ANNUAL REPORT 1982-84

NATIONAL PHYSICAL LABORATORY
Hillside Road, New Delhi-110012

The Prime Minister Shrimati Indira Gandhi lighting the torch with Solar Concentrator installed by NPL for the Torch Lighting Ceremony at the National Stadium on the occasion of IX ASIAD.

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PREFACE

This Report summarises the progress made by the NPL during the two-year period April 1982 to March 1984. The major areas of work were : Standards, Materials Development and Characterization, Radio & Space Science, High Pressure Technology, Solar Energy, Cryogenics and Applied Projects.

The Primary Standards being the statutory responsibility of the Laboratory, much of our efforts and emphasis was devoted to this area. In this, the most important was the increasing effort on intercomparison of standards under *Asia Pacific Metrology Programme*. The parameters covered were :

a) photometric standars (a set of 4 standard lamps - three participating countries),

b) length standard (a set of 10 slip gauges - eight participanting countries),

c) D.C. resistance standard (1 ohm and 10 kilo ohm standard resistors - eight participating countries),

d) High frequency attenuators of 3, 6, 10, 20 & 40 dB calibrated at 30 MHz (carried out amongst Australia, China, India and Singapore).

Intercomparison was also carried out with VNIIM (D.I. Mendeleyev Institute of Metrology, Leningrad), on standards of D.C. voltage and resistance, L.F. and H.F. voltage upto 30 MHz, capacitance, and inductance (at 10 mH level). An atomic clock intercomparison with VNIIFTRI, Moscow, was also done.

The second major activity of standards concerned the question of using satellites for dissemination of standard time and frequency. Preliminary experiments were conducted with INTELSAT-II and INSAT 1B.

An interesting experiment performed by radio astronomers in December 1983 involved very long base-line interferometry (VLBI) in which the participating observatories were Ootacamund (India), Jodrell Bank (UK), Westerbrook (Holland), Torun (Poland) and Crimea (USSR). A crucial component of the experiment was a high level clock synchronisation. This was achieved with two rubidium clocks provided by the NPL and the P&T. The clocks were linked with the primary NPL cesium clock with a synchronisation of 10 μs.

Other important activities in the standards area were : the improvement of capacitance standard to 2-3 parts in 10^7, based on the vertical model of the calculator capacitor; establishment of primary standard of pressure in the region 7.5 MPa - 500 MPa; realisation of low value inductances (0.1 μH to 10 μH) from capacitance; and evaluation of the performance of the iodine-stablished He-Ne laser through determination of its stability and reproducibility by beat frequency experiments.

A Regional Working Group meeting on 'Metrology for South and Central Asia' was held at the NPL from 9-11 August 1982. A Training Workshop on 'Metrology and Standardisation for Developing Countries and Small Island States' was also held from 6-17 February 1984.

Under a bilaterial programme of the DST, some equipment for the Quality Control Laboratory of the Weights and Measurement of Srilanka, duly calibrated by the NPL, was also supplied.

In the area of Materials Development, major activities concentrated on were : Carbon fibres & Carbon-Carbon Composites, Beta Alumina, Polysilicon from trichlorosilane (NPL-NCL collaborative programme), and the initiation of work on Microelectronics.

The quality and the reproducibility of carbon fibres were improved, and work was undertaken for the development of two-directional carbon-carbon composites for biomedical applications using coaltar pitch as a matrix. Composites with density of 1.5 gm/cc, flexural strength of 260 MN/m^2 and flexural modulus of 25 GN/m^2 were developed.

Beta alumina solid electrolyte tubes were prepared.

Large size CVD reactors for preparation of polysilicon from trichlorosilane with the objective of setting up a pilot plant for 1 tonne/year at the NCL, were designed. In ultrasonics area a major achievement was the generation of wide-band parametric acoustic arrays in air.

Since work on materials depends very critically on the quality of material characterization, facilities for characterization of materials were strengthened. Additional new equipment installed included:

i) JEOL scanning electron microscope, together with energy dispersive spectrometer (EDP) and wavelength dispersive spectrometer (WDS) as attachments; and

ii) JEOL transmission electron microscope with SEM attachment (the first 20 KeV electron microscope in India).

A null detection system for measurement of infra-red radiation was developed at the Laboratory.

The Material Characterisation Group has always been active in several areas of fundamental research in addition to its service functions. An original new study concerned observation of microstructural changes induced by microwave electric field in silicon single crystals. This was done in collaboration with PTB, F.R.G., by bringing into play the capability of very high resolution X-ray diffraction developed earlier at the NPL.

In the area of Radio Science, the most important activity concerned is the NPL participation in the Indian Middle Atmosphere Programme (IMAP). NPL's participation occurred in a number of ways: through its own scientific contributions, through its participation in the IMAP Working Groups, and in providing guidance to the entire IMAP programme through the Scientific Advisory Committees of the IMAP.

The NPL experiments for the IMAP were varied and extensive. These included rocket and balloon measurements of ionization, aerosol and Ozone in the middle atmosphere, continuous monitoring of solar UV-B radiations, and work relating to the establishment of a tunable CO_2 laser heterodyne system for the measurement of atmospheric minor species. Two IMAP consolidation reports were prepared by the NPL scientists-one on *Reference Ionization Profiles over the Indian sub-continent* and the other on *Reference Ozonosphere over India.*

One of the most important activities conerced NPL's participation in the Indo-USSR Ozone Intercomparison Campaign conducted during the last week of March 1983 involving a number of rocket-borne optical and chemical ozonesondes (of NPL, PRL and USSR), balloon-borne ozonesondes (IMD), Dobson Spectrophotometer and Surface Ozone measurements (IMD).

A balloon-borne Langmuir probe was launched in May 1983 for the measurement of stratospheric ion densities.

The group contributed substantially to the design of MST Radar which is planned to be undertaken as a national facility.

In addition to IMAP, activities on the tropospheric and ionospheric radio communications continued. A wide variety of organisations including Defence services, P&T, Railways, AIR and Doordarshan continue to seek this consultancy service from the NPL.

A radar campaign was conducted during the pre-monsoon month of May 1982 with cyclone warning radars of IMD located over the east coast of India; the objective was to gather information regarding ducting, super-refraction and anomalous clear-air echoes of critical interest in tactical radar applications.

In regard to communication prediction and prediction of magnetic parameters, the services of NPL were greatly sought after. A new type of prediction introduced was magnetic storm alert

as an aid to low-latitude H.F. communication.

SODAR which was introduced for the first time in India in the seventies went through a new phase it was used on a forward scattering mode. A technique was developed for distinguishing wind shear layers in the atmospheric boundary layer from radiation inversion layers.

Satellite radio beacon observations continued. ETS-II geostationary satellites was used at 136 MHz. A chain of stations was operated by NPL at Delhi, Nagpur, Hyderabad and Bangalore in collaboration with the universities and institutions in these places.

A proposal for an aeronomy science mission in SROSS satellite was submitted to ISRO. A joint NPL-PRL mission on aeronomy is planned.

Efforts to continuously improve the reference ionosphere over India continued. The data used covered observations from a wide variety of sources specially those from incoherent scatter radar.

Four major workshops were also held in this area:

1) Indo-US Workshop on Global Ozone Problems (11-20 January 1983),
2) International Symposium on Beacon Satellite Studies of the Earth's Environment (7-11 February 1983),
3) Indo-US Workshop on Solar Terrestrial Physics (30 January to 3 February 1984), and
4) Workshop on Radio Propagation in Tropics (1-12 November 1982) at Trieste, Italy.

The Workshop on Beacon Satellite Studies was preceded by a specially organised two-day programme on 'Beacon Techniques and Applications' for scientists from developing countries under the sponsorship of URSI. The Trieste Workshop was directed by Dr. A.P. Mitra, and Dr. B.M. Reddy was a member of the Faculty.

In the area of high pressure technology, work continued on synthesis of super-hard materials and material extrusion. A new addition to the facilities was a 1000-tonne hydraulic press commissioned in early 1984. Dialogue was introduced with several industries for the use of the high pressure technology facility and expertise.

Solar Energy has been a programme of interest to the Laboratory for more than two decades. In the thermal area, work continued on the establishment of a national test facility for solar collectors. Lighting of the 9th ASIAD torch by solar energy was successfully executed with a solar concentrator installed by the NPL at the National Stadium, New Delhi. The late Prime Minister Mrs. Indira Gandhi lighted the torch.

On the photovoltaic side, work on the development of polycrystalline silicon substrates continued. Ingots upto 55 mm dia were prepared by directional solidification of silicon melt inside graphite crucibles.

In the Cryogenics area, the major emphasis was in the following directions:

a) Establishment of the Josephson voltage standard,
b) Development of cryogenic materials, devices and systems, and
c) Experiments and theories on the mechanism of superconducivity.

A low-capacity liquid air plant based on Stirling cycle, was successfully designed, developed and assembled.

A two-day workshop on 'Superconductivity-Magnetism Interplay' was also held on 14-15 April 1983.

The Laboratory has been contributing appreciably to specific requirements of other agencies. These included development of space qualified interference filters for the 'Smart' sensor (payload of Rohini satellite D-2), the development of collimating sight glass for use in fighter planes, and transfer of know-how of infra-red hot axle detection system to CEL.

Work on xero-radiography progressed and a Laboratory model was fabricated.

NPL scientists have participated in all the Indian expeditions to the Antarctic. During this period the second and third expeditions to the Antarctica took place. For the second expedition

two NPL scientists were sent : Dr. Amitava Sengupta and Dr. P.K. Pasricha. For the third expedition Dr. A.K. Hanjura was the NPL representative.

NPL scientists continue to receive honours and awards, both national and international. Dr. Krishan Lal was elected Fellow of the Indian National Science Academy for the year 1983 in recognition of his fundamental contributions in high resolution X-ray diffraction studies of crystal defects and growth of crystals. Dr. Kailash Chandra was elected as the Regional Coordinator of the Asia-Pacific Metrology Programme for a 3-year period with effect from October 1983. Dr. Y.V. Somayajuly and Dr.A.K. Saha continued to play a major role for the execution of the IMAP programme as Chairman of IMAP Working Groups on 'Ionization Campaign' and 'Minor constituents and Atmospheric Chemistry', respectively.

A 'Science Week' was organised from November 12-18, 1983 in which the Laboratory was kept open to the public, representatives of the industry, and academic community. A Young *Scientists' Programme* was organised in which about 10 selected young people were invited to be the guests of NPL. Four distinguished lectures as a part of the Science Week were given.

Professor Brian Josephson, Nobel Laureate delivered a lecture on 'Superfluidity, Science and Technology for Coherent Matter Waves' - on 23rd February 1984.

More than 200 papers were published in professional journals and about an equal number were presented in national and international conferences and symposia. These include about 75 papers presented in about 35 international symposia/conferences held during the period.

A. P. Mitra

Dated : 6.5.1985

(A.P. MITRA)
Director

DIVISION OF STANDARDS

AREA COORDINATORS

ELECTRICAL & ELECTRONIC STANDARDS
Dr. Kailash Chandra

MECHANICAL, THERMAL & OPTICAL STANDARDS *Dr. S.R. Das*

INTRODUCTION

The Division of Standards has the responsibility of realizing the units of physical measurements at internationally accepted level of accuracies and of dissemination of the units through calibration of measuring instruments of various agencies engaged in standardization, consumer protection, industrial quality control and scientific & technological advancement.

The activities of the Division are divided into various projects as listed below:-

Mechanical, Thermal & Optical Standards

i. Standards of Length & Angle
ii. Dimensional Metrology
iii. Standards of Mass, Volume & Density
iv. Standards of Force & Hardness
v. Standards of Pressure
vi. Standards of Vacuum
vii. Standards of Temperature
viii. Optical Radiation Standards
ix. Standards of Acoustics

Electrical & Electronic Standards

x. Standards of Time & Frequency
xi. Standards of DC, EMF, Resistance & Current
xii. Capacitance, Inductance and AC Resistance Standards
xiii. AC, LF & HF Standards
xiv. Microwave Standards of Power, Frequency, Noise Attenuation and Impedance.

During the period 1982-84, the standards developed and calibration facilities established are summarized below:

A laser measurement system for the calibration of metre and other line gauges has been designed. The design of 100 kN dead weight machine has been completed. The gas operated secondary pressure standards upto 1k. bar and oil operated pressure standards upto 3k. bar have been established. Ultrasonic hydrophone standard (1-4 MHz) has been developed.

Experiments for standard time and frequency dissemination via satellite were conducted. The accuracy of the calculable capacitor has been improved to 2 parts in 10^7. Calorimetric technique using twin resistance power head for measurement of HF power & voltage has been established.

NPL has been actively associated with various activities of the Asia Pacific Metrology Programme (APMP) and has provided the Regional Coordinator of this Programme for the period 1983-86. Under APMP a number of international intercomparisons through travelling standards viz. slip gauges, lamp standards of luminous intensity, microphone standards for acoustic pressure, DC resistance standards and HF attenuation standards were carried out. Intercomparisons of standards of frequency, capacitance and inductance were also carried out with USSR. These intercomparisons have shown close agreement with other countries in respect of value of the standards thus establishing international compatibility and credibility.

Two International Training Workshops in Metrology and Standardization were organized at NPL for developing countries. Scientists from Division of Standards have also served as consultants in Metrology to some developing countries.

A large number of user organizations such as Defence Establishments, Govt. Departments, Public and Private Sector Undertakings, R&D Institutions etc. have got their reference standards and precision instruments calibrated at the NPL.

STANDARDS OF LENGTH & ANGLE

1. SCOPE AND OBJECTIVES

To establish, maintain and update the standards of length and the facilities of measurement and calibration in terms of those standards.

2. PROGRESS

2.1 Standard of Length

The stability and reproducibility of I_2 stabilized He-Ne laser, operated under controlled environmental conditions, were determined by beat frequency experiment. The frequency stability of our National Standard of Length is now 1.2×10^{-11} for an integration time of 10 sec with a reproducibility of $\pm 5 \times 10^{-11}$. These values are comparable to such lasers developed in other standards laboratories.

Further improvements have been made in the I_2 stabilized laser system and in the beat frequency experimental set-up. The laboratory was prepared for the intercomparison experiment between our stabilized laser with a similar one from PEL, New Zealand. As the PEL laser was already being compared with those of other eight laboratories of the world, it was expected that valuable information on certain characteristic properties of NPL laser with respect to those of other laboratories would be obtained by this experiment.

Frequency stability of thermally stabilized two mode He-Ne laser was measured by intercomparison with I_2-stabilized laser and was found to be 5×10^{-9} for an integration time of 10 sec.

A transfer standard He-Ne laser using Zeeman splitting and thermal stabilization was developed. The stability obtained was of the order of 5×10^{-9}. A technique for stabilizing internal mirror He-Ne laser using PZT controls and PSD technique was also developed. A He-Ne laser operating at 3.39 μm was fabricated.

2.2 Measurement System and Technique

A laser measurement system for the calibration of slip gauges has been designed and is under fabrication. Different laser interferometric configurations for the laser measurement system for line gauges were tried.

A laser measurement system for the calibration of metre and other line gauges has been designed and is under fabrication.

A scanning Fabry-Perot interferometer has been developed for studying the mode characteristics of a laser and for comparing very close-by wavelengths.

A simple method for aligning long cavities of gas lasers has been developed and is described in a publication.

2.3 Calibration

The high precision calibration of three co-ordinates and other length measuring machines using laser interferometer have been started. Calibrations of measuring machines of BHEL, and a private industry were done respectively at their premisses at Hardwar and Bahadurgarh.

2.4 Basic Studies

Studies on Collision-induced excitation transfer processes in a He-Ne plasma and on frequency stabilized lasers were carried out.

Studies on the polarisation properties of multimode internal mirror He-Ne laser and also R&D work on laser metrology is being continued. Studies on hologram interferometry and its applications to precision measurements have been carried out.

Two compact shearing interferometers which can be used for testing optical components and OTF measurements have been developed. Some studies on the polarization fipping of He-Ne lasers have been done and are being still continued.

3. PROJECT TEAM

S.R. Das — Project Leader
V.D. Dandawate, P.N. Puntambekar, V.T. Chitnis, Mrs. Kowsalya, V.G. Kulkarni, H.S. Dahiya, B.K. Roy, A.K. Kanjilal, Ram Narain.

DIMENSIONAL METROLOGY

1. SCOPE AND OBJECTIVES

To establish, maintain and update calibration services and facilities for dimensional measurements.

2. PROGRESS

2.1 Calibration

Calibration service to the industry and other organisations has been continued. Calibration and test certificates have been issued for a variety of items such as slip gauges, length bars, metre bars, measuring tapes, angle gauges, threaded or plain ring or plug gauges, dial gauges, vernier calipers, external or internal micrometers, micrometer setting rods, precision levels, depth gauges, air flow nozzles, viscometers, engineers or cylindrical squares, pressure gauges, test sieves etc.

2.2 New facility

(a) Surface finish measurement facility has been started with the installation of TALYSURF, a surface finish measuring instrument.

(b) Universal measuring machine of Carl Mahr, Germany, equipped with digital read-out system has been installed. This machine is useful for precision measurement of diameter of plug and ring gauges and length of end standards upto 200 mm size. The readability of the instrument is 0.01 μm.

3. PROJECT TEAM

P.C. Jain — Project Leader
Mahesh Chandra, N.K. Balchandani, Mrs. V. Roonwal, R.K. Khanna, M. Karfa, L.M. Bhatia, N.K. Aggarwal, V.D. Sharma.

STANDARDS OF MASS, VOLUME AND DENSITY

1. SCOPE AND OBJECTIVES

Maintenance of national prototype kilogram and other transfer standards of mass through their calibration against the national prototype with an overall uncertainty of 1 part in 10^8.

Building up and calibration of transfer standards from 1 mg to 2000 kg with overall uncertainty ranging from 1 in 10^7 to 3 in 10^6.

Establishment of viscosity scale for the purpose of calibration of master and reference viscometers.

Theoretical study of various quantum phenomena to establish the unit of mass based upon one such phenomenon. Development of various experimental techniques to increase the radability of the weighing system.

2. PROGRESS

2.1 Calibration and Testing

A number of NPL standards as well as several sets of reference and secondary standards of mass for the Weights and Measures Organisations of the State Governments of the country have been calibrated. This includes the standards supplied to various neighbouring countries under the Asia Pacific Metrology Programme. A large number of glass hydrometers of various types, analytical weights and volumetric measures have been calibrated for various user industries and institutions like Bharat Heavy Electricals Ltd. and Misra Dhatu Nigam etc. Under the Asia Pacific Metrology Programme, we participated in the round robin test of two 1 kg travelling standards. The two standards were calibrated against our 1 kg standard. The precision and uncertainty of measurements were calculated and the results were sent for final analysis to S.R.L.M., Singapore, the coordinator of this programme.

2.2 Density Measurement

A thermostatic bath designed in the section was set up for precision measurement of density. The temperature stability of the bath was found to be 0.002°C both at 20°C and 15°C. A solid cylinder was made from corning glass and its volume was established. The values of the volume determined over a period of one year or so have been found to agree with the precision of a few parts in 1 million. Density of Xylene using this solid cylinder has been determined with a precision of better than one part in hundred thousand. The calibration of reference standard hydrometers, using hydrostatic method, is going to be started soon.

2.3 Viscosity Measurement

For the measurement of viscosity, standard viscometers were fabricated in NPL to build up the viscosity scale starting from water as a primary standard. A few NPL made master viscometers for water have been calibrated. In addition, we have procured full sets of reference standard viscometers covering the range

from 1 Cst to few thousand Cst. The facility is almost ready to take up the calibration work of Level II visometers and viscosity.

2.4 1 kg Interchangeable Pan Balance

Efforts have been made to get fabricated knife edges and bearing planes of the 1 kg interchangeable pan balance. The knife edges fabricated in NPL have been found to be the best and have been fitted in the balance.

3. PROJECT TEAM

S.V. Gupta — Project Leader
Mohinder Nath, B.G. Mathur, S.N. Nangia, M.L. Das, Tripurari Lal, A.N. Bulsara, S. Verma (Mrs.)

STANDARDS OF FORCE AND HARDNESS

1. SCOPE AND OBJECTIVES

To realize and maintain standards of Force and Hardness and to offer Calibration service to the user.

2. PROGRESS

Necessary fabrication regarding extension of 500 kN hydraulic multiplication system has been completed. Final assembly is being done.

Design of the 100 kN dead weight machine has been completed and fabrication of some parts has been started.

Development of a standard Rockwell hardness machine has been started.

3. PROJECT TEAM

M.K. Dasgupta — Project Leader
R.S. Sharma, M.K. Choudhary, J.K. Dhawan, Anil Kumar, S.S. Rajput, V.S. Muneshwar, V.D. Arora.

STANDARDS OF PRESSURE

1. SCOPE AND OBJECTIVES

To establish pressure standards and facilities for the calibration of high pressure measuring instruments and to improve the quality of Indian instruments to satisfy international standards.

To set up primary and transfer standards and facilities for calibration of pressure measuring instruments. The primary standards will be used by the NPL to calibrate transfer standards of the user industry. The calibration facilities will be used to calibrate pressure gauges extensively used by the Indian industry in chemical and petrochemical plants, boilers, and the manufacture of compressors etc. A pressure range from 1 bar to 14 K bar will be covered.

2. PROGRESS

The erection and commissioning of the primary pressure standards upto 5 K bar has been fully completed characterised. The analysis of the zero clearance jacket pressure and the operating jacket pressure in relation to the temperature of the piston, speed of rotation and the viscosity of the pressure transmitting fluid has been done, in order to improve the overall uncertainty in the pressure measured with this gauge.

The gas operated secondary pressure standards upto 1 K bar and oil perated pressure standard upto 3 K bar have been fully characterised and established.

Rolling ball high pressure viscometer upto 5 K bar has been fabricated and assembled to measure the viscosity of pressure transmitting fluid under different pressure.

A hand operated high pressure hydraulic assembly has been installed to generate the hydrostatic pressure upto 7 K bar in a moderate volume in order to study the various properties of the disordered organic materials using a newly developed piezo stimulated discharge current technique under different ambient and hydrostatic pressure conditions.

3. PROJECT TEAM

J.K.N. Sharma — Project Leader
K.K. Jain, A.K. Bandyopadhyay, R.L. Meena, R.K. Kulshreshtha.

STANDARDS OF VACUUM

1. SCOPE AND OBJECTIVES

To establish vacuum standards and facilities for the calibration of vacuum gauges and test-

ing characteristics and performance of vacuum pumps and vacuum instruments for improving the quality of Indian instruments to meet the international standards and to develop the indigenous capability for the design of vacuum equipments.

To set up primary and transfer standards facilities for calibration of vacuum gauges, testing of vacuum pumps and vacuum equipments. The calibration facilities will be used to calibrate pressure gauges including altimeters, transducers, vacuum valves, vacuum systems, and fittings. A pressure range of 1 atmos. down to the 10^{-7} torr will be covered.

To establish ultra high vacuum facilities of the order of 10^{-11} torr and to develop the UHV techniques for use in scientific research to surface sciences and in the allied fields within the country.

2. PROGRESS

2.1 Gas Beaming Effect

The effect of gas beaming on the speed of oil diffusion pumps has been studied in detail. The speed of the pump is measured at the four different positions of the test dome by using the tubulated gauge connection and also for the three different orientations of the gauge inlet. A comparison of the measured speeds at the four positions has also been made with the theoretically calculated speeds. The Y_o/R values (position at which the measured speed is the intrinsic speed of the pump) for the remaining two orientations A (towards the direction of flow) and C (opposite to the direction of flow) of the inlet of the tubulated and orifice gauges are theoretically derived and these values are experimentally verified. Further, the theoretical values of the test dome constants for different sizes of the test dome are determined for both the types of gauges. In the light of experimental results obtained, the relationship between the measured speed, the intrinsic speed and the effective conductance due to the gas beaming, is derived.

2.2 Vacuum gauge calibration by Orifice Flow Method

This method is useful in the molecular flow region i.e. for pressures below 10^{-3} torr.

A calibration system has been designed and developed for the calibration of the gauges in the range 10^{-3}-10^{-6} torr. As part of the system, attempt has been made to fabricate a new flowmeter which can be operated both in the constant pressure and constant volume mode. This flowmeter can measure gas throughputs as low as 10^{-5} torr 1 s^{-1}. The throughput measurement range of the flowmeter is proposed to be extended to lower side by making use of improved components. This will enable to extend the calibration range. A few vacuum gauges have been calibrated with uncertainties below 5%.

2.3 Ultra High Vacuum System

The UHV system using ion pump and sublimation pump has been installed and fully commissioned and its performance has been tested and vacuum of the order of 6 x 10^{-11} m bar has been obtained. Mass spectrometer analysis of residual gases in the above system is in progress.

2.4 Piezoelectric Gas Admission Valve

Studies have been carried out on the various characteristics of a piezoelectric (PZT) gas admission valve related to its application to a vacuum system. The effect of a d.c. voltage applied to the PZT gas leak valve in a closed loop vacuum control system and in a dynamic system has been studied. The above study shows that there is an optimum d.c. voltage to be applied to PZT gas admission valve for maintaining each value of set pressure in a closed loop vacuum control system in order to have minimum pressure fluctuations. PZT gas admission valves, when used for continuous gas flow, exhibit hysteresis, which could be avoided by discharging the PZT crystal in the valve and then the d.c. voltage could be re-applied to get reproducible results.

3. PROJECT TEAM

J.K.N. Sharma — Project Leader
A.C. Gupta, P.K. Ashwini Kumar, D.R. Sharma, B.R. Chakraborty, Pardeep Mohan, T.K. Saxena.

STANDARDS OF TEMPERATURE

1. SCOPE AND OBJECTIVES

To establish, maintain and update the primary standard of temperature. To realise the International Practical Temperature Scale by de-

velopment and maintenance of the fixed points on that scale and the transfer standard instruments and to provide the associated calibration service. To provide the service for measurement of thermal properties of materials.

2. PROGRESS

A set up for calibration of standard thermocouples at freezing point of Indium, Tin, Zinc, Antimony and Silver was completed. Calibration of thermocouples can now be done speedily by comparison with a standard thermocouple by using a Recorder or Digital Thermometer.

Determination of Linear expansion by sag method at medium temperatures was undertaken. The temperature of the sample in wire form heated directly by passing current through it was measured from its resistance. The expansion was estimated from the sag. Work on Palladium was completed.

Two platinum sheath capsule type PRTs for use in the cryogenic temperature range have been constructed. Two soft glass sheath capsule type PRTs, also for use in the cryogenic temperature range, have been constructed.

One SPRT and one tungsten resistance thermometer for use upto 962°C have been constructed and calibrated at triple point water and tin freezing point after thermal cycling at high temperatures.

A set up for continuous calibration of clinical thermometers was fabricated. This can give an output of about 500 thermometers per hour for calibration at one point. This can be useful for large consumers like Hospitals and other medical services.

Participated in Round Robin Tests on thermal conductivity. K value of a sample received from N.B.S., USA was determined and value communicated.

The facility for intercomparison of P.R.Ts in an Intercomparison Furnace has been improved by incorporating auxiliary heaters. This gives better control in obtaining constant temperature in the metal-block in furnace. Two new "triple point of water" cells have been made using "Antartica Water expedition-I"

2.1 Evaporative Air Coolers

Facilities for testing of evaporative air coolers have been completed. Testing service made available to the manufactures I.S.I., D.G.T.D. and Association of manufacturers of Air-coolers (Small Scale Sector) have been informed about the facility. The above parties were also informed that the testing facility will be in existence for about one year only. It was impressed upon them that some other Institution I.S.I. or N.T.H. may set up the facility with the N.P.L. know-how and experience.

3. PROJECT TEAM

K.D. Baveja — Project Leader
V.P. Wasan, K.N. Bhatnagar, V.N. Ojha, N.K. Srivastava, Y.P. Singh, Sukhvir Singh, Pinoki Ranjan, R.K. Luthra, P.K. Dutta, S.K. Nijhawan, Mansha Ram, J.K. Gupta, R.S. Khandekar, Gurcharanjit Singh.

OPTICAL RADIATION STANDARDS

1. SCOPE AND OBJECTIVES

Maintenance and Calibration of Standards for Radiometry and Photometry. Testing of light sources luminaires and associated lighting material accessories, light measuring instruments etc. to National and International Specifications. A major R&D activity in this area is to set up a Radiometric basis for measurement of light.

2. PROGRESS

Design of an automatic Goniophotometer for luminous flux measurements, and a radiometer for radiometric standards are on hand. Calibration and Testing of lamps, luminaires, optical instruments and associated optical components have been continued.

2.1 International Collaboration

Under the Regional (Asia/Pacific) Metrology programme of Commonwealth Science Council, participated in a round robin method of calibration of Lamp Standards for Illuminance. The report is under study by Australia for evaluation.

3. PROJECT TEAM

K.S. Sarma — Project Leader
K.C. Joshi, O.P. Bhola, Mrs S. Manrai, H.C. Khandpal, K. Chander, V.K. Sharma.

STANDARDS OF ACOUSTICS

1. SCOPE AND OBJECTIVES

To maintain Primary/derived standards relating to measurements in acoustics such as sound pressure, vibration amplitude, hearing threshold for air and bone conduction and a.f. voltage.

To calibrate instruments used for acoustic and electro-acoustic measurements in terms of these standards.

To test, on a chargeable basis, acoustic and electro-acoustic devices and acoustic materials for their performance characteristics and properties and to render consultancy.

2. PROGRESS

2.1. Standards

Primary calibration of one inch laboratory standard microphones by reciprocity method in a hydrogen filled coupler cavity and in free-field was done in the frequency range 50-12000 Hz.

Calibration of accelerometers by direct microscope measurement at low frequencies was done.

2.2 Calibration

Instruments used for measurements in acoustics have been periodically checked for performance and accuracy for in-house work and calibrated for outside parties.

2.3 Investigations

The increased sound absorption due to cones was investigated with a view to explaining this behaviour.

The noise power output of some domestic air-conditioners, desert coolers and refrigerators was investigated.

A noise survey of Delhi was carried out for Department of Environment.

3. PROJECT TEAM

A.F. Chhapgar — Project Leader
V.N. Sharma, V. Mohanan, Omkar Sharma, P.C. John, C.B.L. Gautam, Gurbir Singh.

STANDARDS OF TIME AND FREQUENCY

1. SCOPE AND OBJECTIVES

To realise the base units of time and frequency and to disseminate standard time and frequency signals to the users.

2. PROGRESS

The monitoring of "Epoch" or 'Time Instant' has been continued using NNSS satellite receiver and GBR (15 kHz) signals. OMEGA monitoring set-up was commissioned and regular VLF phase data is continuously recorded. VLF & HF studies were conducted at Antarctica and during the journey to the sub-continent.

Feasibility experiments for standard time and frequency signal dissemination via satellites INTELSAT-IV & INSAT-1B were conducted.

A laboratory model of Rubidium Vapour Frequency Standards was developed and preliminary studies on the stability have been made.

Accurate time and frequency signals were provided via NPL travelling clock to Radio Astronomy Centre, Ootacamund for experiments on Very Long Baseline Interferometry.

It has been certified that UTC (India) is within 10 microseconds of UTC.

Intercomparison was carried out with USSR through a travelling clock (Portable Cs Atomic Clock) brought from VNIIFTRI, Moscow.

3. PROJECT TEAM

B.S. Mathur — Project Leader
P. Banerjee, A. Sen Gupta, P.C. Sood, P.N. Taneja, A.K. Hanjura, M.L. Shakdhar, G.M. Saxena, G.K. Goel, Mithlesh Saxena (Mrs), A. Chatterjee (Mrs.), D.S. Sachdeva, Gurdial Singh, A.K. Suri.

STANDARES OF D.C. ELECTROMOTIVE FORCE, RESISTANCE AND CURRENT

1. SCOPE AND OBJECTIVES

To realize the units of dc voltage (volt), resistance (ohm) and current (ampere) and to establish the physical standards of these parameters at international level of accuracy.

To establish techniques of measurements of ratios of voltage, resistance and current.

To provide apex level calibration service to user organizations.

2. PROGRESS

2.1 Standard of E.M.F

Initial experiments to introduce automation in mutual intercomparison of standard cells were

carried out in collaboration with Appropriate-Automation Promotion Laboratory of IPAG-DOE. This system uses microprocessor based interface central processing unit, digital nano-voltmeter (IEEE 488-Compatible) and a printer. The switching system gave thermo-emfs of the order of 3-4 micro volts. It was decided to use an automatic scanner coupled to a micro-computer. Standards voltage (1 μV to 1000 Volts) and voltage ratio based on Precision dc Calibrator and Kelvin Varley Divider with traceability to primary standard of dc voltage have been established.

Under Asia Pacific Metrology Programme intercomparison of dc voltage standard using 'Transvolt' as the travelling standard has been completed.

2.2 Standard of D.C. Resistance

International intercomparison of dc resistance standard was carried out under APMP. Literature survey and preparation of feasibility report on Quantum Hall Effect were carried out.

2.3 Calibration Service Rendered

Calibration work for a large number of agencies including public and private sector laboratories and industries was undertaken. The equipment calibrated included standard resistors and cells, potentiometers, constant voltage and current sources, calibrators, voltage, current and resistance measuring instruments.

3. PROJECT TEAM

V.K. Batra — Project Leader
S.K. Mahajan, Ravi Mehrotra, T.V. Ganapathy, P.K. Mittal, B. Sircar, Amreek Singh.

CAPACITANCE, INDUCTANCE AND A.C. RESISTANCE STANDARDS

1. SCOPE AND OBJECTIVES

To set up primary standard of capacitance based on calculable capacitor and to realize the units of Farad, Henry, Ohm and Weber through it and to set up the scales of capacitance inductance and a.c. resistance. To provide apex level calibration service to user organizations.

2. PROGRESS

2.1 Primary Standard of Capacitance

Experiments were performed to improve the accuracy of the vertical model of calculable capacitor. The accuracy was improved to 2 parts in 10^7 by improving the optical alignment of the interferometer system.

2.2 Measurement of large value capacitance upto 1 Farad

A modified Kelvin double bridge using precision inductive voltage dividers was set up and evaluated for measurement of capacitances in the range 1 μF to 10 mF. Accuracies of 0.1% at 10 mF level at 120 Hz have been obtained. Work is in progress to extend the range to 1 Farad.

2.3 Measurement of Small Value Inductances $< 10\ \mu$H

A bridge using precision 8 decade IVD as a precise ratio standard was set up and evaluated for the measurement of inductances in the range 0.1 μH - 10 μH in terms of capacitance. The accuracy obtained at 1 kHz at 1 μH is 1%.

2.4 Design and Development of Inductive Voltage Dividers

Work on the development of 8-decade precision IVDs with ratio accuracies of a few parts in 10^8 was undertaken and is expected to be completed soon. Facilities to calibrate precision 8-decade IVDs are also being created.

2.5 International comparison of Primary Standards of Capacitance and Inductance

International comparison of 10 pF and 10 mH standards of capacitance and inductance respectively was carried out with VNIIM, USSR. The standards of capacitance agreed to within 1 part in 10^6 and the standards of inductance agreed to within 2 parts in 10^5.

2.6 Calibration Service Rendered

Calibration of Capacitance and Inductance Standards and Impedance bridges from various laboratories and public and private organisations at Echelon I level was carried out.

3. PROJECT TEAM

S.L. Dahake — Project Leader
R.N. Dhar, A.K. Saxena, Kewal Kishan, Naib Singh, Bal Kishan, K. Chandra.

AC, L.F. & H.F. STANDARDS

1. SCOPE AND OBJECTIVES

To develop, maintain and update the primary and transfer standards and to establish the associated Echelon - I Calibration Facilities in respect of AC & LF Voltage, Ratio and Attenuation, Current, Power & Energy, H.F. Voltage & Current, Power, Attenuation, Impedance, Noise in the frequency range 6 Hz - 1 GHz.

2. PROGRESS

Bank of 10 multijunction thermal converters have been intercompared in round-robin manner upto 10 KHz. The AC/DC transfer error assigned to the MJTC's varies between 2-10 ppm. This will work as Primary standard of voltage from 10 Hz to 100 KHz.

Comparator technique for measurement of single phase A.C. power based on 3-Phase 2 element torsion-held electrodynamic wattmeter has been set up with AC-DC transfer accuracy of ± 0.05% at 50 Hz. Energy measurement facility has been augmented for voltage and current compliances upto 2 KV, 200 A from 0.25 to unit power factor.

Facilities have been set up to calibrate current transformers upto 800 A with accuracy of 0.1% at 50 Hz. Technique is being set up to calibrate C.T.'s and PT's for ratio and phase angle errors using Inductive Voltage Dividers having accuracy 2×10^{-8}.

Ist Model of Thermal Wattmeter has been fabricated and is being evaluated at 1 KHz.

Calorimetric technique using twin resistance power head for measurement of HF power and voltage has been established with over-all uncertainty of ± 0.5% upto 1 GHz. Transfer standard thermal converters have been assigned values upto 1 V level for 30 MHz to 1 GHz with uncertainty of ± 0.08% to ± 1.1%.

Standard signals from 0.001 Hz to 1 GHz with stability of $\pm 1 \times 10^{-10}$ tranceable to Cs atomic clock have been generated for precision calibration work.

R.F. & I.F. substitution techniques for calibration of precision attenuators have been set up with uncertainties lying between 0.1 dB/10 dB to 0.01 dB/10 dB between 10 MHz and 1 GHz.

The dimensional measurements of Precision Reference Airlines have been done with respect to Primary Standards of Length maintained at NPL and the associated R,L,C values have been computed in the frequency range 30 KHz to 1 GHz.

2.1 Additional Calibration Facilities have been set up for

- Selective Microvoltmeters/Field Strength Meters,
- Precision AC-DC Calibrators and thermal transfer standards,
- Modulation depth meters and Carrier Deviation Meters,
- Synthesizers, timers, converters, reciprocal counters,
- Standard Q coils upto 30 MHz,
- Coaxial RF Power meters and signal analysers,
- Specialized screened twin conductor cables, PLCC and telecommunication cables etc.

2.2 Calibration Services

Reference Standards of about 60 organizations have been calibrated.

2.3 International Intercomparisons

(a) Thermoelectric Standards

In the 2nd phase NPL's Transfer Standard Thermal Converters (0.5V to 7V) were compared at 1 MHz to 30 MHz against respective USSR Standards and agreed to within 0.1% for their AC/DC transfer error.

(b) Calorimetric Standards

In this limited and informal intercomparison, a 1V Thermal Converter was assigned values at 30, 100, 500, 700 & 1000 MHz against the Primary Standards of H.F. voltage at PTB, West Germany. The same TVC was reassigned the values in terms of the corresponding standards at NPL. The AC/DC transfer error assigned in the two laboratories are in agreement to within ± 1% at the highest frequency of measurement (1 GHz).

(c) Attenuation Standards

Five travelling standard attenuators of 3 dB, 6 dB, 10 dB, 20 dB and 40 dB were measured

in terms of NPL's Transfer Standard having measurement uncertainty of 0.005 dB/10 dB at 30 MHz. The results of intercomparison carried out by the different labs. have been sent to the Pilot Laboratory (NML, Australia) for compilation, analysis and publication.

3. PROJECT TEAM

Sharwan Kumar — Project Leader
Joginder Singh, Omkar Nath, V.K. Rustagi, Gurmej Ram, A.K. Govil, Sita Ram, M.K. Mittal, M.R. Nagar, Surinder Singh, Mrs A.R. Kaushik, T.R. Arora, Inder Bhan, Darshan Singh, K. Chandra.

MICROWAVE STANDARDS OF POWER, FREQUENCY, NOISE ATTENUATION & IMPEDANCE

1. SCOPE AND OBJECTIVES

To establish, maintain and update the primary and transfer standards of power, attenuation, impedance, frequency and noise in the microwave frequency range from 1 GHz to 40 GHz at internationally accepted accuracies.

To establish apex level calibration facilities at microwave frequencies (1 GHz - 40 GHz).

2. PROGRESS

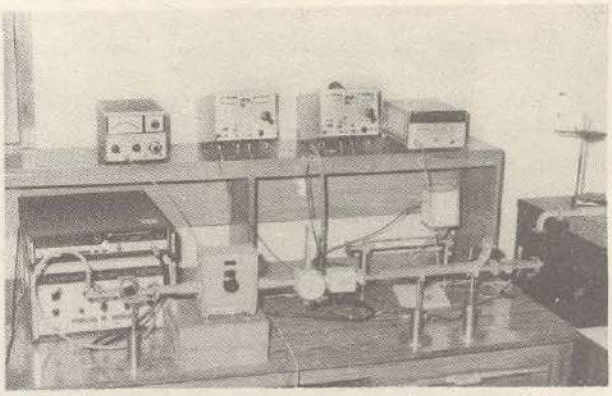
2.1 Microwave Power Standards

(i) Development of Primary Standard bolometer mounts

A set of five primary standard bolometer mounts matched at spot frequencies of 8.0, 9.0, 10.0, 11.0 & 12.0 GHz in the X-band have been fabricated using thin film elements. These mounts have been calibrated for the effective efficiency using microcalorimetric technique established by the group. The total uncertainty in the measurement of effective efficiency comes out to be ± 0.58%.

(ii) Calibration of coaxial bolometer mounts against primary standard waveguide mounts

The two techniques viz. i) Direct comparison technique * and (ii) Adaptor technique used internationally for calibration of coaxial bolometer mounts invariably supplied with commercial microwave power meters have been established. In the adaptor technique an accurate knowledge of adaptor loss, besides its being perfectly matched at the desired calibration frequency, is essential. For this purpose adaptors in the X and XN bands have been evaluated for their loss using power ratio technique with total uncertainty better than 0.005dB. The two techniques have been thoroughly studied experimentally and a detailed error analysis has been carried out. The present uncertainty in the coaxial mount calibration lies within ± 1%.



"The direct comparison technique for the calibration of effective efficiency of unknown bolometer mount against primary standard barretter mount at 10.0 GHz".

With the addition of coaxial RF power transfer standards in the frequency range 2.0 to 18.0GHz and waveguide RF power transfer standards in XN, X and Ku-bands, microwave power calibration facilities are now available at a spot frequencies of 2.0,3.0,4.0,6.0,8.0, 10.0,12.4,15.0 & 18.0GHz in coaxial system and at 6.0,7.0,8.0,10.0,12.4,15.0 & 18.0GHz in waveguide systems with transfer uncertainty of 1.5%.

2.2 Microwave Frequency Standard

The present microwave frequency measurement facility has been extended to 40.0GHz during this period. The measurement accuracy is ± 1 count ± time base accuracy which comes to ± a few Hz in 40.0GHz. Microwave signals derived from BWO sweepers in different bands have been phase locked to a stability of the order of a few parts in 10^9. Therefore, standard signals are now available in 1.0 to 12.4GHz range and 18.0 to 26.0GHz range with 10KHz resolution.

2.3 Microwave Noise Standard

The equipment procured for the measurement of noise parameters namely noise factor, noise

figure, excess noise ratio and equivalent noise temperature in the frequency range of 0.01 to 18.0 GHz has been put into operation

Calibration of transfer standard noise sources have been carried out using Hot and Cold primary standard noise source and the data given verified. Commercial noise sources have been calibrated using the transfer standard noise source with an uncertainty of ± 0.05dB.

2.4 Microwave Attenuation Standard

International comparison of microwave attenuation at 30 MHz; Five travelling transfer standards of attenuation of nominal values 3dB, 6dB,10dB and 40dB were calibrated at 30 MHz by series substitution technique using 30MHz waveguide below cut off attenuator and VM-3 receiver. The international comparison of attenuation standards was carried out amongst NML (Australia), NIM(China), NPL (India) and SISIR (Singapore) under Asia Pacific Metrology Programme of Commonwealth Science Council.

A study of the variation of attenuation offered by rotary vane attenuators with frequency was carried out.

2.5 Microwave Impedance Standard

Precision XN-band waveguide with a residual VSWR 1.004, precision termination of low VSWR (Element VSWR 1.005), three quarter wave short circuits at XN band frequencies (6,7,8 GHz) for use as reflection coefficient standard, and standard mismatches (X-band) of nominal VSWR 1.20 and 1.30 have been designed and developed.

Three quarterwave short circuits at X-band frequencies (10,11 and 12GHz) have also been designed and developed.

3. PROJECT TEAM

V.K. Agrawal - Project Leader

R.S. Yadava, Ram Swarup, P.C. Kothari, H.M. Bhatnagar, Ritander Aggarwal, P.S. Negi, R.L. Mendiratta, Sathu Singh, R.C. Bansal.

K. Chandra

MATERIALS CHARACTERIZATION DIVISION

Area Coordinator - Dr. Krishan Lal

INTRODUCTION

This group, over the years has developed strong infrastructure for characterization of materials regarding : (i) purity and composition; (ii) crystal structure; and (iii) defects in solids. Expertise has also been developed for growth of nearly perfect single crystals. These facilities are being provided to Scientists in the laboratory working on different projects as well as to users in other institutions.

A number of sophisticated equipment and advanced techniques for preparation and characterization of materials have been developed within the Division. All the scientific groups have been engaged in basic research in their areas of specialisation.

The following new major facilities have been established:

(1) A DIGILAB Fourier Transform Infrared Spectrometer.

(2) A 200 KV Jeol Transmission Electron Microscope with Scanning attachment.

(3) A Siemen's Powder X-ray Diffractometer with microprocessor control.

(4) A Double Crystal X-ray Diffractometer designed and developed at the NPL.

(5) A Quadruple Crystal X-ray Diffractometer designed and developed at the NPL.

Some of the major achievements are briefly mentioned below:-

A new technique has been successfully evolved for determination of tungsten in steel. For determination of sulphur dioxide in the environment, techniques have been developed which do not involve use of any poisonous materials.

A compound pyroelectric detector has been developed and used for determination of absolute value of radiation power. Pyroelectric and ferroelectric behaviour of crystals was studied in detail. Detailed EPR studies of rotational motion of nitroxide probes in smectic liquid crystals were carried out. It was shown that molecular geometry in these crystals plays an important role in determining the order parameter. Structural studies of chalcogenide single crystals had been carried out. Crystal structure, thermal expansion and topotactic reactions have been studied in great detail in these materials. Defect structure in silver thin films has been studied by using the defocus contrast techniques in transmission electron microscopy. These results have shown that vacancies trapped in the film during deposition play an important role in the growth of voids in these. With the development of two new diffractometers in the group it has been possible to carry out new experiments in the area of high resolution X-ray diffraction. Anomalous dynamical effects have been observed near diffraction maxima in the Laue geometry on the quadruple crystal X-ray diffractometer. In a collaborative experiment with the scientists of the Physikalisch-Technische Bundesanstalt, F.R.G., anomalously large changes in diffracted X-ray intensities have been observed on application of microwave fields to silicon crystals. Reversible and irreversible microstructural defects were also observed. A study of porosity of porous carbon fibres has led to interesting results which can lead to the application of the materials as a molecular sieve.

The progress of the R & D activities of the Division is described in the following order:

(1) Characterization of Materials by Chemical Methods.

(2) Characterization of materials by Spectroscopic Methods.

(3) Characterization of Materials by electron paramagnetic resonance spectroscopy.

(4) Characterization of Materials by X-ray diffraction and Fluorescence Techniques.

(5) Characterization of Materials by Transmission and Scanning Electron Microscopy and Electron Diffraction Techniques.

(6) Characterization of single crystals regarding perfection and relevant Instrumentation.

(7) Growth of single crystals, their characterization and defects in single crystals.

(8) Characterization of Materials regarding Surface Area and Porosity.

CHARACTERIZATION OF MATERIALS BY CHEMICAL METHODS

1. SCOPE AND OBJECTIVES

To establish, maintain and provide facility of chemical characterization of minor and major constituents in various materials including high purity materials and environmental gas samples.

2. PROGRESS

A method has been developed for the determination of phosphorus (0.1 ppm) by atomic absorption spectrophotometry. Phosphorus is changed into phosphoantimonyl molybdate complex. The complex is extracted in methyl isobutyl antimony concentration. Also, a method has been developed for the determination of tungsten in steel. This method is an improvement on the existing methods and the precipitated tungstic acid does not absorb the other constituents like chromium, molybdenum and vanadium of steel. New methods have been developed for the determination of sulphur dioxide in the environment. These methods are as sensitive and specific as the earlier methods adopted for the evaluation of sulphur dioxide in the environment but do not involve the use of hazardous mercury salts.

Gas chromatographic facility has been established for the analysis of gases and volatile materials for their purity and composition. A method has been developed to analyze the ambient atmosphere for its hydrocarbon content with special emphasis on the methane concentration. R & D work has been done to develop teflon permeation tubes and for the calibration of gas chromatographs and pollution evaluating units. A method has been developed for the recovery of silver from waste hypo solution and a patent has also been filed.

Chemical analysis facility has also been provided to other institutions and industries for testing their products for which the facilities are scarce elsewhere.

3. PROJECT TEAM

D.C. Parashar - Project Leader
V.K. Amar, J.C. Trehan, J. Rai, Mrs. Ramadevi Ramachandran, A.K. Sarkar, Mrs. Vasantha Raman, Mewa Singh, Prabhat K. Gupta, M.S. Dabas, R.C. Sharma and Niranjan Singh.

CHARACTERIZATION OF MATERIALS BY SPECTROSCOPIC METHODS

1. SCOPE AND OBJECTIVES

To establish, maintain and provide to users in the laboratory and outside the laboratory, facilities for characterization of materials regarding purity and composition by spectroscopic methods. To develop techniques and equipments relevant to this area.

Pyroelectric infrared detectors and systems have wide applications in industrial process control, remote sensing and fundamental research.

2. PROGRESS

2.1 Installation of a Fourier Transform Infrared Spectrophotometer

A high performance Digital Fourier Transform Infrared Spectrophotometer (FTIR) has been commissioned. It covers the entire infrared range from 10 cm^{-1} (1000 um) to 10,000 cm^{-1} (1 um) and the maximum available resolution is 0.08 cm^{-1}

The FTIR has an optical console comprising of a Michelson Interferrometer of single beam optics with moving mirror controlled by air bearing and enclosed in a vacuum box. The frequency of the infrared spectrum is calibrated by He-Ne laser.

For low temperature measurements, an open cycle cryostat working down to liquid helium temperature has also been installed.

The performance of instrument was checked for absorption bands of H_2O and D_2O for rotational and vibrational eigen values. A complete agreement from the values of literatures was found. Signatures of different CZ and FZ grown silicon samples were also checked and found correct.

2.2 Compound Pyroelectric Detector and its applications

A new concept of compound pyroelectric detector has been evolved for the detection of absolute value of radiation power. It consists of two poled TGS crystal plates joined together through a conducting layer in such a way that the polarity of domains reverses across the junction. The gold black coating on the front electrode helps to get efficient absorption of radiation while the gold black coating on the back

electrode is used for generating in phase equivalent electric power. The output of the compound pyroelectric detector becomes null when the electric power is equal to radiation power. For this reason the compound pyroelectric detector is named as Pyroelectric null detector or PND. Use of compound pyroelectric detector was made in absolute measurement or radiation power from black body sources and spectral radiation sources.

The compound pyroelectric detector and an auxiliary pyroelectric TGS detector are coupled together in such a way that they receive in phase radiation from the target. The auxiliary TGS detector is used to generate electric heating in the compound detector. The system does not require any additional source to obtain reference signal. The system has been used for absolute measurement of spectral radiation power.

The principle of electrically balanced pyroelectric radiometer (EBPR)was utilised for remote sensing of temperature.

2.3 Reradiation Theory

A comparative study of reradiation theory (which has been published in a series of 8 papers) was made with other existing theories on optical properties of metallic mesh structures. It has been concluded that the reradiation theory explains the experimental data to the nearest values in comparison to theories known as harmonic expansion model, wave guide aperture model and impedance method. Possible error in the diffraction region between experimental and theoretical results, has been explained on the basis of different deviation between axial and peripheral rays resulting lesser power in the optical path. The results of δT as reported in the theory of Chen and Lee, have been ruled out in reradiation theory and these are in agreement with experimental results.

2.4 Investigations on Lateral Structure of Domains in Ferro-Electric Crystals

A new technique has been evolved to delineate the lateral structure of domains in ferroelectric crystals. The configuration of lateral part of domains provide information regarding penetration mechanism of domains inside the bulk crystal.

A focussed beam of He-Ne laser is allowed to fall on the surface perpendicular to ferroelectric axis and the resulting pyroelectric signal is taken from the electrodes fixed on the edges. The pyroelectric signal is analysed for its phase and magnitude in a lock-in-amplifier. Studies of the lateral structure of domains in ferroelectric TGS crystals have been performed.

Major findings of these studies are:

i) The lateral structure of domains has no definite and regular pattern. The size of domains varies from microns to a few millimeter.

ii) There are regions inside the crystal plate where the intensity of the pyroelectric signal is few times greater than the average pyroelectric signal. These regions named as high-pyro regions comprise of clusters of micro domains. These microdomains align and reverse their polarity on passing the heat hemisphere created by modulated laser beam.

iii) Choosing appropriate regions of TGS crystal plate, pyroelectric infrared detector with higher sensitivity can be made.

2.5 Growth of Single Crystals from Solutions and Study of their properties

Work of growth of single crystals from solution was continued and expanded to cover other crystals.

Mixed crystals of KDP & ADP have been grown and various physical properties of these mixed crystals are being investigated. With lower concentration of ADP in mixed solution of KDP and ADP resulted in needle shaped crystals.

We have also grown double sulphates of some crystals which crystalise without water molecule. Apart from this, Sarine doped TGS crystals were also grown.

2.6 Spectrographic analysis

a) Characterization by spectrographic analysis was continued for materials from various R&D projects of the NPL and other institutions. Samples of silicon, silica, Na_2SiF_6 from DST sponsored scheme on Solar Grade Silicon from Rice husk, IIT Kharagpur, from their rural countryside, Polycrystalline Silicon from NPL project on Solar Silicon, Al_2O_3 from IIP Dehra Dun, were characterized, among others.

b) A new design of a multiple-electrode assembly was made, to work in controlled atmosphere, to dispense with the need for allignment after every burn.

c) Experiment is being made to obtain optogalvanic effect using laser, which helps in detecting elements in ultra-trace concentrations.

Laser fluorescence studies have been undertaken. Enhancement of Ne-line intensity near 5250 Å was observed.

Studies are continuing, to investigate the origin of the orange (6120 Å) and green (5480 Å) bands arising from the excitation of Ca in flames and arcs.

Spectral reflection studies of liquid crystals, were made resulting in an exact understanding of their chromaticity and colour characteristics, as display devices.

3. PROJECT TEAM

M.M. Pradhan — Project Leader
S. Parthasarathy, R.K. Garg and Km. Manju Arora.

CHARACTERIZATION OF MATERIALS BY ELECTRON PARAMAGNETIC RESONANCE SPECTROSCOPY

1. SCOPE AND OBJECTIVES

To establish, maintain and provide facilities for characterization of materials regarding composition by Electron Paramagnetic Resonance Spectroscopy and to carry out basic research in this area.

2. PROGRESS

EPR study of rotational motion of nitroxide probes in smectic liquid crystals N-(p-Octyloxybenzylidine)-p-toludine (OBT) and p-nitrophenyl-p-n-Octyloxybenzoate (NPOB) and of vanadyl probe in N-1p-hexyloxy benzylidene-p-toludine (HBT) was carried out. Results show that molecular geometry of liquid crystals play important role in determining the value of the order parameter. It is found that entire smectic A phase in OBT is characteristic of slow tumbling region but in NPOB the slow tumbling region is almost at the end of smectic A phase.

EPR measurements on Rhenium thin film samples deposited on alumina substrate were made from liquid air temperature to 450K, and the orientation behaviour of the EPR signals were also observed. The effect of irradiation was to distort the CESR signal and to bring side absorptions closer.

EPR measurements of Chevral phase compounds $EuMO_6X_8$ (X=S, Se) were done from RT to liquid nitrogen temperature in order to understand their resistance anomaly. The results show that while the interaction between conduction electrons and Eu^{2+} ions is negative in $EuMo_6S_8$, it is possitive in $EuMO_6Se_8$.

EPR study of powder samples of $CuGa_x In_{1-x}Se_2$ for different values of x was made at room and liquid nitrogen temperatures. The signals observed were composition independent and were ascribed to the presence of Fe^{3+} impurities in the sample at sites with wide variation in symmetry from near cubic to very anisotropic. The composition dependence of B signals suggested that for x = 0.50 the intrinsic charge carriers are mainly of n-type resulting due to Se-vacancy and as we move away from x = 0.50, the p-type charge carriers resulting from Cu-vacancy holes are also present.

3. PROJECT TEAM

S.K. Gupta - Project Leader

CHARACTERISATION OF MATERIALS BY X-RAY DIFFRACTION AND FLUORESCENCE TECHNIQUES

1. SCOPE AND OBJECTIVE

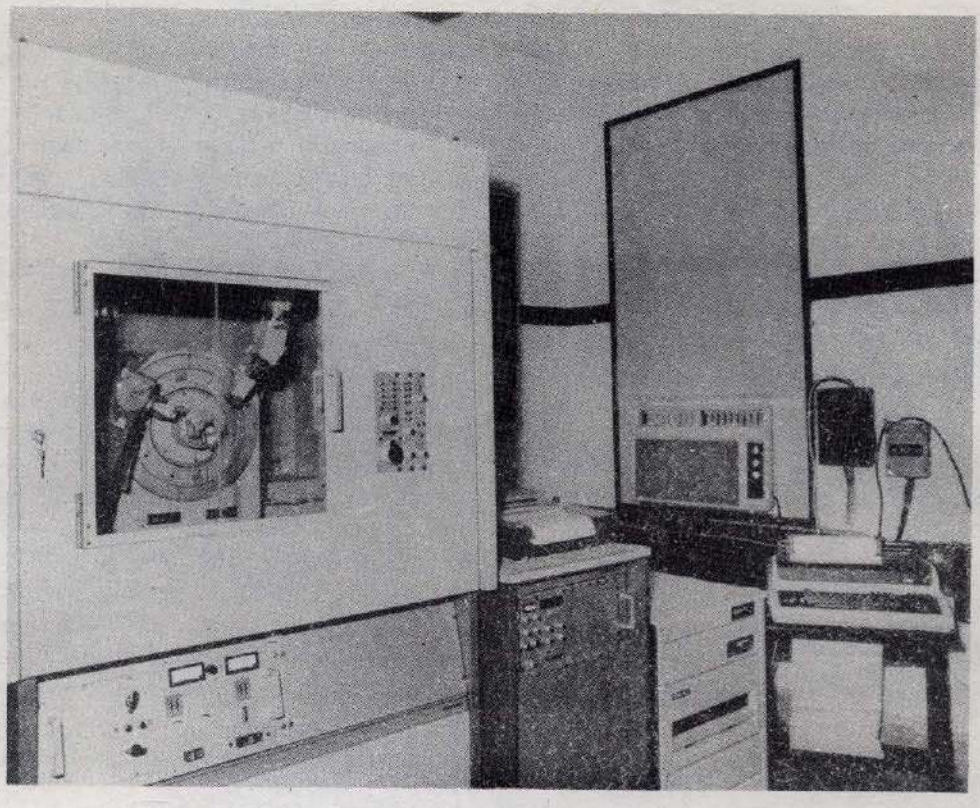
To establish, maintain and provide facilities to NPL scientists and other scientific and industrial institutions for characterisation of polycrystalline and single crystals by using various x-ray diffraction and fluorescence techniques.

To carry out basic research in the area of crystal structure and phase transformation in materials of scientific and technological importance.

2. PROGRESS

2.1 Installation of computer controlled automatic powder diffractometer

A Siemens D-500 automatic x-ray diffractometer has been installed, checked and calibrated by running few standard programmes. The instrument carries out predetermined analysis



Siemens D-500 automatic microprocessor controlled X-ray diffractometer.

programmes, calculates quantitative results incorporating mathematical corrections to compensate for practical deficiencies and presents output information in an easy to understand and immediate usable form. 2θ measurements can be made to an accuracy of 0.001°, and increased resolution is achieved by curved crystal monochromator. Typical computer programmes such as peak search, peak identification, other data acquisition, data reduction and data evaluation programmes can be carried out by Microprocessor PDP 11/03 on the above diffractometer.

2.2 Study of crystal structure of chalcogenides:

X-ray diffraction and other related studies on various chalcogenides have been carried out.

a) From the crystallographic data collected on Ga_2Se_3 it was found that the integrated intensities of the total profile of the peaks and their associated diffuse components corrected for Lorentzpolarization and multiplicity factors from diffractometer intensity records gave the Debye-Waller factor as B 2.14 and 2.35 for α-Ga_2Se_3 and Ga_3Se_3 respectively. The results indicate that the disorder in the structure due to distortion is much more than can be ascribed to temperature alone.

b) Ga_2Te_3 compound semiconductor was synthesized and was studied by both powder and single crystal methods: Some single crystals of Ga_2Te_3 were found to be composite crystals exhibiting contact twinning with complementary forms 111 and 11$\bar{1}$. Single crystals studied by Laue, Oscillation, rotation and Weissenberg x-ray diffraction techniques indicated unique features of sharp satellite reflections. A pair of satellite reflections placed symmetrically with respect to the nodes of 111 reciprocal lattice point was observed, whereas the 226 reflection was found to be surrounded by two such relatively strong pairs of satellite reflections. In the Laue pattern these two pairs of satellite reflections are found to merge into one another forming a di-pyramidal like shape of the satellites around 113 reflections.

c) In the Cu-Ge-Se- system the composition $Cu_2Ge_{1.55}Se_3$ of the type $A_2^{I}B^{IV}C_3^{VI}$ was synthesized. The diffraction patterns were characterised by a set of strong lines along with a set of weak lines confined mainly to the low to medium angle region. The strong lines have been indexed on an orthorhombic super lattice of the cell having a = 3.932A°, b = 22.242A°, c = 11.796A°. The orthorhombic cell constants are related to a by the relations $a = a_o\sqrt{2}$, $b = 4a_o$ and $c = 3a_o\sqrt{2}$.

d) Compounds belonging to the system $CuGa_xIn_{1-x}Se_2$ which crystallise in the chalcopyrite structure were synthesized and studied for various compositions of x. The accurate lattice parameters have been obtained for x = 0.25, 0.5 and 0.75 which are found to obey Vegard law. Thus the compositions of any chalcopyrite in pseudo binary system $CuGaSe_2$ and $CuInSe_2$ can be obtained from the lattice parameter graph. Electron spin resonance study of the samples was also done at room and liquid nitrogen temperatures. The study suggests that for x = 0.50, the charge carriers are mainly of n-type resulting due to Se-valency. Away from x = 0.50 the p-type carriers due to Cu valency holes are also present.

e) Thin films of the compound $Cu_2GaInSe_4$ were grown by vacuum evaporation on glass plates and rock salt crystals at various substrate temperatures. The structure has been confirmed by electron diffraction and x-ray diffraction tehniques. The optical band gap was calculated by measuring reflectance and transmittance values and absorption coefficients were calculated by using a computer programme. The results indicate that the characteristics of films are growth dependent. Electrical conductivity of these films are found to p-type with a_2 resistivity of 1-100 Ω cm and a hole mobility of 1-2 $cm^2 v^{-1}s^{-1}$.

f) In the system SnSe - Sb_2Se_3 some of the results of the x-ray study, carried out on two compositions $Sn_2Sb_4Se_8$ and $Sn_4Sb_4Se_{10}$, have been reported.

2.3 Study of cotton and carbon fibres:

In collaboration with IARI, New Delhi, x-ray studies have been extended to Gossypium arboreum species of cotton. The correlation coefficient between fibrestrength and crystallinity has been found to be low as compared to 40% or 50% x-ray orientation angle. The particles size measurements perpendicular to 002, 101, $10\bar{1}$ reflecting planes when compared to a and c parameters of the unit cell reveal that the fibre crystallites have 5 to 6 unit cells associated laterally.

In addition to this over two dozen varieties of cotton belonging to Gossypium Hebaceum and Gossypium Barbadense species have been analyzed by x-ray diffractometer and Laue method, and results on these are being computed.

Courtella precursor fibres, the base material for carbon fibres, were treated with CuC1 and studied by Laue and x-ray diffractometer techniques before and after stretching. A marked improvement in orientation was observed after stretching.

2.4 Study of thin films of CdS and other materials:

A large number of thin coatings of CdS, tungsten carbide and WO_3 prepared by applied projects of NPL have shown that the structure of CdS is of the normal type in some cases and highly distorted in others while only thick tungsten carbide films have shown prominent lines of some of the carbide phases.

2.5 Study of soils:

In collaboration with CRRI, New Delhi on the project "Study on durability of lime stabilization of soils" extensive x-ray studies have been carried out. Lime was mixed with black cotton soils and the samples were analysed before and after the durability tests which were extended upto several days. The main crystalline phases have been found to be quartz and montimorillonite Calcite was also observed in some of the samples. Further investigations have yielded results contrary to general expectations. Some samples of Alluvial and Karnol soils mixed with free lime have also been analyzed.

2.6 Orientation of single crystal and silicon discs:

Orientation of one dozen silicon wafers, each of 50 mm dia and 0.4 mm thickness from CEERI, Pilani has been determined using back reflection Laue method. Orientation of surface normal

was found to be mainly (111) except in two cases in which it was found to be (001). The error of orientation in these directions varied from, one sample to another, the range of variation being 0-4.5°.

2.7 Studies on matrix correction programme:

Studies on matrix correction programme in x-ray fluorescence analysis had been taken up. Three different types of correction programmes viz. physical parameter programme, pure element programme and empirical coefficients programme for matrix effects have been evaluated with respect to the practical difficulties of measurement.

2.8 X-ray analysis of general materials:

A large number of samples have been tested for various divisions of NPL, industry and research institution. These include InSb, B-alumina, biolite mica, BiNi, CdS, Cas, tungstic acid, carbon rods, coke and pitch, polymer sample, fly ash, synthetic diamond powders, amorphous silicon coatings, indium oxide, iron and carbon powders, quartz plates etc.

2.9 Studies on Adsorption Isotherms:

Theoretical work on vapour adsorption on porous materials by means of a new adsorption isotherm equation has been done for obtaining the different parameters such as mesopore area, degree of microporosity, surface area, limiting micropore area and monolayer capacity etc. The isotherm equation has been extended successfully to binary and ternary isotherms. The equation for binary mixture is derived as

$$\log \quad \log P_{12} = C_{12} + n_{12} \log v_{12}$$

and for ternary mixture

$$\log \quad \log P_{123} = C_{123} + n_{123} \log v_{123}$$

Different parameters based on these equations have been determined. The equation is direct and involves less mathematical calculations.

3. PROJECT TEAM

K.C. Nagpal - Project Leader
K.D. Kundra, U. Dhawan, D.K. Suri, D.P.Singh.

CHARACTERIZATION OF MATERIALS BY TRANSMISSION & SCANNING ELECTRON MICROSCOPY AND ELECTRON DIFFRACTION TECHNIQUES

1. SCOPE AND OBJECTIVES

The main objective of the group is to establish, maintain and provide facilities of the characterization of materials regarding micro-structure, defects in materials, surface morphology and topography by electron diffraction and electron microscopy methods to support various research and development programmes of the NPL. The group also carried out some basic work in the areas of materials science/solid state physics particularly in the microstructure of the thin films of materials relevant to the research programme of the laboratory.

2. PROGRESS

An attachment of the Scanning Electron Microscope JSM-35 CF viz. Energy Disperasive Spectrometer from M/s Kavex, USA was installed and made functional. Various materials were tested to see its performance and functional ability.

New Transmission Electron Microscope of Jeol make model JEM-200 CX alongwith scanning attachment has been commissioned. Its performance and resolution have been tested. Using JEM-200 CX it has been possible to resolve (220) Lattice plans of gold indicating a resolution of 1.442A°. About 95 samples from different research activities within & outside the laboratory were examined with TEM and electron diffraction to study the structure of a variety of materials and their orientation.

About 850 samples from R&D projects within the laboratory and outside organizations have been examined for surface structure and morphology using SEM. Similarly 121 samples have been tested for elemental analysis using Energy Dispersive spectrometer of S.E.M.

Out of these investigations some of the most significant jobs are described below:

2.1 Failure analysis of stainless steel electrodes:

National Thermal Power Corporation, New Delhi had a problem in one of its super thermal power stations about the repeated failure of stainless steel electrodes in the power plant. The fractured surface of the electrodes was examined in detail and it was observed there

Scanning Electron Microscope Jeol-JSM 35CF with Energy Dispersive Spectrometer and Wavelength Dispersive Spectrometer.

were micro cracks in the electrodes materials which caused a failure of electrodes. Thus indicating a clue that the electrode material had inherent defects which resulted in the failure of the electrode.

2.2 High failure rate of electric bulb.

H.M.T. Hyderabad had a high failure rate in electric bulbs using a particular lot of tungsten coated filament. The tungsten filaments used in these bulbs were examined by S.E.M. It showed additional very fine fibre sticking with the filaments wire. The elemental analysis of the fibre using E.D.S. showed that the fibre consists of copper which was shorting the tungsten filaments and causing a high failure rate in the electric bulbs produced from the tungsten wire of a particular lot.

2.3 Selective surfaces produced from the structured Nickel

A large number of samples of selective surfaces were prepared with structured Nickel coating on Aluminium sheet and their surface structure and morphology were investigated using S.E.M. The optical and thermal constants viz. absorptance and emissivity of the surface so produced were also evalued from U.V.I.R. Reflectance measurements. Efforts were made to optimise the preparation parameters and to give different coating layers before the structured Nickel is prepared so as to get selective coating with high selectivity, i.e., high absorptance and low emissivity. The microstructure of the intermediate layer and their elemental analysis has also been done to understand the optical behaviour of selective surfaces. Attempts are being made to correlate the optical properties of the selective surfaces so produced with the microstructure and morphology of the layers.

2.4 Study of defects in silver films

The data collected on the structure of silver films using defocus contrast teachnique in transmission electron microscopy were analysed. The role of vacancies and gas molecules trapped in the film during the film deposition process has been considered in the formation of the voids and their growth. From the results it appears that the vacancies trapped in the film play an important role in the diffusion of gas molecules and in the growth of the voids.

2.5 Analysis of a fractured Cu tube

Pure copper tubes used for water circulation in one of the super thermal power stations (as supplied by N.T.P.C.) showed fracture repeated at the joints. The fractured surface was examined by SEM and electron micro probe analysis of the surface to investigate the reason for frequent failure. Careful examination showed that the copper tube contained precipitate of silicon which caused repeated failure of the tube in the power station.

2.6 Examination of corroded material exposed to geothermal fluid

A large number of bronze and steel samples exposed to geothermal fluid, at various geothermal wells supplied by Central Electricity Authority, have been examined. The micro structure, thickness and electron micro probe analysis of the deposited elements during exposure has been carried out using Scanning Electron Microscope and Energy Dispersive Spectrometer.

2.7 Study of samples collected from sea-bed

A few ore samples collected from sea bed and mines received from R.R.L. Bhubaneshwar have been examined to study the morphology and electron micro probe analysis. The study gave useful information about the various elements present in the ores.

2.8 Study of microstructure of Chromium films evaporated in CH_4

In joint collaboration with the Atomic Energy Commission France the microstructure of Chro-

mium films prepared in methane atmosphere by activated reactive sputtering has been studied. The films prepared under different conditions revealed different structure when examined by H.R. electron microscopy. Using Electron Energy Loss Spectroscopy (EELS) the trance impurities of carbon and oxygen in the films were investigated. The EDS was used to determine the major impurities incorporated in the film during the film growth. It has been observed that the Cr films prepared at higher partial pressure of methane showed the presence of crystalline as well amorphous/micro crystalline phase simultaneously in the films. The preliminary study of micro diffraction of these films did not show the carbide phase of chromium.

2.9 Preparation of silver films under U.H.V. conditions

The study of voids in silver film was carried out. Silver films of 500 A^{o} to 1000 A^{o} have been prepared under U.H.V. conditions. The films so prepared will be studied to investigate the presence of voids using H.R. electron microscopy.

3. PROJECT TEAM

S.K. Sharma - Project Leader
Narendra Kumar, G.L. Malhotra, S.U.M. Rao and N.C. Mehra.

CHARACTERIZATION OF SINGLE CRYSTALS REGARDING PERFECTION AND RELEVANT INSTRUMENTATION

1. SCOPE AND OBJECTIVES

This project aims at setting up of facilities for characterization of single crystals regarding perfection by high resolution X-ray diffraction techniques. The sensitivities of these techniques are aimed to be at the highest level. This project also aims at developing major sophisticated equipments and techniques in this area.

2. PROGRESS

2.1 The high resolution X-ray diffraction facilities established for characterization of nearly perfect single crystals regarding perfection include:

(i) X-ray diffraction topographic system for characterization of grain boundaries, low angle boundaries and dislocations.

(ii) a tripe crystal X-ray diffractometer for recording diffraction (rocking) curves, high resolution topographs and for study of point defects and their aggregates in nearly perfect single crystals by high resolution diffuse X-ray scattering measurements.

These facilities were improved to meet the current requirements and development work on the following two new diffractometers was completed.

(i) a double crystal X-ray diffractometer for recording diffraction (rocking) curves and large area high resolution topographs.

(ii) a quadruple crystal X-ray diffractometer for (i) study of electric field induced microstructural changes in single crystals; (ii) determination of absolute value of lattice parameter of nearly perfect single crystals at 1-10 ppm precision and (iii) study of anomalous dynamical effects near diffraction maxima in nearly perfect crystals.

2.1.1 X-ray topographic investigations

In view of the emphasis being given to the development of LSI/VLSI technology in the country, the existing X-ray diffraction topography system was modified to suit crystals which are to be used in this new technology. With the equipment developed earlier in the laboratory, crystals of diameters upto 25 mm could be characterized. A new collimator and a new vertical circle goniometer were designed and fabricated, with which crystal wafers of diameter upto 100 mm can be characterized. This system has been tested and is being used. An improved anode stem was developed for the microfocus X-ray generator.

X-ray diffraction topographic facilities have been used to study the process of photodimerization in organic crystals like 7-methoxycoumarin in collaboration with the scientists of Indian Institute of Science, Bangalore. Alkali halide crystals grown at the NPL and number of silicon single crystals were characterized on these

facilities. A study of the seed-melt interface in Czochralski grown alkali halide crystals has been initiated and is in progress. Variation of strain with growth parameters is being studied.

2.1.2 *High resolution diffuse X-ray scattering studies of nearly perfect silicon single crystals grown by the float zone method on the triple crystal X-ray diffractometer*

Reciprocal space near 111 reciprocal lattice points of nearly perfect silicon single crystals cut along (111) planes was explored with a highly collimated and monochromated MoK$_{\alpha 1}$ beam.

Diffraction curves of these crystals have half widths of 5-10 sec. of arc. The shape of the diffraction curves shows several dynamical features. Some of these crystals show nearly 100% reflectivity in a small angular range. The diffuse scattering is predominantly due to point defect aggregates. The nature, size and shape of these clusters have been determined and compared with those observed by us in crystals grown by the Czochralski method. The most prominent knee point observed in Czochralski grown crystals at $K^* \approx 1 \times 10^4 cm^{-1}$ is not observed in these crystals. K* is the scattering vector. The prominent knee points in these crystals are at 1 K* 1 values of 2.5 - 5×10^3 cm^{-1} and 4-10 x 10^4 cm^{-1}.

2.1.3 *Study of effect of microwave field on silicon single crystals by high resolution X-ray diffraction method*

As a collaborative research activity of this and the Division of Electricity (Abt.2), Physikalisch Technische Bundesanstalt (PTB), Braunschweig, F.R.G., a new experiment was successfully conducted at the P.T.B. It was aimed to find out whether electric fields at microwave frequencies also produce defects which can be observed and characterised by the high resolution X-ray diffraction methods developed at the NPL. Earlier, reversible and irreversible microstructural changes induced by dc and low frequency ac fields (max. frequency 10 MH_3) were successfully observed and characterized. The microwave experiments were considered to be of importance not only from pure academic points of view but also for potential application in microwave field, power and dose measurements.

A triple crystal X-ray diffractometer similar to the one developed at the NPL was used in this work. In this system a highly collimated and monochromated Mo $K_{\alpha 1}$ X-ray beam is used. The specimen is oriented in symmetrical Laue geometry. Diffraction curves, high resolution topographs and curvature measurements were made. Significant reversible and irreversible changes induced by the microwave fields were observed in these crystals. Successive application of electric field produced strong measurable changes in the curvature and topographs. Successive applications of the field produced remarkable decrease in the curvature and improvements in the half width of the diffraction curve. Topographs showed decrease in the background structure and generation of point like features. A very fascinating new feature has been observed in these experiments. Some regions of the specimen show a large increase in the diffracted X-ray intensity. Such an observation is not known in the literature.

2.2 Instrumentation

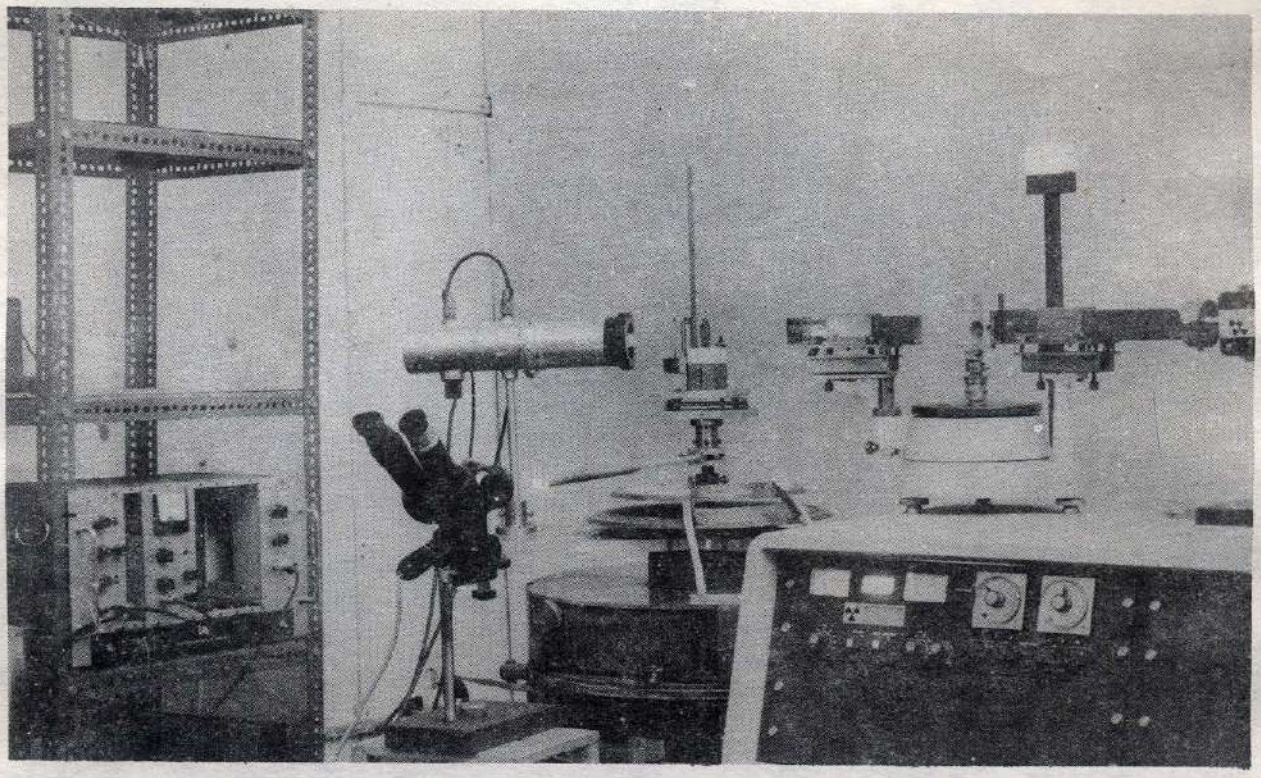
2.2! 1 *Double crystal X-ray diffractometer*

This system has beendesigned and developed for study of perfection of nearly perfect single crystals by double crystals topography and rocking curve measurements. The system has been now set up. At first, it was tested by using a symmetrically cut silicon single crystal monochromated having (111) as the diffracting planes. The specimen could be oriented in Laue as well as Bragg geometry using (+, -) or (+, +) settings. The exploring beam for the specimen is a monochromated $K_{\alpha 1}$ beam. The system has been finally adjusted with asymmetrically cut monochromated crystal. The diffracting planes are (111) and make an angle of about 5^0 with the surface. This makes it possible to record large area topographs without traversing the specimen crystal. Diffraction (rocking) curves can also be recorded.

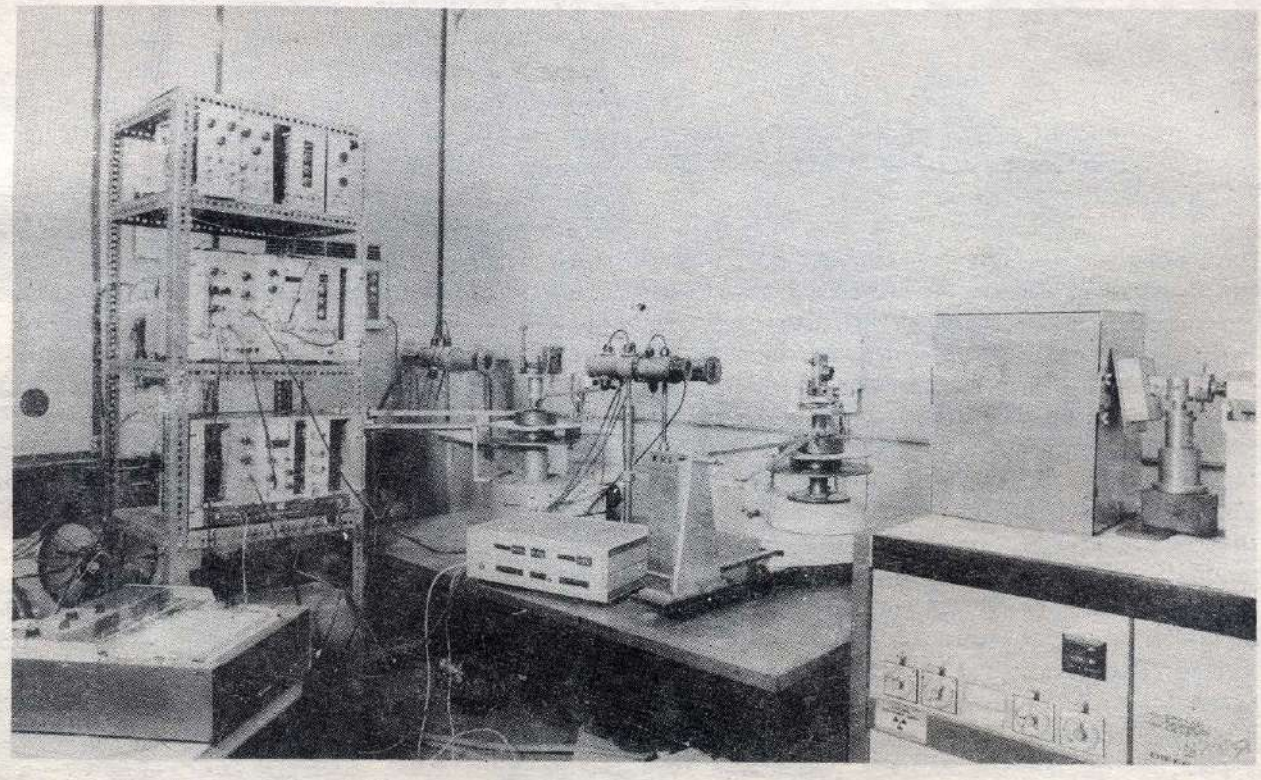
2.2.2 *A quadruple crystal X-ray diffractometer*

The developmental work on this equipment is nearly complete and the system is ready for testing.

A highly collimated and monochromated X-ray beam is achieved by combining a fine focus X-ray tube, a special collimator adjusted for large fore-shortening, two plane crystal



Double Crystal X-ray Diffractometer designed and developed at the National Physical Laboratory.



Quadruple Crystal X-ray Diffractometer designed and developed at the National Physical Laboratory.

monochromators and a second collimator with a fine adjustable slit. The monochromators are made from a dislocation free silicon single crystal with diffracting planes parallel to (111). The crystals are set in the symmetrical (+1, -1) Bragg configuration. A highly collimated $K_{\alpha 1}$ beam is produced and used for diffraction from the other two crystals. The third crystal is generally alligned in Laue geometry in (+, -, +) or (+, -, -) settings. Diffracted beam from this crystal is diffracted from the fourth crystal. The fourth crystal is mostly aligned in symmetrical Bragg configuration in the dispersive or the non-dispersive modes. The third and fourth crystals diffract over an angular range of a few seconds of arc. With the turn tables used to orient these crystals rotations of 1" of arc can be provided and measured. The fourth crystal - turntable also has a stepping motor drive which produces rotations of .002° per step over 360°.

The main outputs obtainable from this system are:

i) diffraction curves or rocking curves;

ii) high resolution traverse topographs;

iii) measurements of curvature of lattice planes (radius of curvature of 1 Km. or so can be detected and measured).

iv) absolute value of interplanner spacing;

v) intensity-vs-glancing angle between the surface and the lattice planes of nearly perfect crystals.

3. PROJECT TEAM

Krishan Lal - Project Leader
Vijay Kumar, S.N.N. Goswami, S.D. Sharma (Part time), G. Bhagwannarayana, Vijay Kumar Gumber (part of the time) and A. Malik.

GROWTH OF SINGLE CRYSTALS, CHARACTERIZATION OF DEFECTS IN SINGLE CRYSTALS

1. SCOPE AND OBJECTIVES

This project aims at producing well characterized nearly perfect single crystals from the melt. The project also aims at developing major equipment like crystal pullers, furnaces etc. and techniques for growth of nearly perfect single crystals.

2. PROGRESS

Work was continued on the growth of alkali halide single crystals by using resistively heated furnaces. A large number of crystal plates were prepared for application in infrared equipment.

A study of the effect of growth parameters on the degree of perfection of these crystals was carried out. Some crystals grown in other laboratories were also characterized.

A study of the strain at the seed-crystal interface has been initiated. KCl single crystals were grown at different rates and with different speeds of rotation. Specimen were prepared with growth axis parallel to their large faces. In such specimen, variation of strain as the crystal grows can be investigated. X-ray diffraction topography has been used for this study. A few topographs have also been recorded by using the double crystal X-ray diffractometer being established in the laboratory. A radio frequency heating system has been installed. A few crystals of LiF have been grown with this facility. A system for growth of crystals with controlled environment has been designed and is under fabrication.

3. PROJECT TEAM

Krishan Lal - Project Leader
R.V. Anantha Murthy, Vijay Kumar, S.K. Haldar, S.D. Sharma and S.N.N. Goswami.

CHARACTERIZATION OF MATERIALS REGARDING SURFACE AREA & POROSITY

1. SCOPE AND OBJECTIVES

To establish, maintain and provide to users in the laboratory and outside the laboratory, facilities for characterization of materials regarding surface area and porosity and to conduct research in this field.

2. PROGRESS

Samples of petroleum coke, pitch coke, metallurgical coke, natural graphite, carbon fibres made from PAN and Rayon were tested for surface area.

Work was carried out on the development of porous carbon fibres using twisted and untwisted viscose rayon yarn as precursor. The carbonized fibres thus produced show a

reasonable flexibility and carbon yield. BET surface area was found to be in the range of 400-500 m^2g^{-1}. Four samples of silica were tested for M/s Shriram Food and Fertilizer Industries Ltd., Delhi. Preliminary draft for Indian Standard for the apparatus and procedure for measurement of surface area using low temperature gas adsorption, was prepared and submitted to I.S.I. for circulation.

3. PROJECT TEAM

J.N. Bohra - Project Leader
R.K. Saxena

CRYOGENICS AND SUPERCONDUCTIVITY

CRYOGENIC PLANTS AND FACILITIES

1. SCOPE AND OBJECTIVES

To carry out R&D in the various technological and scientific directions in the field of Cryogenics at liquid nitrogen and liquid helium temperatures range.

2. PROGRESS

2.1 Cryo-Probes for Medical Surgery

Cryo-probes for cancer treatment were tried on actual patients at the Loknayak Jai Prakash Narain Hospital and Army Hospital, Delhi Cantt. Actual trials on some hundred patents of malignant tumour and an equivalent number on non-malignant tumours were carried out over a period of 3 years. No failure in the case of non-malignant tumour was reported, however, a few cases were reported as failures out of the total hundred cases on the malignant tumours. This success is considered unique in the area of the cancer treatment throughout the world.

2.2 Liquid Nitrogen Plant Based on Stirling Cycle

Major effort of the division was concentrated on the fabrication, design and development of this type of plant which was a very difficult endeavour. Various sub-components like crank case, the connecting rod, the condensor head, regenerator the displacer, piston and the control valves were completed. Various sub-assemblies completed and the total system assembled and tested; the faults rectified. The efficiency of various sub-system improved. Finally, the total system was assembled and tested and the plant became operational.

2.3 Minicooler

The system based on variable orifices was completed and tested for its efficiency, the temperature obtained and the time of cooling etc. Based on this experience, another cooler, smaller in size and weight, which was a requirement of the Electronics Commission, was designed, developed and tested, which proved to be more efficient in terms of lower cooling time and lower temperatures. Heat in leak in the system was reduced considerably compared to the first.

The ultra fast cooler, with cooling times in the order of minutes or less was designed, developed and fabricated. It uses aero-space technology, a very difficult system of generating pressures of 6000 p.s.i. was designed and fabricated. The various sub-components, like the high pressure valve was designed and partially tested. The oil and water adsorbant column was designed and developed. Suitability of various connectors to work at such high pressures efficiently, which is a very difficult area, was being carried out in very small sizes.

3. PROJECT TEAM

A.P. Jain — Project Leader
S.C. Gera, R.B. Saxena, Hari Kishan, N.K. Babbar, Kasturi Lal, Raveesh Kumar.

SUPERCONDUCTIVITY, SUPERCONDUCTING MATTERIALS, JOSEPHSON TUNNELLING AND APPLICATIONS AND QUANTUM HALL EFFECT

1. SCOPE AND OBJECTIVES

To understand the mechanism of Superconductivity. To develop new superconductors with high T_c and in depth study of industrial superconducting systems.

Application of Josephson Tunnelling to voltage standard. To develop thin film Josephson junction technology and planar dc SQUIDs.

Study of nonequilibrium superconductivity and Quantum Hall Effect.

2. PROGRESS

2.1 Mechanism of Superconductivity

The CESR work which was hitherto carried out only on A-15s was successfully repeated for

various other superconducting systems such as Re, Chevrel phase compounds, layer compounds etc. and the new superconducting mechanism was further consolidated. The model could explain host of anomalies which had remained unaccounted in terms of the conventional theory. This way it was possible to explain susceptibility data, pressure induced superconductivity spinx echo measurements etc. on various superconducting systems. ESR measurements could explain the dilemma of resistance anomalies in Chevral phase compounds doped with RE elements. The mechanism proposed by NPL group received theoretical credence from the work of American, German, Dutch and Chinese Scientists.

2.2 Superconducting Materials

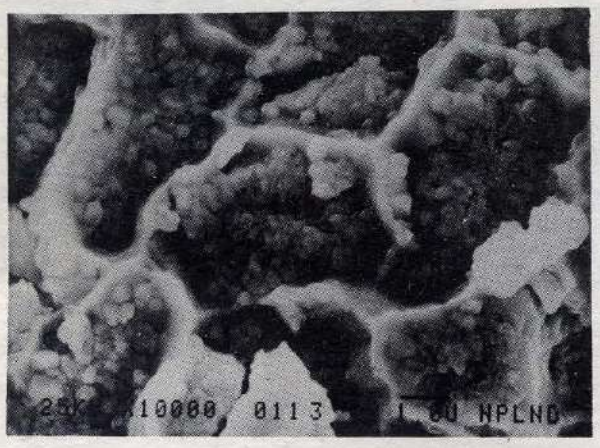
2.2 Superconducting Materials

2.2.1 New Superconductors

Most of new superconductors both binary and ternary consisting of Bi and 3d magnetic elements like Ni, Cr and Co etc. were discovered for the first time. By rapid quenching technique the NPL scientists reported the highest T_c of 10.3K for a Bi-Ni compound.

2.2.2 Industrial Superconductors

Growth kinetics studies of Nb_3Sn formation in multifilamentary systems containing from 1500 to 10,000 filaments have been carried out the results show that the oral growth of Nb_3Sn layer is controlled by diffusion of Sn atoms through the grain boundaries of the compound layer. The theoretical model has been developed which considers the generalised grain growth equation modifying the grain boundary diffusion.



Scanning electron micrograph showing Superconductivity Nb_3Sn formed after full conversion of Nb into Nb_3Sn after diffusion reaction.

2.3 Josephson Tunnelling for Voltage Standard

Several intercomparisons of the standard cell volt with the Josephson voltage were made. Various sources of errors were indentified and efforts were made to reduce both the systematic as well as random errors during intercomparision.

2.4 Development of thin film Josephson Junction Technology

Facilities have been created for photolithography work to fabricate small area tunnel junctions for SQUIDs.

Facilities have been created to grow thin oxide barriers using Greiner's RF glow discharge process.

2.5 Nonequilibrium Superconductivity

A different type of current-voltage characteristic has been observed in solder blob type junctions. In addition to the usual zero-voltage region, a low-differential-resistance region just above the zero voltage critical current has been observed. This region is found to behave like a voltage dependent pair current and is explained in terms of the stimulation of supercurrents in the weak link.

The conditions and consequences of self injection of quasiparticles have been studied in detail by preparing tunnel junctions with extremely thin barriers. Increase in barrier thickness from the lowest limit leads to a gradual transition in behaviour from specially inhomogeneous to homogeneous nonequilibrium superconducting state and finally to usual (stable) Josephson tunnelling behaviour.

2.6 Studies of Quantum Hall Effect

A superconducting magnet system consisting of a 13T magnet, a metal cryostat and an energiser has been procured. It will be installed in 1984-85.

3. PROJECT TEAM

A.V. Narlikar — Project Leader
A.K. Gupta-(Josephson Tunneling), N.S. Nata-

rajan, V.S. Tomer, S.N. Ekbote, N.D. Kataria, B. Jayaram, S.K. Agarwal, S.B. Samanta, V.S. Yadav, A.K. Goel.

A-15 SUPERCONDUCTOR THROUGH IN-SITU TECHNIQUE

1. SCOPE AND OBJECTIVES

Stabilized multifilamentary composites of Cu-Nb_3Sn and Cu-V_3Ga are being prepared following the in-situ technique and studied through their critical superconducting parameters. We plan to develop these high field superconductors on a laboratory scale and optimize various process parameters such as alloy quenching, area reduction ratio, superconducting to copper ratio, Sn or (Ga) coating and the temperature and duration of heat treatment etc. by studying in detail the critical current density in high magnetic field. Apart from being a very promising commercial technique it offers interesting research problems like the mechanism of superconducting filaments via discontinuous filaments and that of the flux pinning.

2. PROGRESS

Fresh series of Cu-V and Cu-Nb alloys 0.5 to 30 at.% were prepared in a very clean atmosphere. Special technique was devised to made very homogenous alloys. Wires of various sizes down to ϕ 0.21 mm were drawn. SEM studies on as-cast alloys revealed uniform dendritic structure whereas fine wires showed highly dense fine filaments. Transition temperature and zero field critical current were measured on these ingots and wires. Sn-coating on Cu-Nb wires and Ga coating on Cu-V wires was also accomplished through several trials. Sn coating has proved quite successful whereas Ga coating still needs perfection. Conversion to A-15 compounds was carried out through heat treatment at 550°C for several hours. T_c and zero field Jc are found to be encouraging. High field J_c measurements are planned after bringing a 7T magnet into operation.

3. PROJECT TEAM

R.G. Sharma — Project Leader
Y.S. Reddy, M.M. Krishna.

PREPARATION, CHARACTERISATION AND APPLICATION OF FINE ELECTRO-CERAMICS

1. SCOPE AND OBJECTIVES

Ceramics made by cryochemical techniques have distinct advantages over the powders made by conventional techniques. Powders made by these techniques have very high surface area, small particles size, narrow particle size distribution, high purity and uniform dopant distribution. Because of such desirable parameters, the powders can be sintered to a much higher density (near to theoretical density) at a considerably lower temperature, keeping the average grain size significantly smaller, which leads to much higher strength of the material. For successful application of ceramics in electronic industry, very high density, high strength, high purity and uniform dopant distribution are very important.

2. PROGRESS

Nickel oxide, manganese oxide powders made by these technique have been used for making nickel manganite which has been successfully used as a thermistor infrared detector in hot axle-box for detecting hot spots in the axles of fast moving railway carriages.

Sinterability of these powders have been found to be much better than that of the powders made by conventional techniques. Alumina made by these techniques have been preliminarly used for making c alumina, which is liminarly used for making β alumina, which is a solid electrolyte.

Some preliminary work has also been done with Ba TiO_3 and Na NbO_3, Solid solution and composites.

3. PROJECT TEAM

S.K. Sarkar — Project Leader
A.P. Jain, M.L. Sharma, H.L. Bhaskar, Mrs. K. Jain.

UTILIZATION OF SOLAR ENERGY

THERMAL CONVERSION

1. SCOPE AND OBJECTIVES

Development and characterisation of solar collectors, solar thermal devices and related materials.

To evolve national test procedure for testing solar collectors and set up test facilities.

2. PROGRESS

2.1 Development of Test Facilities

Under the project funded by DNES for evolving test procedures, a test rig similar to that developed by National Bureau of Standards, USA for testing instantaneous thermal performance efficiency set up earlier was used to test a large number of flat plate collectors received from private/public undertakings. In order to bring the measurement accuracy of the test rig at par with existing international level, an indegeneous multi-channel data logger with microprocessor unit specially designed to meet our requirements is being procured. The Beckman Spectrophotometer acquired under above project have been installed and used for the evaluation of solar absorptance, solar transmittance and normal emittance of selective coatings glazing of reflecting materials received from several industries and R&D institutions.

Flat plate collectors having copper tube-copper sheet and copper tube aluminium sheet absorber have been fabricated and field tested for their instantaneous efficiencies and temperature gradiants. This study has helped in examining the design parameters and thereby improving the collector design.

A simple method for the estimation of emittance based on measurement of stagnation temperature under known insolation, ambient temperature and wind speed etc has been developed.

Hot box solar cookers received from various manufacturers have been tested for maximum attainable temperature (stagnation temperature) and data analysed. Our study shows that in winter months in Delhi the maximum attained temperature is below 100°C due to reduction in incident insolation and low ambient temperature and thus these cookers cannot be used satisfactorily. Therefore, possible modifications in the cooker design has been suggested. Studies on heat transfer from absorber plate to cooking pot shows that it can be improved significantly by using a special base plate. A new test method based on characterising the cooker by the ratio of incident solar insolation on the cooker box to the stagnation temperature above ambient has been suggested.

2.2 Studies on Selective Coatings

Basic studies on black chrome coatings on nickle plated substrates have been carried out. The process parameters of black chrome and nickle coating optimised for better solar selectivity and solar absorptance.

An attempt to develop cheap and durable black nickle selective coating by conversion process on to an aluminium alloy substrate has been made. The effect of various process parameters on optical properties vis-a-vis to their structure and particle size has been analysed.

It is found that solar absorptance of black nickle coating can be considerable enhanced from 0.91 to 0.95 without degrading its thermal emittance by the introduction of a copper layer inbetween the zinc layer and nickle layer. It has also been established that these coatings can be made more stable under humidity exposure and thermal cycling upto 250°C by giving appropriate chromic acid treatment.

A simplified method has been developed for the comparison of thermal performance of two similarly fabricated flat plate collectors having absorbers coated with different selective coatings having known solar absorptance and thermal emittance. In addition, a criteria has been evolved for the proper selection of selective coating for use in flat plate collectors.

2.3 Development of $25m^2$ Cylindrical Parabolic Concentrator System

Fabrication of a $25m^2$ cylindrical parabolic concentrating collector system consisting of four modular reflector system having 175 cm x 360 cm aperture designed earlier was continued. Its various sub-systems like parabolic glass reflectors, fibre glass back-up structure, self tracking electronic unit fabricated earlier have been tested. The profile of fabricated parabolic reflectors have been tested for their optical perfectness using reflection test set up consisting of point source, prisms, optical bench and silicon detector. The profile of fibre glass back up structure has been corrected to match the parabolic reflector profile.

On request from the Director (Conservation), Archeological Survey of India studies on solar insolation and moisture content in the sculptures on the exteror walls of "Vamana Temple" at Khujarao were conducted for assessing the use of solar energy for preservation of these monuments. A feasibility report in this regard has been submitted.

3. PROJECT TEAM

M.S. Hegde — Project Leader
Devendra Singh, R.H. Bhawalkar, J.S. Vaishya and T.C. Tripathi.

STUDIES ON POLYCRYSTALLINE SILICON FOR PHOTOVOLTAIC ENERGY CONVERSION PHASE II

1. SCOPE AND OBJECTIVES

To develop techniques to directionally cast polycrystalline silicon ingots with a circular section of 50 mm dia. To develop a suitable crucible material to be used for directional casting.

To explore the possibility of pulling silicon ribbons from melt using die (EFG) or without die (needs dendritic method). To study correlation of material properties and processing variables with cell parameters for larger diameter cells and optimize the cell efficiency. To develop the screen printing technique for metallisation and AR coated solar cells.

To do feasibility study on fabrication of MOS and ITO silicon type cells on the polycrystalline silicon prepared at NPL. To study theoretically and experimentally the effect of the intensity temperature and environment on characteristics of P. Silicon Solar Cells.

2. PROGRESS

2.1 Silicon Project (NCL-NPL-MERADO Silicon Pilot Plant)

Large size CVD reactors used in decomposition of trichlorosilane have been designed and is under fabrication for use in the 1 ton/year silicon plant being set up at NCL Pune. Power Control System and other support systems are also under fabrication.

2.2 Polycrystalline Silicon Solar Cells

Techniques to directionally solidify molten silicon inside a crucible was under further development during this period. Various materials like graphite, glassy carbon and silicon nitride have been tried, but most success was achieved with graphite crucibles. Silicon ingots upto 80 mm diameter have been successfully cast. Using semiconductor grade silicon feed stocks, ingots with columnar grains with grain size more than 1 mm were obtained. The ingots were doped to obtain both n and p type wafers of resistivity range 1-5 ohm-cm. The life time of minority carriers were measured to be 20-30 sec. by a modified photoconductivity decay method. Solar cells have been fabricated from these wafers. Short circuit current density of 25-30 mA/cm^2 and open circuit voltage of 520-540 mV and efficiency of more than 10% have been obtained in these cells under AM1 illumination (Fig.). A link up with M/s Central Electronics Ltd. to evaluate the wafers has been established. Using standard processing, they report obtaining AM1 efficiency of 8.5% on these wafers.

Various specialised characterisation techniques like DLTS, EBIC, LBIC, C-V, Surface Photovoltage etc. have been established to study the behaviour of the grain boundary and the impurities in the silicon wafers. Studies on majority carrier mobility, photoconductivity and minority carrier lifetime in polycrystalline silicon have led to a theoretical explanation of the role of grain boundary and grain interior in electrical conduction through polycrstalline semiconductors. Majority and minority carrier effects can be explained from this model without resorting to fitting parameters.

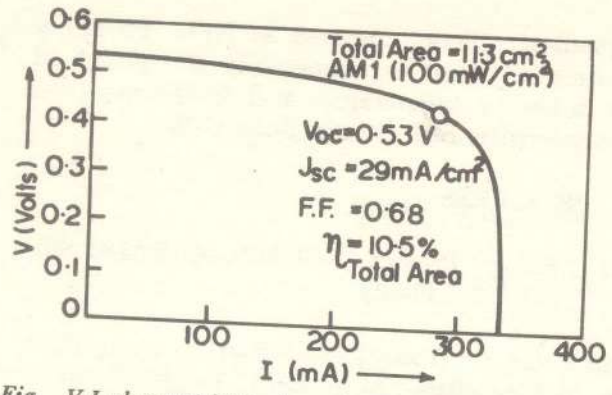


Fig. V-I characteristic of a polycrystalline silicon solar cell showing efficiency of 10.5% (AM1 illumination).

3. PROJECT TEAM

B.K. Das — Project Leader

P.V.N. Ramanathan, V.D.P. Sastri, Shiv Nath Singh, S.C.K. Misra, Santosh Kumari, N.P. Singh, Mohan Lal, R.K. Sharma, P.K. Singh, R.K. Kotnala, R.N. Sarna, B.R. Awasty, Balbir Singh, N.S. Bangari, S.B. Manmohan, N.K. Arora, Ram Kishore, B.C. Chakravarty, H.P. Gupta, Prem Prakash, Ravi Kumar, T. Podikunju, M.S. Pawar.

APPLIED PHYSICS PROJECTS

ELECTROSTATICS & ELECTROPHOTOGRAPHY

1. SCOPE AND OBJECTIVES

To develop the technology of xeroradiography for medical radiology.

Fabrication of prototypes of dust collectors for ambient air and test their performance using ASHRAE standard test bench to optimize the configuration of such devices.

To develop newer materials for electrophotography.

2. PROGRESS

2.1 Xeroradiography

Towards the improvement in xeroradiographic photoreceptors, parameters like nature of material, its purity, thickness of the film, heat treatment, nature of dopants have been studied and efforts are being made to optimize them for best performance of photoreceptor plates. Preliminary studies had been made with Se+Te alloy.

Different metallic substrates, e.g. aluminium, stainless steel, chromium plated brass, etc. have been tried as substrates. Technique to coat large thicknesses of photoconductive materials is being developed.

2.2 Toners

Work on the development of different coloured toners, namely black, blue and white having high contrast and good resolution for obtaining good quality X-ray images have been continued.

2.3 Cloud Chamber Development

A few prototypes of cloud chamber have been designed and fabricated for the defect free development of images on photoreceptors. This would ensure tiner details in X-ray images for correct diagnosis in radiology.

2.4 Newer Materials

Number of materials such as lead monoxide (orthorhombic and tetrahedral) and Zinc Oxide in pure form as well as dispersed in polymer matrix have been studied for their electrical, photoconductive and electrophotographic properties. Their charge storage and charge decay characteristics have been studied. In addition to this, dielectric and electrical properties of some polymeric materials have also been studied for their use as binder layers, as interfacial barrier layers and as top protective coating of photoreceptors.

2.5 Electrostatic Dust Collectors

To start with a test bench based on ASHRAE standard has been set up and performance of a couple of designs of electrostatic dust collectors have been studied. The study for the efficiency of collection of dust particles as a function of the velocity of flow, fields applied to ionizer and collector systems have been made.

3. PROJECT TEAM

P.C. Mehendru - Project Leader
D.C. Sharma, S.C.K. Misra, V.S. Panwar, M.N. Kamalasanan, Ramadhar Singh, Suresh Chand, T.K. Chaudhuri, S.D. Bahl and R.C. Bhateja.

AMORPHOUS MATERIALS AND THIN FILM DEVICES

1. SCOPE AND OBJECTIVES

To carry on Research and Development in the field of thin film technology covering both theoretical and experimental aspects.

To undertake sponsored projects from outside agencies. To offer consultancy service.

2. PROGRESS

2.1 Thin Film optical coatings and devices

Space qualified multicavity interference filters were supplied to ISRO and the same have been used in the Indian Satellite Rohini-D2. (Sponsored).

Non-polarising type beam splitters have been developed and they are used by optics division of NPL. Neutral density filters (100 mm dia with different optical densities) and Laser mirrors have been supplied to M/s Bharat Heavy Electricals Ltd. and M/s Optiregion respectively.

Theoretical designs have been developed for broad band suppression filters having T 90% and HbW 2000A°. Representative design of such a filter is:-

air/L 2H L 2H L 2H L 2H L / Glass

where L & H corresponds to low index and high index quarter wave thick layers. Such filters have been experimentally fabricated and performance found to be satisfactory.

Experiments have also been conducted to determine a suitable all dielectric structure, which can give high reflectance zone (1600 to 2000 A° width) and a ripple free transmission zone (T 90% HbW 2000A°)

2.2 Optical Components for MIG

Collimating sight glass and elliptical mirrors developed at NPL are approved by HAL, Nasik and a number of such pieces have been supplied to them. Gun Sight Reflector Glass with hard dielectric Coatings has been developed for HAL, Nasik Optical characteristics of the coated reflector glass have been approved and physical tests (environmental, adhesion, abrasion etc.) are being carried out at HAL.

2.3 Amorphous Silicon Films

During this period amorphous silicon films produced in glow discharge reactor designed and fabricated in the laboratory were characterised by TEM, SEM, infrared spectroscopy, Auger spectroscopy, photoaccostic spectoscopy and their electrical and optical properties studied. As a result of all such studies it was asertained that amorphous silicon material grown in this laboratory is of device quality.

2.4 Films grown in cascaded reactors

It is well known that in the conventional Glow discharge reactor under optimum conditions of growth almost about 50% of silane remains unreacted. A novel cascaded glow discharge reactor to utilise this unreacted silane to grow amorphous silicon films further down the line (i.e. in a II reactor) was designed and fabricated. On characterising the films grown in the two different reactors of this cascade it was found that, while films grown in the first reactor of the cascade is in no way different from what is reported in the literature, the film grown in the II reactor of the cascade exhibit unusually high resistivity (4 orders higher) with excellent photoresponse and are least affected under prolonged light exposure (Stabler Wronski, effect).

Table 1 show the characterstics of films grown in the two reactors (designated as R_1 films & R_2 films).

3. PROJECT TEAM

V.V. Shah - Project Leader
R. Bhattacharyya, A. Basu, B.S. Verma, B.M. Loganathan, P.N. Dixit, O.S. Panwar, (Miss) M. Kar, C. Anandan, Bachan Singh, T.K. Bhattachrya, T.K. Chakraborty.

DISPLAY DEVICES

1. SCOPE & OBJECTIVES

Development of a variety of alphanumeric display devices, namely: Black & White Liquid Crystal displays, Coloured Liquid Crystal displays, Electro-chromic displays and Planar gas discharge displays, Basic studies on the physico-chemical behaviour of new electro-optic materials.

2. PROGRESS

Coloured liquid crystal displays with white digits on black background (based on dye-phase change effects) having better electro-chemical stability using "Black Dyes" have been developed. These displays exhibit better contrast and wider viewing angle in comparison to earlier coloured displays using single colour dye, Coloured liquid crystal displays using

TABLE - 1

Electrical and Optical Parameters of a-Si:H films in cascaded glow discharge reactors

Sl.No.	Parameters	30°C		280°C		Reference 15,18-23	
		R_1	R_2	R_1	R_2	30°C	280°C
1.	σ_d at 30°C $(\Omega cm)^{-1}$	10^{-11} -10^{-10}	10^{-12} -10^{-11}	10^{-9} -10^{-7}	10^{-13} -10^{-12}	10^{-11} -10^{-10}	10^{-9} -10^{-7}
2.	σ_{ph} at AM_1 light (100 mW^{-}/cm^2) at 30°C $(\Omega cm)^{-1}$	10^{-7} -10^{-6}	10^{-7} -10^{-6}	10^{-5} -10^{-4}	10^{-6} -10^{-5}	--	10^{-5} -10^{-4}
3.	Photo sensitivity (σ_{ph}/σ_d) at 30°C	10^3 -10^4	10^5 -10^6	10^3 -10^4	10^6 -10^7	--	10^3 -10^4
4.	Activation energy, ΔE_d (eV)	0.8 - 0.9	0.95 - 1.05	0.6 - 0.8	0.95 - 1.05	0.30	0.6 - 0.8
5.	ΔE_{ph} (eV)	0.12 - 0.15	0.12 - 0.15	0.10 - 0.12	0.15 - 0.20	--	0.16 - 0.18
6.	Optical gap, E_{op} (eV)	1.8 - 2.0	2.0 - 2.1	1.7 - 1.8	2.0 - 2.1	--	1.6 - 1.8
7.	H. Content (at. %)	10-30	10-30	10-25	10-25	--	10-30
8.	Staebler-Wronski effect	--	--	Present (relatively small)	Absent	--	Present

negative dichroic dyes exhibiting positive contrast i.e. coloured digits on colourless background have also been developed.

Developmental models of 3½ digits 7 segmented electro-chromic displays have been fabricated based on tungsten trioxide thin films and Li^+ containing organic electrolytes. We have introduced new techniques in our display technology in order to bring international design compatibility and performance. This includes simultaneous application of ion insertion and charge transfer mechanism and utilization of separate electrodes of controlled dimensions for switching on and off the display segments. Thus, we have now designed precise electrode configuration and dimension with main auxillary electrodes.

Basic studies on "Two Frequency" switchable liquid crystals have led to better understanding of their anisotropic dielectric behaviour. Special circuit has been designed and fabricated for simultaneous application of high frequency and low frequency signals of variable amplitude and frequency to liquid crystal electro-optic cells. Our electro-optic response behaviour studies on special LC-mixture cells have shown that the simultaneous application of low and high frequency signals results in great sharpening in the contrast ratio vs. voltage curve. These results will help us in making much faster displays with high multiplexing capabilities.

2.1 Development of highly electrically conducting transparent glass plates

The electrooptical response of an electrochromic display depends, in addition to many other parameters, on the electrical conductivity and transparency in the visible spectral region. We have developed two techniques namely (i) dc sputtering and (ii) electron beam deposition which yield glass plates with sheet resistivity of 50 ohm/□ or less and transparency better than 85% in the visible region. In DC reactive sputtering process a very thin layer of In/Sn alloy (10% Sn) target and high sputtering power level have been employed. UNiqueness in this process is that no post-deposition annealing is required. Substrate heating is accomplished entirely by the ion-bombardment intrinsic to DC sputtering. The characteristic features of the ITO films are very low resistivity, high carrier density, high mobility, low temperature co-efficient of resistivity and smaller grain size in comparison to pure indium oxide films. It has been found that non-stoichiometry and oxygen vacancies play important role in imparting electrical conductivity.

However, the electron-beam deposition techniques has been found to be more easily reproducible and coating can be done at relatively low substrate temperatures (not exceeding 250°C).

2.2 Studies on liquid crystalline and solid crystalline polymorphism in liquid crystals

Investigations on polymorphism in liquid crystalline materials using thermal, infrared, optical and x-ray diffraction was extended to many other liquid crystalline systems. It has been found that polymorphism is a continuous process of step-wise liberation of molecular degrees of freedom. Solid crystalline polymorphism appears to arise out of different molecular arrangements in the lattice network and conformational changes in the central core of the molecules whereas liquid crystalline polymorphism is predominently associated with conformational changes in the central core and the tail ends of the molecules.

2.3 Exploratory Programme on Conducting Polymers

A new exploratory research programme on conducting polymers has been initiated with an aim to develop newer materials for display devices and applications. Conventionally, chemical methods are generally employed to polymerize the monomers and then dopants are introduced by either chemical methods or by electro-chemical process. A major success has been achieved in our laboratory whereby simultaneous polymerization and doping in 5-membered, hetrocyclic compounds is obtained by electrochemical techniques using organic electrolytes conducting films of perchlorate (ClO_4^-) and tetrafluoroborate (BF_4^-) doped polypyrrole and polythiophene have been obtained. The growth kinetics, morphology, temperature variation of electrical conductivity, optical and SEM studies are under progress.

3. PROJECT TEAM

Subhas Chandra - Project Leader
S.C. Jain, S.S. Bawa, S.A. Agnihotry (Mrs.), C.P. Sharma, A.M. Biradar, K.K. Saini, N.S. Verma, Dr. B.D. Malhotra (Pool Officer).

PILOT AND DEMONSTRATION PLANT IN HYDROSTATIC EXTRUSION & MATERIAL SYNTHESIS

1. SCOPE AND OBJECTIVES

To establish laboratory and pilot plant facilities in metalforming and to determine the process parameters for the extrusion, drawing and shear spinning of tubes, shapes and sections of ferrous and non-ferrous metals and alloys.

To batch-produce extruded products and cold forged components for trial runs by the industry. To establish laboratory facilities in the synthesis of superhard materials and to develop the process technology for the synthesis of superhard materials.

2. PROGRESS

The erection and commissioning of the Induction furnace along with the conveyor system was undertaken and completed. Hot extrusion of cupro-nickel, aluminium-brass and different grades of stainless steel tubes and sections were carried out.

On the basis of experience in trial runs on hot extrusion, it was felt that some modifications were required on the 500-tonne vertical hydraulic press procured from the UK under Colombo Plan assistance. In that connection, detailed plan for the rectification of nitrogen leakage in the accumulator system and a proposal of installing retractive type mandrel, to facilitate extrusion of tubes, and an additional accumulator, were submitted to the British Council for further assistance.

On the basis of detailed consultations with Maruti Udyog Ltd. and Scooter India Ltd. a few automobile components were identified to be developed in the first instance by cold forging technology. The design of tooling and sequence of operations for these two components have been completed. Tool fabrication is awaited to start the actual trial runs.

Trials on the shear spinning of tube hollows in 70 / 30 Cu-Ni alloy which is required as heat exchanger tubing in thermal power plants were carried out and process parameters established. Mechanical properties of the processed tubes were also evaluated and they met the specifications laid down by the Bharat Heavy Electricals Ltd.

The existing shear spinning equipment requires long mandrels for processing tube hollows which have to be imported. To circumvent this problem a new stationary short mandrel system has been designed and will be evaluated.

Some trials on the hydrostatic extrusion to develop 7 x 28 mm rectangular silver bearing copper strip for Bharat Heavy Electricals Ltd. were carried out.

The erection and commissioning of the Vacuum Brazing Furnace and a Tool and Cutter Grinder required for processing of cBN compacts into actual tool tips was undertaken and completed. The equipment was subsequently used for making brazed cBN compact tool tips which were handed over to M/s Widia India Ltd. and M/s Bhukhanwala for actual trials.

From a detailed dialogue with the concerned industries and other experts of international repute, it was found that cBN compacts without a substrate were coming up very fast and were better in performance. The effort, therefore, was directed towards developing such compacts. Laboratory trials were made using different binders with encouraging results.

The erection and commissioning of the 1000-ton vertical hydraulic press for upscaling the process parameters established in the laboratory press was completed. The necessary tooling to be used on this press was installed on the press.

3. PROJECT TEAM

B.K. Agarwala - Project Leader
M.M. Bindal, A.K. Gupta, B.V. Kumaraswamy, Bhanu Pratap Singh, Islamuddin Anwar Malik, R.K. Nayar, O.P. Tagra, R.C. Anandani, S.S. Verma, Sunil Kumar Singhal, Ganga Prasad, T.K. Chakravarty, Ajay Dhar, Rajeev Chopra, Virendra Babu, Rajiv Sikand, K.L. Ahuja, Jai Bhagwan, Harinder Bir Singh, Jaswant Singh, Sham Lal Sharma, K.D. Sharda, Rakesh Khanna, Yash Pal, M.L. Sharma, Chander Kant.

DIVISION OF MATERIALS

AREA COORDINATOR

Dr. V.N. Bindal

INTRODUCTION

The Division of Materials continued its activity in the areas:

1. Studies on Polycrystalline Silicon.
2. Development of conducting Ceramics & Ferrites.
3. Ultraconic transducers, materials & devices.
4. Development of Carbon Products.
5. Carbon Fibres, composites and glassy Carbons.
6. Luminescent materials and devices.

These projects were chosen to meet the national requirements of sophisticated materials for electronics, energy and engineering sectors. The emphasis was not only in preparing materials, but also its use in working devices and components to study feasibility of these materials under actual operating conditions.

The work regarding the design and fabrication of reactors for the silicon pilot plants at N.C.L., Pune was initiated. Polycrystalline Silicon ingots upto 80 mm dia. were successfully cast and evaluated for use as cheaper substrates for photo-voltaic applications. High altitude carbon brushes were type tested and supplied to Hindustan Aeronautics Ltd. after their approval. Post spinning modifications of PAN fibres have lead to carbon fibres with superior mechanical properties. Carbon fibres have been surface treated to improve adhesion with epoxy resin matrix. Carbon fibre-reinforced epoxy composites based on indigenous resin system and carbon- carbon composites using modified coal tar pitch invited special attention during this period. Solid electrolyte grade beta-alumina tubes of 9 mm dia. and acceptable quality were prepared for use in sodium-sulphur batteries.

Work on ultrasonic standards for calibrating ultrasonic hydrophones and a programme on Underwater Acoustics for development of marine acoustic systems involving development of transducers for pingers and parametric airborne and underwater system were initiated. An ultrasonic A-scan ophthalmic unit has been developed indigenously.

Large batches of TV phosphor of accetable quality were supplied to BEL, Bangalore for their evaluation and testing in mass production of picture tubes.

STUDIES ON POLYCRYSTALLINE SILICON

The details are given under Utilisation of 'Solar Energy'.

DEVELOPMENT OF CONDUCTING CERAMICS AND FERRITES

1. SCOPE AND OBJECTIVES

Development of Solid Electrolyte Grade β''-Al_2O_3 Tubes for Na-S battery.

Investigatory studies on preparation and characterisation of Ceramic Materials for electronics and energy sources.

2. PROGRESS

2.1 Solid Electrolyte Grade β''-Al_2O_3 Tubes for Na-S Battery

Reactive α-Al_2O_3 powders with a mean particle size of < 0.7 μm have been prepared for using as the basic raw material for synthesis of β''-Al_2O_3. β''-Al_2O_3 powder of < 1 μm particle size has been produced. Densities of 3.2 gm/cc have been achieved at a low sintering temperature of 1600°C. Studies to understand influ-

ence of particle size, optimum composition, pressure, sintering cycle etc. have been carried out. Sintered β''-Al_2O_3 tubes of 9 mm ID and 1.2 mm wall thickness possessing densities over 3.15 gm/cc were made by isostatically pressing the powder and sintering (Fig. 1). The axial electrical resistivity of 5-7 ohm-cm at 300°C has been achieved.

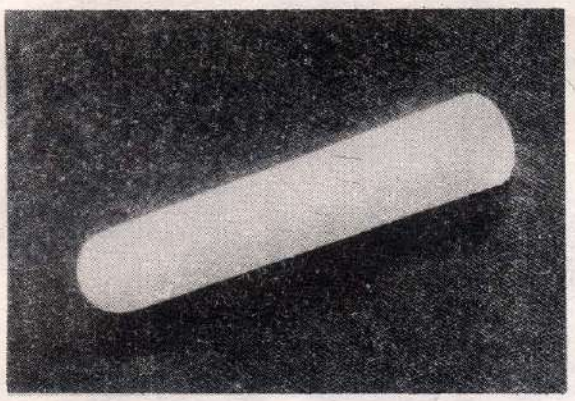


Fig. Phtograph of a solid electrolyte grade beta alumina tube of 9 mm inside diameter.

2.2 Ferrites

Effect of addition of SiO_2, GeO_2 and SnO_2 to nickel-zinc ferrite was studied extensively. The presence of a non-magnetic second phase at the grain boundary affects the magnetisation mechanism inside the grain interior due to disruption of the continuity of the domain walls at the grain boundaries. The pinning force, which binds the domain wall to the grain boundary, and the domain wall energy were measured from the B-H loop characteristics and were related to the presence of solute in the grain interior and second phase at the grain-boundaries.

2.3 Varistors

Dependance of the nonlinearity coefficient of zinc oxide varistors on temperature was studied. The role of grain boundary on the characteristics was investigated.

2.4 Silver Cement

A variety of silver cements useful for electronic applications were batch produced and supplied to actual users.

3. PROJECT TEAM

B.K. Das — Project Leader
R.B. Tripathi, G. Govindaswamy, Balbir Singh, R. Kumar, R.B. Tandon, S.M. Khullar, H.S. Kalsi, Satbir Singh, B.S. Khurana, R.C. Goyal, S.K. Sharada, A.P. Gera, T.R. Pushpagadan, K.P.S. Nair, Mukul Sharma, T. Podikunju.

ULTRASONIC TRANSDUCERS, MATERIALS AND DEVICES

1. SCOPE AND OBJECTIVES

To set up ultrasonic standards, to develop and characterise ultrasonic transducers and materials for application in underwater acoustics, and to take up studies in high power ultrasonics, biomedical ultrasonics and Nondestructive testing for specific problems in instrumentation.

2. PROGRESS

2.1 Ultrasonic Standards

Work has been initiated on the measurement of ultrasonic field intensity using reciprocity calibration of ultrasonic hydrophones. Feasibility of the technique has been established in the frequency range 0.7 to 1.0 MHz. To extend the facility upto 10 MHz, precise methods of scanning and alignment as to remain in the same calibration region are necessary. A 60 x 60 x 100 cm. movable tank has been made. Work is in progress to equip the tank with precise manipulating systems and to make it anechoic. Characterisation of materials, for lining the tank has been carried and echo reduction, insertion loss and attenation coefficients in the frequency range 0.5-4.0 MHz have been measured.

2.2 Underwater Acoustics

The work has been reoriented to development of marine acoustic systems and to provide facility of their characterisation. Specific thrust is on the development of transducers for pingers and transponders for various depth ratings, needed for position and location marking in the sea.

Transducers having a centre frequency of 150 kHz have been developed, which give an output of $\sim$ 190 dB re 1 μPa m^{-1} in a sufficiently wide frequency range. Preliminary testing has been carried at sea also. The beam directionality has been subsequently increased to 40°. Works is in progress to keep the operational frequency in the range 12-38 KHz.

Tests have been made on the indigeneously developed tube of PZT-4, which shows predominant vibration at 15 kHz and 64 kHz. An acoustic output of $\sim$ 150 dB re 1 μPa m^{-1} at 100 V input, with an ominidirectional response in the X-y plane has been observed, for this transducer provided with a rubber encapsulation.

Investigations have been made on generating parametric acoustic sources in water. A low power source has been achieved at a frequency of 13 kHz, with a beam width of 6^{o}, using primary frequencies in the vicinity of 160 kHz. The characteristic of this source has been studied and compared with a nonparametric source. Parametric system has also been built around 160 kHz, using primaries $\sim$ 1 MHz.

Using these it has been shown that transducer encapsulations of very small size can be characterised. Work is now proposed on development of parametric sonar.

2.3 Piezoelectric ceramic materials

Materials with high dielectric constant 3000 and charge sensitivity 500 x 10^{-12} C/N have been developed.

The influence of manganese oxide on the dielectric and piezoelectric properties of lead zirconate titanate materials have been studied. The combined effect of MnO and La_2O_3 yields a material with k $\sim$ 1150, while Fe_2O_3 + La_2O_3 yields a value of K $\sim$ 1100 and tan δ = .007, and has been standardised and is in production. Studies have been made on the addition of Lanthanum oxides (5%) at various Zr/Ti ratio of improving the dielectric characterise to achieve greater capacitance value for a given dimension.

The composite material based on lanthanum doped PZT ceramic powder empedded in epoxy resin has been fabricated, and standardised for batch production. The material possesses a high voltage constant and would find applications in Shock wave transducers.

Studies have been made to optimise the performance of tubular transducers using isostatic press. Tubes of 25.4 mm diameter with different wall thickness, and tubes of O.D. 73 mm and ID.52 mm have been made.

2.4 High Power Ultrasonics

An ultrasonic atomiser working at 33 kHz has been developed and supplied to Physical Research Laboratory, Ahmedabad.

Studies have been made in the phenomenon of ultrasonic levitation in air. Objects of few mm. diameter and few milligrams in weight have been suspended and positioned in 1 g space using intense ultrasonic field of 165 dB re 1 μPa. The method can be used to get an estimate of the acoustic pressure (Fig. 1).

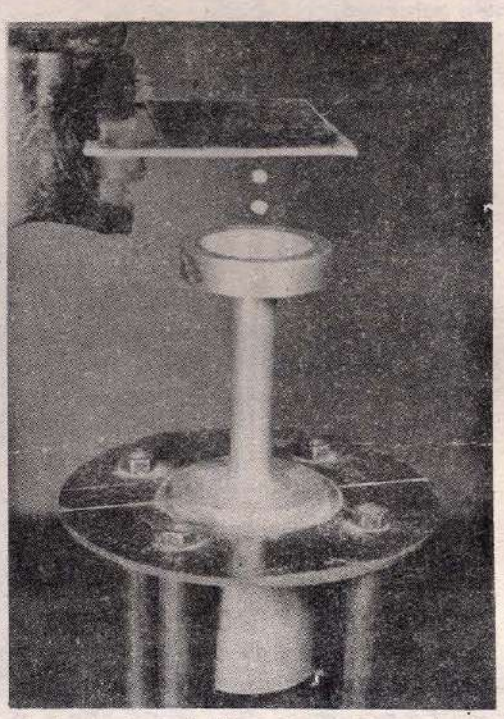


Fig. 1. Levitation of objects in an ultrasonic standing wave field.

The system has been used to measure the instantaneous velocity of falling steel balls and to verify the law of freely falling bodies (Table 1) within 5%. The method can be useful as a teaching aid at the college level.

Using an improved version, a laboratory system for speed monitoring of automobiles has been field tested. The system uses ultrasonic beam which interogates the car, near to normal incidence from a distance of 2-3 meters. It is observed that a correlation between the observed Doppler shift and the speed of automobiles is possible.

Successful generation on parametric arrays in air have been shown and propagation range of over 70 metres have been achieved. The parametric source has been created using nonlinear interaction of two high power beam S.P.L. 165 dB re 1 μPa. generated using combination transducer. The system can be used for selective audio signalling in both CW and pulsed mode without being percepted in the neighbourhood.

Table 1. Comparison of velocity of freely falling steel ball as observed by Ultrasonic Doppler method and calculated by law of falling bodies.

($C = 343 \times 10^2$ cm/s, fo = 32.8 kHz, $\theta = 56^\circ$, $T = 25^\circ C$)

S.No.	Distance (S) (cm)	Average Doppler Shift		Experimental values of velocity by Doppler method Vexp (cm/s)	Calculated values of velocity by law of falling bodies Vcal (cm/s)	Variation in Vexp and Vcal %
		Frequency (Hz)	Standard Deviation			
1.	66.5	370	0	345.2	361.2	4.4
2.	56.5	345	12.0	321.9	332.9	3.3
3.	46.5	307	9.6	286.3	302.0	5.3
4.	36.5	286	6.5	266.7	207.6	0.33
5.	31.5	263	11.3	245.7	248.6	1.3
6.	21.5	213	7.4	198.7	205.4	3.3

2.5 Biomedical Ultrasonic N.D.T.

Investigations have been made to help in the design of good NDT probes. A method for studying the effect of angle of incidence on reflectivity from Solid-Solid interface has been made.

Ultrasonic normal beam twin probes have been characterised for estimation of near surface defects.

Investigations have been made for estimating the strength of bonds nondestructively. It has been observed that the response of an ultrasonic transducer swept in frequency around 300 kHz, shows significant variations, when placed over an adhesive bonded joint between 6 mm thick metallic sheet, if the composition of resin to hardener is varied from 1:1 to 1:4. Correlation of the ultrasonic parameters, with the destructive joint strength has been observed to some extent, for a specific adhesive adhered combination.

A complete prototype model of ultrasonic A-scan opthalmoscopes with improved opthalmic probes has been made. The probe resolution and the beam characteristics have been studied and also compared with the imported Kretz probes. The system has been initially tested on the goat's eye (see Fig. 2). Four prototype models have been fabricated and clinical trials have been made on the patients at A.I.I.M.S.

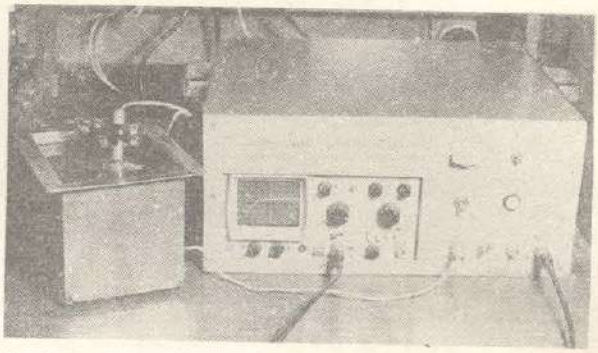


Fig. 2. Ultrasonic A-scan Ophthalmoscope with in vitro goat eye (immersed in a tank).

3. PROJECT TEAM

V.N. Bindal — Project Leader
T.K. Saksena, V.R. Singh, Janardan Singh, Ashok Kumar, S.K. Jain, R.P. Tandon, Ved Singh, J.N. Som, Mukesh Chandra, N. Narayan Swami, S.K. Singhal, Subhash Chandra, Jagdish Lal, Reeta Gupta, Yudhister Kumar, N.C. Soni, G.S. Lamba.

DEVELOPMENT OF CARBON PRODUCTS

1. SCOPE AND OBJECTIVES

Development of various carbon products both extruded and moulded by utilizing raw materials and equipment available indigenously.

2. PROGRESS

The work of development as approved in the modernization programme was taken up. The development work of Midget Electrodes of sizes, 25 mm dia was continued. The batches were processed and a few thousand pieces were supplied to a small scale industry of Delhi for making IR-40G batteries used by P&T Department and Railways. Satisfactory reports were received and the technical details were passed on to M/s Shreyas Engg. & Chemical Industries Ltd., Mysore for their production.

A die of size 11.5 x 11.5 x 7.5 cms was designed for the work of development of carbon bricks. This was being fabricated. The experiments of moulding and baking of carbon blocks of size 12 cm x 6 cm were undertaken. The compression ratio and the density were studied. The development of clutch carbons used in the tractor is continued.

3. PROJECT TEAM

S.K. Kapur — Project Leader
P. Sivaram, Rattan Lal, R.N. Malhotra, Darshan Singh.

DEVELOPMENT OF AVIATION GRADE BRUSHES AND RESINOUS PITCHES FOR CARBON PRODUCTS

1. SCOPE AND OBJECTIVES

Development of high altitude brushes and to study the phenomenon of film formation during sliding operations.

Development of Resinous pitches for Carbon products.

2. PROGRESS

Metal graphite composite blocks containing copper, graphite and small quantities of tin and lead were made and their bulk properties compared with original imported brush samples. Friction and wear parameters were measured at a particular peripheral speed and different current loads. Six different grades were fabricated according to design specified by HAL, Nasik. The performance of NPL made brushes was found comparable in all respects.

In addition, basic studies relating to reactivity of graphite in presence of copper, lead and tin at temperatures 200-600°C were undertaken. This had a bearing on the oxidation aspect of graphite transferred film formed on the counterface which would adversely affect the wear out rates. Water vapour adsorption of graphite and graphite metal mixtures was also studied on heat-treatment upto 600°C. The adsorbed water vapours play an important role in brush performance in saturating the refractory edges of graphite crystallites.

2.2 Pitch was made from coaltar by using processes of solvent fractionization and distillation. The primary α resins which do not contribute to structural development in pitches on subsequent thermal treatment were systematically removed using the solvent fractionization at various molecular weight cuts and hot filteration employing several grade of filters with pore size varying from 1-150 μ. The intermediate pitch obtained from fractionization of coal tar had primary α resins nearly equal to 0.2% and the pitch obtained from hot filteration process contained about 0.5% primary resins.

The intermediate pitch containing very small quantities of primary resins was subjected to reactions of thermic polymerisation and varieties of pitches with softening point 80°C, 90°C, 110°C, 140°C and 175°C were made. These pitches were characterized for other properties such as benzene insoluble, density, coking yield and quinoline insoluble. Use of scanning and optical microscopy, besides X-ray diffraction was made to investigate development of structure and topography. The development of mesophase spherules was observed with sharpening of diffraction peaks. An important outcome of the investigation was the processing of impregnating pitch which is used for densification of carbon products such as graphite electrodes and carbon composites being made at NPL.

Viscosity measurements of low quinoline in soluble pitches having softening points 80°C and 90°C were carried out at temperature 150-200°C using Rheomat 30, a rotational visometer, at different shear rates. The pitch behaves as a pseudoplastic material and the viscosity falls with increase in shear rates at any temperature tending to a constant values at higher shear rates. In the case of low softening point pitch thermal decomposition of the pitch was more predominant at higher temperatures leading to increase in viscosity on increases of shear

rate. This is an important factor which determines the suitability and life of pitch for impregnation. The viscosity measurements at temperatures 200-300°C are one of the most important factors deciding the suitability of pitches for impregnation of carbon products such as graphite electrodes, and carbon bricks.

3. PROJECT TEAM

R.L. Seth — Project Leader
K.K. Datta, C.L. Verma, Chhotey Lal, C.V. Mohan Das, S. Ramanathan.

DEVELOPMENT OF CARBON FIBRES, CARBON CARBON COMPOSITES AND GLASSY CARBONS

1. Scope and objectives

To develop know-how for high performance carbon fibres of mechanical properties equivalent to those available commercially.

To develop glassy carbons and carbon carbon composites for biomedical applications (bone plate).

2. PROGRESS

2.1 Carbon Fibres

The work was concentrated mainly on modification of PAN fibres by incorporating certain lewis acids namely CuCl solution, Benzoic acid and persulphates. It was found that CuCl is the best choice for such treatment. Infrared studies of such precursors as well as that of stabilized fibres helped in understanding the behaviour of modified precursor before and after stabilization.

Reducing treatment of overstabilized PAN fibres with pyrogallol before carbonization has been used effectively to improve the mechanical properties of resulting carbon fibres. IR spectroscopy has been used to establish a model for the structure of overstabilized PAN fibres.

A series of experiments was done to optimize various parameters such as current density, concentration of electrolyte and residence time etc. These fibres when reinforced with epoxy resin to form composites show an improvement of 75% in the interlaminar shear strength over that of untreated fibres.

High modulus (type I) carbon fibres have been intercalated with conc. HNO_3. Electrical conductivity at room temperature of intercalated fibres improved by 30%. Results have been explained on the basis of the density and type of charge carriers.

With the help of new thermal analyzer TA-3000 obtained under UNIDO programme a thorough study on the heat flow behaviour of various PAN precursors and oxidised fibres have been undertaken. By using DSC technique the kinetics of cyclization reaction in modified PAN precursors have been well understood. The energy of activation (Eo) of the reaction has been found to be the most important factor in ascertaining the extent of precursor modification.

A new technique to study shrinkage behaviour of PAN precursors has been employed. The studies could accurately correlate the shrinkage of the fibre at different processing temperatures upto 1000°C and thus helped in the precise control of the processing parameters.

Another significant achievement has been the improvement in the carbon fibre mechanical properties. This has been possible through critical analysis carried out on the DTA behaviour of the modified PAN precursors.

	Previous Value	*Present Value*
Tensile strength (σ)	300×10^3 psi	400×10^3 psi
Young's modulus (y)	25×10^6 psi	30×10^6 psi

2.2 Development of Carbon fibre Reinforced Composites

2.2.1 Carbon fibre-reinforced expoxy composites of different sizes were made with carbon fibres and indigenous resin system, and effect of processing parameters was studied. It has been found that exotherm associated with curing of the resin is the main cause in deteriorating the mechanical properties of the composites. This has to be controlled. The effect of other processing parameters like pressure etc. was also studied. Studies were made on the moisture absorption of carbon fiber epoxy andcarbon fibre Kevlar fibre epoxy hybrid composites. It was found that by choosing a particular configuration in hybrid composites, the moisture absorption can be reduced to 3-5%.

2.2.2 *Development of Carbon-Carbon Composites*

A technique was developed to make uni-directional C/C composites with graphite fibres and thermally modified coal tar pitch. The technique comprised of making low density (1.1 g/cc)

preforms. These are carbonized to 1000°C at programmed slow heating rate. The effect of type and properties of constituent materials i.e. coal tar pitch on the mechanical properties and structure of ultimate C/C composites was studied in detail. It has been concluded that coal tar pitch having high softening point of about 170°C and low Q.I. is best suitable for making C/C composites. Improvements in the composite properties with six densification cycles was studied critically. The fracture behaviour and structure of C/C composites was studied using Instron machine., SEM and Optical microscopy.

20 Carbon-Carbon composites were developed using different type of carbon fibre fabrics (Rayon based high modulus carbon fibres, Rayon based high strength carbon fibres, PAN based high modulus carbon fibres, of fibre type, weave type of carbon fibre fabric on the mechanical properties and microstructure of carbon-carbon composites was studied. It was found that carbon fabric with 84 satin weave pattern and made with high modulus type carbon fibre yield better carbon-carbon composites than plain weave and carbon fibres (HTT 1200°C) based fabric. Effect of impregnation pressure on the properties and structure of C/C composites was studied. It was found that by increasing the impregnating pressure from 10 bars to 20 bars the mechanical properties of composites are improved by about 20%. The 20 carbon-carbon composites developed at NPL have mechanical properties higher than those of bone and can be utilised for making C/C bone plates.

Carbon fibre reinforced polymer composites were developed using indigenously developed Furan resin. Cure kinetics of this resin were studied. Based on this curing cycle of CFRP composites was optimised. Mechanical as well as thermal properties of these composites were studied and compared with those of phenolic based CFRP composites. It was found that Furan based composites show better mechanical properties (10% higher) than phenolic based composites.

3. PROJECT TEAM

O.P. Bahl — Project Leader
L.M. Manocha, G. Bhatia, R.B. Mathur, T.L. Dhami, R.K. Aggarwal, S.S. Hanspal, S.K. Rai.

LUMINESCENT MATERIALS AND DEVICES

1. SCOPE AND OBJECTIVES

Preparation of group II-VI compounds from indigenous raw materials. Development of luminescent and optoelectronic materials, devices and their characterisation. Study of the chemistry of gas - liquid reaction to determine coefficients and reaction kinetics for the preparation of II-VI compounds.

2. PROGRESS

2.1 TV Phosphor

A final programme of testing four independent large batches of NPL TV phosphor at BEL, Bangalore was initiated with BEL's financial involvement. This was undertaken to determine whether NPL material conformed to specifications set out mutually by BEL and NPL. This was completed to BEL's entire satisfaction. The know-how was then made available to entrepreneurs through NRDC.

The project was concluded, after doing some necessary work towards reduction of production cost by use of cheaper raw materials. A cost reduction of 30% was achieved, bringing the process well within the economic viability limit.

2.2 Gas - Liquid Reaction

The need for gas-liquid reaction study has emerged as a result of our pilot plant R&D. Very little is known about the reaction kinetics of ZnS precipitation by H_2S. A knowledge of reaction kinetics would be essential in designing a spray reactor which could replace several process stages of the plant, making the TV phosphor process even cheaper. The experimental set up of the reactor has been completed.

2.3 Basic Research

CdS screen printed substrates have been studied with the purpose of obtaining conducting and substantially pore-free substrates for application in solar cells. A substantial reduction in pore volume by about two orders of magnitude over previous ones has been achieved.

Work is in progress to use TSL techniques to identify traps in CaS prepared by various techniques. The trapping parameters in different materials have been compared to study the effect of preparation condition on the formation of defects.

3. PROJECT TEAM

P.K. Ghosh — Project Leader
H.P. Narang, V. Shanker, Harish Chander.

RADIO SCIENCE DIVISION

Area Coordinator
Dr. A.P. Mitra

The major areas of study in the Radio Science Division are (a) tropospheric and ionospheric communications, (b) exploration of the terrestrial atmosphere from surface to several thousands of kms and (c) space research activities using balloons, rockets and satellites. The period under review has produced a number of new and interesting results; some project activities have consolidated their scheduled targets.

Perhaps the most significant of these is the Indian Middle Atmosphere Programme (IMAP) which has yielded a string of valuable results. The efforts include rocket and balloon payloads for ionisation, aerosol, nitric oxide and ozone measurements in the stratosphere-mesosphere as well as a tunable carbon-dioxide laser heterodyne system for measuring atmospheric minor constituents. Major highlights include consolidation reports on reference ionisation profiles over the Indian sub-continent and on reference ozonosphere over India. Several rocket flights were conducted from Thumba successfully as part of Indo-USSR collaborative programme for ozone intercomparison. Solar UV-B radiations were monitored continuously for a three month period and the results were compared with actual ozone measurements made by IMD.

A new area on planetary ionospheres has been initiated and the ionospheres of Venus and Saturn were explored using the latest available data. A pattern recognition technique was perfected to distinguish various types of Sodar structures formed under different atmospheric conditions. Travelling ionospheric disturbances were intensely studied by using the data from a chain of satellite beacon stations established earlier. A proposal was submitted to ISRO for the inclusion of retarding potential analyser and energetic particle spectrometer payloads onboard SROSS Aeronomy satellite to be launched in 1987.

Information on ion composition during high solar activity was provided as input to the International Reference Ionosphere (IRI). A comprehensive technique was developed for long-term ionospheric predictions using a set of coefficients derived from ionospheric data of the last 40 years. Short-term ionospheric variability has been modelled to take advantage of geomagnetic forecasts. An Atlas of Tropospheric Water vapour over the Indian sub-continent was brought out to aid in the design of terrestrial and satellite radio systems above 10 GHz. The fabrication of the solid state digital microwave refractometer was completed and was successfully flight tested for its air worthiness over Kanpur in June 1983 on a CESSNA 182 H Skyline aircraft.

GROUND BASED FACILITY FOR ENVIRONMENT MONITORING

1. SCOPE AND OBJECTIVES

The project covers monitoring technique of sensing Radio and Upper atmospheric environment. This includes design, construction and operation of equipments needed for the monitoring, development and use of data analysis techniques and study of the radio and atmospheric environment.

2. PROGRESS

2.1 Antarctic studies

The following instruments were provided to the second and third Antarctic expeditions in 1982-83 and 1983-84.

Two microbargraphs, two riometers at 20 and 30 Mhz, VLF receiver for phase and amplitude measurement and an automatic pressure temperature and humidity recorder.

The data obtained in the second expedition during 1982-83 have been analysed. The microbarograph records along with similar records taken at Delhi and Hyderabad provided insight into the generation mechanism of atmospheric waves caused by joule heating effects due to particle injection in the auroral belts. The riometer records have provided study of ionospheric absorption phenomena associated with proton flare event and magnetic storms. The atmospheric pressure, humidity, temperature recorder provided data at two levels, 2 meters and 40 meters, above the sea surface in the route from Goa to Antarctica. This provided an input to refractive index profiles and inversion layer

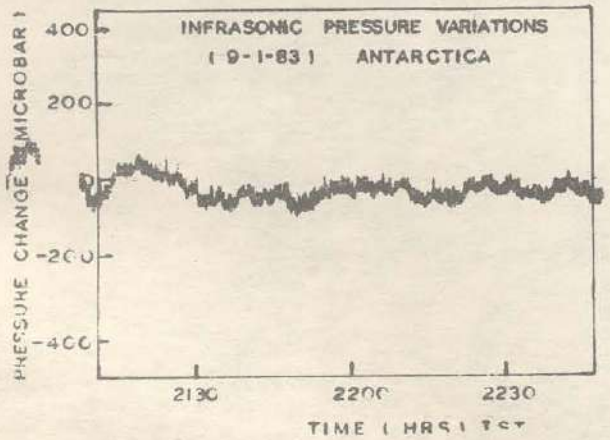


Fig. 1. Sinusoidal pattern in infrasonic pressure variation during a magnetic sub-storm (9 Jan. 1983) at Antarictica.

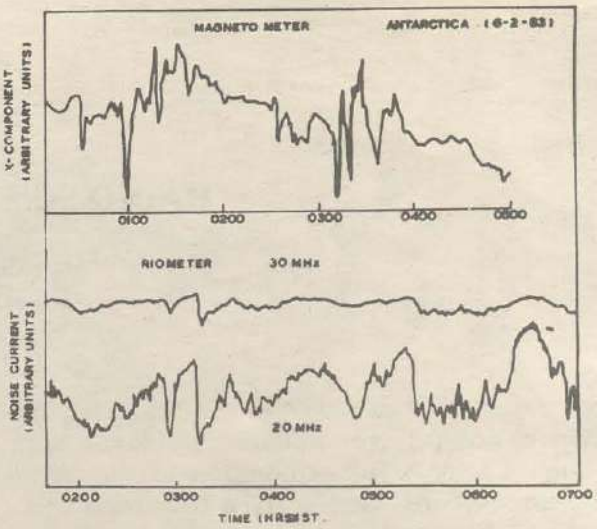


Fig. 2. Magnetic field changes (x-comp) and corresponding riometer records at Antarctica (6 Feb. 1983) when a SC storm was in progress. There is similarity in the pattern with a time delay.

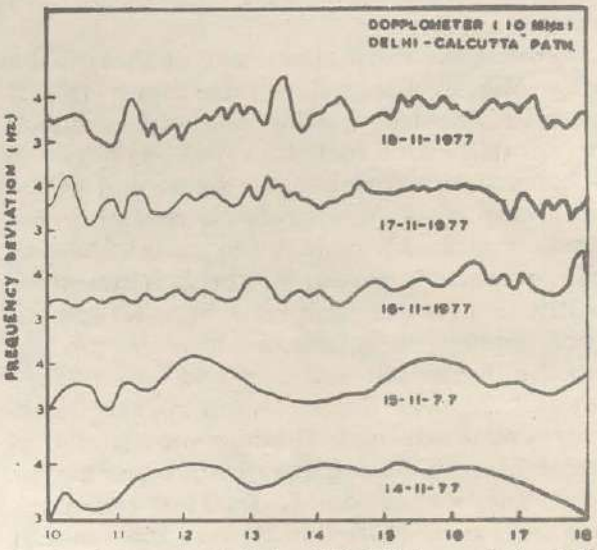


Fig. 3. Frequency deviation (10 MHz) records for Delhi-Calcutta path during a cyclone in 1977. Short period oscillations take over when the cyclonic storm is severe.

formation relevant to tropospheric radio wave communication. Studies on plasma heating phenomena have been continued. The results of 81-82 series of experiments were further analysed and theoretical studies initiated on non linear phenomena associated with the heating and the consequences.

2.2 Gravity waves generated by cyclone centres

Continued use of HF doppler equipment at 10 MHz (Delhi-Calcutta path) and microbarographs at Delhi, Hyderabad, Calcutta and Madras (part of the time) has shown pressure oscilla-

tions associated with the formation of strong cycline centres in the Bay of Bengal prior to their hitting the coast. Further studies towards investigating possibilities of using these techniques for cyclone prediction is being continued.

2.3 Paleo atmospheric studies

From astronomical and ultraviolet satellite observations of several sun-like stars in various stages of evolution, an attempt has been made to construct a possible variation of solar spectral laminosity pattern during the evolution of the solar system. Work is in progress on developing consistent models of atmospheric composition at various stages of evolution, that along with the spectral radiation change patterns, would allow inference on the possible climatic changes in the past.

3. PROJECT TEAM

A.K. Saha - Project Leader
R.C. Saksena, M. Ramakrishna, R. Venkatachari V.P. Sachdeva, A.R.S. Vashist, Abdual Hameed, Didar Singh, C.B. Nair, K.M. Sood, Kanwaljit Singh, T.R. Srinivasan, Arun Kumar Arora, V.N Lakshmi (Miss), Rashmi Paul (Mrs.).

ENVIRONMENTAL HAZARDS — SODAR STUDIES

1. SCOPE AND OBJECTIVES:

To study monostatic sodar for its possible applications in hazardous situations of air pollution and wind shear.

To develop the Doppler Sodar facility.

2. PROGRESS

The forward scattering experiment was conducted for one full year to study wind shear conditions in the lower atmosphere. The results as shown in fig. 1 have demonstrated that the component due to wind shear in the forward scattered echo can be clearly defined since the backscattered signal is exclusively due to temperature inhomogeneities. The forward scattering system consisted of a monostatic transmit-receiver and an oblique transmitter placed at a distance of 100m from the monostatic system.

Pasquill stability classification of the lower atmosphere has been developed based on the observed sodar structures. For this purpose surface wind direction fluctuations in the horizontal direciton have been used to study the prevalent Pasquill stability class and to correlate it with the observed sodar structure at that time of the day. Table 1 shows the stability classifi-

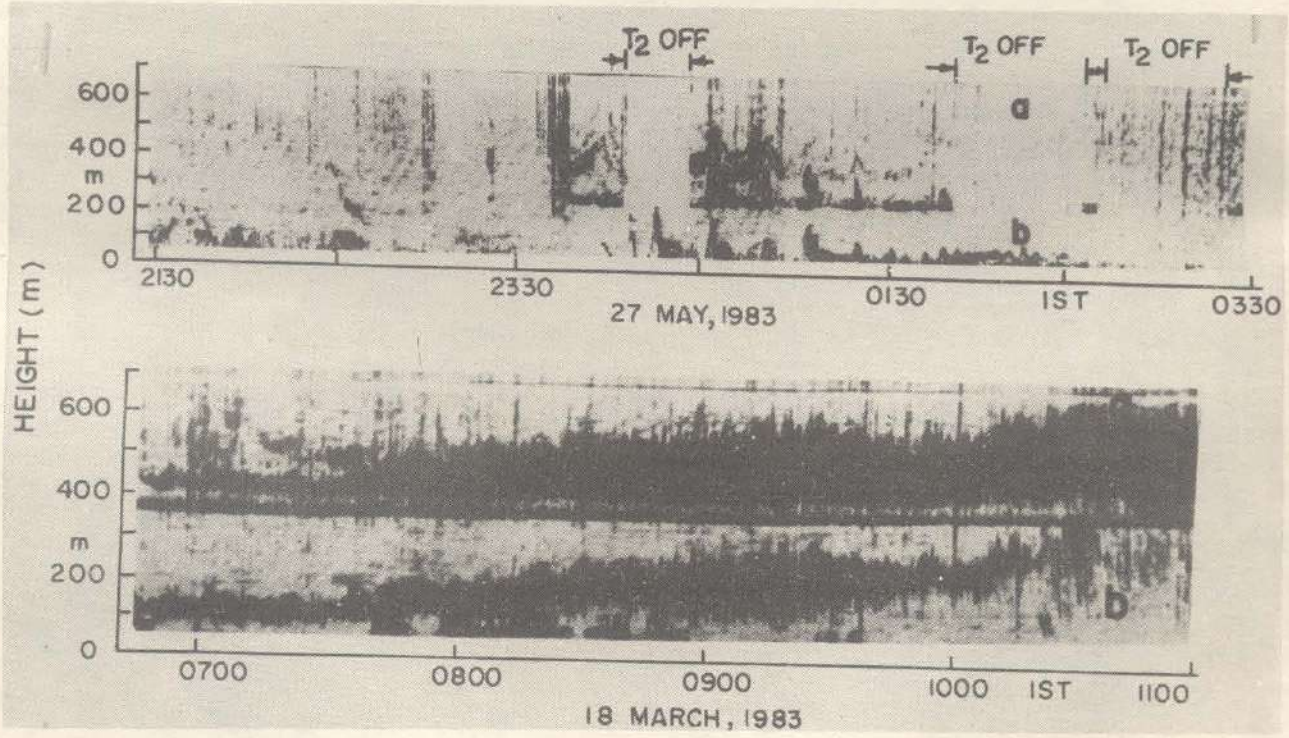


Fig. 1. Forward and back-scattered echoes. The lower layer of echoes are due to back-scattering and the upper layers are due to forward scattering. The record of May 27, 1983 shows through intermittent switching off oblique transmission that the upper layer of echoes are due to forward scattering. The difference in echogrammes shows that forward scattering is partly due to wind inhomogenetics.

Table I : Classification of Sodar Echograms in terms of Stability categories

S.No.	Stability Class (Pasquill)	Wind direction fluctuation criteria (degrees)		Nature of Sodar echograms	Outlook
1.	Strongly Unstable (A)	$\sigma_\theta \geq 23$	i)	Well defined thermal plumes upto heights more than or equal to 275 m.	Clear sunny day with strong solar heating and light/calm winds.
2.	Moderately Unstable (B)	$18 \leq \sigma_\theta < 23$	i)	Well defined thermal plumes upto shallow heights (less than 275 m).	Moderate solar heating and moderate winds.
			ii)	Rising layer with thermal plumes below.	Bright sunny morning.
3.	Slightly Unstable (C)	$13 \leq \sigma_\theta < 18$	i)	Thermal plumes upto shallow heights (less than 275 m).	Weak solar heating cloudy day, moderate to strong winds, and late afternoons.
			ii)	Layer with spiky top height more than 150 m.	
			iii)	Stratified layers of depth more than 200 m.	
4.	Neutral (D)	$8 \leq \sigma_\theta < 13$	i)	Spiky top layer of height within 100 to 150 m.	Early evening hours on clear days. After rain or storm, cloudy/windy conditions.
			ii)	No structure	
			iii)	Darkness due to rain or wind induced noise	During rain or heavy winds (storm)
			iv)	Stratified layer structure of depth more than 200 m.	
5.	Slightly Stable (E)	$4 \leq \sigma_\theta < 8$	i)	Flat top layer of depth more than 100 m.	Clear night with moderate winds.
			ii)	Surface based layer with spiky top of depth generally within 100 to 150 m.	
			iii)	Stratified layers of depth more than 200 m.	
6.	Moderately Stable (F)	$\sigma_\theta < 4$	i)	Surface based layer with flat top of depth within 100 m.	Clear night with strong radiative cooling and light/calm winds.
			ii)	Stratified layers of height less than 200 m.	

cation and the sodar structure criteria so obtained. The information obtained can be employed to monitor hazardous air pollution situations.

To set up the Doppler sodar facility at NPL a Pertec bufferedformatter tape transport system was acquired. Three parabolic antennas have been set up on the terrace of the NPL building. The central antenna will be active acting as both transmitter and receiver while the other two antennas placed arthogonally to it, at a distance of 80 m are inclined passive receivers. The transmit-receive systems to estimate the Doppler shift in frequency in the received signal from the vertically sounding system have been developed and tested. It has been found that the system is picking up too much of noise. Efforts are in progress to reduce noise in the system as also to operate the full system to obtain information about wind velocity in the boundary layer at many range gates.

3. PROJECT TEAM

S.P. Singal - Project Leader
D.R. Pahwa, R.M. Khanna, B.S. Gera, V.K. Ojha, S.K. Aggarwal.

INDIAN MIDDLE ATMOSPHERE PROGRAMME (IMAP)

1. SCOPE AND OBJECTIVES

The middle Atmosphere Programme of NPL forms part of the National Indian Middle Atmosphere Programme, which is a multi-disciplinary, multi-agency project, with the prime objective of studying the middle atmosphere defined as the region from 15 Km to 100 Km. N.P.L. has a long and continuing interest in this programme.

2. PROGRESS

2.1 Laser Heterodyne system

The system consists of a tunable CO_2 laser in the 9-11 micron band, that is used as a local oscillator/mixer and a Heliostat that follows the sun and brings in solar radiation, that is mixed with the laser beam in a liquid nitrogen cooled mercury cadmium telluride detector. The detected signal is analysed in an RF spectrum analyser that allows tracing absorption line profiles. A number of minor constituents in the troposphere and stratosphere such as that of O_3, H_2O etc. are in the 9-11 micron band. A Computer programme of inversion that takes care of doppler broadening and pressure broadenging at various heights gives the height profiles of the minor constituents.

The experimental system has been made operational and trial observations taken. The analysis • procedure and computer programme has been developed.

A study has been made of ozone distribution height profiles in tropical latitudes in the upper troposphere and lower stratosphere to seek possible connection of deformation in profiles and thunderstorm activities.

2.2 Rocket and Balloon Experiments

The data obtained from the extensive rocket compaign carried out during Feb. 16,1980 solar eslipse have been analysed. The percentage variation in the electron density in D-region and the loss coefficients during eclipse period have been computed. The variations in Proton flux in the F-region of the Ionosphere during eclipse have also been computed from these results.

Data from the Balloon flight carrying langmuir probe payload flown during March 1982 has been analysed. The positive and negative ion densities in the stratosphere have been computed from these results.

During the year 1982-83 four rocket flights carrying optical ozonosonde payloads have been carried out as a part of ozone intercomparison campaign. The participating institutes under this compaign were Space Science Group from NPL, Physical Research Laboratory and USSR. These measurements were supported by the extensive balloon borne measurements carried out by Indian Meteorological Department, VSSC and Indian Institute of Tropical Meteorology. The intercomparison of NPL data shows good agreement with both PRL and Soviet measurements thereby achieving the very purpose of this compaign.

A Balloon flight carrying langmuir probe payload was conducted during May 1983. But the payload did not work satisfactorily due to some technical problems.

Serveral rocket compaigns were approved and proposed to be carried out during early 1985. These campaigns are (a) D-region ionization intercomparison & (b) Aerosol intercomparison. This program involves the comparison of various techniques available for measuring electron and ion densities and for measurement of Aerosol density.

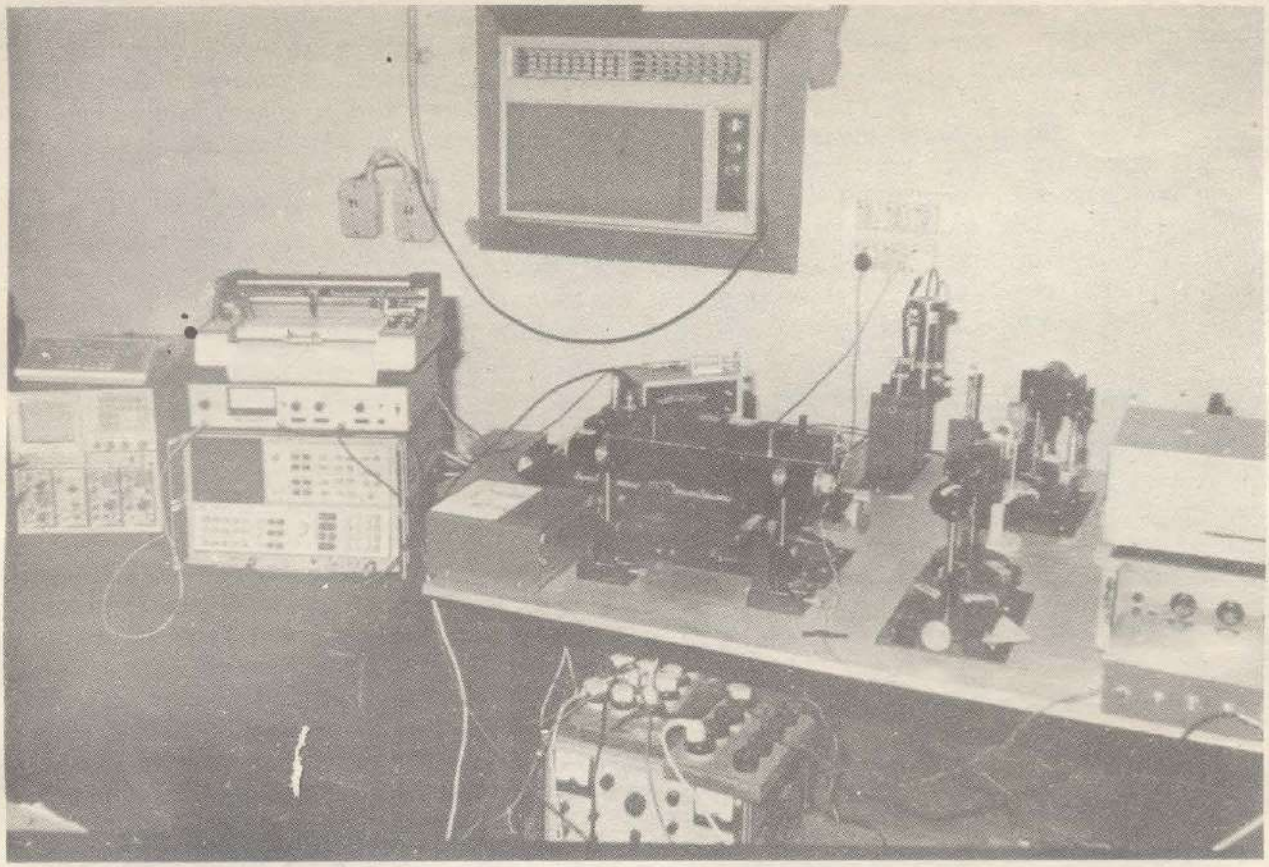


Fig. 1. Phtograph of the laser Heterodyne System.

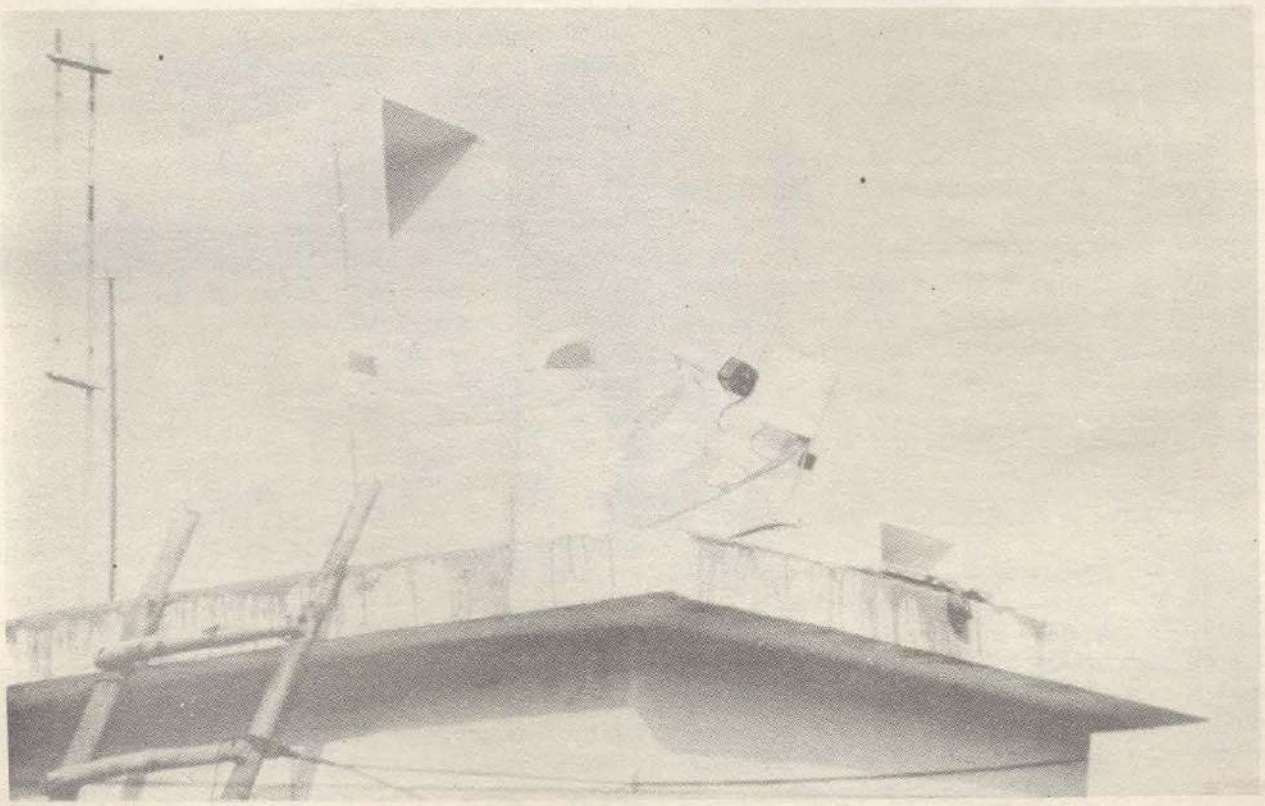


Fig. 2. Heliostat arrangement of the system.

Participated in the ionization compaign. Gerdien condenser rocket payloads, with automatic gain swtiching and a sensitivity of 10^{-12} Amp for the measurement of positive ion density profile, above about 60 km using RH-300 or centaure rockets were built.

Participated in a high altitude balloon experiment at Hyderabad on 4 May 1983, with Gerdian condenser payload for the measurement of positive ion density profile between 0 to 30 km height. But the current due to the positive ions was found to be less than the sensitivity limit of the electrometer (10^{-13} Amp.). It was concluded that it is essential to use an exhaust pump which can draw air through the Gerdien condenser at a rate of about 10 m/sec so as to be able to measure the positive ion density in this height range.

2.3 Dual-hot wire neutral temperature sensor

In collaboration with the University College of Wales, Aberystwyth, U.K. a new sensor was developed for the measurement of neutral temperature in the altitude range of 60-100 km. The instrument is essentially a dual hot wire anemometer employing two fine platinum wires, 25 μm diamter and a few millimeters long, suspended between needle-mounts which project forward at the top of a rocket payload to ensure the wires are free of the stagnation zone. The wires are identical in all respects apart from convection properties, one wire being treated in a controlled vacuum process to modify its thermal accommodation coefficient. Both wires are maintained, throughout the useful flight, at the same constant average temperature by means of wheatsone bridges incorporating high gain electronic feedback loops. Monitoring of bridge currents allows the difference in convection between the two wires to be measured with accuracy. Mount temperatures are monitored by miniature bead thermistors. The energy balance equations for the wires are solved and yield neutral gas temperature via the recover temperature.

2.4 VLF/LF D-Region

The utility of VLF/LF observations from D-region modelling is re-examined. Electron density profiles extending over a wide frequency range from ELF to MF through VLF/LF are compared with International Reference Ionosphere (IRI) models which are mainly based on direct rocket observations. The characteristics of the D-region IRI profiles and the dependence of electron density on solar zenith angle, sunspot number, latitude and season are obtained. The sensitivity of certain reflection coefficients to the height distribution of electron density and its implications on D-region modelling are also studied.

The description of the International Reference Ionosphere models of electron for the lower ionosphere is examined in relation to the experimental data. The reported best fit models from VLF and LF reflection data are compared amongst themselves and with rocket profiles in order to see whether the profiles obtained through the inversion process are similar to each other and with the direct rocket measurements.

2.5 SOLAR UV-B Measurement

The solar UV-B photometer was calibrated by a standard quartz iodine lamp to provide absolute value of UV-B radiation reaching at ground. The main tasks were to consolidate the data analysis of solar UV-B measurements and to correlate the absolute values with existing theoretical calculations. The analysis of past four years of solar UV-B measured data for direct and diffuse components at 280 nm, 290 nm, and 310 nm wavelength regions by photometer has clearly shown that the variation of solar UV-B radiation reaching at ground with stratospheric ozone is highly wavelength, solar zenith angles and weather conditions dependent. The atmospheric condition plays a major role in actual amount of radiation reaching the ground. The average variations in solar UV-B with changes in ozone are given below:-

Solar zenith angle	290nm filter	310 nm filter
30^{o}	24%	15%
40^{o}	25%	16%
50^{o}	35%	20%

The increase in global solar UV-B radiations at ground with 10% decrease in total ozone contents at 50^{o} solar zenith angle for 290nm and 310nm filters are 22% and 20% respectively.

Continuous observation of solar UV-B radiation has been taken during IMAP compaign period (15th Dec., 1983 to 29th Feb. 1984). The UV-B radiation received at ground in terms of micro watt cm^{-2} nm^{-1} for all the three filters have been derived from the observed data.

A UV source was also set up in the project using Xenon lamp, zero, one and two airmass filters and different broad band filters in UV-B region.

An automatic filter rotating integrating type multiwavelength radiometer has been designed and developed. This instrument records solar UV-B radiation by 280 nm, 290 nm, 300 nm, and 310 nm filters - by rotation and each filter remains in the field of view for nearly 45 seconds.

2.6 Microwave Radiometer

Printed circuit boards have been designed and fabricated for low noise amplifier, phase sensitive detector, low noise IF amplifier and detector to improve the sensitivity and performance of microwave radiometers at 11 GHz, 18 GHz and 22.235 GHz. Also integrated circuits have been designed and developed.

Longterm cummulative distribution of attenuation and rain rate at 11 GHz and 18 GHz show that for 0.017% of time the attenuation for whole year is 7.4 and 13.0 dB respectively, corresponding to the rainfall rate of 75 mm/hr. Cummulative distribution at 22.235 GHz show that for 0.7% of time attenuation exceeds 4.2 dB while for 0.4% it exceeds 8 dB. Correspondingly the rainfall rate exceeded would be 15 mm/hr and 30mm/hr respectively. Simultaneous measurements between 11 and 18 GHz and 11 and 22.2 GHz show that 18 GHz and 22.2 GHz rain attenuation is on an average 2.2 and 2.8 times larger than 11 GHz respectively.

Attenuation results under clear conditions for water vapour measurements at 22.235 GHz show that for different seasons it varies between 0.3 dB and 2.2 dB corresponding to the water vapour content in the atmosphere. This attenuation corresponds to the antenna temperature between 10 to 120^{o}K above the sky level. The average values of integrated water vapour content for winter, premonsoon and post monsoon are found to be 1.6×10^4; 2.7×10^4, 6.0×10^4 and 3×10^4 gm/m^2 respectively. The corresponding average attenuation values show that for different seasons it varies as 0.56 dB for winter; 1.2 dB for pre/post monsoon and 1.8 dB for monsoon period. The attenuation and correlation studies reveal that the clusters in the water vapour phase play an important role in the measurement of total attenuation.

An algorithm has been developed for determining cloud liquid using 11 GHz and 17.47 GHz brightness temperature of the atmosphere. The cloud liquid have been calculated for cumulus congestus (CU cong.) Cumulus mediocris (Cu med) and Alterostatus (AS) type of cloud over New Delhi.

3. PROJECT TEAM

A.P. Mitra - Project Leader
Y.V. Somayajulu, A.K. Saha, M.N.M. Rao, T.R. Tyagi, S.C. Garg, A. Banerjee, G.S. Uppal, B.N. Srivastava, C.V. Subrahmanyam, Y.V. Ramanamurty, M.C. Sharma, M.K. Raina, S.L. Jain, K.S. Zalpuri, P. Subrahmanyam, N.Kundu (Mrs.), D.R. Nakra, B.C. Arya, J.K. Gupta, T. John, P. Chopra (Mrs.), C.B. Tandel, M.N. Kaul, Visram Singh, Dhan Singh, Hitesh Jain, R.S. Tanwar, P. Saxena, C.K. Bhattacharya, Shambu Nath, G.S.N. Murty, T.S.R. Murali Krishna, Anju Bali (Miss).

SATELLITE RADIO BEACON STUDY

1. SCOPE AND OBJECTIVES

To study the ionosphere using satellite radio beacon transmissions (with special reference to ionospheric electron content, scintillations, large and medium scale irregularities etc .) and to use this ionospheric study for various space applications such as refraction errors, satellite ranging and position fixing, effects of irregularities in communications etc.

2. PROGRESS

A detailed analysis of the IEC measurements simultaneously carried out at Delhi, Hyderabad, Nagpur, Waltiar, Bangalore and Calcutta during the total solar eclipse of Feb. 16, 1980 and those at Delhi during the eclipse of July 31, 1981, reveals that though TID's are generated by the solar eclipse but their detection by the satellite beacon technique is critically dependent on the location of the observing station relative to the path of totality.

A study of Fresnel type fading recorded at Delhi over half a solar cycle period (1974-1980) has been made. These are more frequent during low solar activity period as compared to high solar activity period and are generated on most occasions by sporadic-E layers around 105-110 kms.

Some important features of the studies of scintillations using multi-station data collected from a chain of stations spread over a magnetic latitude belt of 3°N to 21°N (420 km sub-ionospheric points) have established unambiguously the control of equatorial spread-F irregularities in producing low latitude night-time scintillations. Estimated integrated Production and loss rates in the ionosphere have been estimated utilising the Faraday Rotation data obtained with ATS-6 and ETS-II VHF radio beacons. Some general and specific features of IEC and scintillations have been found out using Satellite Beacon Data.

3. PROJECT TEAM

Y.V. Somayajulu - Project Leader
T.R. Tyagi, Lakha Singh, P.N. Vijayakumar, S.C. Garg, S.R. Bakshi, Vijay Chaudhary, J.K. Gupta.

SROSS AERONOMY SATELLITE

1. SCOPE AND OBJECTIVES

To study the thermal structure of the equatorial and low latitude ionosphere and to establish the response of the thermal structure to the dynamical effects and particle precipitation by carrying out experiments with retarding potential analyser (RPA) and energetic particle spectrometer (EPS) on-board SROSS Aeronomy Satellite.

2. PROGRESS

2.1 RPA and EPS Payloads aboard SROSS-3

A proposal was submitted to ISRO from NPL for the inclusion of RPA and EPS payloads on-board the first Indian Aeronomy Satellite SROSS-3 scheduled to be launched in 1987. RPA experiment will be used to measure F-region electron and ion densities and temperatures and EPS to measure proton-electron energy spectra in the range 20 to 120 KeV. The proposal has been accepted in principle and payload design is in progress.

2.2 Monte-Carlo Calculations of energetic particle precipitation into equatorial atmosphere

The problem of the precipitation of KeV protons and neutral hydrogen atoms into the equatorial atmosphere is studied by the Monte-Carlo technique and the energy deposition is calculated for different atmospheric models corresponding to low-medium and high solar activity conditions. It is found that the total energy deposited is independent of the atmospheric model and is equal to 16% but the energy deposition profile varies. The dependence of the profile parameters on the neutral atmospheric model is examined in detail. An empirical model of the Chapman type distribution, involving only the neutral atmospheric density, has been developed to represent the energy profile for any solar activity condition.

3. PROJECT TEAM

Y.V. Somayajulu - Project Leader
B.C.N. Rao, M.N.M. Rao, T.R. Tyagi, S.C. Garg, P. Subrahmanyam, V.K. Vohra, J.K. Gupta, Parvati Chopra, N.M. Kaul, Vishram Singh Yadav, Dhan Singh Chaunal, Hitesh Jain.

STRATOSPHERIC IONIZATION

1. SCOPE AND OBJECTIVES

To study the physics of the upper atmosphere using ground based night airglow experiments.

2. PROGRESS

Night airglow studies

Three channel-night airglow-photometer continuously measuring the zenith intensities of (OI) 5577A (OI) 6300A and OH (8-3) band was operated at Kodaikanal (1978-79) and at Visakhapatnam (1980-81). On the basis of this data, the following studies have been made.

a) A new method has been developed for deducing the atomic oxygen density profiles in the lower thermosphere (90-120 km) using the ground based night airglow measurements only. This technique permits us to deduce the [O] profile at any moment of the night.

b) A new semi-emperical method has been developed for deducing the vertical eddy diffusion coefficient in the height range of 85-120 km. as well as the turbopause level at any instant of the night.

c) A method has been suggested to resolve the Chapman-Barth controversy as to the probable excitation mechanism of (OI) 5577A line emission in the lower thermosphere. It is quantitatively shown that the uncertainties in the laboratory measured rate coefficients can considerably effect the volume emission rate, particularly by Barth mechanism, whereas the height of maximum emission is insensitive to these uncertainties.

d) The amplitude and phase of the lunar semidiurnal component of the oxygen green line (L.S.C.) have been theoretically estimated, using Chapman and Barth mechanisms for different assumed [O] profiles. These are compared with those obtained from the night airglow observations over Kodaikanal, from which it is concluded that the Barth mechanism agrees more favourably with the observations.

3. PROJECT TEAM

M.N.M. Rao - Project Leader
G.S.N. Murty

PLANETARY IONOSPHERES AND IONOSPHERIC STUDIES USING INCOHERENT SCATTER RADAR

1. SCOPE AND OBJECTIVES

To study the different regions of the upper atmosphere and ionosphere with experimental data obtained from various incoherent-scatter radar observatories in the world.

To utilise these studies for improvement of ionospheric and atmospheric models.

To understand the atmospheres and ionospheres of Venus, Mars, Jupiter and Saturn.

2. PROGRESS

2.1 Nighttime Thermospheric Bulge

Analysis of electron and ion temperature measurements have shown the presence of a bulge in the nighttime thermospheric temperature. The bulge extends from a few degrees on one day to a few tens of degrees on another. The bulge, however, does not exhibit any uniform shape. The occurence of the bulge is found to be closely related to the ion drifts.

2.2 Total electron Content Studies

Some 800 daytime profiles of electron density and ion drifts have been analysed to study the relationship between these two parameters. the electron content is found to increase with the increase in the vertical ion drift. There is however, a time lag between the change in the ion drift velocity and the effect on electron content. This time lag varies from a few minutes to several hours, depending upon the height of the F-layer peak.

2.3 Ion-neutral Collision frequency in the Turbopause Region

Ion neutral collision frequency measurements in the turbopause region over a period of about three years were analysed. Large day to day and seasonal changes in the collision frequency were observed thereby indicating the variability of neutral composition in the turbopause region.

2.4 Planetary Ionospheres

A detailed review has been made on the ionosphere of various planets, based upon the latest measurements. Data based on the ionospheric measurements from the Pioneer Venus orbiter has been completed. The data have been compared with those published by the experimenters. The discrepencies noted are being resolved.

The possibility of the presence of equatorial anomaly in the ionosphere of Saturn has been explored. It appears from the available measurements that the presence of anomaly can not be ruled out.

Effects of solar flares have been identified in the ionosphere of Venus. Further studies are underway to understand the effects.

3. PROJECT TEAM

K.K. Mahajan - Project Leader
A.R. Jain, V.K. Pandey, Risal Singh, M.K. Goel, R. Kohli, J. Kar, M.V. Sri Lakshmi (Miss).

TROPOSPHERIC & IONOSPHERIC COMMUNICATIONS

1. SCOPE AND OBJECTIVES

The primary objective of the Project is total characterisation of our radio environment for application in Radio communications in a wide spectrum of frequencies from VLF to microwave bands. The future scope would also include extension to mm waves.

Fig.1 shows the activity structure of the project.

2. PROGRESS

2.1 Solar Predictions

Regular sunspot predictions, six months in advance are being continued. The minimum of the present cycle is likely to occur sometime in December 1986. The peak value for the next sunspot cycle is predicted to be around 100 and is likely to occur in the year 1990.

2.2 Ionospheric Predictions

The basic index used to predict the ionospheric parameters is the smoothed sunspot number R. The linear relation of foF2 and M(3000)F2 did not give very good results near the peak of the cycle and the well known saturation effect was evident. Since the saturation for different stations and at different times of the day did not start for the same value of sunspot no.(R)second degree relations have been determined statistically using all the ionospheric data available for different stations. The relation used is of the kind.

$$Y = A+BR + CR^2$$

where Y is monthly median ionospheric parameter [foF2, M(3000)F2] for a fixed station, month and hour and R is the smoothed sunspot number. Since predictions are provided on monthly basis the three coefficients A, B and C can be presented in the form of contour maps for every month. A sample diagram for March over the Indian subcontinent is shown in Fig.2. By using the predicted value of R, ionospheric parameters can be obtained for the required location and time of the day. A complete set of such diagrams for twelve months will be published in the form of an Atlas for users and can be used for any frequency planning.

In addition to the monthly median frequencies it is also required to know their variation over the month to determine the reliability of a circuit operating at a given frequency. Statistical distribution functions for the F-region parameters have been calculated over a solar cycle for a few Indian stations for all the seasons. A compendium of the lower and upper decile values is being prepared for the Indian subcontinent.

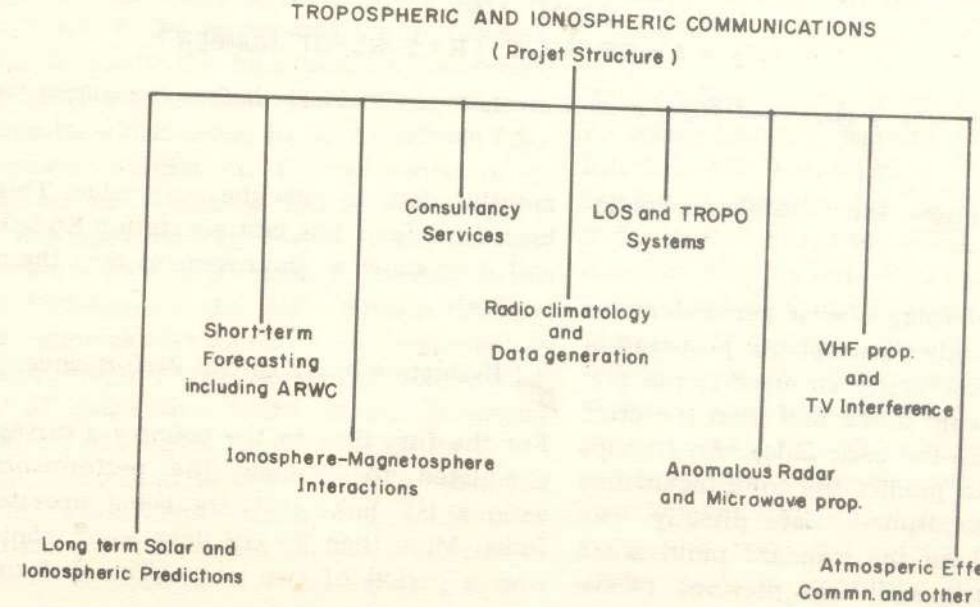


Fig. 1. The structure of the communications project showing the aetails of independent activities.

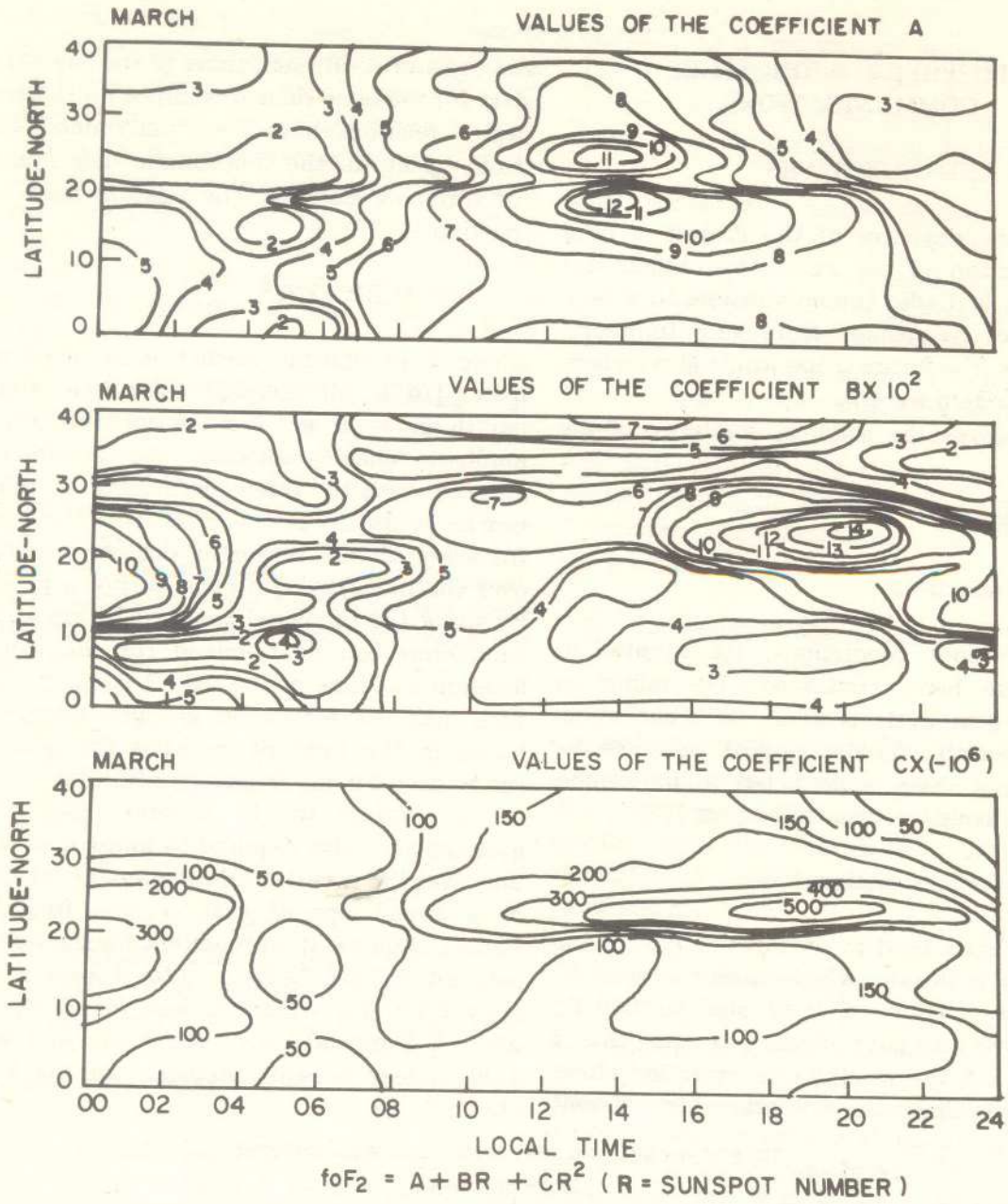


Fig. 2. Contour maps of the second degree coefficients A, B, and C over the Indian sub-continent for March.

2.3 Studies to Improve the Ionospheric Predictions

The technique of using a solar parameter as a basic index to predict ionospheric propagation parameters involves firstly an error in the prediction of the basic index and then the error of correlation with the basic index. An attempt has been made to predict the foF2 parameters using previous ionospheric data directly. The method is based on the standard multivariate regression analysis and uses previous twelve months' data to give the next value. This has been tried for a low latitude station Kodaikanal and does show an improvement over the other methods.

2.4 Evaluation of HF Circuit Performance

For the first time in the country a survey was conducted to evaluate the performance of various HF links that are being operated in India. More than 50 HF links were monitored over a period of two years. The performance

of the circuits is in general found to be poor during night-time, the situation being particularly unsatisfactory during 0200-0700 hours.

It was suggested that a proper choice of frequencies along with well designed antenna systems could improve the performance. It was also recommended that a separate frequency should be assigned for operation during transition periods.

2.5 Modelling of Short-Term Ionospheric Variations

Prediction of short-term variations in ionospheric communication parameters is an essential requirement to improve the reliability of HF links. At present, reliable forecasts on magnetic activity are available through IUWDS network and these forecasts can be advantageously used by HF circuit operators, if a good model of these short-term departures is developed. TIC group has developed separate models for these short-term variations for magnetically disturbed and quiet conditions. Possible actions which a communicator can take to improve the reliability of HF circuits operating through reflections in India and other low latitude regions have also been suggested, based on these models.

2.6 Study of High Latitude Ionosphere using AE-C Satellite Data

Considerable stress has been laid on studies related to basic characteristics of the medium through which the radiowaves are propagated. Efforts to study the high latitude ionosphere using AE-C satellite data yielded some significant results which hither to have not been fully understood. Studies on thermal structure of ionosphere have revealed that the ion temperature was considerably higher than electron temperature in a large number of cases at the exact location of the high latitude trough. These anomalously large ion temperatures are also found to be associated with higher levels of magnetic activity. It was suggested that direct heating of the O^+ ions by the precipitating protons, in addition to Joule heating in the convection zone auroral oval, could be a formidable mechanism for the sharp increase in the ion temperature for exceeding electron temperature.

2.7 Advisory Services

RSD is the only advisory body in the country on problems related to radio communications. During the last few years services were also extended to other countries. Prediction charts for HF communications over the entire country of Somalia were supplied in response to a request from Ministry of Communications, Somalia. Predictions were also provided to Iraq as a part of bilateral exchange programme.

This group had also rendered consultancy services to several research organizations who are involved in research projects of national importance. ISRO was provided with detailed information on ionosphere - supported interference from a proposed MST Radar at 52.0 MHz to other radio systems in the country. Ionospheric predictions were provided to LRDE, Bangalore to aid in their design studies for a classified ionospheric system. A special document was prepared for this purpose giving complete HF communication parameters for several HF Radar locations.

HF predictions were also provided for the second and third Indian Expeditions to Antarctica. An algorithm to locate a distant ship radiating in HF band has been developed at the instance of Indian Navy. Similar services were rendered in radar and microwave communications.

2.8 Associate regional warning centre and short-term forecasts on solar and magnetic activities.

Radio Science Division has been designated as Associate Regional Warning Centre (ARWC) of International URSIGRAM and World Days Service. A variety of solar data from observatories located round the world (Tokyo, Sydney, Boulder, Moscow and Paris) pours in daily by Telex, most of it in URSIGRAM codes (Fig.3). The data is decoded, analysed and interpreted and based on this a daily warning on solar and magnetic conditions is issued. These Warnings are being used by radio communicators, rocket experimentors and researchers for their special experimental studies. In the last two or three years, this particular activity has taken rapid strides both in improving the quality of its forecasts and also in extending its services to

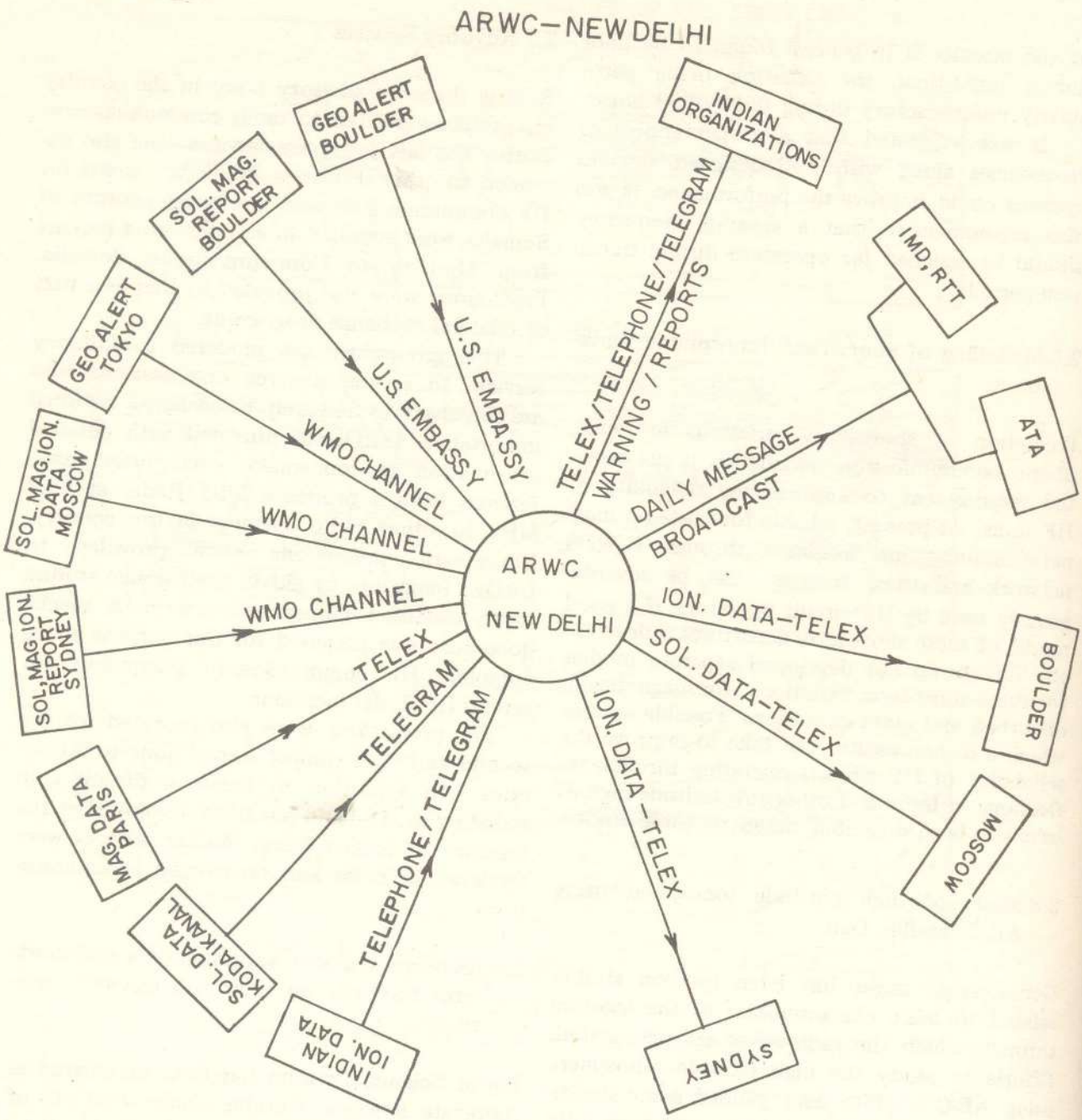


Fig. 3. ARWC channels for Near-real time exchange of solar geophysical data.

various users in the country. The weekly forecasts issued on solar radiation at 10.7 cm wave length are being used by ISRO in their estimates on satellite life times and satellite orbital parameters. A large number of special alerts were issued during the last two years on solar and magnetic activities for the benefit of rocket experimentors for their studies on equatorial electrojet, equatorial spread F etc.

2.9 GHz Scintillation experiment

A mini satellite earth station (operating in 'Receive only' mode) was established at NPL to investigate experimentally the cause and extent of ionospheric scintillations observed in GHz transmissions from geosynchronous communication satellites. Though, the earth station was planned for experiments using INSAT-1B, its performance was checked with APPLE

satellite. The system installed can operate with any geosynchronous satellite transmitting in 3.7 to 4.2 GHz band. Since October 1983, NPL system has been continuously operating and the last one year's operation has generated valuable data on scintillations and rain effects in this frequency band. The system has monitored INSAT-1B transmissions for a total of 10000 hrs. However, scintillations were observed only during some days of October 1983 and from middle of May 1984 to July 1984. Thus about 100 hrs. of scintillation data in which amplitude varied from 0.5 dB to 2.0 dB have been collected.

2.10 Estimation of antenna gain degradation using height profiles of C_n^2

Depending on the nature of irregularities in the atmospheric refractive index which cause the scattering, the angular spectrum of the flux incident on the receiver may, at times, extend beyond the receiving aerial beam. The group has developed a general expression for unidentical antennae to estimate 'medium-to-aperture' coupling loss G_L using scattering cross-section in terms of structure parameter C_n^2. Typical calculations have been carried out and results were compared with the observed G_L for a path length of 160 km at a frequency of 4.7 GHz. The two results compared well and the technique will be modified for computer adaptation.

2.11 Atlas of tropospheric water vapour over the Indian sub-continent

The results of preliminary attempt in quantifying the water vapour morphology over the Indian sub-continent are documented in the form of an Atlas with maps of water vapour density for various pressure levels and also height profiles for specific regions of the country. It is planned to bring out attenuation algorithms for different elevation angles at a number of frequencies.

2.12 Line-of-sight microwave link over hilly terrain

A study of the propagation characteristics over hilly areas is particularly important. Line-of-sight microwave amplitude measurements at 7 GHz were made round the clock from March 1981 to April 1983 using an operational communication link of Posts and Telegraphs between Tiruttani and Tirupati situated in the southern part of India. The fade outs were interpreted in terms of inadequate Fresnel Zone clearance by using ray tracing techniques (Fig.4).

2.13 Evaluation of duct thickness and C_n^2 in the Indian Ocean

Efforts have been made to evaluate the evaporation duct thickness in the maritime boundary

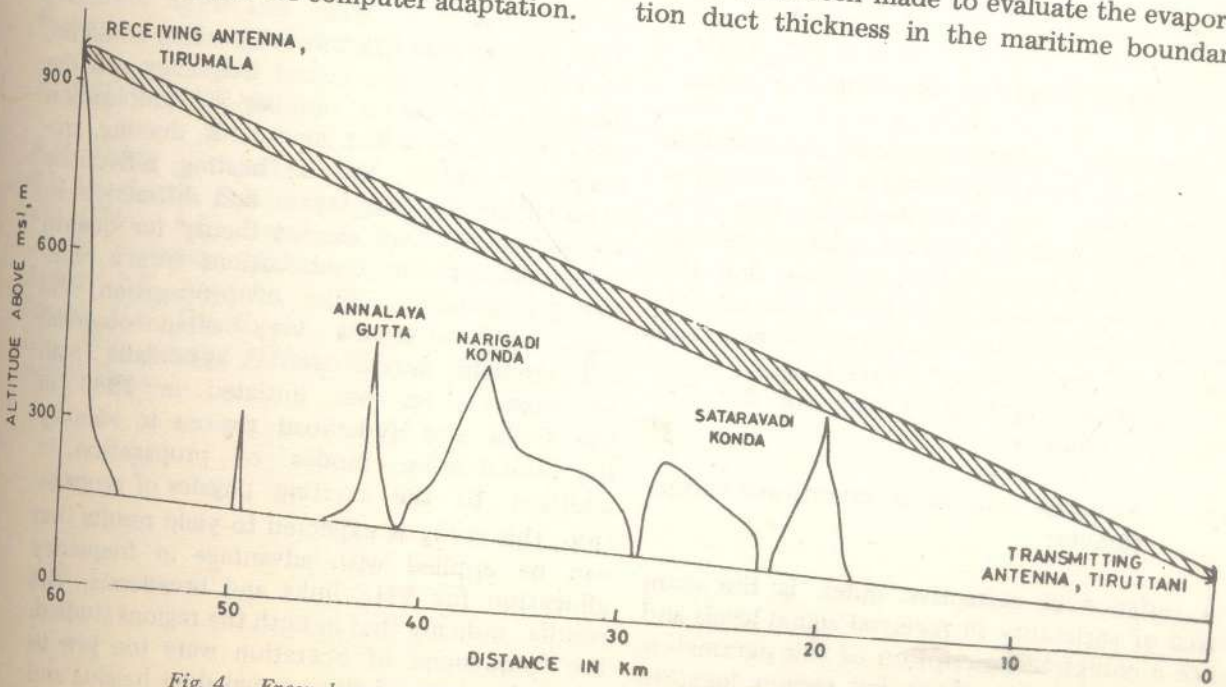


Fig. 4. Fresnel zone clearance depiction for the Tirupati - Tiruttani LOS link.

layer using the routine meteorological observations: (a) Data compiled by the India Meteorological Department from observations of ships of the voluntary observing fleet under the auspices of the WMO. (b) Observations taken on a cruise to Antarctica in 1982-83.

Monthly mean maps of duct thickness have been prepared. At large distances ≈200 km, the scatter mode surpasses the duct influence. The scattered power in a scatter mode depends on the radio refractive index fluctuations in the turbulent atmosphere. This is characterized by the Tatarski's structure constant C_n^2. A height profile of C_n^2 has been evaluated upto 50 metres from the actual observations.

2.14 Anomalous radar propagation

A radar campaign was conducted in the east coast of India during the month of May, 1982, in which S-band, cyclone warning meteorological readars situated at Karaikal, Madras, and Machilipattanam were operated simultaneously. A detailed study indicates that the superrefraction and ducting conditions all along the Bay of Bengal coast are not similar. Corresponding routine radiosonde data from these stations does not always correlate with the occurrence of super-refraction or ducting conditions. It is noted that land and sea breezes were closely associated with the occurrences of super-refraction and ducting and the later were more marked when light winds were easterly, south easterly or south-westerly.

2.15 Radar range and elevation angle errors

With the aim of calculating range and elevation angle errors in radar tracking, a new computer algorithm has been developed. In this both surface value and the initial gradient of the refractive index in approximately the first 100 metres above the earth's surface will be used. It is planned to calculate the range and elevation angle errors for different target heights, elevation angles and apparent ranges for different parts of the country.

2.16 Airborne solid state microwave refractometer

The variance in refractive index is the main source of variability in received signal levels and hence a complete description of this parameters versus weather, time of the day, season, location etc. is highly desirable. In order to collect such information very accurately with a short response time, over Indian sub-continent for the first time, a solid state digital airborne microwave refractometer has been designed and fabricated. This refractometer was successfully flight tested for its airworthiness in Kanpur in June 1983. The refractometer was mounted in the CESSNA 182 H SKY LANE aircraft of I.I.T., Kanpur for field trials. The refractometer sampling cavity (sensor) was mounted under the wind such that the air sampled was undisturbed by the aircraft's slip stream and the rest of the electronic system was mounted in the body of the air craft. A thermister was also mounted (in a radiation shield) just above the sensor to measure the atmospheric temperatures. Initial flights were conducted only to evaluate the system for its airworthiness.

Vertical profiles have shown substantial turbulence below 1000 metres (Fig.5) indicating sharp gradients in the refractive index. Values of 11 N units per thousand feet have been observed. Further, the profiles indicate the detailed structure and orientation of the layers. In addition the presence of extended layers in the refractive index structure are also seen. In some cases there is a marked discontinuity in the vertical gradient of refractive index. Using the atmospheric temperature information and the refractivity profile, water vapour profiles were also derived over Kanpur IIT airstrip.

2.17 VHF(TV) propagation over the horizon

VHF Propagation beyond the horizon could be, depending upon the actual frequency and the distance, due to a number of propagation mechanisms including sporadic-E, ducting, tropospheric scatter, Fregion heating, reflections from trophospheric layers and diffraction. In the absence of an elegant theory for quantifying the relative contributions from a number of possible modes of propagation, the high field strengths very often observed still remain anomalous. A systematic plan of observations was initiated in 1983 in the Delhi and Hyderabad regions to identify the dominating modes of propagation. In addition to the exciting physics of propagation, this study is expected to yield results that can be applied with advantage in frequency allocation for VHF links and broadcasts. The results indicate that in both the regions studied, the frequencies of operation were too low to take advantage of the normal duct heights and

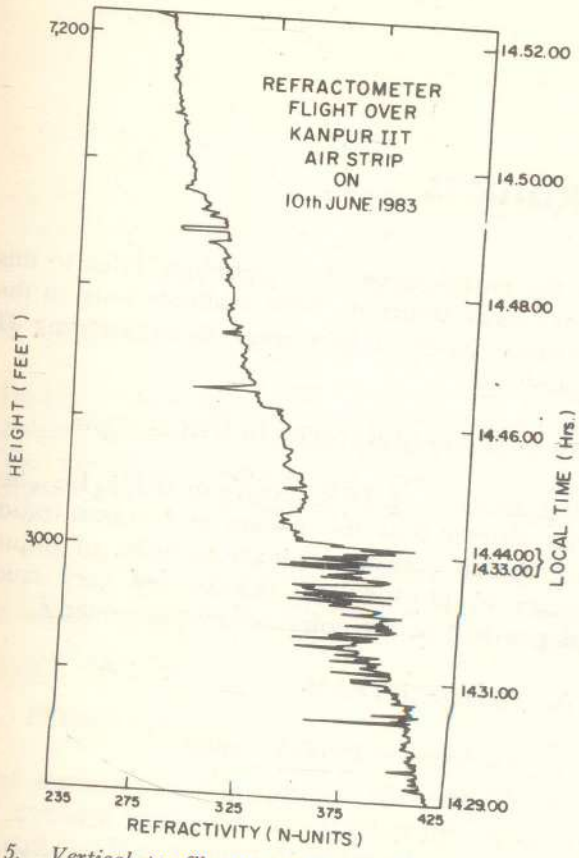


Fig. 5. Vertical profile of refractivity from Air-borne solid state microwave refractometer. The large turbulence at lower altitudes is obvious.

most of the large field strength situations are combinations of superrefraction and diffraction. Comparison with simultaneous radiosonde data wherever available also shows that reflection from layers and glints could be a major factor in causing high field strengths.

3. PROJECT TEAM

B.M. Reddy - Project Leader
S.B.S.S. Sarma, D.R. Lakshmi (Mrs.), S. Aggarwal (Mrs.), P.K. Banerjee, H.N. Dutta, A.B. Ghosh, Mahendra Mohan, P.L. Malhotra, S.K. Sarkar, P.K. Pasricha, R.S. Dabas, M.V.S.N. Prasad, U.C. Upreti, S.S. Shastry (Mrs), M.K. Dua, Shiv Kumari (Mrs.), K.G.M. Pillai, Manmohan Gupta.

IONOSPHERIC & NEUTRAL ATMOSPHERIC MODELLING

1. SCOPE AND OBJECTIVES

To develop models of ionospheric and atmospheric parameters applicable at low latitudes over the Indian subcontinent for quiet and disturbed conditions.

2. PROGRESS

Ion composition behaviour during high solar activity period was analysed and given as input to the International Reference Ionospheric (IRI) for modifying their models- Development of F region theoretical models for equatorial latitudes are in progress. In connection with the lower ionosphere electron density modelling, the existing ground based and rocket observations on electron density profiles are compared with the IRI models and the state of the art in D region IRI modelling effort is reviewed. Short term departures in ionospheric F-region parameters have been modelled for both quiet and disturbed periods separately for Indian zone.

The coefficients of the second degree empirical model of foF_2 and $(M3000)F_2$ with respect to solar activity have been evaluated for Indian ionospheric stations.

3. PROJECT TEAM

B.C.N. Rao - Project Leader
Y.V. Somayajulu, A.K. Saha, B.M. Reddy, K.K. Mahajan, M.N.M. Rao, Y.V. Ramana Murty, A.R. Jain, T.R. Tyagi, D.R. Lakshmi, S.Aggarwal, A.B. Ghosh, M.K. Goel, N.K. Sethi, Lakha Singh, P.K. Pasricha, R.Venkatachari, K.S. Zalpuri, V.C. Jain, V.K. Pandey, R.C. Saxena.

OTHER R & D PROJECTS

THEORETICAL INVESTIGATIONS IN CONDENSED MATTER PHYSICS

1. SCOPE AND OBJECTIVES

These investigations are undertaken to gain an in-depth understanding of the problems in the areas of phase transition, non-equilibrium superconductors and impurity effects in superconductors. Phase transition in quasi one-dimensional systems is of current interest because of the experimental observations in charge-transfer compounds like TTF-TCNQ Superconductors driven away from thermal equilibrium by external fields hold promise of raising the transition temperature. Quantum field theoretic methods are used for these investigations.

2. PROGRESS

2.1 Non-equilibrium superconductivity

Kinetic equation method was used to study the non-linear charge imbalance dynamics in a non-equilibrium superconductor. This treatment confirmed the results obtained earlier by the Greens' function method viz. the soliton behaviour. The soliton solutions obtained are very similar to the solutions in the problem of charge carriers in weakly pinned charge-density wave condensates.

2.2 Kondo effect in superconductors

Bethe ansatz approach was used to solve this problem. Exact diagonalization of the Himiltonian in this case has not yet been achieved. However, a modified self-energy expression was obtained and it gave an enhanced depression of the transition temperature.

2.3 Jahn-Teller interaction in solids

Using a canonical transformation and variational approach we have evolved an analytical solution to the JT problem in cobaltocene which is valid in the entire range of JT coupling. Prior to this work such solutions were available only in the extreme cases of very weak or very strong JT coupling.

2.4 Theoretical studies in ESR analysis

The analysis of ESR spectra in $CuGa_xIn_{1-x}Se_2$ has shown that the nature and concentration of charge carriers in these samples of importance in photovoltaic devices are very much dependent on the composition parameter X.

3. PROJECT TEAM

R. Sundaram — Project Leader
Ramji Rai.

INSTRUMENT MAINTENANCE AND ALLIED ACTIVITY

1. SCOPE AND OBJECTIVES

To inspect out of order instruments for repariability or write off. To trace the faults and rectify where feasible.

To provide consultancy on instrumentation matters.

2. PROGRESS

Completed the UNIDO assignment for one year at TIRDO, Tanzania regarding the maintenance cum calibration Centre for instruments.

The instruments of different divisions and projects of N.P.L. were inspected and serviced. The advice on instrumentation matters was provided to various institutions and hospitals such as IIT, Delhi, IARI, New Delhi, Delhi University, Delhi, Agriculture University, Hissar, Saferjung Hospital and R.M.L. Hospital, New Delhi.

3. PROJECT TEAM

S.K. Suri — Project Leader.

SERVICE SECTIONS

CENTRAL WORKSHOP

1. SCOPE & OBJECTIVES

Design & fabrication of instruments, apparatuses, gadgets etc. for the projects of the laboratory. The workshop is assisted by drawing and design section, and consists of following shops.

Machine Shop, Fitting & Sheet Metal Shop, Carpentary & Pattern Making Shop, Welding Shop, Foundary Shop, Painting & Electroplating Shop.

2. PROGRESS

The workshop is well equipped with various kinds of machine tools and undertaking jobs from industry and Government departments.

During the period 5388 job orders were executed valued at Rs.32 lakhs approximately. The major jobs undertaken & completed during this period were:

1. Fabrication of PAN assembly for Weights & Measure Division.
2. Parts of Liquid air plant of Cryogenics Division.
3. Horizontal vertical rotation device for R.S.D.
4. Fabrication of Reaction Chamber for Materials Division.
5. Fabrication of Masks for Cryogenics Division.
6. Fabrication of two housing for length standard.
7. A carbon pressing die for Materials Division.
8. Stand for laser for Length Standard.
9. Pyramids for Microwave Division.
10. Fabrication of R/T measuring device for Thin Film Division.
11. Drive for Length Standard.
12. Screw jack for Optics Division.
13. Three worm-reducer for "Force Standard Division.
14. Interferometer photo for Sound Division.
15. Automatic Filter System for RSD.
16. Balloon pay-load for RSD.

2.1 Fabrication for other Agencies & Institutions:

1. Fabrication of solar cooker for STEC (DST)
2. Four couplings for IARI, Pusa.
3. Model of solar evaporative unit for CSIR.

2.2 The Drawing and Design Section rendered assistance to various R&D projects and undertook drawing jobs for seminar, science week, printing, publication and exhibitions etc. About 740 jobs were completed during the period. Some of the major design jobs completed related to:-

(i) Conveyer for clinical thermometer

(ii) Piston phone for generating infra sound.

(iii) Mask alignment system.

(iv) Automatic filter shifting photometer.

(v) Angular calibration unit for Rocket experiment.

(vi) X-ray collimation system for single crystal camera lens.

(vii) Standard Hardness Testing Machine.

(viii) Precision X-ray diffractometer.

(ix) Silicon cracking chamber

(x) 100 KN Dead Weight Machine.

3. PROJECT TEAM

S.K. Kapoor — Project Leader
H.N.P. Poddar, M.L. Sarkar, C.S. Dua, Kartar Chand, M.K. Chibber, M.L. Nagpal, M.G. Sehgal, Harish Chand, Dharam Chand, J.P. Saini, T.R. Marwaha, Ram Sarup, Ganpat Singh, K.K. Sharma, T.K. Parmeswaran, P.P. Singh, Bhupendra Singh, Sham Singh, Khazan Singh, Satya Prakash, S.L. Pandey, V.P. Arora, Malkiat Singh, Dharam Singh, Bishamber Nath, G.K. Kapoor, Shadi Lal, E.W. Browne, Pratap Singh, S.P. Sharma, Brij Lal.

GLASS TECHNOLOGY WORKSHOP

1. SCOPE & OBJECTIVES

This Unit has continued its activities in the field of fabrication and reconditioning of sophisticated scientific glass & silica equipments for use in the various projects of the Laboratory as well as for outside industries, R&D Organisations, educational and medical institutions.

2. PROGRESS

The Unit assisted various R&D Projects of laboratory. With high vacuum standard joints, stop-cocks, mercury & oil diffusion pump, quartz stop-cocks, teflon Stop-cocks, discharge tube including laser tubes, glass to metal seals, liquid purification Apparatus, chromotography columns with stop-cocks and sintered discs, cylinderical & spherical dewar flask silvered quartz reaction chamber, quartz ampules and like.

The assistance was given in design, fabrication and reconditioning of glass & silica equipment for various institute & departments such as:

I.A.R.I. New Delhi, University of Hyderabad, I.I.T. Kharagpur, I.I.P., Dehradun, I.O.C. Faridabad, M/s Hindustran Insecticides Ltd., Indian Oxygen, Electric Supply Undertaking, Kanpur, Usha Rectifier, etc.

3. PROJECT TEAM

S.S. Sen - Project Leader
V.P. Varma, S.K. Sen Gupta, M.K. Biswas, Chandan Singh, J.P. Vashisht, Shashi Bhushan, M.C. Jusht, G.S. Hans, M.L. Verma, D.N.Razdan, Kani Ram, Karnail Singh, Jai Bhagwan, V.P. Sharma, D.C. Upadhaya, V.K. Oberoi, Bal Kishan, Pitamber Dutt Joshi, Ram Chander, R.K. Sodhi, V.K. Sharda, Keshar Dev, Davinder Bhannot, Tapeshwar Parshad, M.K. Wadhwa, Gurpyaray Ram, I.D. Negi, Shiv Dayal, Jaswant Singh.

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2. Puntambekar (PN), Dahiya (HS) and Chitnis (VT) "Frequency stabilized and tunable multimode He-Ne lasers" Opt. Commun. Vol. 42(1982) 60.

3. Roy (BK), Puntambekar (PN) and Sen (D) "An optical scanner for testing parabolic trough solar collectors" J. Optics. Vol. 11(1982) 17.

4. Dandawate (VD) and Roy (BK) "A simple method for aligning gas laser cavities" J. Optics. Vol. 11 (1982) 62.

5. Kulkarni (VG) and Sen (D) "Holographic phase aberration balancing with an inexpensive liquid gate." J. Optics. Vol. 12(1983) 1.

6. Dandawate (VD), Ram Narain and Kowsalya "A scanning Fabry-Perot interferometer" J. of Optics. Vol. 12 (1983) 145.

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16. "Precise Time Transfer Using Direct Television Broadcast by the Satellite Symphonie", P. Banerjee et al, JIETE, Vol. 28, No.8, 1982, pp.425-428.

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OTHER R & D PROJECTS

1. Variational approach to the Jahn-Teller Problem in cobaltocene. R. Rai, Physica 115B(1983) 247.

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3. Jahn-Teller interaction in Ferricenium cation. R.Rai, Canadian Jour of Phys, Vol 60, No.3 (1982), 329.

4. Excitation transfer through electron-atom collision processes in neon. V.D. Dandawate and R. Rai. J. Phys. B. 17(1984), 3805.

TECHNICAL REPORTS/BOOKS

Books Published :

1. Superconductivity and Superconducting Materials by A.V. Narlikar and S.N. Ekbote, South Asian Publisher, New Delhi, May, 1983.

TECHNICAL REPORTS

1. Primary Standards of dc voltage at NPL and related calibration facilities' V.K. Batra, S.K. Mahajan, T.V. Ganapathy, P.K. Mittal, B. Sircar and K. Chandra.

2. 'Primary Standards of dc resistance at NPL and related calibration facilities' V.K. Batra, S.K. Mahajan, T.V. Ganapathy, P.K. Mittal, B. Sircar and K. Chandra.

3. 'Development of Electronic Voltage Standard' V.K. Batra, S.K. Mahajan & K. Chandra.

4. Technical Report on H.F. Voltage Standards and Calibration Facilities (6 Hz - 1 GHz) at NPL, A.K. Govil, V.K. Rustagi, Sharwan Kumar & K. Chandra.

5. Technical Report on R.F. Coaxial Cable Testing, A.R. Kaushik, M.R. Nagar, Omkar Nath, Sharwan Kumar, K. Chandra.

6. 'Microwave Noise Measurement Facility in 0.01 to 18.0GHz range' MW-07, December 1982. V.K. Agarwal, P.C. Kothari, H.M. Bhatnagar, Ritender Agarwal, K. Chandra.

7. 'Calibration of coaxial bolometer mounts by adapter as well as by direct comparison techniques' MW-08 March, 1984. V.K. Agarwal, P.C. Kothari, H.M.Bhatnagar, Ritender Agarwal, K. Chandra.

8. Audio frequency substitution technique for measurement of microwave attenuation. R.S. Yadava, Ram Swarup, K. Chandra.

9. ' Microwave attenuation measurement by IF Substitution technique' R.S. Yadava, Ram Swarup, K. Chandra.

10. 'Impedance measurement by coupled sliding load technique'. R.S. Yadava, Ram Swarup, K. Chandra.

11. 'Reflection coefficient measurement by tuned reflectometer technique'. R.S. Yadava, Ram Swarup, K. Chandra.

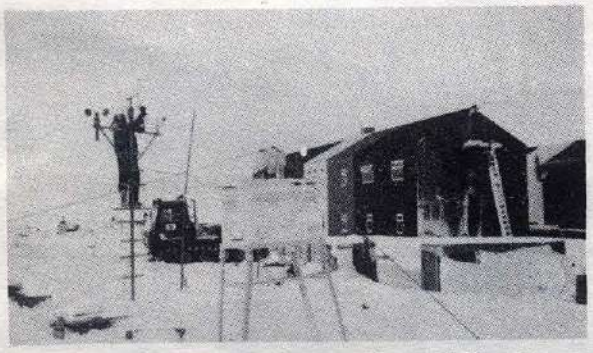
Ph.D's Awarded

Awardee	Title of Thesis	University	Year
G.M. Saxena	Representations of Two Mode Para-Bose Operators	IIT, Delhi	1983
R.K. Kotnala	Simultaneous Difffusion of Boron & Phosphorus into Silicon for Fabrication of Solar Cells	IIT, Delhi	1982
N.K. Arora	Studies on Solar Grade P. Crystalline Silicon Solar Cells	Delhi	1983
Ram Kishore	Effect of various Material Parameters on Performance of Silicon Solar Cells	Agra	1983
Mohan Lal	Contributions to Transducers & their Applications using FET and I.C. Instrumentation	Meerut	1983
J.P. Agrawal (UGC Fellow)	Studies of Electrical Conduction and Dielectric Relaxations in Polycarbonates	Rohilkhand	1983
Naresh Kumar (UGC Fellow)	Thermally Stimulated Discharge Current and Dielectric Relaxation Studies in Organic Polymers	Rohilkhand	1984
V.P. Mittal	Studies on Carbon Products	Meerut	1983
S.R. Singhal (Teacher Fellow)	Electron Paramagnetic Resonance & Optical Studies on Some Liquid Crystals	Delhi	1982
S.C. Jain	Solid Crystalline Polymorphism and Technical Studies in Some Liquid Crystals	Delhi	1983

SIGNIFICANT EVENTS

1. EXPEDITIONS TO ANTARCTICA

NPL Scientists have participated in all the Indian expeditions to the Antarctic. The experiments performed by NPL relate to Radio Propagation. Measurements included VLF observation from OMEGA stations, use of riometers and microbarographs, operated simultaneously in the Antarctica and in India. During this period the second and third expeditions to the Antarctica took place. For the second expedition two NPL scientists, Dr Amitava Sen Gupta and Dr P.K. Pasricha were sent. For the third expedition Dr A.K. Hanjura was the NPL representative.



Microbarograph installation outside Dakshin Gangotri during III ANTARCTIC EXPEDITION.

2. NPL SCIENCE WEEK

A 'Science Week' was organised from Nov. 12-18, 1983 in which the laboratory was kept open to the public, representatives of industry, and academic community. *A Young Scientist's Programme* was organised in which about ten selected young people were invited to be the guests of NPL. Four distinguished lectures, as a part of the science week were given. These were:

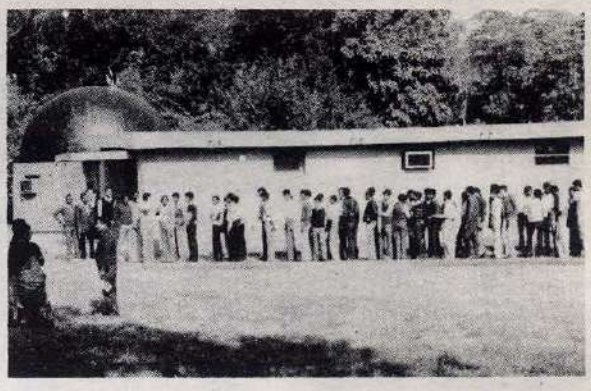
1) 'Cryogenics in the Service of the Nation' by Prof. A. Bose.

2) 'Metrology through the ages' by Prof. A.R. Verma.

3) 'Tailoring of Surfaces on Materials for the Required Specifications' by Dr V.G. Bhide.

4) 'Tailored Micromaterials' by Prof. K.L. Chopra.

More than 6,000 persons including scientists industrialists, engineers, students and other citizens visited various sections and pilot plants of the laboratory. Exhibits were displayed in the rooms of various sections to high-light the achievements of the laboratory. NPL projects of Xeroradiography, Standards, Characterosation sections like Scanning Microscope, X-Rays, Luminiscent Materials, Radio Science Div. attracted large crowds.



Glimpses of NPL Science Week.

3. IX ASIAD

The responsibility of lighting the IX ASIAD torch by Solar Energy was successfully executed by the NPL scientists. The Prime Minister Late Shrimati Indira Gandhi lighted the torch, with solar concentrator designed and fabricated by the scientists of the laboratory, for the Torch Lighting Ceremony on 19th Nov. 1982 at the National Stadium in New Delhi. The achievement is more significant, as the device functioned even under unfaourable cloudy conditions. The system is now one of the exhibits at the National Sports Museum at Jawaharlal Nehru Stadium.

4. KRISHNAN MEMORIAL LECTURE

The Krishnan Memorial Lecture was held during the Science Week Celebrations in Nov. 1983. Prof. I. Prigogine, Noble Laureate delivered the lecture on 'Thermodynamic Aspects of Field Theory'.

Prof. I. Prigogine, Noble Laureate, delivering the Krishnan Memorial Lecture at NPL.

SYMPOSIA/WORKSHOP/TRAINING COURSES

An International Workshop on 'Radio Propagation in Tropics' was directed by Dr. A.P. Mitra in Trieste, Italy during November 1982. Dr. B.M. Reddy was also a member of the faculty.

An Indo-US Workshop on "Solar Terrestrial Physics" was organised from January 30 to February 3, 1984 with Dr. B.M. Reddy as the Chief Convener. The specific objectives of the workshop were to review and consolidate the recent observations of the Solar Maximum Mission Experiments and to assess the importance of Solar Terrestrial Interaction in the areas of communication and navigation and also to identify viable collaborative programmes between India and USA in the areas of Solar Terrestrial Physics.

An Indo-US Workshop on Global Ozone problem was conducted in January 1983 with Dr. A.K.Saha as a member of the Steering Committee and Chairman of the local Organizing Committee.

A two day workshop on Superconductivity - Magnetism Interplay was arranged at NPL on April 14 and 15, 1983. The Workshop was well attended and invited talks were delivered by renowned scientists from TIFR, Bombay, IIT, Kanpur, IISc, Bangalore, IIT, Madras and Senior Scientists of NPL.

Workshop on Ultrasound Therapy and Ultrasonic Power Measurements' was organised on Febrary 14, 1983 in collaboration with Ultrasonic Society of India.

'Seminar on Ultrasonic Non-Destructive Testing (SUT-83) was Organised in collaboration with Ultrasonic Society of India on December 5-6, 1983 at Hotel Maurya, New Delhi.

Workshop on Medical Ultrasonics and Seminar on Ultrasonic Measurements was held on March 1-2, 1984.

National Symposium on Acoustics, with its main theme of architectural acoustics, was held in September, 1982. It was cosponsored by Acoustical Society of India, University Grants Commission, National Physical Laboratory, Central Electronics Engineering Research Institute, Defence Research and Development Organisation (NPOL) and Delhi College of Engineering.

A course on Low Temperature Physics was conducted in July 1982 for ten days. Research Fellows from IIT, Kanpur, IIT, Kharagpur, Indian Association for Cultivation of Science, Saha Institute of Nuclear Physics, University of Delhi and NPL participated. Professor P. Bhattacharya of TIFR, was the principal lecturer.

Training was imparted to the State Govt. Weights and Measures officials, and defence personnel from the Department of Standardization and Inspection, Ministry of Defence. The Div. of Standards has actively participated in organising a Training Workshop on Metrology and Standardization for Developing Countries & Small Island States held from 6-17 February, 1984.

Sponsored delegates from 17 ERTL's and ETDC's received practical training in our lab. in November, 1982.

Practical training in mass and dimensional metrology was imparted to trainees from Nigeria, Phillipines, Burma, Iran, Iraq and Nepal.

A number of officers from the Armed Forces were trained in HF and Microwave Communications by the Radio Communication Div. in the summer of 1982 and 1983.

EXCHANGE PROGRAMME VISITS

Shri K.S. Sarma visited Federal Republic of Germany during March to May 1982 under INDO-GERMAN Exchange programme to visit various Lighting Laboratories of Industry and Govt. and PTB.

Dr. K.C. Joshi visited Australia from June to September 1983 under Asia-Pacific Programme for familiarization in latest techniques in Photometry and Radiometry at N.M.L.

Dr. R.N. Dhar visited U.K. from February to October 1983 under the TCTD programme of the British Govt. to undertake research and development work on Capacitance Standards at NPL (Teddington).

Dr. S.C. Jain visited FRG from June 1981 to March 1983 as DAAD Fellow to work at Physikalisches Institute, University of Munster.

Dr. R.C.Saksena visited FRG from August to October 1982 under DAAD programme to work at Institute for Ionospheren Forschung, Lindan.

Dr. A.K. Gupta visited U.K. during October to December 1983 under INSA-Royal Society Exchange programme to interact with Superconductivity and Josephson Tunneling group working at NPL Teddington, Cambridge University, University of Strathclyde, University of Oxford, and University of Sussex.

Shri S.K.Suri visited Tanzania during July 1982 to July 1983 for a UNIDO assignment to set up a Maintenance-cum-Calibration Centre for Scientific, Electrical, Electronic & Electro-optical Instruments at TIRDO (Govt. of Tanzania).

ADVICE AND CONSULTANCY

Shri K.S. Sarma was deputed as expert to establish the Photometric Laboratory at the Department of Industry, Colombo, Sri Lanka and also trained the scientists in the corresponding work.

Consultancey services were rendered by the scientists of Optical Radiation Standards Project to Lamps and Lighting Industry for establishment of Quality Control Laboratory and Designing of Lighting schemes to ISRO.

The scientists of the Electrophotography Project have provided consultancy to M/s Chaudhary Traders, New Delhi for investigating the properties of new Resins & Polymers which could be used in toners.

The advice was also given to M/s Hindustan Reprographics, New Delhi for the evaluation of clays and polymers used in special conductive coatings and the factory of M/s Reprographic India, Hardwar was visited regarding their problems concerning the Zinc Oxide paper.

The Acoustics Standards project of the laboratory provided consultancy for noise reduction, acoustic treatment and designing of auditoriums shooting galleries power plants etc. to various organisations like Delhi Telephones, CPWD, ICAR, M/s Voltas Ltd., Bhakra Beas Management Board Nangal Township and others. A sum of Rs.17,400/- has been realised towards consultancy fees.

Consultancy advice has been rendered by Mass Standards Project to Shankar wire Products Industires, Deogarh (Bihar) regarding updating of their facilities for manufacturing and calibration of various types of weights.

Consultancy was provided regarding instalation of hot water system at Wood Stock School Mussorie. A field visit was also undertaken to promote utilisation of solar thermal gadgets at Mathrewal Rural Centre of Technology, Mathrewal, Amritsar.

COLLABORATION WITH OTHER INSTITUTIONS/AGENCIES

France and Space & Environment Centre, Boulder regarding solar and geophysical data exchange for improving the short-term forecasting service. The project had also collaborated with the Institute of Radio Physics and Electronics, Calcutta University, S.V. University, Tirupati, Punjabi University, Patiala and Regional Engineering College, Warangal on areas relevant to Radio Communications.

The project of Aviation Grade Brushes of Carbon Products had collaborated with M/s Hindustan Aeronautics Ltd., Nasik for scaling up work.

The Thermal Conversion project of Solar Energy Div. had collaborated with U.S.S.R. under Indo-Soviet Cooperation in Science & Technology on mutual exchange of solar selective coated samples and test data under environmental conditions of respective countries. This project had also collaborated with Department of Science and Technology (now DNES) with its financial support for setting up test facilities for solar collectors.

The Electrostatics and Electrophotography project had collaborated with Dr. R.M.L. Hospital, New Delhi, National Tuberculosis Institute, Bangalore, Centre of

Advance Studies in Orthopedics, Safdarjung Hospital Delhi and Koron Business Systems Ltd., Bombay regarding development of Xero-radiography and Electrophotography.

The Cryogenic Plants & Facilities project had collaborated with L.N.J.P. Narain Hospital, Delhi and Army Hospital, Delhi Cantt. regarding cryosurgery for cancer.

The Superconductivity, Superconducting Materials, Josephson, Tunneling and Applications and Quantum Hall Effect Project had initiated a collaborative programme with T.I.F.R., Bombay on search for new Superconductors using Ion Implantation. The programme will be funded jointly by DST and NPL.

The project of Vacuum and Pressure Standards had collaborated with National Bureau of Standards, U.S.A. and Instituto Di Metrologia Szzione Dinamonetrica (IMGC), Torino, Italy.

The Materials Characterization Div. had collaborative programmes with Physikalisch-Technische Bundesanstalt Braunschweig (P.T.B. - FRG) regarding High

desanstalt Braunschweig (P.T.B. - FRG) regarding High Resolution X-ray Diffraction study of Electric Field Induced Defects in Semiconductors and Insulators. The Div. has collaborated with Institute for Crystallography (USSR) through INSA regarding crystal Growth and Lattice Imperfections and with Institute for Metrology (USSR) through ISI regarding properties of Materials & Physical constants. The Div. had also collaborated with Institutes like CEERI, NEERI, IIP, RRL, Bhopal, RRL, Bhubaneshwar, B.A.R.C., N.T.P.C., B.H.E.L., H.M.T., Customs etc. and Universities like IISc, Bangalore, IIT, Delhi and Kharagpur, BHU, AMU, JNU etc. regarding characterization of materials.

The project of Environmental Hazards-Sodar studies had a scientific collaboration with Micro-metrological Laboratories, Tarapur (BARC) and Water & Airpollution Control Board, Delhi regarding studies using Sodar.

The project of Satellite Radio Beacon Studies had collaborated with Osmania University, Hyderabad and Indian Institute of Astrophysics, Bangalore.

Ground Based Facilities for Environment Monitoring project had collaborated with Institute of Radio Physics and Electronics, Calcutta regarding Dopplometer & Microbarograph observations and with NGRI, Hyderabad regarding Microbarograph observations.

The Tropospheric & Ionospheric Communications project has expanded its collaboration with Ionospheric Prediction Service, Australia, Neudon Observatory,

On the invitation of Cambridge University, U.K., Dr. A.V. Narlikar visited Cambridge University in October 1983 for about six months to interact in the field of superconductivity.

Shri Gurmej Ram, received training in the area of A.C., L.F. Power Measurement at NML (Australia) under the Asia Pacific Metrology Programme for a period of 3 months in 1982.

Dr. R.H. Bhawalkar attended a training course on Alternative Energy Technology at University of Florida, USA under US AID programme during August to December 1983.

HONOURS & AWARDS

1. Dr. Krishan Lal has been elected as a Fellow of the Indian National Science Academy, New Delhi with effect from 1st January, 1984.

2. Dr. Kailash Chandra was elected as the Regional Coordinator of the Asia-Pacific Metrology Programme for 3 years w.e.f. October 1983.

3. Dr. K.K. Mahajan was nominated a member of the COSPAR sub-commission C-3 on Planetary Atmospheres - Aeronomy and Reference Atmospheres during 1982-84.

4. A certificate and medal was awarded to NPL by the Organizing Committee of IX ASIAD '82 games for its contribution for Solar Torch Lighting Ceremony.

5. A certificate of merit was awarded to the paper "Sodar echoes and line of sight microwave propagation", by S.P. Singhal, B.S. Gera and A.B. Ghosh by the Institution of Engineers (India) published in their Journal Vol. 63 ETI, August 1982, p. 49.

6. The poster paper "Wind shear studies through forward scattering sodar", by S.P. Singal, B.S. Gera and S.K. Aggarwal contributed to National Space Sciences Symposium held at Pune during Dec. 7-10, 1983 won the first prize with a cash award.

7. Dr. V.N. Bindal, was elected as a Member of Editorial Board of Acoustics Letters (1982) and Archives of Acoustics (Poland) - 1983. He was invited as an Advisor, for 'Document on Environmental Health Criteria 22 : Ultrasound, WHO/IRPA Task Group.

8. Dr. V.R. Singh received 'Distinguished Alumni Award' of Silver Jubilee of Thapar Engineering College, Patiala, in 1983. He was also awarded ICMR Shakuntia Amir Chand Prize Award for 1983.

VISITS ABROAD
(MEETINGS/CONFERENCES/WORKSHOPS ATTENDED AND TALKS GIVEN)

Dr. A.P. Mitra visited USA and Canada in May 1982 to attend Workshop on Equatorial Middle Atmospheric Measurements and Middle Atmosphere Radars and MAP Programme with FAA and GSFC and also to attend COSPAR/SCOSTEP Assemblies and 100th Anniversary of the Royal Society of Canada as INSA representative.

Dr. A.P. Mitra visited Cambridge, Brussels and Italy in September 1982 to attend General Meeting and the ICSU General Assembly and URSI Board of Officers Meeting.

Dr. A.P. Mitra visited Trieste, Italy during October-November, 1982 to attend the Workshop on "Radio Propagation in Tropica".

Dr. A.P. Mitra visited China in November 1982 as a member of Indian delegation sponsored by INSA.

Dr. A.P. Mitra visited Stockholm, W. Germany in January 1983 to attend the meeting of ICSU Executive Board and PTB.

Dr. A.P. Mitra visited USA, Belgium, W. Germany in June 1983 to attend the SCOSTEP Bureau Meeting in Baltimore, to visit URSI Head quarters, Brussels and to visit Max Plank Institute for Technique Physik.

Dr. A.P. Mitra visited Poland to attend the ICSU Meeting, Italy for discussion regarding course to be organised by ICTP-Trieste, U.K. to visit NPL-Teddington and Brussels to attend IUGG General Assembly and a meeting of URSI in August 1983.

Dr. A.P. Mitra visited USSR in September-October 1983 to discuss and sign a new Protocal on Space Meterology and Aeronomy.

Dr. A.P. Mitra visited France in January 1984 to attend the meetings of the ICSU Executive Board and to visit the Centre de Recharches en Physique de L'environment Terrestre at Planetaire of CNET, France.

Dr. V.N. Bindal visited Switzerland in June, 1982 under W.H.O. Programme.

Dr. B.M. Reddy visited R&D Centres in USA in July, 1982 under CSIR-NSF Programme and delivered a lecture at the Naval Research Lab., Washington.

Dr. B.M. Reddy visited Italy in October-November 1982 to participate in the workshop on "Radio Propagation in the Tropic" organised by ICTP.

Dr. B.M. Reddy visited Bagdad in October-November 1983 under Science and Technology Programme between CSIR-CSIR Iraq and delivered a series of lectures.

Dr. B.K. Agarwala visited Singapore and Malaysia in October, 1982 to attend the tube Asia Symposium under UNDP Project.

Dr. B.K. Agarwala visited Japan in Aug.-Sept., 1983 to visit High Pressure Labs. under UNDP Project.

Dr. K. Chandra visited Australia in Aug.-Sept., 1982 to attend the Workshop on Metrology of CSC under the Regional Metrology Programme for Asia/Pacific.

Dr. K. Chandra visited U.K. and W. Germany in Aug. 1983 for study of Calibration service at NPL-Teddington and P.T.B., West Germany.

Dr. K. Chandra visited China in Sept., 1983 to attend the Steering Committee meeting of Asia Pacific Metrology Programme.

Dr. Y.V. Somayajulu visited West Germany to attend the General Assembly of IUGG and the MAP Steering Committee meeting at Hamburg and visited Belgium for Technical discussions with the Scientists regarding development of mass spectrometer pay loads for balloon and rocket experiments.

Dr. Krishan Lal visited USSR in Sept., 1983 to coordinate in the joint R&D work in the area of Metrology Standard and Materials and Constants under Indo-USSR Exchange Programme.

Dr. Krihan Lal also visited West Germany in Sept.-Dec., 1983 to visit PTB and to work on measurement of dielectric loss in single crystals at high frequency by using a new high resolution X-ray diffraction technique.

Dr. B.S. Mathur attended CSIR Study Group VII meeting held in Geneva, November 27 to December 2, 1983.

Dr. S.L. Dahake, attended the 'Conference on Precision Electro-magnetic Measurements' June 28 - July 1, 1982, at Boulder, Colorado, USA.

Mr. V.K. Batra, visited Leningrad, USSR, June 6-19, 1982, D.I. Mendeleyev Institute of Metrology for intercomparison of NPL and VNIIM Standards, under Indo-Soviet Collaboration Programme and Moscow, USSR, June 20-27, 1982 to attend the 9th meeting of Indo-Soviet Working Group on Scientific & Technical Cooperation on Standardization and Metrology.

Dr. S.N. Ekbote and Mr. V.K. Batra attended training in High Field Superconducting Megnets of Oxford Instruments Ltd., Oxford, U.K. in December 1983.

Dr. S.S. Bawa & Dr. (Mrs.) S.A. Agnihotry participated in the symposium by S.P.I.E. in USA and visited Japan in August 1983.

Dr. S.P. Singal participated in the Second International Symposium on Acoustic Remote Sensing of the Atmopshere and Oceans held at Rome, Italy, during August-Sept. 1983 and visited Paris, to visit CNET sodar facility.

Dr. Y.V. Ramanamurty gave an invited talk on "The state-of-the art in D-region IRI modelling" jointly with Prof. K. Rawer, Chairman, IRI Steering Committee during the URSI/COSPAR Workshop on IRI held at Stara Zagora, Bulgaria in 1983.

PATENTS FILED, ACCEPTED AND SEALED

PATENTS FILED (INDIA)

No.	Title	Inventors
112/DEL/83	An improved process for the preparation of white emitting phosphor materials.	H.P. Narang

PATENTS FILED (FED. REPUBLIC OF GERMANY)

DE 3418194 A1/83	Verfahren Zur Messung der electrischen Feldstarlce einrd electromagnetischen Feldes an eirnem Einkrislall.	P. Thomsand Krishan Lal

PATENTS SEALED

150467 929/Del/78	A process for making heat sensitive copying paper for use in document copying machine	P.C. Mehendru, Kamlesh Jain, V.S. Panwar, Satbir Singh, R.C. Bhateja.
150484 930/Del/78	Improved photoconductive plates for used in electrophotographic machines and a process of preparation of the same.	P.C. Mehendru, Kamlesh Jain, V.S. Panwar.

PROCESSES RELEASED TO INDUSTRY FOR COMMERCIALIZATION

Title	Party	Terms		
		Premium	Royalty	Nature
Hot Axle Detection system	Central Electronics Ltd., Sahibabad (U.P.)	Rs.40,000/-	NIL	Exclusive
Flat Plate Solar Collector	M/s Raunaq Enterprices New Delhi.	Rs. 3000/-	2%	Non-Exclusive
-do- -do-	M/s Industrial Boiler (P) Ltd., Calcutta	-do-	-do-	Non-Exclusive

PREMIA & ROYALTIES OF THE PROCESS RELEASED EARLIER AND IN PRODUCTION (UPTO 31.12.83)

Process	Party	Premium	Royalty
Cinema Arc Carbon	1. M/s Advani, Oerlikon Ltd., Bombay.	-	7,51,029.47
	2. M/s Isocarbon Co. Private Ltd.,	-	2,550.00
Photocopy machine	M/s Advani Oerlikon Ltd., Bombay.	-	3,63,676.41
Soft Ferrites	1. M/s Ferrites India Ltd.	-	4,000.00
	2. M/s Morris Electronics Ltd., Pune.	-	2,09,649.78
	3. M/s Semi-conductors Ltd., Bombay.	-	51,446.15
Hard Ferrites	1. M/s Elpro International Ltd.	-	19,795,21
	2. M/s Ferrites India Ltd.	-	7,343.75
Reconditioning of T.V. Picture Tube	M/s Videotronics	15,000.00	711.20
Indelible Ink	M/s Mysore Lac & Paints Ltd.	-	75,000.00
Film thickness monitor	M/s Vacuum Instruments Co. Ltd.	-	1,953.00
Microwave Components KU-Band	M/s Scientific Instruments Co. Ltd., Allahabad.	2,500.00	585.20
Klystron Power Supply	-do-	-	8,203.88
X-Band	-do-	-	1,850.75
K. Band	-do-	-	435.75
S-Band	-do-	2,500.00	665.25
J-Band	-do-	-	293.00
Viscometer	M/s Associated Instruments Mfrs., New Delhi.	-	65.00

RECEIPTS ON ACCOUNT OF TESTING/CALIBRATION/GLASS FABRICATED AND OTHER CHARGES REALISED DURING APRIL 1982 TO MARCH 1984

Sl.No.	Division	Amount. (Rs.)	No. of reports
1.	Optical Standards	2,75,099.68	406
2.	Force Standards	2,97,880.00	1,006
3.	Length & Related Standards	1,95,895.00	1,641
4.	Mass & Related Standards	71,807.00	1,038
5.	Acoustical Standards	58,894.00	148
6.	Temperature Standards	78,935.00	421
7.	Vacuum & Pressure Standards	17405.00	9
8.	Electronic & Electrical Standards	1,59,047.50	466
9.	Chemical Testing Division	60,970.00	278
10.	Specialised Techniques (Solar Energy, Carbon, T.E.C., X-ray etc.)	46,245.00	56
11.	Glass Fabrication	1,90,000.00	-
12.	Workshop	1,431.60	-
	Total :	14,57,609.78	5,469

Staff Strength as on 31.12.1983

Designation	Nos.
Director	1
Scientist (E-I to F)	66
Scientist & Engineer (B to C)	229
Technical Officer (B to C)	34
Scientist & Technical Officer (A)	42
Officers (Administration & Accounts)	8
Information Officer & I.L.O. (C)	2
Scientific & Technical Assistants	193
Technical Supporting Staff (Gp. II)	394
Secretariat Staff	171
Technical & Non-Technical (Gp. I)	208
Total :	1348

MEMBERSHIP OF RESEARCH ADVISORY COUNCIL
(1.7.1982 to 30.9.1984)

Dr. R. Ramana - (Earlier) Director Bhabha Atomic Research Centre Bombay-400085.	Chairman	Prof. E.V. Chitnis Director Space Application Centre (ISRO) Ahemdabad-380053.	Member
Prof. Yash Pal - (Later) Chief Consultant Planning Commission New Delhi-110001.		Prof. E.S. Raja Gopal Department of Physics, I.I.Sc., Bangalore-560012.	Member
Dr. S.C. Jain Director, Solid State Physics Lab. Delhi-110007.	Member	Dr. R.S. Sirohi Professor, Engineering Design Centre IIT, Madras-600036.	Member
Prof. C.K. Majumdar Head, Magnetism Department, Indian Association for the Cultivation of Science, Jadavpur, Calcutta-700032.	Member	Director General (SIR) CSIR, New Delhi-110001 Or His Nominee	Member (Ex-Officio)
		Director NPL, New Delhi-110012	Member (Ex-Officio)
Dr. A.K. Gupta Director General, ISI, New Delhi-110002.	Member	Chairman Coordination Council for Physical and Earth Sciences Group of CSIR Laboratories.	Member (Ex-Officio)
Prof. S. Sampath Director, IIT, Kanpur-208016	Member	Dr. Krishan Lal Scientist, NPL, New Delhi-110012.	Member-Secretary

MEMBERSHIP OF EXECUTIVE COMMITTEE
(1.7.1982 to 30.9.1984)

Dr. A.P. Mitra Director National Physical Laboratory New Delhi-110012.	Chairman
Dr. S.C. Jain Director Solid State Physics Lab. Delhi-110007.	Member
Prof. E.V. Chitnis Director Space Applications Centre (ISRO) Ahmedabad-380053.	Member
Dr. R.S. Sirohi Professor Engineering Design Centre IIT, Madras-600036.	Member
Dr. Kailash Chandra Scientist NPL, New Delhi-110012.	Member
Dr. Krishan Lal Scientist NPL, New Delhi-110012.	Member
Dr. B.K. Das Scientist NPL, New Delhi-110012	Member
Sr. Finance & Accounts Officer NPL, New Delhi-110012.	Member
Chairman Coordination Council for Physical & Earth Sciences Group of CSIR Laboratories.	Permanent Invitee
Director General, SIR CSIR, New Delhi-110001. OR His Nominee	Permanent Invitee
Administrative Officer NPL, New Delhi-110012.	Member-Secretary