure the pressure under the dynamic vacuum conditions.

1.3 Scanning Electron Microscope

A new automatic electronic sequence controller was designed and fabricated for integration with the vacuum system of SEM. Two new printed circuit boards for various controllers and power supplies were designed. The complete automatic vacuum system was supplied to CSIO, Chandigarh and was integrated with the Electron Optical Column of SEM. The demonstration of the vacuum system was shown at CSIO, Chandigarh and was found to be satisfactory. The time taken for changing specimen was around 1 minute to achieve pressure of 5×10^{-5} Torr.

2. Surface Physics

Two major facilities in surface physics studies were established after installation and standardisation, namely (1) Low Energy Electron Diffraction (LEED) and (2) High Resolution Auger Electron Spectroscopy using Cylindrical Mirror Analyser (CMA), etc. After establishing the 4-grid Retarded Field Analyser (RFA) in the existing VT 112 UHV system, attempts were made to use the system in the LEED as well as in the Auger mode.

2.1 LEED Pattern of Silicon Single Crystal (111) Surface

A silicon single crystal was introduced in the chamber for analysis and the initial surface contamination like carbon, oxygen etc. were removed by subsequent heating and etching cycles till it was pure silicon surface. A heat treatment of about 1000°C could give a crystalline surface which gave a perfect LEED pattern of the Si surface which were then photographed. During the cleaning process of the Si surface, the finger printing of Auger LVV peak of Si (92 ev) has revealed some interesting results which were then analysed and showed effect of ion bombardment on the shift of peak position due to Si-O and Si-C bonding.

2.2 Installation of CMA, Auger Mapper and Depth Profiler

A Cylindrical Mirror Analyser with 0.18% resolution with a concentric 10 Kev electron gun (spot size 5 micron), a scanning sample positioner, and Auger mapper and a multiplexer depth profiler were installed in the system to improve its optimum performance. A number of samples like Si, InSb, OFHC Copper etc. were analysed to optimize the equipment in the Auger mode.

2.3 Electron Loss and Core Loss Spectroscopy

A complete range of plasmon loss, core loss and related Auger lines were observed for Silicon & Titanium in their K, L & M shells. The chemical shift of the binding energies were observed due to its bonding with Oxygen in SiO_2 system & with Ti in $TiSi_2$ system.

TEMPERATURE STANDARDS

Freezing point of copper was realized to gain experience for establishment of Gold Point and the difference between Gold and Silver Points using a Photoelectric Pyrometer. Freezing curves giving constant temperature within 0.1°C were obtained for durations upto 30 minutes.

Triple point of oxygen was established thereby extending the range of IPTS down to 54.361K with a reproducibility of ± 1 mK.

Industrial PRTs (2 No.) for use as secondary standards for the range 0-500°C, Triple Point of water cells (1 No.) and Tungsten Resistance Thermometer, 4-lead system (1 No.) were fabricated.

Facility for intercomparison of Industrial Platinum Resistance Thermometers against Standard PRT for low temperature range at 77K, 90K and 196K has been established with a precision of ± 5 mK.

A bath on the principle of heat pipe was designed to be used with commercially available

Shallow circulator bath. This helps in calibration of long thermometers.

OPTICAL RADIATION STANDARDS

In our efforts to correlate the existing NPL photometric references with radiometric base units, the absolute radiometer was modified and more precise measurements were made. The conversion factor between photometric and radiometric units, Km, has been determined within $\pm$ 1% of the internationally accepted value.

The reference standards for Luminous Intensity were intercompared with those maintained at VNIIOFI, U.S.S.R. The agreement was found to be well within $\pm$ 0.5%.

INFRARED RADIATION STANDARDS

A single beam, double pass monochromator for the spectral region of 0.8 to 15 microns (of SOPRA, France) alongwith APPLE IIe computor for data acquisition and processing was procured and installed. The preliminary experiments for sensitivity, performance and resolution of the system and for radiance measurement of a source in 0.8 to 6 microns were conducted.

The set-up for absolute measurement of specular reflectance and transmittance at normal incidence in the spectral region of 0.8 to 2.8 microns had been completed and specular reflectance measurements on a few films of known reflectance have been performed. The modifications are being incorporated to optimize the sensitivity and the performance. In order to establish transmittance and reflectance standards in 2 to 15 microns spectral region, the specular reflectance measurements at variable angles were taken first. A computer programme was made to compute values of reflectance from reported values of n & k for the film surfaces of various materials.

The services of Perkin Elmer Infrared and custom built Photoacoustic spectrophotometers were extended for measurements of samples obtained from various sections of the laboratory and other institutions. Preliminary experiments were performed to determine the power of a source by using Photoacoustic technique. The optimization of the measurement and accuracy are in progress.

ACOUSTIC STANDARDS

1. Developmental Activities

An experimental set up was assembled to measure vibration amplitude by laser interferometer and some preliminary experimentation was conducted.

Participated, jointly with STQC Directorate of Deptt. of Electronics, in quality improvement programme for audio magnetic tapes for high speed duplication for manufacture of prerecorded cassettes.

Participated in International Round-Robin Calibration of Standard Condenser Microphones initiated by NPL, U.K.

The Noise Survey in NPL Campus and the work on Acoustics of Domestic Environments were completed.

1.1 Sodar Studies

The studies of atmospheric boundary layers of Delhi were undertaken using monostatic sodar system installed at NPL and Mukherjee Nagar (Central Pollution Control Board).

The studies of marine boundary layer at Tarapore and the studies on the size and chemical composition of aerosoles at Delhi were undertaken. Experimental recording of wind velocity (vertical) data on magnetic tapes using Doppler Sodar and Vax Computer was done and analysed.

1.2 Testing & Calibration

Testing and calibration of electroacoustical items and acoustic products was continued.

ULTRASONIC STANDARDS

Measurements for reciprocity calibration were taken extensively from 5 MHz to 10 MHz using PVDF hydrophone. The reproducibility of measurements was within 1 dB. The measurements point to the necessity of evaluating effective radiating area in order to evaluate ultimate accuracy at frequencies $\geq$7.5 MHz. Intercompa-

rison was done by evaluating the sensitivity of the PVDF membrane hydrophone obtained precalibrated from P.T.B., West Germany by the N.P.L. technique. Fig. The agreement at frequencies upto 6 MHz is very good and within 1.7 dB.

Reciprocity technique for hydrophone calibration

Piezoelectric ceramic hydrophone was developed with a probe tip of 2 mm. diameter for the frequency range 0.5–6MHz having a sensitivity 0.5 mV/Pa. The performance has been examined over long periods of use. Essential components including a laser source and concave mirrors. (120 mm diameter, focal length 2 m) for Schlieren system have been procured. The work of installation of system is under progress.

CHARACTERIZATION OF SOLAR THERMAL DEVICES

The work on the development of a copper disc absolute pyrheliometer has been continued. The sensor housing and its peripherals were modified so as to obtain consistency in the accuracy of measurement of solar radiation. By operating the shutter provided in the instrument, heating/cooling rates during exposure/shielding from the sun are recorded. The uncertainty of solar radiation measurement is as low as 0.61%.

Test facilities established earlier, were used for the determination of solar transmittance and absorptance, normal thermal emittance and UV-transmittance of sa..ples received from DNES and industry and reports were issued. The project work has been completed following the establishment of simulated environmental facility for evaluating heat loss coefficient of solar flat plate collector under varying climatic conditions (Temperature 10°C-45°C and RH 10%-90%).

The fabrication of a refrigeration unit from local agencies did not materialise inspite of repeated efforts. However, an intermitant system has been designed and fabricated. The performance evaluation would be done to assess the suitability of the system

ELECTRICAL AND ELECTRONIC STANDARDS

TIME AND FREQUENCY STANDARDS

A Global Positioning Satellite (GPS) Receiver was installed and six clock carrying satellites orbitting at a height of 20,000 kms were tracked for Time, Frequency and Positioning information. This has improved the time keeping accuracies at NPL to 100 nanoseconds, an improvement of more than one order of magnitude. Similarly international time intercomparisons are now being made to few tens of nanoseconds precision by viewing GPS satellites in the common view mode. GPS antenna positions have been determined to 10-20 metres accuracy by viewing four GPS satellites simultaneously. NPL Time Scale data (NPL1) as measured via GPS, is now being communicated to B.I.H.

Standard Time and Frequency Signals (STFS)

are now being regularly transmitted via Indian Satellite INSAT-1B on RN channel V of transponder II and the users are being encouraged to procure the needed equipment and to utilise these services. The existing high frequency standard time broadcast services are expected to improve considerably with the purchase of two new more powerful (10kw) high frequency amplifiers. The present solid state ATA processor was replaced with a microprocessor based fully automatic one.

Other activities included the exploratory research work on the development of Rubidium Vapour Frequency stdd. & feasibility studies on Cesium Primary Standard automatic TV data recording system with continuous TV time intercomparisons between NPL and ATA and development of hardware and software for work connected with STFS dissemination via Satellite INSAT-1B and High Frequency, Time Scale Algorthon etc.

A new multi-institutional (NPL, NGRI, DOS, TIFR) activity initiated is the Geodetic Very Long Baseline Interferometry Experiment which is expected to lead to very precise (ultimately a few cms) measurement of baseline.

D.C. ELECTROMOTIVE FORCE, RESISTANCE AND CURRENT STANDARDS

1. Maintenance of Standards of e.m.f.

Mutual intercomparison of the e.m.f. value of the national group of saturated cadmium cells in temperature controlled air enclosure was carried out using the automated measurement system of a desk top computer, scanner, digital nanovoltmeter etc. with uncertainty of 0.1 to 0.2 ppm. The high voltage divider upto 100 KV was commissioned and the user agencies have started availing of the high voltage calibration facility for their high voltage sources.

1.1 International Intercomparison of dc Voltage and Resistance Standards

Intercomparison of standards of dc voltage using the travelling standard 'TRANSVOLT' comprising of four standard cells in the temperature controlled air enclosure, under A.P.M.P., was continued.

Participated in the intercomparison of dc voltage with V.N.I.I.M., U.S.S.R. The results agreed within a few microvolt at 1 volt level. The intercomparison of standards of dc resistance at one-ohm level was also completed.

1.2 Maintenance of Standards of Resistance

The dc standards of resistance were maintained in the form of a group of one ohm standard resistors kept in a constant temperature oil bath. The assigned values of the resistors are traceable to the calculable capacitor (accuracy 5×10^{-7}).

L.F. & H.F. IMPEDANCE STANDARDS AND MAGNETIC MEASUREMENTS

1. Developmental Studies

An electronic temperature controller was designed & installed to control the temperature of the oil bath to within $\pm$ 0.05°C. The reference standards of 10 pF, 100 pF and 1000 pF air dieleetric capacitors are maintained in this oil bath at a constant temperature.

The scale of A.C. Resistance was extended upto 1 MΩ on the higher side with an accuracy better than 50 ppm at 1 MΩ level. A technique for calibration of 8-decade inductive voltage dividers against a standard IVD with a precision of 1 part in 10^8 was established. The accuracy in calibration is 3–4 parts in 10^8 at 1kHz.

The computer-aided evaluation of reference air lines in the range 1 MHz – 1 GHz at frequency steps of 5 MHz was completed.

1.1 International Intercomparison of Standards

Intercomparison of 10 pF capacitance standard (silica) and 1 kΩ resistance standard (at 1592 Hz) was carried out with V.N.I.I.M; U.S.S.R; under Indo-Soviet Programme of Cooperation in Standardization & Metrology. The capacitance standards of the two countries agreed to within 5 parts in 10^7 and the 1 kΩ resistance standards agreed to within 1 part in 10^6.

Computation and analysis of data of international intercomparison of 10 pF and 1 nF capacitance standards under A.P.M.P. was completed

A.C. AND L.F. STANDARDS (POWER, ENERGY & RATIO)

Calibration facilities for Potential Transformers upto 40 KV (50 Hz) with 0.01% accuracy have been established at a new site specially prepared for this activity.

Calibration facilities for Current Transformers up to 1000A have been set up with an overall accuracy of 1–10 ppm in ratio and 0.01 min in phase angle measurement.

L.F., H.F. AND MICROWAVE STANDARDS OF VOLTAGE, CURRENT POWER, FREQUENCY AND NOISE

1. International Intercomparison with V.N.I.I.M., U.S.S.R.

Under Indo-Soviet Programme of Cooperation, with V.N.I.I.M., USSR, LF current standards were assigned AC/DC correction factor against current standards of NPL, for nominal current values of 10mA, 30mA and 50mA at frequencies of 1 KHz, 20 KHz, 100 KHz and 1 MHz. The AC/DC correction factor was found to be within 10ppm at all these current values upto a frequency of 100 KHz. It established that the current standards of the two countries were in close agreement. However, the AC/DC correction factor values at 1 MHz differed by 250 ppm.

Three thermal voltage converters of nominal values of 3 volt, 5 volt and 10 volt were designed, developed and fabricated. These were assigned AC/DC transfer error at 1 KHz, 10 KHz, 30 KHz and 100 KHz against MJTC, the primary standard of AC & LF voltage and current. The AC/DC transfer error found to be between +5 ppm to-29 ppm. These thermal converters have been prepared for intercomparison against V.N.I.I.M standards.

A 1 volt thermal voltage converter of V.N.I.I.M was compared against NPL thermal voltage converter at frequencies 1 KHz, 100 KHz, 1 MHz, 10 MHz and 30 MHz. The AC/DC correction factor ranges from 5 ppm at 1 KHz to 0.045% at 30 MHz and these values were in very close agreement with those assigned by V.N.I.I.M

Three thermistor type voltage standards upto 1 GHz of V.N.I.I.M; brought by the Soviet expert, have been compared against calorimetric standard of NPL at 1 volt level at frequencies of 200 MHz, 500 MHz and 1 GHz. The measurement results showed that only one of them was in close agreement with NPL's standard. The agreement between the two laboratories was within −0.21%, +0.84% and +0.17% at 200 MHz, 500 MHz and 1 GHz respectively.

1.1 Power & Frequency Measurement

Pure calorimetric loads in XN–, Ku–, and K-bands have been designed and got fabricated. The performance characteristics of the loads are:

i) XN-Band (5.8–8.2 GHz). The Maximum VSWR of the load is 1.08 in the band.
ii) Ku-band (12.4–18.0 GHz). The maximum VSWR of the load is 1.06 in the band.
iii) K-band (18.0 to 26.0 GHz). The maximum VSWR of the load is .06 in the band.

Other characteristics of the loads were under evaluation by single load microcalorimetric technique.

Frequency measurement facility, including provision of standard frequency signals of high resolutions in the frequency range of 0.01 Hz to 40 GHz was fully established. The accuracy achieved ranged between $\pm 1 \times 10^{-8}$ to $\pm 1 \times 10^{-10}$ depending upon the frequency range as detailed on the next page.

The facility is being utilized for the Calibration of Frequency Counters, Frequency Meters, Synthesizers, Signal Generators, Spectrum Analysers, etc

MICROWAVE ATTENUATION AND IMPEDANCE STANDARDS

"Tuned Reflectometer Technique" was established for calibrating the standard mismatches at XN-band (5.85 to 8.2 GHz) microwave frequencies using indigenously developed precision waveguide, quarter wave short circuits and low VSWR termination (Element VSWR $\simeq$ 1.005). Three broad band standard mismatches of VSWR 1.10, 1.20 & 1.30 have been indigenously developed and calibrated at spot frequencies with an

(A) STANDARD FREQUENCY SIGNALS

Frequency Range		Accuracy
0.01 Hz to 1000 Hz	In decade step	$\pm 1 \times 10^{-8}$
10 KHz to 500 MHz	In step of 0.1 Hz	
500 MHz to 1.2 GHz	In step of 0.2 Hz	$\pm 1 \times 10^{-10}$
2 GHz to 6 GHz	In step of 1 KHz	
6 GHz to 12 ZGHz	In step of 2 KHz	
12 GHz to 18 GHz	In step of 3 KHz	$\pm 5 \times 10^{-10}$
18 GHz to 26 GHz	In step of 4 KHz	
26 GHz to 36 GHz	In step of 6 KHz	
36 GHz to 40 GHz	In step of 8 KHz	

(B) MEASUREMENT OF FREQUENCY

0.01 Hz to 10.0 Hz	$\pm 1 \times 10^{-8}$
100 Hz to 40 GHz	$\pm 1 \times 10^{-9}$

uncertainty of $\pm$ 0.005 in VSWR and have an over all variation of 0.01 about the nominal value throughout the frequency band.

The IF substitution technique was set up in waveguide systems in Ku band (12.4 to 18.0 GHz) using VM-3 attenuator and signal calibrator for calibrating rotary vane attenuators. (calibration accuracy $\pm$ 0.02dB/10dB)

JOSEPHSON VOLTAGE STANDARDS

The accuracy of the Josephson voltage standard has been improved by incorporating a highly stable resistive divider, having a very low temperature coefficient of resistivity. The accuracy was now increased to 0.8 ppm. The facility was utilised for periodic intercomparison of as-maintained volt based on standard cells. Efforts to further enhance the accuracy by use of thin film tunnel junctions are under way.

LOW DIMENSIONAL COULOMB SYSTEMS

Work was initiated to realise a quasi-one dimensional system of electrons on a liquid helium surface. The density profiles of electrons in such a system are being calculated using conformal mapping techniques and numerical solutions on computers.

Computer simulations of a 2D array of Josephson junctions driven by an external field were performed. Complicated dynamics of vortices in the system was observed. This dynamics was found to depend upon an appropriately defined Reynolds number in analogy with hydrodynamics. It is proposed to study the statics and dynamics of vortices and their relation to chaos in hydrodynamical systems. This work is in collaboration with the University of Hyderbad.

CHARACTERIZATION OF MATERIALS

CHARACTERIZATION OF MATERIALS REGARDING PURITY AND COMPOSITION

1. Chemical Methods

A Perkin Elmer gas chromatograph model Sigma 2000 was installed. This is a versatile unit with flame ionization detector, thermal conductivity detector, electron capture detector, data processor and printer. Work is in progress to establish the capability to determine ppb and ppt concentration of impurities/minor constituent in gas or atmospheric samples. Facilities have been developed for grab sampling and analysis by gas chromatography. Air samples from Antarctic, Meghalaya (collected before and after slash-and-burn) and from different rice paddy fields have been analysed for methane.

Gas Chromatograph Sigma-2000 (Perkin Elmer)

The development work has been done on determination of boron by spectrophotometer using curcumin solution. The method is sensitive and 10 ppb concentration of boron can be determined.

The atomic absorption spectrophotometric method for determination of phosphorus in steel using bismuth phosphomolybdate complex, has been applied for determination of phosphorus in different kinds of industrial samples such as steels, cast iron and other alloy steels. Standard samples with certified values of phosphorus were taken and estimations were carried as per the method developed earlier. A close agreement in the standard value and experimental value was found.

The process developed earlier, for making black stamp cancellation ink, was assigned to M/s Mysore Lac & Paint Company for commercial trials. Some difficulties were faced by the firm in productionization of the process. This was attended to and solutions to the problem of stabilization of ink and dispersion of carbon black in the oil has been provided.

1.1 FTIR Absorption and UV-Visible Emission Spectroscopy

A number of silicon samples were analyzed for quantitative estimation of oxygen and carbon contents. Measurements were carried out as per ASTM procedure. Some measurements were carried out in the temperature 10K to 130K. Four of the silicon samples were analysed for SCL, Mohali.

Infrared absorption measurements were carried out on small diamond samples. Studies on multiphonon IR absorption in the 2000 to 400 cm^{-1} by FTIR were carried out on single and poly crystal of silicon. Recent calculations of total energy of silicon lattice by Pseudopotential method were used to obtain multiphonon by frequencies in the IR absorption spectrum. Combination frequencies of different TO, LO, TA, and LA modes at T, X and L points of Brillouin zone were correlated with experimentally observed results from FTIR. Different lattice bands were assigned as two-phonon, three phonon and four-phonon bands. Deviation between theoretical and experimental results were calculated and compared with the work of earlier authors. Our results were found in better agreement with Pseudopotential theory of phonon frequencies than earlier work. The absorptance of the three phonon mode increases between 30K to 70K

whereas the absorptance of the antistretching mode decreases within the same temperature range.

Characterization of materials regarding elemental constituents was continued by emission spectrographic facilities. Samples of cast iron sleeves, oxygen free copper,lanthanum fluoride, calcium tungstate, scum in zone-passed silicon and silicon were characterized. Rotational temperature studies of $B^2\Sigma - X^2\bar{\Lambda}$ system of SnF were made.

1.2 EPR Spectroscopy

Keeping in view the capability of EPR technique to characterize paramagnetic centres in different materials, study of natural diamond crystals was undertaken. EPR measurements have shown the presence of more than one type of nitrogen centres in the system. Signal due to nitrogen impurity was also obtained in synthetic diamond powders.

Quantitative determination of spin density in hydrogenated amorphous silicon was made by using DPPH as a standard reference sample. A number of samples of different projects were analysed.

CHARACTERIZATION OF MATERIALS REGARDING CRYSTALLINE STRUCTURE

1. X-ray Diffraction Methods

Among the inhouse jobs from NPL, X-ray diffraction studies on $LiNbO_3$, synthetic diamond, BN, Ta thin films, polymer samples, Se-Te alloys, CaS, LaF_3 carbon fibres, Nb and Nb_3Al, Titanium silicide, Amorphous silicon films, intercalated graphite were carried out.

As a concluding part of the collaborative work with CRRI, X-ray diffraction studies on actual field soil plus lime mix samples and the steam cured samples were carried out. The results obtained were compared with the earlier work done by us on alternate wetting and drying cycle of soil lime mix samples. In collaboration with IIT, Delhi, manganese oxides and manganese sulphides have been characterised and their physico-chemical and catalytic properties correlated with X-ray studies. X-ray diffraction studies of natural graphite flakes intercalated by a mixture of $HNO_3 + H_2SO_4$ have been carried out further. The expansion behaviour of these intercalated flakes have been characterised on the basis of X-ray results. Studies on varietal characterization of cotton fibres in collaboration with IARI, New Delhi were extended further. Further work on environmental pollution studies in collaboration with CAFS, IIT, New Delhi was carried out on the quantitative analysis of metallic contents of soil and suspended particulate matter by XRF technique. Limited help to other institutions and industries such as SCL, Mohali, CEERI, Pilani; CECRI, Karaikudi; University of Delhi; M/s Superintendence Co. of India Ltd.; Ranbaxy Laboratories Ltd., Dewas, M/s Shriram Pistons and Rings Ltd., Ghaziabad; M/s Electroboronium, New Delhi, regarding the crystalline phase analysis of polycrystalline materials, was given from time to time.

In the area of chalcogenide materials, extensive experimental studies were carried out on deviations from stoichiometry in Ga_2Te_3. Studies on alloy system Se_xTe_{1-x} have been carried out, for detailed analysis for $x = 0.2$ to $x = 0.8$, in collaboration with the Indian Association for the Cultivation of Science, Calcutta.

A Rigaku 3070E automatic X-ray fluorescence spectrometer was installed and checked by

Rigaku X-ray Fluorescence Spectrometer–3070 E

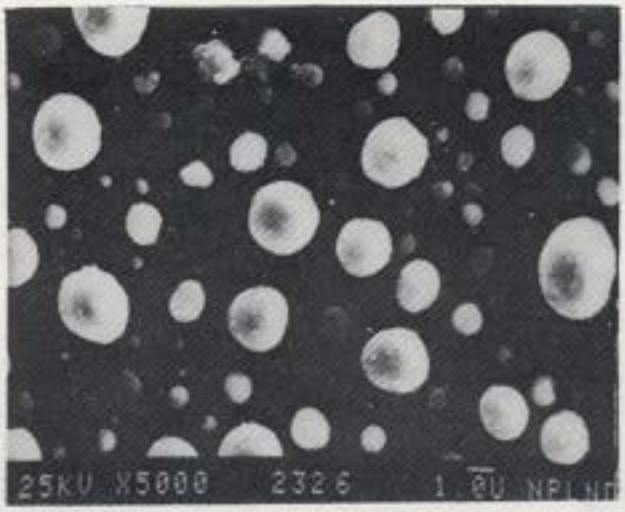
running a few standard qualitative analysis programmes. The instrument is computer controlled with 492KB memory and data processing capacity of 300 elements per disc, monochrome graphic display and print out arrangement.

1.1 Electron Microscopy and Electron Diffraction Techniques

About 150 samples from different projects and outside institutions were examined with T.E.M. with a view to study their microstructure. The materials included superconducting specimen, a-Si films, silver films, copolymers, channel black, CdI_2, In_2S_3, Cu_2S & Titanium silicides.

About 550 samples were investigated by S.E.M. for their surface structure and morphology. About 140 samples were studied for elemental analysis. The materials studied were mainly CdS, Cu-Nb, Cu-V, glass ceramics, AlZn alloy steel, silicon, Fe/Mn ores. The institutions which have been helped are: Indian Association for the Cultivation of Science, Calcutta; IIT, Delhi; IARI; New Delhi, Delhi University; BHU, Varanasi; SPL, Delhi; CEL, Sahibabad; RRL, Bhubaneshwar; NTPC, New Delhi; Deptt. of Civil Aviation, R.K. Puram, New Delhi; Govt. Aero Engines Overhauling Workshop, Patiala.

The research work was continued on the study of microstructure of thin films of materials using Transmission and Scanning Electron Microscopes. The study of surface structure of silver films (500–5000A°) prepared on to quartz under very high vacuum conditions (5.3×10^{-5}pa) was continued. As deposited films showed little surface structure. These films, after annealing in vacuum (1.3×10^{-4}pa) at 400°C; on examination with S.E.M. showed hillock formation. The size of the hillock did not change appreciably with thickness. However, the films annealed in air at 400°C showed agglomeration. After agglomeration it was observed that 68.5 to 69.5% of the area of the substrate was without film in different thickness range. From the investigation it appears that the microstructure of the as deposited films prepared by different techniques, their adherence with the substrate play an important role in the process leading to agglomeration under different conditions.



SEM micrograph of thermally evaporated silver film annealed in air at 400°C showing agglomeration

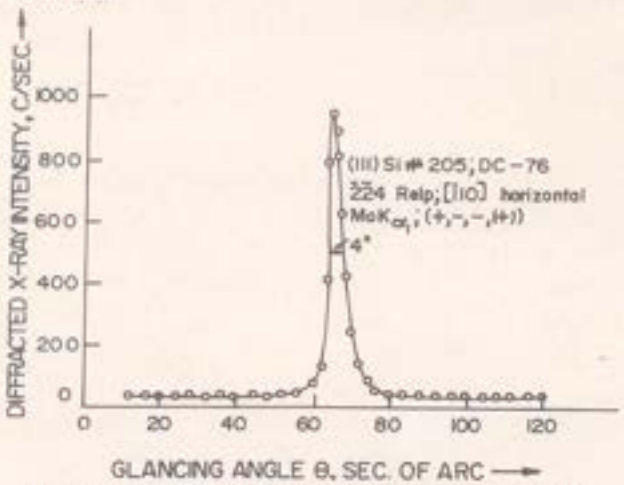
The study of voids in thin silver films was continued. The silver films prepared by cathodic sputtering showed a very high density of small voids while the films prepared under very high vacuum (5.3×10^{-5}pa) did not show voids. Primarily it appears that the existence of small voids in thin films is an intrinsic character of the films formed due to the statistical fluctuations on deposition conditions. The films formed under very high vacuum conditions have been found to possess voids but their size is extremely small (below the resolution of T.E.M.) and do not show adequate contrast to be observable. The vacancy diffusion mechanism explains suitably the phenomenon of void growth while gas molecules act as stabiliser for the vacancy cluster. Some work has been initiated on the study of materials for electronics. Some samples of Si prepared by NCL, Pune have been examined by S.E.M. and E.D.S. to determine the compactness and the presence of impurities and their point to point variation in the sample.

CHARACTERIZATION OF MATERIALS REGARDING PERFECTION

1. High Resolution X-ray Diffractometric & Topographic Techniques

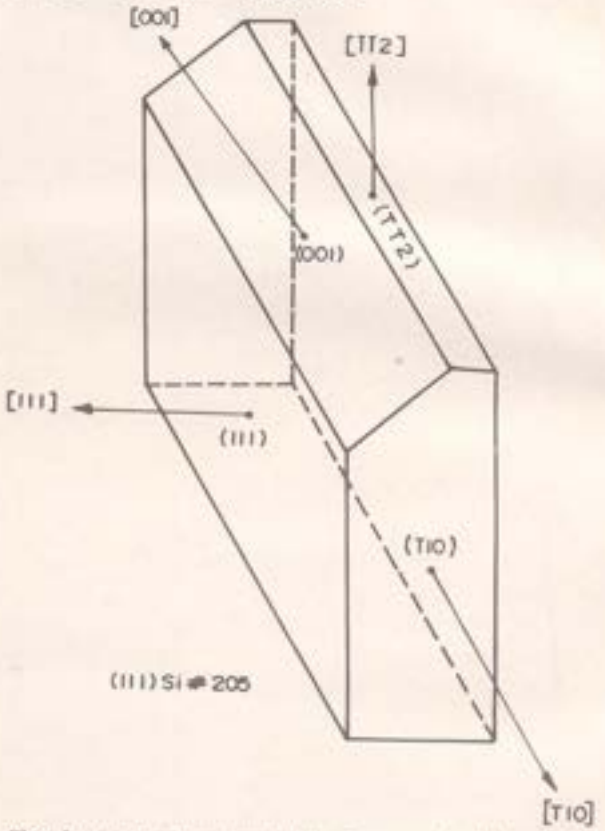
A systematic quantitative study involving high resolution diffractometric topographic eva-

luation of natural diamond crystals was carried out by using a quadruple crystal X-ray diffractometer (Mo $K_{\alpha 1}$ radiation) and a triple crystal X-ray diffractometer ($CuK_{\alpha 1}$ radiation). Accurate measurement of absolute peak and integrated intensities of 111, 333, $\bar{2}20$, $\bar{4}40$, $\bar{2}\bar{2}4$ and $\bar{1}\bar{1}3$ reflections of natural diamond and nearly perfect silicon single crystals were made. For comparison, experiments under identical conditions were also carried on nearly perfect silicon crystals. High resolution diffraction curves stationary and traverse topographs were also recorded. The observed ratios of peak intensities and integrated intensities for diamond and silicon crystals are anomalous. Extinction does not explain the observed anomaly. High resolution X-ray diffractometry and topography method were used to study charge carrier lattice interaction during two dimensional conduction in Si MOSFETs. Diffraction curves show a small but measurable change in the shape when the device is conducting. In topographs small changes in contrast could be observed. The resolution of topographs further improved by employing a Ni filter to cut off fluorescent radiation from the device. Traverse topographs were also recorded while maintaining the glancing angle of the crystal at half intensity point of the diffraction curve, before and during the conduction. This leads to higher sensitivity, and therefore, stronger changes in the contrast.



A typical diffraction curve of the silicon single crystal block recorded with $(\bar{2}\bar{2}4)$ diffracting planes in symmetrical Bragg geometry using MoK_{α_1} radiation. It has a half width of only 4 sec of arc.

A silicon single crystal block has been prepared with four of its surfaces along the following planes: (111), $(\bar{1}10)$, (001) and $(\bar{1}\bar{1}2)$. The surfaces have been ground, lapped, polished. Diffuse X-ray Scattering (DXS) measurements were made in two planes of the reciprocal space which were prependicular to each other around each of the following four reciprocal lattice points (relps): 111, $\bar{2}20$, 004 and $\bar{2}\bar{2}4$. The interstitial defect clusters of platelet type with sizes in the range 0.3–1×10^{-4} cm were observed.



Sketch of a specimen crystal block prepared with surfaces along the following lattice planes: (111), $(\bar{1}10)$, (001) and $(\bar{1}\bar{1}2)$. With this specimen DXS measurements could be made in eight planar sections of the reciprocal space around four different reciprocal lattice points.

Crystallographic orientation of a few 100 mm dia. [(100) Si] and 62 mm dia. [(111) Si] crystals have been accurately determined. Similar measurements have been carried out on 100 mm diameter silicon single crystal wafers for M/s. S.C.L., Mohali.

The indigenously built facilities for crystal growth are being modified for growth of crystal of high melting point materials. Alkali halide crys-

tals are being grown and supplied to users in NPL and outside.

1.1 Surface Area and Porosity Measurements

Experiments were continued to establish the reproducibility of specific surface area of activated carbon fibres. In all 21 samples were carbonized and activated, out of these 17 samples were characterized for BET surface area using nitrogen adsorption at liquid nitrogen temperature. Most of the samples showed BET surface area to around 1000 m^2g^{-1}. 13 samples, consisting of activated carbons, zeolite molecular sieves, carbon-carbon composites, precipitated silica and silicon solar cell, were tested for their BET surface area using either nitrogen or Krypton adsorption at liquid nitrogen temperature. The draft "Method for determination of specific surface of powders and porous particles using low temperature gas adsorption techniques" proposed earlier has been published as Indian Standard I.S. 11578–1986.

STANDARD REFERENCE MATERIALS

1. Preparation of High Purity Water

The preparation of high purity water and inorganic acids suitable for use in microelectronics industry has been initiated. Sub-boiling distillation equipment made of Pyrex has been changed to all quartz apparatus. Throughput of the new equipment was increased to four times. The efforts were made to characterize the distillates by atomic absorption spectrophotometric methods. It was observed that these elements lie below the detection limit of flame atomic absorption spectrophotometric methods. The efforts are now being made to evaluate these trace elements by furnace atomic absorption spectrophotometry and other techniques like ICP emission spectrometry, ion chromatography etc.

1.1 Determination of Crystallographic Orientation

Precise determination of orientation of the crystal surface as well as that of the straight edge is done by using non destructive high resolution diffractometry and topographic methods employing multicrystal X-ray diffractometers. The orientation of the straight edge was determined by a new direct and accurate method employing high resolution traverse topographs. For surface orientation determination, a four crystal X-ray difractometer and triple crystal X-ray diffractometer have been employed. Special vertical circle goniometers have been developed and used in these measurements after proper calibration. The accuracy of measurements achieved till now is about 15 seconds of arc.

MATERIALS

SILICON AND SILICON DEVICES

Polycrystalline silicon ingots upto 85 mm dia, were directionally solidified inside quartz crucible coated with silicon nitride powder. Typical values of average grain size, mean resistivity and minority carrier lifetime were found to be 1–5 mm, 1–5 ohm-cm and 20–30 μ sec, respectively. Solar cells have been fabricated at CEL, Sahibabad on 75 mm dia. Polycrystalline silicon wafers cut from these ingots using $POCl_3$ diffusion and screen printed silver contacts. These solar cells show a short circuit current density of more than 26 mA/cm^2 and an open circuit voltage of 540mV at AM1 illumination. It is, therefore, possible to obtain solar cells of 9–10% AM1 efficiency while using these ingots for terrestrial photovoltaic applications.

A rigorous procedure to measure the resistivity of silicon wafers in 1–10 ohm-cm range to an accuracy of $\pm$ 5% was set up. This involved tracing the accuracy of voltage and current measurements to the NPL DC voltage standard. The four point probe used for the purpose was accurately calibrated to obtain the probe factor. This has enabled to obtain a Standard Reference Material of silicon for resistivity. This SRM can now be used for comparative measurements.

A study has been completed to understand the kinetics of an increase in the electrical activity of silicon grain boundary with temperature. Kinetics of the growth of thin oxide layers on silicon by anodic oxidation was studied. It was found that the oxide thickness varied linearly with time for low anodizing voltages and short times showing that the rate controlling process was an interface -controlled one.

A dual e-beam UHV system (Varian VT 118 A Spl) was installed for preparation of silicides used as contact material in micro devices. Bilayer films of Ti/Si and single layer films of Ti were deposited on silicon substrate and studied using SEM and TEM. Investigations revealed that, for ambient temperature deposition, in-situ sputter cleaning of substrate led to a rough microstructure. Aluminium and titanium films were also patterned upto 2.8 μm line width using lift off and wet chemical etching techniques.

Electrical sheet resistivitance measurements on silicides have shown that the values are similar to the published results. An optical system for static stress measurement was set up and preliminary work was completed. A Monte Carlo computer programme was developed for studying diffusion phenomena. This was used to study the heterojunction model of photo diffusion in chalcogenides. In addition the model was extended for the study of general two dimensional film diffusion.

A complete apparatus for the measurement of spectral responsivity of large area solar cells under bias light conditions of one sun, was assembled and tested for its satisfactory working. It is now possible to make these measurements for any R&D system of photovoltaic activities. The apparatus is shown in the photograph.

Fig. 1: Spectral Responsivity Measurement Apparatus.

BETA ALUMINA TUBES FOR SODIUM SULPHUR BATTERY

The main R&D effort was directed at improving the dimensional aspects of the beta alumina tubes. The latex rubber moulds used for isostatic pressing were replaced by polyurethane moulds. The moulds were prepared in the laboratory after fabricating the necessary jigs and fixtures. An anhydro laboratory spray drier was put into operation and, initially, granules of α-Al_2O_3 of diameter varying between 30–60 μm were prepared. Afterwards, granules of β—Al_2O_3 of similar size were spray dried. As expected, the use of spray dried granules and polyurethane moulds gave beta alumina tubes of better surface finish and more uniform wall thickness. Over 100 tubes of 10 mm nominal diameter were prepared and 50 of these were supplied to CECRI, Karaikudi and IGCAR, Kalpakkam, for the fabrication of Na-S battery. The tubes were characterised for ionic resistivity, density and diametral fracture strength which were <5 ohm-cm at 300°C, >3.18 g/cc, >150 MPa and 2–5 μm, respectively.

Polyurethane moulds and sintering jigs were perepared for fabricating beta alumina tubes of 25 mm diameter x 200 mm length x 1.5-2 mm wall thickness. A few tubes of these dimensions were prepared by using the zone sintering technique.

Several new glass compositions were tried to develop a glass seal, between the beta alumina tube and the α—alumina collar. A soda free borate glass composition was found to be the best suited for this purpose. This has enabled us to supply beta alumina tubes with α—alumina collars to be directly used in the sodium-sulphur battery.

MAGNETIC RECORDING MEDIA

For potential application as magnetic recording media, thin films samples (typically 0.5–2 μm thick) of Co-P and Ni-P were grown by the electroless deposition method and characterised by means of VSM, SEM, X-ray diffraction and other techniques. The electroless deposition method was preferred over other techniques as the magnetic properties as well as the chemical/mechanical characteristics of the films so grown can be precisely controlled. Various types of substrate materials such as Al, Cu, brass were tried and the cleaning, degreasing procedure was standardised. It was found that Ni-P coatings deposited from a Nickel plating bath with hypo phosphite as reducing agent had superior chemical and mechanical properties (such as corrosion and abrasion resistance). It was also found that an acidic bath yielded a higher growth rate of Ni-P film as compared to an alkaline bath. Likewise, slight variations in the bath conditions strongly affected the magnetic properties of these films. It was observed that co-deposition of Co-P films over Ni-P films on Al-substrate led to better grain structure and film adherence.

LUMINESCENT MATERIALS AND DEVICES

The effort was continued in the preparation of basic engg. design of 30 TPA phosphor plant, cost estimates and technical documentation for incorporation in the Project Report for TV phosphor jointly with NRDC, CEL and EIL. The techno-economic project report required a considerable amount of process data evaluation particularly in effluent treatment. A scheme was suggested for effluent treatment which has been approved by NEERI and finally accepted by EIL and CEL.

Some work was done during the year in fine optimisation of TV phosphor process parameters by monitoring impurity contents of certain grades of raw materials, and composition of firing atmospheres.

A systematic study of structural and electrical properties of screen printed Zn CdS films was carried out in the entire range $0 \leq x \leq 1.0$. For the range $0 \leq x \leq 0.8$ the films have wrutzite structure and for $x = 1.0$ a cubic structure. Resistivity increases in the range $0 \leq x \leq 0.6$ but decreases beyond this region, as shown in Fig. 2.

The development of TB activated rare earth oxysulfide phosphor, sponsored by ISRO for their use in X-ray imaging, was initiated for Y_2O_2S: Eu a red phosphor to investigate methods of oxysulfide preparation, purity of obtained composition, and efficiencies. Fig. 3 shows a

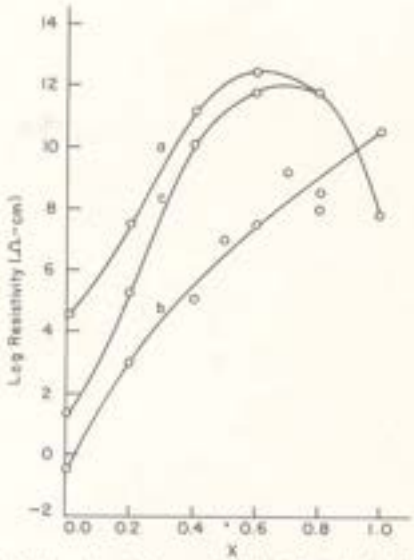


Fig. 2: Variation of Log resistivity Vs × for (a) Screen printed and sintered film of $Zn_x Cd_{1-x} S$. (b) Vacuum evaporated $Zn_x Cd_{1-x} S$ thin film (c) Film (a) annealed in H_2 atm at 200°C for 30 min.

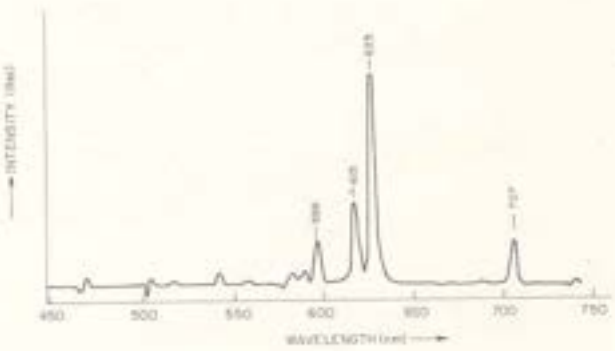


Fig. 3 Emission Spectrum of Y_2O_2 S: Eu Under UV Excitation (365 nm).

typical line spectrum of Eu in Y_2O_2S prepared using indigenously available rare-earth compounds. X-ray diffraction analysis showed a pure oxysulfide lattice. Luminescence also exhibited a pure oxysulfide spectrum of Eu.

DISPLAY DEVICES

1. Super Twisted Nematic Liquid Crystal Displays

Investigations on the novel electro-optic effect in highly twisted (super-twisted) nematic liquid crystals were started. Super-twisted nematic (STN) liquid crystals exhibit extremely sharp electro-optic transmission characteristics which make them highly suitable for high information density flat displays. The preliminary investigations have shown that the performance characteristics of STN displays seems to greatly depend on fabrication parameters such as:

(i) surface tilt angle
(ii) total twist angle of the display
(iii) ratio of cell thickness versus pitch
iv) uniformity of the cell thickness
(v) orientation of the polarizer & analyzer

A new simple optical method based on birefringence measurements was developed to measure the tilt bias angle of the LC molecules at the bounding surfaces. A wedge gap method was also set up to measure the pitch of the LC mixture accurately. Fig. 4 is a typical transmission characteristics of STN display device observed on La-Roche LC mixture: 3010, with a pitch of 8 μm and cell thickness 6 μm. The surface tilt angle was $\simeq 25°$. It is observed that the STN cell exhibits a very sharp threshold voltage, a small amount of bistability, high contrast ratio and wide viewing angle.

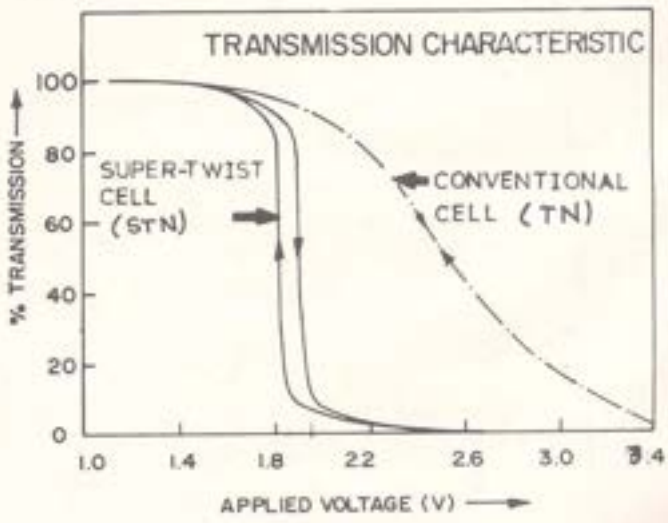


Fig. 4

1.1 Double Guest-Host Liquid Crystal Displays

A novel technique was developed to make coloured liquid crystal displays which do not use any

external polarizer. Basic design of such a display is shown in Fig. 5. Essentially, it is a combination of two guest-host display cells which exhibit positive contrast. The two cells are so prepared as to produce homeotropic alignment in the "off" state and homogeneous alignment (but at right angles to each other) in the "ON" state.

For the realization of an actual double guest-host display, the central glass plate (Fig. 5) was

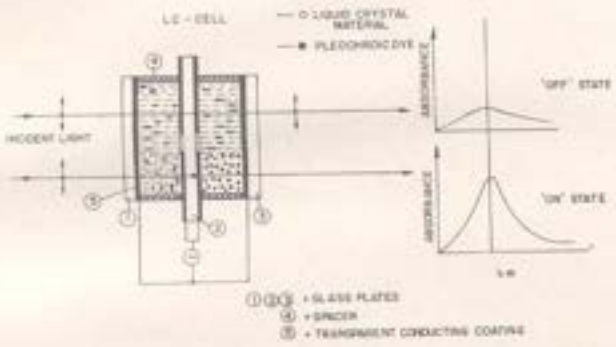


Fig. 5 Basic Construction of a Positive Contrast Colour Display without Polarizers

specially prepared so as to have transparent mirrored electrode patterns on both sides. Special photolithographic procedures were developed to achieve the desired electrode patterns on the central glass plate. The desired controlled tilted homeotropic alignment at the boundaries was imparted by special alignment procedures.

A number of $3\frac{1}{2}$ digit displays based on the above mentioned principle have been made and characterized for their electro-optic performance characteristics.

1.2 Ferroelectric Liquid Crystal Displays

The tremendous applications in this area will be made possible due to occurence of spontaneous polarization and tilt of ferroelectric liquid crystal molecules which can be exploited to make electro-optical display devices with inherent memory and of microsecond electro-optical switching response. A novel pulse technique was developed for studying the spontaneous polarization, the dynamics of polarization changes and molecular reorientation processes thatsuccessivelytake place in the bulk or in the boundary surface layers during switching amongst uniform states in ferroelectric liquid crystal. Techniques for measuring the free value of helical pitch in thin samples and surface alignment over large area were also developed.

Colour switching in very thin samples of the ferroelectric liquid crystal was observed for the first time. The colour of the film changed with the applied electric field. The sequence of colours observed in one micron thin cells are as follows: green $\pm$ 5V; blue at $\pm$ 20V; violet at $\pm$ 35V; red at $\pm$ 47V and yellow $\pm$ 95V. These voltage-tunable-colour liquid crystal cells may find tremendous applications in electro-optical modulators and fast-switching coloured graphic information display devices.

1.3 Process Optimization Anodic Oxidation of Tantalum

Various process parameters for anodic oxidation of tantalum acting as insulating films in metal-insulator-metal (MIM) configuration were optimized so as to result in high non-linearity. The Poole-Frenkel conduction mechanism was confirmed by temperature and thickness dependence of conductivity. The field dependent conductivity established by current-temperature variation indicated an energy level of about 1.42 eV. Annealing at moderate temperature led to MIM configurations with better non-linearity, which seems to be adequate for activating a liquid crystal pixel.

1.4 Transparent Conductive Coatings

A comparative study of the optical and electrical properties of transparent conductive films of oxides of indium and tin, deposited by various techniques in our laboratory was done. A theoretical model explaining electrical and optical properties has been suggested. Both e-beam and r-f sputtering techniques have been observed to result in high quality films. However, the e-beam technique was found to be more advantageous as the substrate temperature while deposition can be

as low as 200°C without any post deposition annealing.

1.5 Exploratory Studies on Conducting Polymers & Sol-Gel Process

A variety of conducting polymers such as polyanilene, poly-α-naphthol and polythiophene were electrochemically prepared primarily with a view to generate synthetic metals having better mechanical properties as well as improved processibility than those known earlier. A comprehensive review highlighting the recent studies of hetrocyclic and aromatic conducting polymers was prepared. The techniques of polymerization, mechanism of polymerization, mechanism of conduction and characterization of polyheterocyclics and polyaromatics were critically examined.

Various organometallic compounds of tin (IV) and bis (isodicylopentadienyl derivatives of cobalt (II), Nickel (II), Titanium (IV) and Zirconium (IV) were synthesized and characterized for making use in thin film metal oxide coating by Sol-Gel process. The basic studies included the elucidation of their structures, bonding, coordination number etc. In case of tin (IV) complexes synthesized included dithiocarbamates, carboxylates and adducts of diorgano tin (IV) and triorganotin (IV) derivatives. These organometallic compounds of tin (IV) on pyrolysis or by Sol-gel method give transparent electrically conducting tin (IV) oxide coating.

ULTRASONIC TRANSDUCER MATERIALS AND DEVICES

1. High Power Ultrasonic Systems

Rubber moulds using neoprene based composition for pinger transducers of diameter upto 82 mm were got fabricated. Thyrister based circuits have been developed to produce high voltage spikes to drive pinger transducers.

The design of the high pressure tube (diameter 125mm length 2m) with sliding carriage for transducer was made. A tube with diameter 76 mm, length 1m and wall thickness was installed. Extensive measurements were taken on establishment of free field using active impedance termination and the evaluation of sensitivity was made. The water fitted tube was pressurised and free field conditions were obtained at pressures upto 200 p.s.i.

1.1 Primary Sources for Parametric Studies

Three approaches have been used for development of primary sources:

(i) A single element source of diameter 50 mm, for operation in the frequency range 300–350 KHz, yieldingacoustic output $\simeq$ 188 dB re 1 μ Pa m^{-1}, was developed using NPL.ZT-4 elements.

(ii) Multi-element source was developed in which a mosaic of 16 NPL.ZT-4 ceramic plates (16m × 16m) with air backing was used to deliver acoustic output of 210 dB re 1 μ Pam^{-1} at frequency 310 KHz.

(iii) Components of line in cone transducer comprising of radially vibrating transducer elements and a metallic cone were got fabricated. Initial trials have been made.

Intermodulation effects were seen using a pair of the developed primary sources. A high directionality of the modulation frequency was observed.

1.2 Anechoic Lining for the Tank

Work has been done to identify constituents of the materials for making suitable anechoic lining for the small submergable tank. Studies have been made with butyl rubber loaded with cork & aluminium powder of particular size and echo reduction & insertion loss have been measured. Studies are continuing by varying the particle size upto 1000μ and keeping the composite density $\leq$1.2.

1.3 Acoustically Transparent Pressure Vessel

Investigations have been carried on design of pressure vessel of glass fibre reinforced polyester for exploring the feasibility of measuring transmitting response of acoustic projectors at high frequencies($\geq$10kHz $\geq$50kHz) at high pressures. A vessel of diameter 30 cm, length 50 cm was fabricated and acoustic transmission & reflection characteristics of vessel in the freq. range 10–100

KHz were studied. Measurements were in progress by making step wise increase in wall thickness to yield information about its pressure rating.

An ultrasonic atomizer operating at 60 KHz has been developed on request of Prof. D. Lal, Physical Research Laboratory, Ahmedabad. This can give a mean droplet size of 17μm instead of 25 μm.

1.4 Performance Evaluation at High Electric Drive

Studies have been made to evaluate transducer performance at high electric drives using the following additional techniques.

(i) Plotting the motional loop by measurement of phase between voltage and current at high input currents upto 0.8 Amp.

(ii) Study of acoustic output, its frequency characteristics and variance with time using hydrophone and radiation pressure techniques upto input drives of 0.6 amp.

A significant monitoring parameter evaluated is the shift in resonance frequency at high driving current and charges in mechanical Q. Measurements are restricted to samples having resonant frequency in the range 300 kHz–800 kHz.

Preliminary studies have also been made to make computer based analysis of complex impedance of a thickness mode disc to determine parameters e.g. E_{33} & tan δ.

2. Transducer Materials

Batch production of standardised NPL ZT-4, was made in various shapes & sizes for developmental projects and other users. Work was done to improve the d_{33} constant for lead metaniobate for use in applications requiring low mechanical quality factor and workability at high temperatures.

Towards the design of the transducer for 900 Hz, a disc of 12.5 cm diameter was fabricated from 4 segments of piezoelectric elements. A trilaminar system was constructed. The transducer mount with provision of adjustable cavity was also fabricated.

Ultrasonic NDT marble Schematics for analysis of the scattered wave form samples treated with various amount of sulphur was worked out. Feasibility of transmission of ultrasonic wave through fibres using wave concentration was studied. Computer modelling of wave concentrators was carried out.

Work on improving drift and noise in opthalmic probes was conducted. Ultrasonic lenses of plastics & metals have been fabricated and performance compared with shaped piezoelectric ceramic radiators.

CARBON FIBRES

In continuation of setting up of experimental pilot plant, the installation of the oxidation line was completed. Several trial runs were undertaken on the fully automatic set up and the fibres were found to be properly thermally stabilized. These fibres were then carbonized on batch scale upto 1000°C, taking samples from the entire length of several metres of the oxidised fibre. The properties were very encouraging ensuring the precise control of the processing parameters during continuous operation of the plant for several days. Part of the equipment for the carbonization unit was received and was under installation.

A systematic study aimed at improving the quality of carbon fibres further by modifying the available PAN precursor was initiated. Success was achieved in stretching the PAN fibres to 70% by employing a special plastisizer. The modified fibres were characterized for their mechanical properties, structure and thermal behaviour. The strength of the PAN fibres was improved by 50% and that the Young's modulus by over 100%. The average angle of orientation of the molecular chains was improved by almost 100%. Thermal analysis of these samples revealed that the complete reaction kinetics of the modified PAN precursor shifted towards the lower temperature range. All these findings lead one to believe that this PAN precursor can be an excellent starting material for making high performance carbon fibres.

Intercalation of graphite flakes was carried out and the flakes were characterised. These studies proved to be extremely helpful in understanding the intercalation mechanism of crystalline graphite. These flakes upon heating expanded

to 300 times the original thickness. These expanded flakes were pressed into dies to make an industrially important product, flexible graphite foil.

CARBON-CARBON COMPOSITES

Under the DRDL sponsored project, 3D carbon-carbon composites have been developed with density 1.74 g/cc. These composites were non-destructively tested for homogeneity etc. at DRDL, Hyderabad. After having completed the inspection, a scaled down prototype nose tip was fabricated out of these densified composites and was tested at DRDL, using LP Exhaust test, showing good results. Carbon fibre reinforced polymer composites as supplied by DRDL, Hyderabad were evaluated for thermo-mechanical properties.

Work has also been carried out to evaluate carbon-carbon composites for biomedical applications. 2D carbon-carbon composites of medium density (1.5–1.6 g/cc) and desired pore structure have been developed and sent to Sri Chitra Tirunal Institute of Medical Science & Technology, Trivandrum for in vitro and invivo bio-compatibility testing.

GLASSY CARBONS & PITCHES

Glassy carbon dental implants (40 nos.) were made and supplied to Dental Centre, Army Hospital, Delhi to replace damaged teeth of human beings. All the implants have shown good bio-compatibility results over a period upto 18 months. The periodic performance and life tests were in progress. Glassy carbon heat resistor plates were made at 2700°C and supplied to Thin Film Project. These have worked well on field trials. A novel method was developed for making impregnating pitches from coal tar precursors. This technique differs completely from conventional methods such as filtration, solvent extraction or centrifugal methods. This pitch has tremendous potential in special carbon products fabrication, carbon-carbon composites, needle cokes and pitch based carbon fibres. The experiments are in progress to establish the complete process details. A theoretical equation has been worked out to evaluate the coking value of coal tar pitches from their physical characteristics such as softening point (SP), quinoline insolubles (QI) and benzene insolubles (BI).

$$(CV)_{th} = QI \times 0.95 + (BI\text{-}QI) \times 0.85 + BS \times K$$

where K depends upon softening point of the pitch.

AVIATION GRADE BRUSHES

The work on batch production of 125 nos. of carbon brushes was carried out under a project sponsored by HAL, Nasik. The brush fabrication techniques were developed. Silver plating of the terminal strips was tried and parameters were established for 4–7 micron thickness. Natural Graphite obtained from Sri Lanka was evaluated for oxidation loss and carbon content. Four types PR-72–002, 003, 004 and 008 of brush varieties were made as per specifications and supplied. Tests on high temperature, high altitude, vibration and humidity under specified conditions were found comparable to the original imported sample.

The rheological behaviour of impregnating pitch was studied at temperatures exceeding 200°C using a heating attachment with the Rheomat-30. The pitch indicated a uniform flow behaviour in the temperature range 250–275°C. Differential Scanning Calorimetry was studied at temperature 100–500°C and it was observed that at temperature around 380°C there appears a new phase. Such a pitch can be utilized for making mesophase pitches on giving suitable heat-treatment. Table 1 shows resistivity values of pitch coke made from conventional coal tar pitch and solvent extracted pitch made at NPL. The coke from solvent extracted pitch possesses lower values of resistivity both at 850°C and 2000°C of treatment which could be related to development of better graphitic structure showing its possibility in the manufacture of pitch needle coke.

Intercalation compounds of Ferric chloride-natural graphite were made at temperature 200–400°C under vacuum for different reaction times

varying from 4–12 hours. It was observed that amount of ferric chloride intercalated varies both with temperature and time. At 350°C the amount was most appropriate. The resistivity decreases with tempeature and time of treatment. At 400°C there appeared to be some decomposition of the compound when heat-treatment was carried for 12 hours.

Table 1
RESISTIVITY OF CONVENTIONAL PITCH COKE & PITCH COKE OBTAINED FROM SOLVENT FRACTIONED PITCH

Size Fraction (mesh)	Resistivity (ohm cm) Conventional Pitch coke	
	Pitch coke obtained from solvent fractioned pitch	
	850°C	2000°C
100–150	4.24/2.35	2.53/1.40
150–200	4.16/2.24	2.47/1.43
200	3.63/3.49	2.0/1.41

INDIAN MIDDLE ATMOSPHERE PROGRAMME

1. Solar UV-B and Visible Radiation Measure ments

Regular observations of direct and diffuse solar UV-B radiation at 290, 300 and 310 nm wavelengths were undertaken during the year. The UV-B radiation data for the year 1985 for all the three wavelengths have been scaled in absolute energy and it was observed that UV-B radiation reaching the ground is higher when compared to all the earlier measurements made since 1983. This was due to abnormal low ozone content in the atmosphere during the year 1985 in comparison to the previous years. This type of continuous observation has given enough evidence to study long term effects due to ozone changes in the atmosphere.

A multiwavelength radiometer in visible and near infra-red region received from ISRO Trivandrum was installed on the terrace of N.P.L. building to monitor direct solar radiation at nine wavelengths (from 400 to 1025 region). From these measurements aerosol density and size distribution will be estimated and measurement at two wavelengths will provide gross value of ozone and water content in the atmosphere.

NPL built UV-B photometers are being calibrated with the help of a spectro-radiometer. The spectro-radiometer measures global UV-B radiation in unit of Watt/cm^2-nm from 200 to 800 nm wavelength.

2. Laser Heterodyne System

An infrared CO_2 Laser heterodyne system has been set up at this Laboratory to monitor the minor constituents in the troposphere and stratosphere. The Block Diagram is shown in Fig. 1.

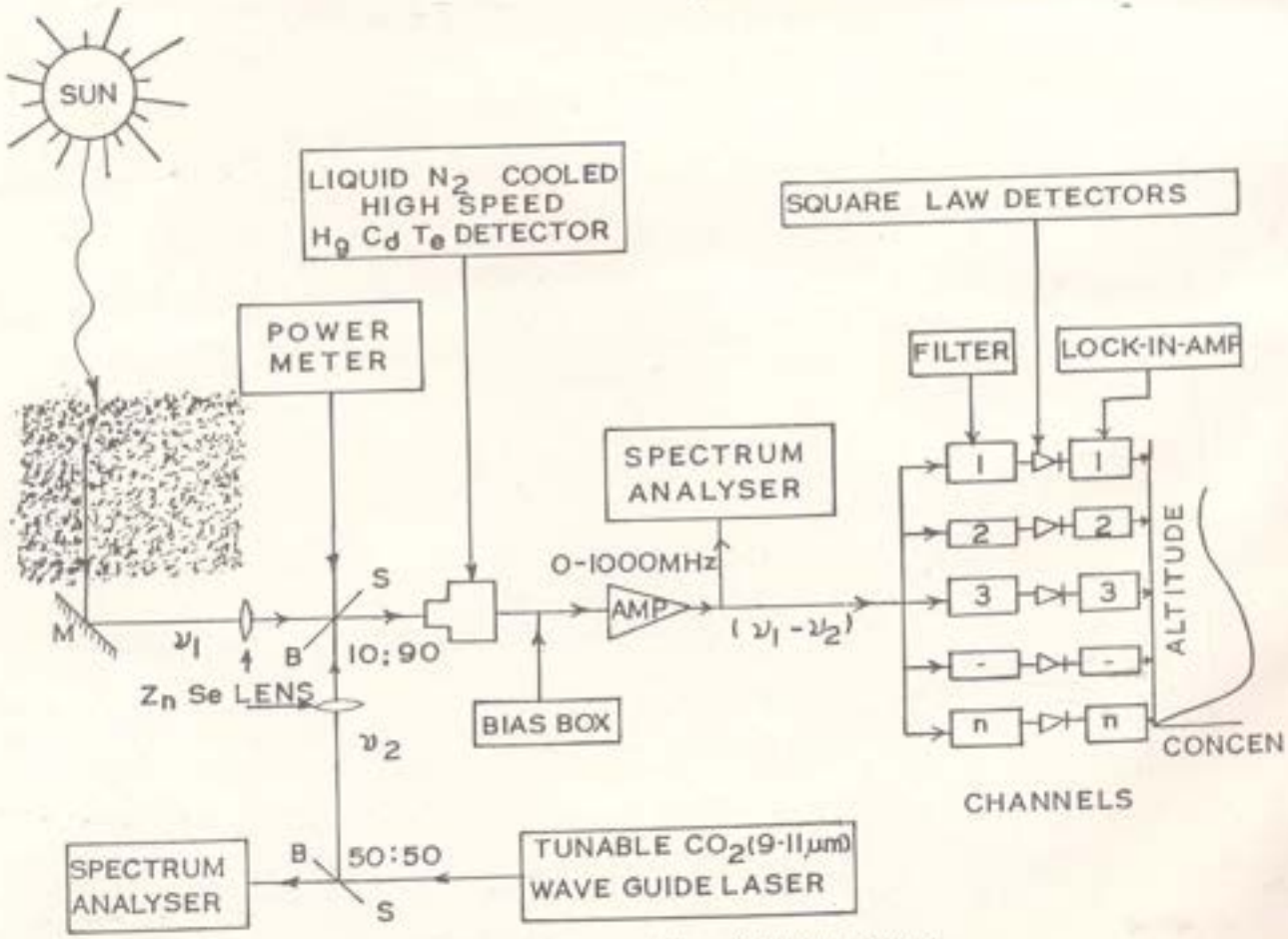


Fig. 1 Block Diagram of Laser Heterodyne System

The ozone height profiles have been obtained using laser heterodyne system successfully. This is a unique facility to monitor a large number of trace species having characteristic absorption lines over-lapping with CO_2 laser transition lines in the window region (9-11μm). Due to ultra high spectral resolution and high quantum detection efficiency absorption lines can be resolved completely with laser heterodyne system.

The ozone line selected was 1046.8491 cm^{-1} which is near the P(20) line of the CO_2 laser. The data were collected on few points in the wing of the absorption line. The data obtained were inverted and an ozone profile was obtained in the height range 22 km to 40 km, Fig. 2. The other lines are being tried to get the complete height profiles down to tropospheric heights.

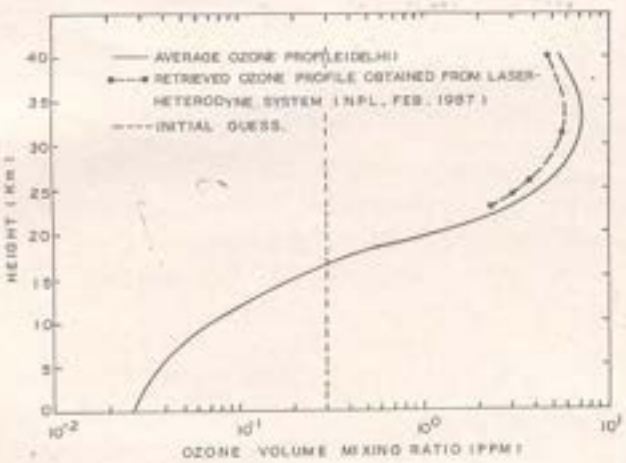


Fig. 2

2.1 Ozone Study

Total ozone values have been retrieved from Nimbus 4 and Nimbus 7 satellite data tapes of back scattered ultraviolet experiments. Values over Indian subcontinent were analysed. Total ozone values for 10°N, 20°N, 30°N and 40°N over the period 1970 to 86 were compared with ground based Dobson spectrometer observations from representative Indian Stations. Reference ozonesphere over India was updated to 1986 and rocket sonde data incorporated.

3. Balloon Experiments

A Langmuir probe payload was fabricated, tested and successfully flown on IMAP-C1 balloon from Hyderabad balloon facility on 22nd Dec. 1986. This flight was a night time flight and balloon reached a ceiling altitude of about 33 km. The data obtained from the flight was analysed and positive ion conductivity profiles were obtained. The analysis of data from IMAP-V & IMAP-VIII balloon flights were completed and positive and negative ion conductivities and density profiles were obtained. These profiles have been shown to be in fairly good agreement with those obtained theoretically assuming models for recombination coefficient.

The results obtained from these three balloon flights have been used to study the effect of Volcano Nevado Del Ruiz in Columbia, South America which erupted in November 1985 and believed to have injected a heavy load of aerosols in to the upper atmosphere. It has been found that there has been significant reduction in the ion conductivity values as measured on IMAP-VIII flight held in December 1985 immediately after the volcanic eruption as compared to values obtained from IMAP-V flight held in February 1985 and considered as a representative of quiet time profile. The conductivity values obtained from IMAP-C1 flight were found to be higher than IMAP-VIII but lower than IMAP-V thereby indicating the recovery phase of stratospheric ionization after the volcanic eruption.

3.1 Rocket Experiments

The data obtained from two rocket flights conducted on 7th & 10th March, 1986 as part of D-region ionization campaign of IMAP was scaled and analysed. Each flight had three experiments, namely,. propagation experiment operating on two frequencies, Langmuir probe and Lyman-alpha experiment as part of payloads. The electron density profiles obtained both from Langmuir probe and propagation experiment show very good agreement with each other and with those derived by spherical probe of PRL, Ahmedabad.

Payloads for aerosol campaign of IMAP were fabricated and then tested under different environmental conditions. The payloads involved IR and visible sensors for aerosols, two ozone sensors and Langmuir probe experiment. This flight was successfully carried out from Thumba on 2nd Oct. 1986. The data obtained from this flight has been analysed and preliminary results have been obtained.

In view of the forthcoming NPL-UTK (Japan) nitric oxide rocket flight, fabrication of Indian payloads was undertaken during this period. The payloads involved are Langmuir probe, propagation experiment operating on two frequencies, Layman-alpha and ozone, Fig. 3.

Fig. 3: Nitric Oxide Payload

SROSS AERONOMY SATELLITE

Pre-engineering model of the Retarding Potential Analyser (RPA) and Energetic Particle Spectrometer (EPS) satellite payloads have been fabricated & tested. This included main instrumentation, satellite interface for the payload data acquisition and transfer, telecommands, house keeping data transfer etc. The configuration of this model is very similar to the engineering and flight model of the payload, except that the commercial grade components and hardware have been used in its fabrication. The PCB design and artwork preparation, components mounting, soldering and other practices have been followed in accordance with the strict guidelines laid down by the Quality Assurance Division of ISRO Satellite Centre (ISAC), Bangalore for satellite payload fabrication.

The performance and working of both payloads have been successfully demonstrated to a reviewing committee of Engineers and Scientists from ISAC, Bangalore & IIT, Delhi. The data transfer from the payloads to the main satellite telemetry has been shown in the desired format and with real time clock of 100 KHz. The control of payload through satellite-telecommand has also been demonstrated satisfactorily.

TROPOSPHERIC AND IONOSPHERIC COMMUNICATIONS

1. Prediction of Solar Cycle No.22

The coming solar-cycle No.22 has been generated (by using a computer programme) much before it started with a minimum in 1986. The philosophy behind the present method is to consider the cycle to have started in December 1979 with the peak sunspot number of 165 i.e. a cycle from peak to peak is considered rather than a cycle from minimum to minimum. Statistical relationships have been established between peak and various points with increasing time-lag from the peak (using previous 20 cycles). The next peak is expected to be in March 1991 and the value is expected to be 103. The decaying part of the solar cycle 22 is generated assuming this estimated peak value of 103. The same statistical relations obtained between peak and various points with increasing time lag from the peak are used to evaluate the decaying part of cycle No.22.

2. Ionospheric Predictions

2.1 EUV Data for Ionospheric Predictions

Long-term ionospheric predictions are traditionally based on a predicted sunspot index and correlations established between observed sun-

spot indices and ionospheric parameters. However, with the recent availability of EUV data from satellites, it is considered more appropriate to use these radiations which are directly responsible for production of ionosphere to develop models for prediction of ionospheric parameters. These studies have shown that use of EUV flux for ionospheric prediction has certain advantages over the usual solar indices such as R_{12} and $F_{10.7}$. Saturation effects that are usually seen in foF2 variation with sunspot-numbers at low latitudes are not apparent with EUV flux (Fig. 4). EUV flux values require much lesser extent of smoothening when compared to sunspot-numbers and is more suitable for predicting ionospheric parameters one or two months in advance.

2.2 Long term Ionospheric Predictions

Orthogonal polynomials have been effectively utilized to improve the prediction of foF2 using sunspot number. The improvement is affected through the determination of most likely order of polynomial fit between observed foF2 and sunspot numbers (smoothed) for the last four cycles. Data from four low latitude stations viz. Delhi, Ahmedabad, Kodaikanal and Singapore was used.

2.3 F-region Variability

The variability in foF2 from month to month has been studied for the station Ahmedabad. The monthly median foF2 variance can be decomposed into three major components: diurnal, seasonal and solar cycle. The three component model was compared with the observed foF2 median data and the residuals so obtained have been shown to fit a first order autoregressive process. Using this model, a forecasting method is constructed and the likely errors estimated.

3. Ionospheric Scintillations

3.1 VHF Night-time Scintillations

VHF night-time scintillation observations from a

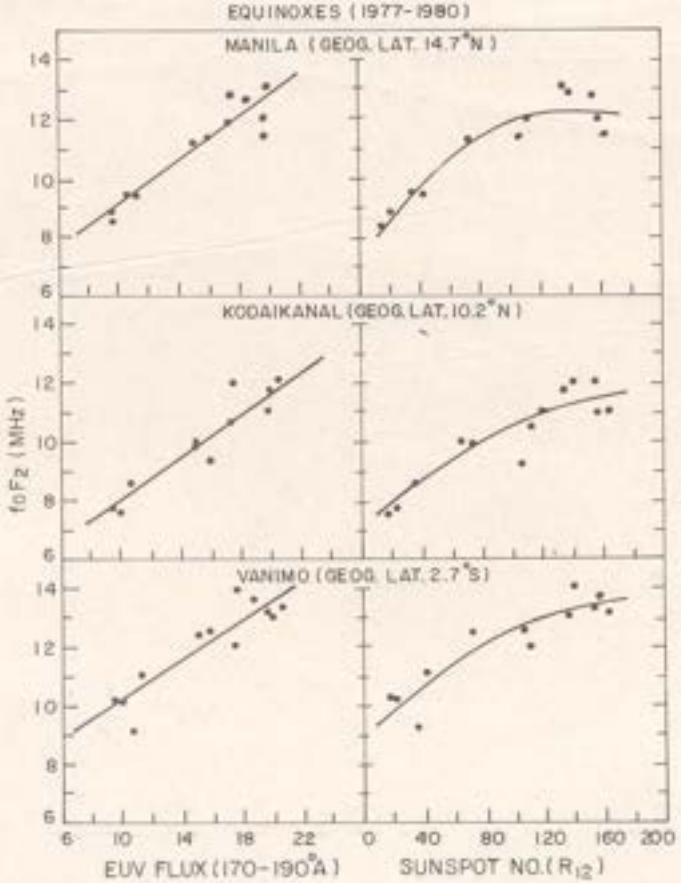


Fig. 4

chain of stations in the Indian zone and at Lunping in the Far Eastern Zone, were examined during five individual geomagnetic storms of varying strengths for predicion purposes. The study has shown that in all the cases the usual scintillation activity during the main phase of the storm remained unaffected. For cases in which recovery phase of the storm starts during midnight to dawn local time sector, strong post-midnight scintillations extending well beyond sunrise hours were observed in a wide latitudinal and longitudinal belts. However, in case of those storms whose recovery phase starts during local day time hours the scintillation activity was found to be suppressed completely or partially on the following night depending upon the severity of the storm. The results were interpreted in terms of the reversal of the equatorial electric field direction under magnetically disturbed conditions.

3.2 Gigahertz Scintillations

Scintillations at gigahertz frequencies is relatively an unexplored phenomenon in our country. However, launching of INSAT-1B in 1983 has provided us with an excellent opportunity to undertake investigations of this phenomenon. Monitoring of 4 GHz telemetry transmissions from INSAT-1B has been going on for the last four years. Night-time data collected during the year 1984-1985 (approximately 19 months data) has been analysed for scintillation occurrence patterns at Delhi. Figs. 5 and 6 show scintillation activity for equinoctial, summer and winter seasons. It is seen that:

1) Percentage occurrence of gigahertz scintillation is highest during summer months and minimum during winter. The occurrence ratio is about 4.1

2) Activity during equinoctial months is significantly lower than that in summer which is at variance with most of the earlier observations at VHF from equatorial latitudes.

3) Scintillation activity persists throughout the night during summer months. The study shows that scintillation activity is high during low solar activity summer months.

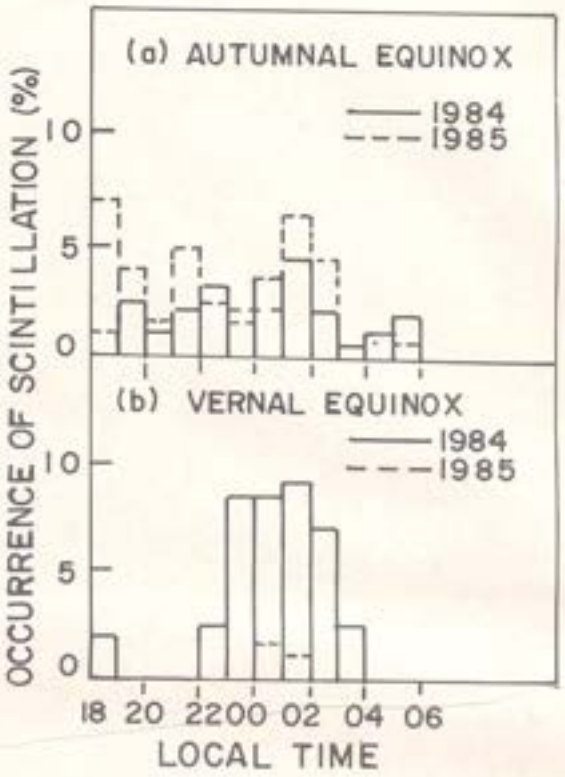


Fig. 5 Night Time Equinoctial Occurrence

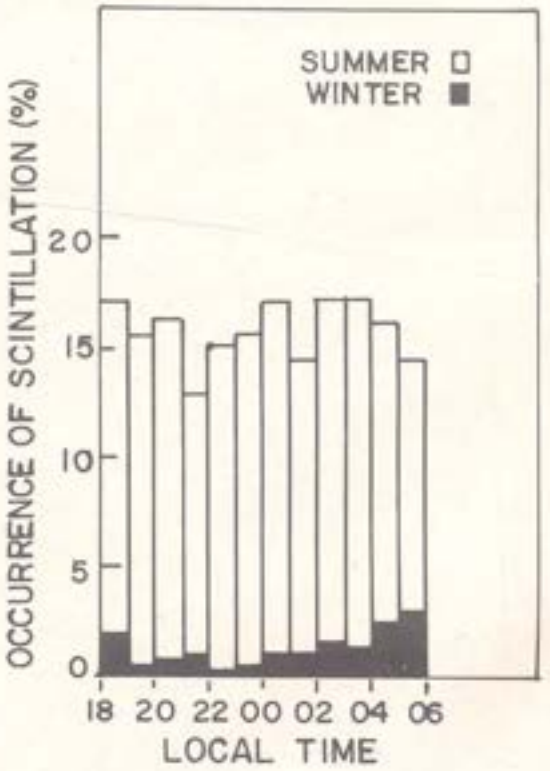
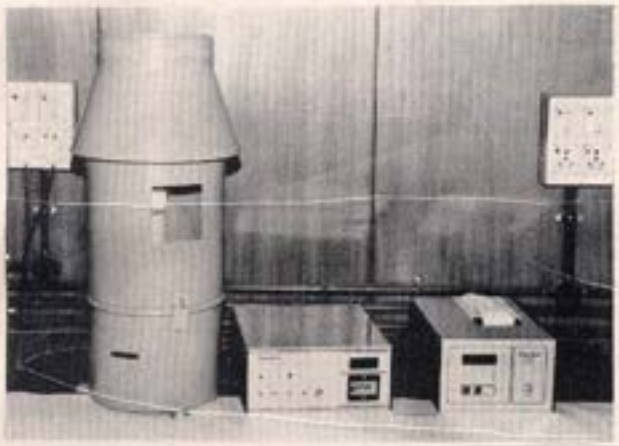


Fig. 6 AV. Summer & Winter Occurrence

4. Tropospheric Communications

4.1 Rain Rate Measurements

The total attenuation due to rainfall can be calculated with fair amount of accuracy provided the rainfall rate is known with good time resolution. The statistics over India on rain rate is extremely poor. It is proposed to use rain gauges with a fast response (Fig. 7) as it is necessary to have a good rain morphology for India with good time resolution. The data will be used to derive conversion factors which will be used on the past data of IMD and derive the required morphology indirectly. Several rapid response rain gauges have been installed at Shillong (Air Force Station), New Delhi (NPL), Tirupati (S.V. University) and Warangal (REC).



Rain Gauge

4.2 Water Vapour Attenuation

Water vapour plays dominant role in terrestrial and earth-space communication systems. Based on radiosonde observations, water vapour concentrations are estimated over the Indian subcontinent. It is found to exihibit strong geographical and seasonal variations. Attenuation due to water vapour are deduced from 1 to 350 GHz at various elevation angles (Fig. 8). The study shows that the attenuation even in window regions is significant particularly along the Indian southwest coast.

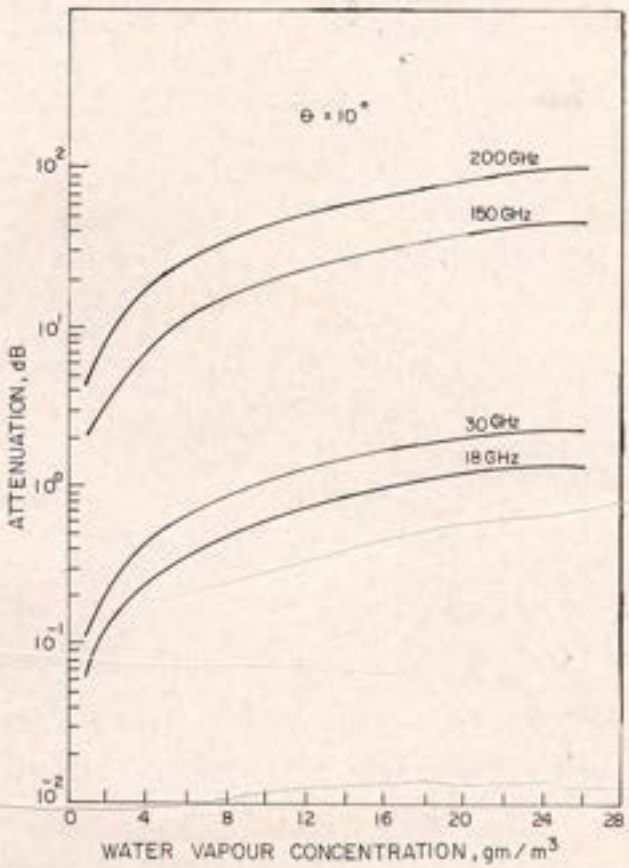


Fig. 8

4.3 LOS Link Monitoring

The monitoring of Delhi-Meerut LOS link at 2 GHz, belonging to Overseas Communication Service, commenced from June 1986 and is in progress. The records reveal that daytime signal is of the order of −30 dBm and the nighttime signal about −42 dBm. During daytime the signal remains almost steady with negligible fade depth. After sunset the signal exhibits slow and deep fades with fall in median signal level and the process continues through out the night. The signal undergoes a change of 20 to 25 dB during the sunrise.

4.4 VHF Propagation

VHF data collected from Jalandhar and Mussorie TV stations in Band-III reveals that Jalandhar signal propagates through scattering in daytime and combined scattering and reflection in night-

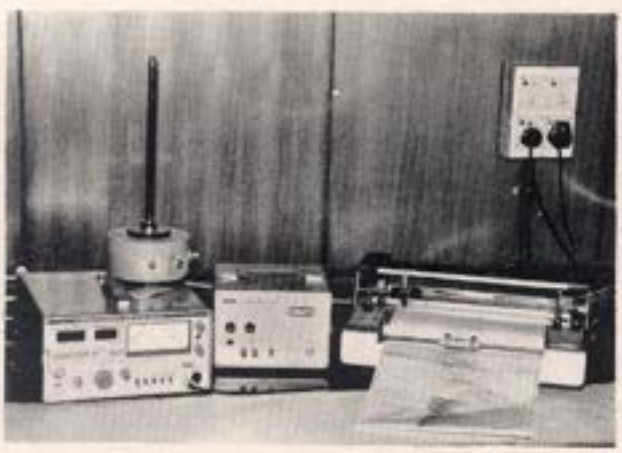
time. Mussorie signal propagates in line of sight mode. The study reveals that the cumulative distribution of median signal level of Jalandhar TV exceeds 13 dB and Mussorie TV exceeds 36 dB for 50 percent of time.

4.5 Evaporation–Duct Heights

A large set of meteorological parameters over sea-surface compiled by IMD, have been used to compute statistics on the height of the evaporation duct (δ) at tropical latitudes. The values of δ for different seasons range between 15 and 40m. Such large values of δ are not compatible with the measurements of signal strength at beyond the horizon ranges. Equivalent duct heights (D) which are indicative of 'intense' ducting conditions over the sea-surface are found to lie between 3 and 5 m for various seasons.

4.6 Microwave Refractometer

The structure intensity parameter, C_n^2 has been estimated using vertical profiles of refractive index. These profiles were obtained over Kanpur and Lucknow during summer and winter months from Air borne Refractometer experiments. The estimated values of C_n^2 have been used to determine the path loss of a troposcatter link of 300 Km at 2 GHz.



Anritsu Interference/Field Strength Meter

4.7 Field Strength Measurements

An Anritsu Interference/Field Strength Meter ML 428B has been installed in NPL for measuring field strength of atmospheric radio noise and radio communication signals in HF range. The equipment can make measurements in the frequency range 0.01 to 30.0 MHz (Fig. 9).

RADIO AND ATMOSPHERIC PHYSICS

1. Planetary Ionospheres

1.1 Ionospheric magnetisation on Venus

The variation of the average low altitude dayside ionospheric magnetisation with solar wind dynamic pressure was studied using the magnetometer measurements from Pioneer Venus Orbiter. The data analysed include the first three dayside periapsis passes by the orbiter. Passes with even low magnetisation values were included in the analysis. The results indicate a statistically linear relationship between the ionospheric magnetisation and the solar wind dynamic pressure, even below the critical pressure for magnetisation adopted by earlier workers. The observations point to a continuous rather than time evolving mechanism of generation of ionospheric magnetic fields of Venus and thus have resolved a controversy between episodic magnetisation and continuous magnetization.

1.2 Solar Wind Heating in the Upper Atmosphere of Venus

In-situ measurements of various neutral species from the Pioneer Venus Orbiter, as available in the Unified Abstract Data System, were analysed to investigate any possible effect of solar wind dynamic pressure on the dayside Venusian upper atmosphere. The data analysed covered the second and third sets of dayside periapsis passes by the orbiter. Significant deviations in the densities of various neutral species were detected on two occasions (viz, Orbit Nos 220 and 230) following high solar wind dynamic pressure on the preceding orbits (Fig. 10). Further the solar zenith angle was high (50°) on both the orbits. The neutral exospheric temperature inferred from the scale

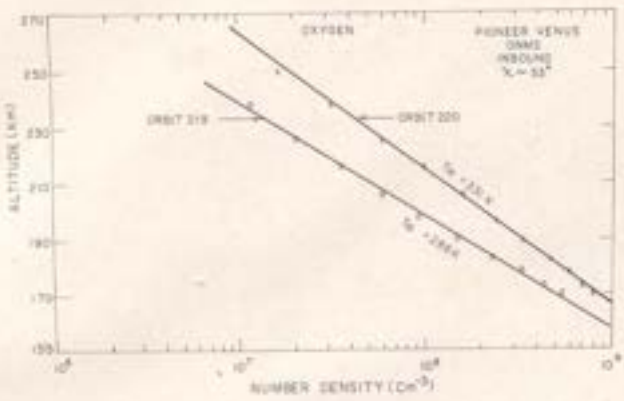


Fig. 10

heights of the various neutral species indicate significantly higher temperature on these orbits. These observations are consistent with the theoretical predictions that, precipitation of solar wind particles should take place only for high solar zenith angles. The time delay between the high solar wind pressure conditions and the subsequent temperature increase on the next orbit may imply a sluggish response of the neutral upper atmosphere to energy injection from the solar wind, as has been found in the terrestrial atmosphere.

2. Incoherent Scatter Studies

2.1 Protonospheric Heat Flux during Sunspot Cycle 20.

The daytime measurement of electron temperature (T_e) and concentration (N_e) from incoherent scatter radar at Millstone Hill were analysed for the sunspot cycle 20. The purpose of the analysis was to look for the seasonal and solar activity changes of F-region electron temperature and protonospheric heat flux during the declining part of the sunspot cycle 20: and also to compare these with the earlier results during rising part of that cycle. It was found that while there were no major differences in the seasonal behaviour of F-region electron temperature and concentration between the rising and declining parts of sunspot cycle 20, the variation of daytime protonospheric heat flux shows significant asymmetry between the rising and declining phase of this sunspot cycle.

2.2 E-region Valley

On request from the Task Group on "International Reference Ionosphere", we have undertaken a study of E-region valley. It is difficult to study this valley from the conventional ionosonde measurements and therefore we are studying this valley from the incoherent scatter measurements recorded at Arecibo. Preliminary results (Fig. 11) indicate that the valley is very deep during night and extends from 130 km to the base of the F-region near 200 km with densities less than 10^3 cm^{-3}.

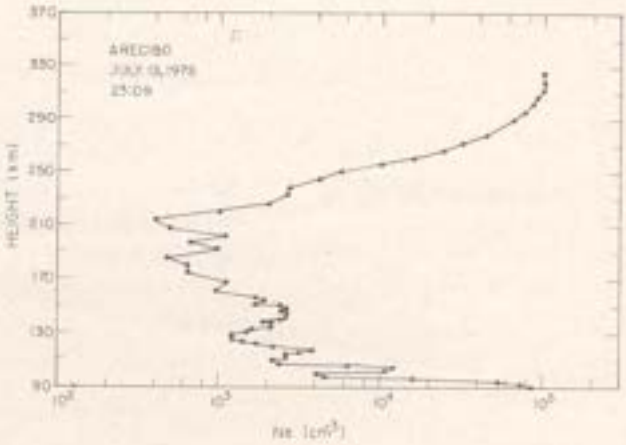


Fig. 11

3. Satellite Radio Beacon Studies

3.1 Study of Slab Thickness

The diurnal seasonal and solar cycle variations of slab thickness of the ionosphere were studied by analysing the data obtained during the ascending half of the solar cycle. The diurnal variation is characterized by daytime plateau and occasional peaks of varying magnitude in pre-sunrise and pre-midnight periods. While there was linear increase in daytime slab thickness with 10.7 cm solar flux, no correlation was observed with geomagnetic activity.

3.2 Satellite Beacon TID Data Campaign

A TID data campaign was organised at Delhi.

Meerut and Panipat from June to July 1986. Another TID campaign was organised at Hyderabad, Vikarabad and Shadnagar from May to July 1986.

3.3 Sunset Enhancement of the Ionospheric Total Electron Content at Equatorial Latitude

Anomalous post sunset enhancements have been observed in TEC at equatorial station Ootacamund during winter and equinoctial months. Simultaneous TEC measurements at Bombay and Ahmedabad and ionosonde data at Trivandrum and Kodaikanal show that these enhancements were caused by the reversal of the electric field driven (EXB) drifts at equator and consequent reversal of the equatorial plasma fountain .

4. Ionospheric and Neutral Atmospheric Modell ing

4.1 Electron Density profiles over India

There is a need to develop reference ionospheric electron density model over India both for scientific research and radio communication using the available observations over India. The efforts were made to model the electron density distribution in the middle ionosphere. The International Reference Ionosphere (IRI) profiles using Interim IRI 1985-86 model for different Indian stations using the CCIR coefficients was generated. On comparison with the observed data it was found that the observed values of $N_m F_2$ and $h_m F_2$ as well as the profile shape show considerable differences from the IRI values.

Therefore it is essential to evolve a different approach to obtain the $N_m F_2$ and $h_m F_2$ values as well as profile shape for Indian stations based on observations. A second degree equation relating foF2 and (M3000) F2 with sunspot number for different Indian stations was established making use of the observed data covering more than two solar cycles.

On comparison of the true height profiles of Indian stations with the IRI profiles it was found that there were significant differences. Therefore attempt was made to develop a technique to build the model of the electron density profiles. A modified Chapman type of function given by Anderson et al for the low latitudes was used upto one modified scale height below the F2 peak. From this point down to E-peak an exponential distribution was used. These two profiles were merged together to get a smooth profile using Booker's technique.

By using the above technique, the middle ionosphere profiles at a difference of 4° dip latitude from 0 to 24°N covering the entire Indian subcontinent have been developed.

4.2 Neutral Atmospheric Modelling

The currently available atmospheric model, MSIS 79, on computer code, was used to generate the neutral atmospheric densities like O, O_2, N_2, H_e & H and neutral temperature over the various stations of Indian sub-continent. However, recently the latest version of this model i.e. MSIS 83 is available in the form of formulae. This is being converted in the form of a computer programme so that it can be used to generate the necessary parameters for any location. Apart from taking the daily Ap value, it has the provision for taking 3 hourly Ap value, useful for the studies of storm time phenomena.

5. Microwave Radiometry

Requirements for parametrisation of low noise microwave/mm wave radiometric systems were studied. The expected accuracies and the extent to which they have been incorporated in the system were evaluated. The parameters considered were sensitivity, bandwidth, system noise, receiver noise temperature, system gain and stability noise factors in the waveguides, calibrators and attenuators. Finally the method of calibration with the noise source reference to thermal loads was done. The experimental set up was reoriented to include an additional channel at 9.6 GHz also altered to 8.2 GHz to supplement the already existing 11 GHz channel. The observations were carried during monsoon and winter of 1986. The attenuation results were obtained for fog, mist and liquid water content.

Studies were initiated to know the propa-

gation characterisation on point to point transmission in the microwave frequency bands. From the analysis, for a required degree of transmission reliability, tradeoffs between the link design parameters and transmitter power levels have been determined.

6. Anomalous Long Distance TV Signals

The anomalous long distance TV signals have been monitored systematically between early morning and late night for Band-I and Band III at Delhi. Various modes of propagation mechanism considered are Tropospheric, Ionospheric sporadic-E, Meteor ionization, normal F-layer in the equatorial anomaly region and Equatorial Forward-scatter. It was found that the percentage of these TV receptions at Delhi on Band I via above modes of propagation was more than expected. These extra TV signals have been considered due to artificial modified ionosphere caused by high power, high frequency broadcast transmitters.

Recently, a spectrum analyser has been used for the measurement of field strength of these signals manually.

7. Micropulsation Studies at Delhi

The study of geomagnetic micropulsations are useful in understanding the coupling between solar wind, magnetosphere and ionosphere. These measurements are being made at NPL since 1985 and preliminary analysis showed that with increasing magnetic activity the period of observed pulsation decreased, which is a manifestation of decrease in the magnetospheric cavity size.

8. Study of Atmospheric Waves

From the analysis of data on vertical velocity obtained from Urbana MST radar, it was found that the short period waves contain velocity oscillations with a dominant period of about 10 min. and the amplitude ranging from less than 1m/s to 5m/s. As a complete study of waves in this region, the horizontal velocity was also derived in South-East direction for all these observations and is being analysed.

9. Vertical Transport of Air in the Troposphere–stratosphere Region

Vertical distribution of moisture, temperature, meridional and zonal wind components are studied during the month of June, using data from three Radiosonde stations situated in mid latitudes. An attempt was made to compute vertical wind component from three station horizontal wind measurements during jet-stream phenomenon upto lower stratospheric region to study the dimension of the irregularities.

10. Indian Mesosphere, Stratosphere & Troposphere Radar (MST-RADAR)

A new generation, high power, coherent, pulse doppler radar in VHF (53 MHz) band is being set up in India (Tirupati, 13°N, 79°E) for the purpose of atmospheric studies. The ability of the MST radar to continuously monitor the atmospheric dynamical process will enable the investigation of prevailing winds, planetary and equatorial waves, gravity waves and turbulence.

This radar is presently being developed with multiagency funding. ISRO would act as nodal agency for the development phase. NPL has been participating in the design of this radar from the very beginning and would be one of its prime users. The Radar would be operational in ST Mode in about 2 years time and in full MST mode in about 4 years time.

11. Analysis of Ionograms using Overlay Technique

Overlay or theoretical ionograms have been prepared for a low latitude station Delhi. The values of parameters q_o, β_o, H_o, T_o, $I_n b_o$ and R obtained using this technique were found to be of the same order as those derived by other techniques. Variation of these parameters during magnetic storms was studied.

CRYOGENICS & SUPERCONDUCTIVITY

CRYOGENIC PLANTS, SYSTEMS AND DEVICES

1. Liquid Nitrogen Plant

The emphasis was given in getting liquid nitrogen instead of liquid air from the indigenously developed liquid air plant based on Stirling Cycle.

A small PSA nitrogen generator of 10 NM^3/hr capacity was purchased and installed with appropriate water and electrical connections. It was made operational with 99.5% pure nitrogen gas with $-40°C$ dew pt. R&D to couple this nitrogen generator with the developed liquid air plant for the production of liquid nitrogen is being pursued. During the year the plant produced more than 15,000 litres of liquid nitrogen. A prototype unit of submersible liquid nitrogen transfer pump of 5 litres/min. was designed, fabricated and tested. A prototype unit of measuring liquid nitrogen level, based on capacitance measurement, was assembled and tested.

1.1 Development of Cryo-coolers for Infra-red Detectors

Two types of cryo-coolers, one with the phosphor-bronze wire mesh of 300 size acting as the Joule-Thomson orifice and the other having laser drilled orifice in the range of 50–100 microns were perfected. In the wire mesh type, the liquid N_2 was produced repeatedly with cool down time in the range of 40 seconds. In the laser-drill hole type, which was specially got made from outside, the cool-down time of the cryo-coolers was in the range of 150 seconds.

Efforts have been made to develop self regulating cryo-coolers where the orifice size can be controlled by an automatic needle movement in the orifice utilising the compression characteristics of a nitrogen gas filled bellow at liquid nitrogen temperatures and thereby decreasing the flow-rate and increasing the bottle consumption time. The feasibility tests have been completed and a cryo-cooler based on this self-regulating technique is being developed. A multistage purification system was developed with output of less than 12 ppm of hydrocarbon and was used for the purification of H.P. nitrogen before it was allowed to expand.

SUPERCONDUCTING MATERIALS

1. A-15 Superconductors Through Insitu Technique

Encouraged from the short sample studies on Cu-Nb_3Sn composites which carried a critical current density, J_c of $3 \times 104 A.cm^{-2}$ at 12T and 4.2K, the material preparation (Cu-Nb) was upgraded from 10 gm to 85 gm. Wires over 70 metres long were drawn without intermediate annealing. Homogeneity of niobium filaments over a single length of 28 metres, determined through room temperature resistivity, was found $\pm$ 2.2 percent which is within the acceptable limit. A large number of Cu-V_3Ga composite specimens with vanadium 10–25 at. percent in copper and 5.5 to 13.34 wt. percent gallium were prepared following the insitu technique. A midpoint transition temperature as high as 15K and an overall critical current density of 1.1×10^5 (6.5T, 4.2K) was obtained.

1.1 High Temperature Superconductors

The breakthrough discovery of high temperature ceramic superconductors came during 1986-87. The mixed metal oxide of La, namely La-Ba-Cu-O with superconducting transition temperature T_c of 30 K was discovered in September 1986 while the announcement of Y-Ba-Cu-O system possessing T_c in liquid nitrogen temperature range of 70 to 90 K came in March, 1987. The scientists followed these discoveries closely and within no time these systems were successfully made at NPL. In fact in March itself several

yttrium based mixed metal oxides superconducting at liquid nitrogen temperature were synthesized. This included, the single phase 1, 2, 3 oxide of Y, Ba and Cu showing a sharp transition at 90 K. This has initiated an active R&D program pertaining to both basic and applications aspects of these superconducting materials.

1.2 Superconductivity of Binary and Ternary Compounds of Bi

Binary and ternary compounds of Bi formed with 3d transition elements Ni, Co, Fe and Cr have been studied. Resistance behaviour at low temperatures showed two superconducting transitions, one between 4 and 5 K and the other at 10 K. Resistance data above T_c, upto about 25 K revealed a temperature exponent of 2 for higher T_c samples and 3 when T_c was lower. ESR studies seem to indicate an increase in the density of states at Ef. Results have been analysed in terms of various models based on the Landau Fermi liquid theory and the observed data were interpreted in terms of spin density fluctuation model.

1.3 Ordering Kinetics of Nb_3Sn-Solid State Reactions

A systematic study of ordering of superconducting Nb_3Sn layers formed in the bronze process was carried out in respect of multifilamentary composites containing 10,000 niobium filaments embedded in a bronze matrix. Composites have been reacted at various temperatures for short durations of a few minutes, and the resulting changes in T_c were analysed in terms of analytical models. The results showed that ordering was governed by a sequential operation of both first and second order kinetics and they were in conformity with the reported studies on disordered bulk samples annealed for long durations. A typical transmission electron micrograph showing Nb_3Sn grains formed after 40 minutes of diffusion reaction at 800°C is shown in the Fig.

1.4 Tunnel Junctions and SQUIDS

Preliminary work was done in the fabrication of thin film tunnel junctions based on lead-indium technology. Various process parameters for growth of oxide barrier using Greiner's r.f. glow discharge oxidation technique were investigated.

Preliminary work relating to design and fabrication of first derivative gradiometer, for detection of very weak magnetic fields using r.f. SQUID, was initiated.

APPLIED PHYSICS PROJECTS

XERORADIOGRAPHY

The first prototype of xeroradiographic machine became operational. A demonstration of this prototype was arranged for the radiologists of Delhi.

A proper sequence of electronic control has been provided. The unit has provision for taking both positive or negative image. An improved prototype of xeroradiographic machine was developed for use in A.I.I.M.S. New Delhi.

The most important constituent of the xeroradiographic process is the X-ray sensitive photoreceptors. The fabrication of such plates and their testing on a standard medical X-ray machine has been going on. In order to optimise various parameters for best performance, the effect of thickness, deposition condition, substrate temperature, effect of impurities on the X-ray sensitivity of Xeroradiographic plates as well as the effect of dose-rate, heat treatment and dopants on the fatigue characteristics of the photoreceptors were studied. Initially, selenium plates upto thickness of 100 μm were fabricated, plates upto 200 μm are now being fabricated. Experimentation on these plates were showing encouraging results.

Various compositions of high contrast black and blue toners were formulated. Freeze-drying technique was now used to process basic material for making toners. The constituents of the toner were dispersed in an organic base and freeze dried. The material so obtained was first fed into a ball mill where toner of particle size down to about 100 μm was obtained. There after, fluid energy mill (FEM) was being used to further reduce the particle size. On characterization of particle size the range of 5μm – 10 μm could be obtained. A full characterization bench for toners is being planned.

THIN FILM & AMORPHOUS MATERIALS

1. Thin Film Optical Coatings and Devices

SAC, Ahmedabad has sponsored the development of space qualified interference filters. Improved deposition technique, for fabricating four cavity interference filters using ZnS and Na_3AlF_6 was developed which exhibited desired optical characteristics and also better adhesion and environmental stability. Four batches (16 filters) covering four bands of the visible and near IR regions were fabricated and subjected to environmental tests (Viz. $-40^{\circ}C$, $+70^{\circ}C$ and 95% humidity at $45^{\circ}C$, duration 24 hrs. for each test) at NPL and at Space Application Centre, Ahmedabad. The filters passed through all the tests at NPL and report from SAC was awaited.

The development of highly conducting coating of ferrite rods using sputtering technique, sponsored project of DRDL, Hyderabad, was continued. The existing DC/RF sputtering plant was suitably modified for magnetron sputtering of Cr, Cu & Au layers sequentially. A special holder to rotate the ferrite rods, during sputter deposition of various metal layers, was designed, fabricated and installed in the plant. A number of ferrite rods for 'X' and 'C' bands were coated with metal layers and submitted for test and evaluation to I.I.T., Delhi. The performance of the metallised rods has been found to be satisfactory.

A sample piece of Rear View Prism (of MIG-21 Plane) was fabricated with ITO coated side plates, and submitted to HAL, Nasik for test and evaluation.

1.1 Theoretical Computations

Computer aided five layer design of broad band anti-reflection coating was successfully carried out exhibiting a bandwidth of 1900Å at 0.2% level of residual reflectance. The layers were quarter-wave thick at the design wavelength and are

stacked in the following sequence:
Air/n_1 (1.38)/n_2(2.35)/n_3(2.40)/n_4(1.82)/n_5 (1.59)/n_s (1.52)

where $n_1, n_2, n_3 \ldots$ are dielectric materials of refractive indices indicated in small brackets and n_s is the index of glass substrate.

Theoretical computations of multilayer structures consisting of half periods with three refractive index layers showed that one of the structures can be used as a heat reflecting mirror with visible transmittance of approximately 85% and IR reflectance greater than 90%.

2. Hydrogenated Amorphous Silicon Films for Solar Cells

Plasma diagnostics involving mass spectrometry and optical emission spectroscopy were carried out in a cascaded reactor system. Systematic plasma diagnostic studies have since revealed the way to optimise the behaviour of amorphous silicon films in the reactor down the line of a cascade system by changing appropriately the experimental variables in the discharge reactor upstream. Electrical properties of P doped amorphous silicon films grown by glow discharge in diluted silane mixtures were investigated and found to be different in many respects from films grown using 100% silane.

For the fabrication of efficient amorphous silicon p-i-n thin film solar cells, a state of art multizone system, was procured from M/s Glasstech Solar Inc., U.S.A. and commissioned. In the experimental runs carried out in this system, more than 6% efficient cells over an area of 1 cm^2, were fabricated.

An important step in the fabrication of amorphous silicon solar cell panels is scribbing fine lines for separating group of individual solar cells as per a particular series-parallel combination scheme. A low cost dry scribbing technique, was experimented without the use of lasers and without taking recourse to wet chemical methods.

HIGH PRESSURE PHYSICS & TECHNOLOGY

Having developed the single crystal diamond, work was initiated for their mechanical characterization. Friability is the measure of toughness of an abrasive particle. Extensive work was carried out to study the friability of diamond crystals synthesized in our laboratory using different catalyst-solvent materials and of those obtained from commercially available diamonds in the market. It was established that the NPL made diamond crystals compared well with commercially available samples.

A systematic study of hexagonal boron nitride (hBN)—cubic boron nitride (cBN) conversion was undertaken to develop cBN single crystals. The first step was to use magnesium as the catalyst. The work involved the optimization of various process parameters such as the pressure, temperature, mode of filling the starting materials in the reaction cell and the duration for which the reaction was carried out.

Heat transfer characteristics of heated stainless steel and cupro-nickel billets were determined. Detailed design and sequence of operation of two automobile components, (i) speedometer drive (ii) differential gear side, were completed. Detailed working drawings were prepared and the order for the fabrication of tooling was placed. Other process parameters such as lubrication and heat treatment were optimised. The prototype of a copper component was developed by cold forging on trial basis.

The development of short mandrel process for tubes upto 4 metres in length was continued. This new technique replaces the existing long mandrels which are clumsy to use and not available indigenously. This new process was utilised in the fabrication of nuclear grade stainless steel tubes for Indira Gandhi Centre for Atomic Research, Kalpakkam. A batch of 40 tubes, each of 4 metres length, was delivered to them. The design and fabrication of toolings were completed for upscaling the spinning equipment for the development of corrosion resistant plastic lined pipes upto 50 mm outer diameter.

SERVICE SECTIONS

TECHNICAL SERVICES

1. Workshop

The sections of the workshop assisted various projects of the laboratory as usual. About 2450 jobs were executed and completed. Some of the major jobs were goniophotometer, prism, RPA payload, housing arrangement for super conductivity, parts of dead weight machine etc.

1.1 Drawing & Design Section

The section assisted the scientists for mechanical design & drawing, writing of charts for seminars and making of graphs for their publication work. About 600 jobs were completed. Some of the important jobs were: X-ray Diffractometer; SROSS; Tuning Cardiometer; Lifting System; Differential Screw Micrometer; Interferance Comparator Mirror Mount; Angle Goniometer and Coating Chamber etc.

2. Glass Workshop

Assistance was provided, in the design and fabrication of glass and silica equipment, to various projects of the laboratory such as Standards, Materials, Materials Characterization, Thin Film, Superconductivity etc. The jobs included vacuum standard joints, stop cocks, mercury & oil diffusion pump, quartz & teflon stop cocks, mercury arc rectifiers, laser tubes & seals etc.

Various organisations & institutions were assisted in the fabrication of specialised glass equipment as per the requirements. Some of the beneficiaries were- I.I.T, Kharagpur; NTPC, New Delhi; I.I.Sc. Bangalore; I.A.R.I, New Delhi; B.H.E.L, Haridwar; I.O.C, Faridabad; N.P.C, New Delhi; C.F.T.R.I, Mysore; L.N.J.P.N Hospital, New Delhi; & Punjabi University, Chandigarh. The receipts of the jobs done for the outside parties amounted to Rs. 1.65 lakh approximately.

3. Photography

The section assisted the scientists in taking photographs of equipment, experimental set-ups, apparatuses, copying of charts, graphs, duplicating of colour slides etc. It also covered a good number of conferences, seminars, workshops, CSIR functions & exhibitions. The jobs including about 13,000 colour as well as B&W prints, about 2000 colour tone & slides were completed. The photo-colour lab. was well established which is producing quality prints & slides.

LIBRARY

Library continued to meet the educational, research and information requirements of scientists. Library was actively engaged in computerisation of its activities for improving efficiency and productivity. Besides its utility in bibliographic control, the system was now capable of producing subscription bills, payment letters, mailing lists etc. It was also capable of monitoring payment status and expenditure incurred in respect of journals.

The emphasis in collection development had been once again on need based collection in physics and related areas. It procured 684 books against specific demands from scientists. To regulate the expenditure the journal list was evaluated on the basis of perceived usage. 6 new titles appeared on account of expansion in the subscribed journals. With their addition the subscription list had a total of 335 journals including 34 journals being received as gratis. The expenditure ratio between books and journals rose from 14:86 in 1985–86 to 20:80 in 1986–87. 3017 bound volumes of journals were added and 188 standard specifications catalogued. As an inspection centre for Indian Patents, it continued to receive patents from the Indian Patent Office, Calcutta.

The library provided circulation and reference service, SDI service, bibliography service, literature service & photocopy service. It issued on loan a total of 4767 publications to its scientists and 535 to libraries such as from DESIDOC, INSDOC, IOC, EIL, IMD, IIT, Delhi University. It borrowed 105 publications on inter-library loan. Under the SDI service a total of 2305 references were provided covering about 35 topics. Under its bibliographic services a total of 10 bibliographies were supplied. The library turned out a total of about 1,28,000 photocopies during the year.

COMPUTER FACILITY

A fairly large VAX-11/780 computer system with the following configuration was installed and commissioned in October 1986. Since then it has been in regular operation with 10 terminals in the computer room.

Hardware

i) 4MB Main Memory
ii) 850 MB Back-up memory on 3 disk drives
iii) Two numbers of dual density 800/1600 BPI Mag Tape Drives
iv) 8" SSSD or SSDD Dual Floppy Drives
v) A 600 CPM Card Reader
vi) Two numbers of 600 (1pm) Printers
vii) Two numbers of Graphic Terminals with Copiers
viii) Sixteen VDU Terminals

Software

i) VMS Operating System
ii) BASIC, FORTRAN, PASCAL, COBOL & PL/I Programming Languages
iii) Internation Scientific & Mathematical Library (to be installed)
iv) DBMS (to be installed)
v) Plot-10 Graphic Package

RAJ BHASHA

The Raj Bhasha Unit brought out its quarterly magazine based on scientific & technical articles. Hindi classes were regularly held for the non-Hindi speaking officials of the laboratory. Technical and Administrative material received from various Divisions/Sections from time to time was translated into Hindi. Well known quotations of various greatmen were put on the notice boards and distributed to various Divisions/Sections. Name plates, file covers, envelopes, letter heads of all the Divisions/Sections were made bilingual and in place of devnagri numerals, international numerals were being used.

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ration method. S.K. Sharma, S.N. Singh, B.C. Chakravarty, B.K. Das, R.K. Kotnala, Ravi Kumar, No. 86-190.

83. Characteristics of an ultrasonic opthalmic probe developed at NPL New Delhi. V.N. Bindal V.R. Singh Reeta Gupta, No. 86-191.

84. Investigation relating to the development of adsorptive carbon fibres at NPL Part-I carbonization in a horizontal furanace. J.N. Bohra, O.P. Bahl, T.L. Dhami, Rajiv Kumar, R.K. Saxena, No. 86-192.

85. Lunar and solar daily variations of equivalent slab thickness at Delhi. P.K. Bhuyan, T.R. Tyagi, No. 86-193.

86. Indirect atomic absoption spectrophotometric method for determination of phosphorus in steel using Bismuth phosphomolybdate complex. R. Ramchandran, P.K. Gupta, No. 86-194.

87. Computer aided evaluation of the standard value of complex impedance using coaxial reference Air lines and the standard terminations. Omkar Nath, A.R. Kaushik, M.R. Nagar, Sharwan. Kumar, K. Chandra, No. 86-195.

88. High power ultrasonic system for Oceanographic studies. T.K. Saxena, S.K. Jain, Mukesh Chandra, Reeta. Gupta, V.N. Bindal, No. 86-196.

89. Development of positive contrast coloured liquid crystal (IC) displays without any polalizer. S.C. Jain, K.S. Balakrishnan, No.86-197.

90. Performance characteristics of pressure release materials for underwater acoustics transducers through material admittance studies up to 300 psi. V.N. Bindal, T.K. Saxena, S.K. Jain, Reeta Gupta, No. 86-198.

91. Results of a TID Compaign. Y.V. Somayajulu, Lakha Singh, T.R. Tyagi, No. 86-199.

92. Magnetic thin film recording media for mass storage. B.K. Das, No. 86-200

93. Reversal of EXB different post sunset enhancement of the ionospheric total electron content at equatorial latitude. A.R. Jain, No. 86-201.

94. Synthesis and X-ray diffraction study of superlattice in Ga_2Te_3. K.D. Kundra, D.K. Suri, U. Dhawan, K.C. Nagpal, No. 86-202.

95. Study of hysterisis loop characterisation of Ni-Zn ferrite samples using a B-H loop recorder. B.K. Das, R.B. Tripathi, Satbir Singh, No. 86-203.

96. Spectrophotometric determination of Caffeine as its murexide. A.K. Agrawal, S.K. Sharma, No. 86-204.

97. Theoretical evaluation of coking values of coal tar pitches. G. Bhatia, R.K. Aggarwal, O.P. Bahl, No. 86-205.

98. A new apparatus for determining the thermal conductivity of insulating materials. K.N. Bhatnagar, Sukhbir Singh, No. 86-206.

99. Effect of geomagnetic disturbances on the VHF Night time scintillation activity as equatorial and low latitudes. R.S. Dabas, D.R. Laxmi, No. 86-207.

100. Computerized H.F. link prediction at NPL India. B.M. Reddy, Dr. Laxmi, S. Shastri, A.B. Ghosh, No. 86-208.

101. Nightime VHF Scintillation at 23°N magnetic latitude and their association with equitorial F-region irregularities. R.S. Dabas, B.M. Reddy, No. 86-209.

102. Atmospheric alternation measurement at 19.4 and 22.235 GHz. M.K. Raina, No. 86–210.

103. Propagation characteristics on point to point transmission in the microwave freq band. M.K. Raina, No. 86–211.

104. Seasonal and solar activity charges of F-region electron density electron temp and protonospheric heat flux. V.K. Pandey, K.K. Mahajan, No. 86-212.

105. Inter comparison of capacitance and A.C. resistance standards under Indo-Soviet cooperation in standardization and Metrology theme 5.12. S.L. Dahake, A.K. Saxena, R.N. Dhar & K. Chandra, No. 87–01.

106. Precision measurement of A.C. resistance and realization of the scale of AC resistance. R.N. Dhar, A.K. Saxena, S.L. Dahake & K. Chandra, No. 87–02.

107. Multi wave length solar uv-B radio meter. B.N. Srivastava, Anju Bali, C. Sharma, R.S. Tanwar & Shambhu Nath, No. 87–03.

108. Ultrasonic bonding for electrical contacts. Joginder Singh & S.P. Verma, No. 87–04.

109. Poole Frenkel effects in Anodically oxidized tantalum . S.A. Agnihotry, K.K. Sarin & Subhash Chandra, No. 87–05.

110. Effect of depolarization field on the polarization reversal current response of a triangular pulse in ferroelectric liquid crystal. S.S. Bawa & A.M. Biradar, No. 87–06.

111. Theoretical investigations of the special characterstics of symmetrical periodic multilayer thin film system with materials of three different refractive indices. A. Basu, R. Bhattacharya & V.V. Shah, No. 87–07.

112. Parametrisation of low noise microwave/mm wave radiometric systems. M.K. Raina, No. 87–08.

113. Energetic particle spectrometer instrument for SROSS-3 Aeronomy satellite mission. M.N.M. Rao, B.C.N. Rao & V.K. Vohra, No. 87–09.

114. Ionosphere of Outer planets. K.K. Mahajan, No. 87–10.

115. Investigation of low resistivity filler materials for carbon electrodes in primary batteries. R.L. Seth, Chhotey Lal, Ashok Kumar & K.K. Dutta, No. 87–11.

116. Wedge type omnidirectional acoustic emission transducer. V.N. Bindal & Ashok Kumar, No. 87–12.

117. Development of low freq. sources for studies of parametric generation. V.N. Bindal, T.K. Saxena, Mukesh Chandra & S.K. Jain, No. 87–13.

118. Transducer calibration in a tube by establishing free field condition using active impedance termination. V.N. Bindal, T.K. Saxena, S.K. Jain, R.P. Tandon & Reeta Gupta, No. 87–14.

Dr A.P. Mitra visited the Science & Technology Exhibition for M.P's held at Parliament House Annexue. NPL participated and assisted in the arrangement.

Dr Krishan Lal explaining the working of Quadruple Crystal X-ray Diffractometer to Mr. John Gunther Dean, U.S. Ambassador in India, during his visit to N.P.L.

The 60th Birthday of Dr A.P. Mitra, DG, CSIR, was celebrated on 20th Feb., 1987 at NPL. Prof. D.S. Kothari presided.

The Minister of State for Science & Technology & Vice President CSIR, Shri Shivraj Patil inaugurating the CSIR-INDUSTRY GET-Together. Seated from left to right are Dr. Ram. K. Iyengar, Shri V.K. Dhar, Dr A.P. Mitra, Shri M.M. Sabharwal & Dr K. Chandra.

Prof. P.W. Anderson, Nobel Laureate, delivering the XVI Krishnan Memorial Lecture on the topic "Puzzles and surprises in Condensed Matter Physics"

Shri Shivraj Patil, Minister of State for Science & Technology & Vice President CSIR inaugurating the Exposition of CSIR laboratories held at NPL on the occasion of CSIR-Industry Get-together.

CSIR-INDUSTRY GET-TOGETHER ON MEASUREMENT STANDARDS, CALIBRATION & QUALITY ASSURANCE

A CSIR-Industry Get-together on Measurement Standards, Calibration and Quality Assurance was held on 30th September, 1986 at the National Physical Laboratory, New Delhi. The Get-together was inaugurated by Hon'ble Shri Shivraj Patil, Minister of State for Science & Technology and Vice President, CSIR. 70 Representatives of various public sector and private sector industries and various industrial associations such as Confederation of Engineering Industries (CEI), Instrument Manufacturers and Dealer's Association (IMDA), Punjab Haryana and Delhi Chambers of Commerce and Industry (PHD), Federation of Associations of Small Industries of India (FASII) and about 100 scientists from CSIR laboratories participated.

Dr. Kailash Chandra, Acting Director welcomed the participants and mentioned that this particular Get-together has been organised with a focus on Quality Assurance which is achieved through precision measurements, calibration, testing, evaluation, future analysis and optimization of process parameters.

Dr. A.P. Mitra, Director General, CSIR brought out the point that due importance has not been given to the quality control and quality assurance aspect in our country. Quality assurance is ultimately linked with precision measurements and it is often said that the level of industrial progress of a country can be judged by the level of measurement capability of that country. During the last few years the status of measurements standards and calibration facilities at NPL has now developed to a level comparable with the international status with high credibility established through international intercomparison of standards. He emphasised the point that development of measuring instruments is very vital and industry should consider giving a thrust to this particular area.

Shri V.K. Dhar, Secretary Department of Public Enterprises, Ministry of Industry made a point that quality assurance has to be built into the system from 'concept' to 'commissioning' which means from the design state to the finished product stage. He emphasised that permanent linkages with practical objectives should be established with CSIR laboratories in selected areas.

Shri M.M. Sabharwal, Chairman, IECC, Punjab, Haryana, Delhi Chamber of Commerce and Industry recommended 'value analysis' to be jointly undertaken by laboratories and industry. He also emphasised the need for better communication and exchange of information between laboratories and industry.

In his inaugural address Hon'ble Minister Shri Shivraj Patil emphatically pointed out cost-wise and quality goods should be competitive in the national and international market. We have built a good infrastructure and raw material and technical man power of requisite expertise and it is time to improve the quality of our products. He quoted the example of Japan which is now synonomous with 'Quality'. He referred to the emphasis given by the Prime Minister to achieve excellence in selected fields and to produce the best. One of the most important factors for achieving quality is the desire and will power in the administrators and workers to achieve perfection. The CSIR Laboratories have established excellent facilities and expertise in various fields and should be fully utilized by industry for updating the technology, tooling control of process parameters, which are basic ingredients of quality assurance process.

Dr. Ram K. Iyengar, Additional DG, SIR in his vote of thanks, mentioned that in addition to 'Capital' and 'Labour' 'Consumerism' is the third dimension. The Quality improvement process requires thorough understanding of the physical and chemical process in production ultimately requiring precision measurements and control of parameters at every stage.

During the Plenary Session, presentations were made on behalf of CSIR and various Industrial Associations.

On this occasion, an Exposition highlighting the facilities and capabilities of CSIR laboratories in the area of Measurement Standards, Calibration, Testing and Evaluation for Quality Assurance was also arranged. The CSIR laboratories included CSIO, CEERI, NAL, NCL, CBRI, CMERI, CLRI, CECRI, ITRC & NPL.

DISTINGUISHED VISITORS/SCIENTISTS

(Visited NPL between 1.4.86 to 31.3.87

S. No.	Name	Organisation/country	Date
1.	Mr. Yohahnes Afewerk	Eithopean Standards Institute. Eithopia.	14. April
2.	Mr. Tranhuu Phuc Mr. Nguyen Van Tinh Mr. Nguyen Van Thinh Mr. S.K. Suri	State Committee for Science & Technology. Vietnam.	15. May
3.	Dr. Janos Csikos	Fluid Control Research Institute. Palghat (Kerala)	10. July
4.	Mr. John Gunther Dean Mr. P.C. Chambra Mr. Richard Blue	U.S. Ambassador to India Science Attache Scientific Adviser	21. July
5.	Dr. Donald Langenperg Prof. James Stukel Prof. (Mrs) Annetle Yonkey Prof. G. Pandey	Members of US Delegation	03. Sept.
6.	Dr. Anderzej Hryjnkiewice Dr. Powel Wodinecelei Dr. K. Krolas	Polish Academy of Sciences. Poland	05. Sept.
7.	Prof. R. Arnaloo Coro	University of Nabana. Cuba	11. Sept.
8.	Dr. Peter L.M. Heydemann	Programs. Budget and Finance. USA	09. Oct.
9.	Dr. K. Roaloffe Dr. (Mrs) B. Brandy Dr. Hoffman	German Academic Exchange Service. Bonn.	28. Oct.
10.	Dr. Jesus Sebastian Dr. Salvador Meca Dr. Conruel Pascual	CSIC. Spain	03. Nov.
11.	Mr. Stuart Holland	Member of Parliament of United Kingdom	02. Jan.
12.	Mr. A.L. Yanshin Dr. V.A. Tkachenko Dr. A.S. Kulshercho	USSR Academy of Sciences	14. Jan.
13.	Mr. Hamiclullah Malyar	Ministry of Mines and Industry. Kabul. Afghanistan	06. Jan.
14.	Mr. Colin Whitfieldlayne	Barbados National Standards Institution. Barbados.	06. Jan.
15.	Mr. Kaentsho Sumpai	Deptt. of Trade & Commerce. Bhutan	06. Jan
16.	Prof. P.W. Anderson	Princton University. USA	12. Jan.
17.	Dr. Anthony R. Michoels	Interdisciplinary Science Review Magazine. London	14. Jan.
18.	Mr. Hal-suo Ishizaki	Kinki University. Japan	21. Jan.
19.	Mr. Gennady A. Mesyats Dr. Dimitu Agrachev Mr. Mikhael G.B.	Academy of Sciences & Technology. USSR	23. Jan.
20.	Prof. Peter Enzelmann	KFA. West Germany	02. Feb.
21.	Dr. A. Altamemi Mr. S. Halan Mr. Malik Cabizitti Mr. N. Al-Agalah	Royal Scientific Society. Jordan	06. Feb.
22.	Prof. F.A. Kuznetsev Prof. V.G. Lutsan	USSR Academy of Sciences	20. Feb.

RECEIPTS ON ACCOUNT OF TESTING/CALIBRATION/GLASS FABRICATION AND OTHER CHARGES REALISED DURING 1986-87

Activity	Amount (Rs.)	No. of Reports
CALIBRATION		
1. Mass Standards	1,11,517	334
2. Length Standards	10,000	2
3. Dimensional Metrology	1,72,100	425
4. Temperature Standards	1,45,385	329
5. Optical Standards	2,57,852	180
6. Force Standards	2,82,825	361
7. High Vacuum & Pressure Standards	40,609	29
8. Acoustical Standards	60,764	45
9. Time & Freq. Standards	4,750	5
10. D.C. Standards	38,875	72
11. Cap. & Ind. Standards	20,000	36
12. AC, LF & HF Standards	1,30,675	56
13. Microwave Standards	8,875	13
MATERIAL ANALYSIS & SPECIALIZED TESTING		
1. Material Analysis	24,400	21
2. Chemical Testing	7,675	23
GLASS FABRICATION & MATERIALS		
Glass Fabrication	1,65,000	—
Carbon Products	15,155	—
PZT Materials	10,084	—
Total	15,06,541	1,933

Ph.D's AWARDED

Awardee	Title of Thesis	University
A.K. Gupta	Hot extrusion of Metals	Delhi
Satbir Singh	Effect of tetravalent impurities on the Microstructural Magnetic and Electrical properties of $Ni_{0.55}Zn_{0.40}Fe_{2.04}O_{4-\delta}$ ferrite system	Delhi (I.I.T.)
Chhotey Lal	Studies of Carbonaceous Materials	Agra
Ashok Kumar	Studies on Carbon Materials	Meerut

CONSULTANCY

Sl. No.	Title of Consultancy	Party	Amount (Rs.)
1.	Acoustical design, treatment & estimate of Nirala Auditorium, Unnao.	U.P.R.N.N. Ltd., Kidwai Nagar, Kanpur.	6,000/-
2.	Acoustical treatment of auditorium of Horticulture Directorate, Lucknow.	U.P.R.N.N. Ltd., Sapru Marg, Lucknow	6,000/-
3.	Improving the quality of PA System installed at Term. II. IGI Airport, New Delhi.	Airport Authority of India, Yashwant Place, New Delhi	15,000/-
4.	Multi-crystal X-ray diffractometer for high resolution X-ray topography.	M/s. KLB Electronics, Private Limited. 1E/17, Jhandewalan Extn, New Delhi	15,000/-
5.	Standardisation of conditions for efficient working of the testing facilities.	M/s. Gurshant Motors Limited 1-H, 59BP N.I.T., Faridabad	3,200/-
6.	Noise reduction due to generator operation.	A.I.I.M.S., Ansari Nagar, New Delhi	6,000/-
7.	Acoustical treatment in the Teleprinter Hall at Police Radio Muckhylaya, Lucknow.	Housing Division, P.W.D., Lucknow	5,000/-
8.	Acoustical design of two rooms at High Court, Lucknow.	Housing Divn., Jawahar Bhawan, Lucknow	5,000/-
9.	Standardization of conditions for efficient working w.r.t. yield and quality of their product.	Modern Indl. Enterprises, WH-69, Mayapuri, Industrial Area, new Delhi	8,400/-
10.	Testing of evaporative air coolers	M/s. Aristo Evaporators, 701/2, Village Alipur, Delhi-26	8,400/-
11.	Constant temperature oil baths	AMSE Air Force Station, Palam, New Delhi	30,000/-

STAFF STRENGTH

(As on 1.4.1987)

Category	Nos.
Scientific/Technical	
Scientists	307
Technical Officers	98
Technicians	620
Technical (Gp.D)	75
Administrative	
Officers	18
Establishment	165
Group D	108
Total	1391

VISITS ABROAD

(1.4.86 to 31.3.87)

Sl. No.	Name of Scientist	Country	Month	Purpose
1.	Shri. Rajive Sikand	U.K.	April–Oct.	Training in the Colombo Plan
2.	Dr. A.K. Saha	U.S.S.R.	April	ISRO—SCHCNE[1]Collaboration.
3.	Dr. B.M. Reddy	Argentina	April	Attended the Workshop on Radio Propagation & for URSI Handbook.
4.	Dr. A.K. Saxena	U.S.S.R.	May	Indo-USSR S&T Programme on Standardization.
5.	Dr. A.V. Narlikar	U.S.S.R.	May	ANSSU-INSA Exchange Programme, participated in the IInd Soviet-Indian Symp. at Moscow
6.	Dr. B.K. Das	U.S.A.	April	Attended INTERMAG 1986 Conf. at Phoenix Arizona, and visited University of California, San Diago
7.	Dr. A.P. Jain	Bangladesh	May	Attended the workshop on rice husk fueled Stirling Engine
8.	Sh. V.P. Wasan & Sh. V.N. Ojha	Australia	July–Oct.	Training under Colombo Plan
9.	Dr. K. Chandra	UK & USA.	June	Discussion with C.S.C. and attended the CPEM-86.
		Fiji	Nov.	Attended meeting of APMP Steering Committee.
10.	Dr. P.C. Kothari	USA	June-July	Attended CPEM-86 & visited NBS, Colorado
11.	Mrs. Mithlesh Saxena	USA	June	Attended the CPEM-86.
12.	Dr. T.R. Tyagi	Finland & FRG	June	Attended the Satellite Beacon Symp. and visited Max Planck Inst.
13.	Dr. SBSS Sarma	Italy	May	Attended the Intl. Conf. on Optical & Millimeter wave propagation.
14.	Dr. K.K. Mahajan	France	July	Attended the 26th COSPAR meeting.
15.	Dr. L.M. Manocha & Dr. O.P. Bahl	FRG	June-July	Attended the Intl. Conf. on Carbon-Carbon 86.
16.	Dr. Ashok Kumar	Poland	Aug–Oct.	CSIR-PAS Exchange Programme.
17.	Dr. V.D. Dandwate	USSR	Aug.-Nov.	Indo-USSR S&T Programme.
18.	Dr. J.S. Vaishya	Bulgaria	Sept–Oct.	CSIR-Bulgaria Exchange Programme.
19.	Dr. S.N. Ekbote.	FRG	Oct–Nov.	Visited Max Planck Inst. & P.T.B.
20.	Dr. P.N. Dixit Dr. R. Bhattacharya	USA	Sept.	For training with M/s Glastech Solar Inc.
21.	Dr. K. Lal	USA	August	Attended the Intl. Conf. on Low Energy Dislocations.
		USSR	Nov–Dec.	Indo-USSR and INSA-USSR Exchange Programme.

22.	Dr. B.S. Mathur	UK & USA	Oct.	Lectured at NPL, NBS & visited U.S. Naval Observatory, Washington.
23.	Dr. K.C. Joshi	USSR	Nov-Dec.	Indo-USSR S&T Programme.
24.	Dr. K.C. Nagpal	Japan	Nov.	For training on Automatic X-ray fluorescence spectrometer.
25.	Dr. V.N. Bindal	UK	Jan.	As Indian coordinator of the MOY project on Ultrasonic under British Council.
26.	Dr. R.S. Dabas	Italy & UK	March–April	Attended the 5th International Conference on Antina & Propagation, University of Yark.

PROCESSES RELEASED TO INDUSTRY

Sl. No.	Process	Party	Terms
1.	Piezoelectric Materials and Bimorph Elements	M/s. Electro Ceramic Industries No. 17, Hussain Maistry Street, Royapuram, Madras.	Premium—10,000/- Royalty—2½%
2.	Cinema Arc Carbons	M/s. Sahani Industries Pvt. Ltd., Dalton Ganj. (Bihar)	Premium—30,000/- Royalty—3%
3.	Silver Impregnated Graphite Contacts	M/s. Greyhound SIG Contacts, B-17, Community Centre, Janakpuri, New Delhi.	Premium—15,000/- Royalty—5%
		M/s. Modison Metals Pvt. Ltd., 33-Nariman Bhavan, Nariman Point, Bombay	
4.	Carbon Thrust Bearings	M/s. Raja Motors, T-1697, Gali Basheshar Nath, Subzi Mandi, Delhi	Premium—7,500/- Royalty—5%

SYMPOSIA/WORKSHOP/TRAINING COURSES

* The Workshop on Tropospheric & Ionospheric Radio Communications was held at NPL in Feb. 1987. The National Workshop on World Ionosphere Troposphere Study was held in March 1987.
* Third National Symposium on Ultrasonics and the training programme on NDT were held in the months of Sept. 1986 & April 1987.
* A no. of I.A.S. Officers visited NPL in Nov. 1986 & a series of lectures were held for them.
* A seminar cum workshop on Carbon Fibres was held in Dec. 1986 by the Indian Carbon Society in collaboration with NPL. Delegates from Japan, France, Korea & W. Germany also participated.
* Training was imparted to one UNDP Trainee from Vietnam on Platinum Resistance Thermometry.
* Training was imparted to four foreign trainees from Uganda, Ethiopia & Sudan & Shri N.C. Goswami, Asstt. Controller (Wts. & Measures), Assam in Mass Standards & Dimensional Metrology.
* A training programme on Precision Measurements & Calibration for senior officers of Weights & Measures (from W.Bengal, Bihar & Assam) was arranged at Calcutta in July, 1986.
* Shri A.K. Pandey of Nepal sponsored by UNDP & Shri A.N.M. Nehani of Yemen, sponsored by UNESCO, were trained in the glass Workshop for 12 & 6 weeks respectively.
* Shri B.G. Vishwakarma of BHU was given training for one week regarding the maintenance of TEM. Shri S. Changkija & Ms. B. Okhar of RSIC, Nehu, Shillong were trained on the preparation of specimen for TEM examination.
* A student of BITS, Pilani got training on characterization of materials using SEM/EDS for his internship programme. Two students of Springdales School, New Delhi were assisted for their project on preparation of Ag. films.
* The training courses on VAX/VMS Operating System & Fortran/Basic Programming Languages were held in the months of Nov-Dec. 1986.

COLLABORATION WITH OTHER INSTITUTIONS/AGENCIES

* The collaboration with TIFR, Bombay on the basic aspects of Superconductivity in the area of high temperature superconductors was in progress.
* The Deptt. of Industries & Commerce, Karnatka State, was assisted in their seminar on Non-Conventional Energy Systems held at Shimoga & NPL participated also.
* The contacts were made with BARC, Trombay regarding determination of isotopic abundance ratio of distilled water used at NPL for precision density measurements & their standards of mass & density floats were calibrated.
* The Standards Division collaborated with PTB, W. Germany & NBS, U.S.A regarding the work of flow measurement, Mass Standards & Time & Frequency Standards etc.
* There was active collaboration with V.N.I.I.M. U.S.S.R under Indo-Soviet Programme of Cooperation in the area of Electrical & Electronic Standards. A number of Soviet experts visited NPL during the year.
* The Radio Science Division had collaboration with ISRO, PRL, Ahmedabad; ISAC, Bangalore; Defence Deptts.; TIFR; IMD; P&T, Electronics Commission & Universities of Tirupati, Calcutta & BHU.
* The collaboration between I.F.T.R, Poland & NPL, regarding the investigations by ultrasonic methods was renewed.
* DRDL, Hyderabad collaborated in the activities of carbon-carbon composites.
* Regarding the Materials Characterization activities, the NPL collaborated with M/s Semiconductors Ltd. Mohali; IARI, New Delhi; NCL & CEERI; CEL; NTPC; I.I.T., Delhi; Delhi university & BHU.
* There was active collaboration with CSIO, Chandigarh regarding the Scanning Electron Microscope project.
* The collaboration with CECRI, Karaikudi & IGCAR, Kalpakkam, about the Sodium Sulphur Battery project, was continued.

HONOURS & AWARDS

Dr. Ravi Mehrotra was awarded INSA medal for Young Scientists for the year 1986. He was elected as Young Associate of the Indian Academy of Sciences, 1986.

Dr. P.C. Kothari was awarded URSI Young Scientist award to attend CPEM-1986 at Gaithersburg USA.

Dr. S.K. Sharma was nominated as a member of the Consultative Committee of RSIC-EM of All India Institute of Medical Sciences.

Dr. B.S. Mathur was elected Fellow of the National Academy of Sciences, India and was nominated as Member-Secretary, Advisory Committee on Primary Electronic Standards.

ADVICE/CONSULTANCY

The section of Acoustic Standards provided consultancy regarding acoustical design & treatment of auditoria & noise reduction to various Govt. & State Deptts. Consultancy service was provided to a firm regarding testing of evaporative air cooler by the scientists of Temperature Standards.

Two units of constant temperature oil bath were fabricated & supplied to the Defence Deptt. The Division of Materials Characterization rendered consultancy to M/s KLB Electronics (P) LTD, New Delhi for their project of Multi-crystal X-ray Diffractometer.

The Thin Film Section advised the Ordnance Factory, Dehradun regarding setting up facilities for the production of Opto-electronic Instruments involving thin film coatings. M/s Astro-optical Industries, Bombay were also assisted in their technical & scientific problem regarding a coating plant.

The scientists of Radio Science Division rendered a variety of consultancy services to various Defence & Civilian Organisations regarding HF, radar & microwave communications. Some of the major jobs assisted were:

Frequency predictions for HF links of Indian Navy for their "Skylark" project; frequency predictions being operated by the Army Signals for the next year; ASWAC Indian Air Force on problems due to conducting rain & water vapour attenuation to their radar at 13–14 GHz; TIFR in their design of a radio telescope (150 MHz) being established at Pune; estimation of interference potential of P&T microwave links operating at 3.5 GHz to satellite communication links for the Deptt of Electronics

CALIBRATION & TESTING SERVICE

The calibration and testing of instruments, products and equipment were done by the various sections of the Standards Division as usual. These services were provided to various Govt. & Defence Deptts., Public Sector Undertakings and Private Sector Organisations. In a number of cases advice and consultancy were provided.

High precision calibration of vacuum, pressure and force measuring devices & length measuring machine, using laser interferometers, was done. A large number of glassware like hydrometers, burettes and butyrometers etc. were calibrated for dairy industry. A number of secondary standard capacity measures for Weights & Measures Deptts. of State Govts. were calibrated and recalibrated. The calibration of watt meters, energy meters, power factor meters & transformers was carried. The calibration of dc precision measuring instruments of the Electronic Regional Testing Laboratories and other Echelon II laboratories was done. 1933 test reports were issued during the year realising Rs. 13.17 lakh as testing fees.

PATENTS ACCEPTED/SEALED

Patent No.	Title
Accepted	
157508	Improved Process for the manufacture of carbon-fibres from Polyacrylonitrile Fibres
157565	Process for preparation of Indelible Ink for making a permanent mark on a substrate
Sealed	
156150	Improved process for the preparation of Duplicating Ink

PERSONNEL

(as on 1.4.1987)

DIRECTOR, JOSHI, DR. S.K. (w.e.f. Nov. 19, 1987)
ACTING DIRECTOR, KAILASH CHANDRA, DR. (up to Nov. 18, 1987)

SCIENTISTS & OFFICERS

STANDARDS

Aggarwal, N.K.
Aggarwal, Ritander
Agrawal, Dr. V.K.
Anil Kumar
Arora, T.R.
Bahadur, Harish
Bahl, (Mrs.) Madhu
Bahl, S.D.
Banaudha, Inderjeet
Bandopadhyay, Dr. A.K.
Banerjee, Dr. P.
Batra, V.K.
Bhan, Inder
Bhaskar, H.L.B.
Bhatnagar, H.M.
Bhatnagar, K.N.
Bhola, O.P.
Bhawalkar, Dr. R.H.
Chakraborty, Dr. B.R.
Chatterjee, (Mrs.) A.
Chaudhuri, M.K.
Chitnis, Dr. V.T.
Dahake, Dr. S.L.
Dahiya, Dr. H.S.
Dandavate, Dr. V.D.
Das Gupta, M.K.
Das, M.L.
Devendra Singh
Dhar, Dr. R.N.
Dhawan, J.K.
Dutta, P.K.
Ganapathy, T.V.
Gera, Dr. B.S.
Gautam, C.B.L.
Goel, G.K.
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Ram Swarup.
Ranjit Singh.
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Srivastava, N.K.
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VITH SCIENTIFIC EXPEDITION TO ANTARCTICA

The VIth Expedition to Antarctica was led by Dr. A.H. Parulekar. The expedition sailed from Goa on 26th November, 1986. National Physical Laboratory, New Delhi was represented by Dr. A.K. Hanjura and Dr. S.D. Sharma. The team reached Antarctica on 21st December, 1986. A summer camp was set up at MAITRI in the Schirmacher hills some 80 kms south of Dakshin Gangotri Station. The NPL experiments were carried out for the entire duration of the Maitri Camp i.e. from 27th December, 1986 to 15th February, 1987. Various experiments that NPL scientists performed were:

—Study of Cosmic Noise Absorption at 30 MHz using riometer.
—Study of Surface Pressure Fluctuations using microbarograph.
—Study of Ground level UVB using UV photometer.
—Study of Turbidity using sun photometer.
—Study of High Latitude D-region using VLF signals.
—Study of Trace Gases (methane and carbon monoxide) in Antarctic atmosphere using gas chromatograph.

The UV Photometer and Sun Photometer studies were done to study the 'Ozone hole' in Antarctica. A connecting experiment is the study of trace gases, which can be linked with Ozone depletion studies.

Evacuated containers were filled with Antarctic air and brought back for detailed studies at NPL.

A continuous recording of various parameters was made for a period of 50 days and the data brought back. The following experiments were left behind for collection of data during the Antarctic Winter:

—UV Photometer
—Gas Chromatograph
—Riometer