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NATIONAL PHYSICAL LABORATORY
HILLSIDE ROAD, NEW DELHI 110 012

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DIVISION OF STANDARDS

AREA COORDINATORS

ELECTRICAL & ELECTRONIC STANDARDS	Dr. Kailash Chandra.
THERMAL MECHANICAL & OPTICAL STANDARDS	Dr.D.Sen

INTRODUCTION

The Division of Standards has the responsibility of realising 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 consumer protection, industrial quality control and scientific and technological advancement. Primary and transfer standards of six of the seven base S.I. units and for many of its derived units have been established at NPL. The international traceability of these standards is established through periodic calibrations/international intercomparisons with other countries. Since, all calibrations in the country should be traceable to the standards maintained at NPL, a large part of the activity of the Division of Standards is directed towards the development and maintenance of transfer standards, measurement systems and techniques and to provide calibration to user agencies.

During the last few years intensive R&D work has been carried out to update our primary standards in order to realise the units through their quantum phenomena based definitions. This has been successfully implemented for the units of time, length, electromotive force and electrical capacitance. The fundamental physical constants play a vital role in realisation of the system of units from phenomena based definitions. Measurement of these constants through different paths provides a test of our understanding of the physical phenomena and establishes the consistency of the units, realised through these phenomena. In view of the capability which has been generated at NPL in quantum metrology, we propose to begin work in the near future on determination of a few fundamental constants which are important for realisation of the system of units.

The total activity of the Division of Standards is divided into different projects. In each project a team of scientists is engaged in maintenance and updating the standards and calibration facilities related to a single or a group of closely related parameters. These projects are:

1. Standards of Length and Angle
2. Standards of Mass, Volume and Density
3. Standards of Force and Hardness
4. Standards of Pressure
5. Standards of Vacuum
6. Standards of Temperature
7. Standards of Radiometric and Photometric quantities
8. Standards of Acoustical Parameters
9. Standards of Time and Frequency
10. Standards of D.C. Electromotive Force, Resistance and Current
11. Standards of Capacitance and Inductance
12. Standards of Low and High Frequency Voltage, Current, Power, Energy, Attenuation, Impedance and Noise
13. Standards of Power, Attenuation, Frequency, Impedance and Noise at Microwave frequencies.

STANDARDS OF LENGTH AND ANGLE

1. SCOPE AND OBJECTIVES

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

2. STATUS AS ON 1.4.1981

The standards maintained were Hg^{198} lamp, national prototype metre for length and a pair of 12 sided polygons for angle. The uncertainties of the standards are respectively 5×10^{-8}, 0.2 μm and 5 μ rad. Calibrations made were traceable to these standards. The accuracies of transfer were respectively 0.03 μm, 0.5 μm and 20 μ rad. During the last few years R&D work was carried out to establish the wavelength standard and laser measurement systems. The Kr^{86} standard was installed and frequency stabilized He-Ne lasers were developed.

The dimensional calibration and testing service was continued. Measurement and testing facilities were updated by installation of a laser interferometer and other digital measuring instruments and by the development of a laser interferometer and of improved measurement techniques. Particular mention may be made of the work done on holographic interferometry and multiplexing.

Basic studies were made on the instabilities and collisional energy transfer in the He-Ne laser plasma and on the polarization properties of internal mirror He-Ne laser radiation. These studies enabled us to make improvements to the techniques of laser frequency stabilization. Theoretical studies were made on the coherence properties of laser radiation and on the thermal properties of gases.

3. PROGRESS IN THE YEAR

3.1 Standard of Length

Improvements have been made to the laser frequency comparator to be able to measure optical beat frequency by direct counting. The iodine stabilized He-Ne laser along with this frequency comparator has been installed and is being maintained as the primary standard of length. The frequency stability obtained is 5 part in 10^{10}. Frequency of He-Ne laser of NPL calculable capacitor has been calibrated by comparison with the iodine stabilized laser. The uncertainty in this frequency intercomparison was 2 parts in 10^9.

3.2 Measurement System and Technique

A technique has been developed for frequency stabilization of the two mode randomly polarized He-Ne laser using a passive cavity. The method is useful for very small displacement measurement by heterodyning interferometry. We are now getting 2×10^8 resolving power (l/dl). Work is being carried out to increase the resolving power to 10^{10} or better in order to make this technique suitable for earth strain and similar geophysical measurements.

A servo-controlled Fabry-Perot interferometer has been fabricated. It can be locked for maximum transmission of radiation from a single frequency stabilized laser and also on the mean radiation frequency of a two mode stabilized laser. The performance of the Fabry-Perot interferometer is being evaluated for use in laser wavelength measurement. A scanning Fabry-Perot interferometer (optical spectrum analyser) has been fabricated to study spectrum of multimode lasers.

The resolution of the laser interferometer developed earlier has been improved from $\lambda/16$ to $\lambda/80$. An automatic switching control system has been designed and built for the interferometer for registration of data. It operates through relay controls actuated by zero crossing pulses and can be used also for automatic control in thin film coating and in frequency locking of lasers. A measurement system for block gauges based on this laser interferometer has been designed and is under fabrication [1].

An optical scanner has been designed and set up for testing parabolic trough solar collectors of size 1m x 1m. Data generated by the scanner has been useful in improving the collection efficiency of parabolic trough collectors designed at NPL.

3.3 Calibration

Calibration service to the industry and other organizations has been continued. A gauge block comparator of 0.02 μm resolution and digital readout has been installed. Developmental tests have been carried out on bearing rollers (straightness) for HMT Bearings Ltd. and on blood cell counting slide for ISI. 766 calibration and test certificates have been issued and Rs.42,890/- have been realised as calibration fee.

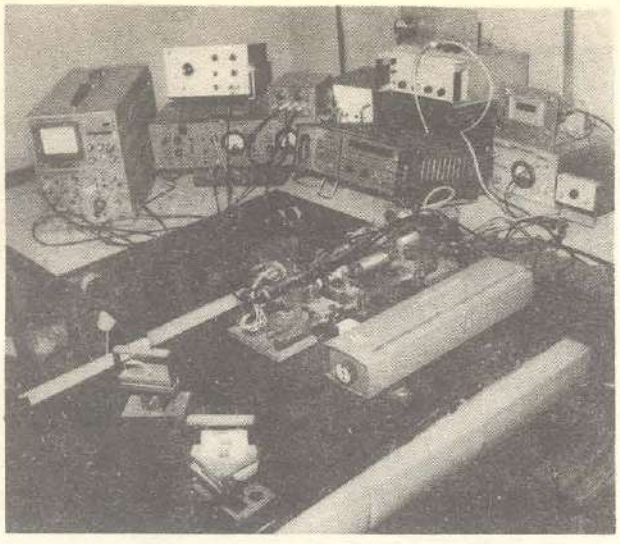

Fig.1 : Calibration of a stabilized commercial laser by frequency intercomparison with the Iodine stabilized He-Ne laser.

3.4 Basic Studies

Experimental investigation of the collision processes in the He-Ne laser plasma was extended to the 2 p group of energy levels of neon. The influences on these energy levels by radiative cascade transitions and non-radiative transitions by atom-atom collisions have been separated out. The collision cross-section has been determined for excitation transfer from $2p_4$ to $2p_3$ levels of neon under near resonant condition. Our measured value agree well with the recently reported value obtained by probing with the tunable dye laser radiation.

Studies on the polarization behaviour of multimod He-Ne laser was continued and observations were taken on the saturation induced polarization of the laser modes due to anisotropy of the cavity. It has been found that the laser becomes bi-stable under certain power and tuning conditions.

Work has been started to study the feasibility of using holographic multiplexing for optical diffractometry. The preliminary results are encouraging [2,3,4].

References :

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4. PROJECT TEAM:

D. Sen – Project Leader.

P.C. Jain, V.D. Dandawate, P.N. Puntambekar, V.T. Chitnis, Mrs. Kousalya, Mahesh Chander, V.G. Kulkarni, H.S. Dahiya, R.K. Khanna, Mrs. V. Roonwal, L.M. Bhatia, B.K. Roy, A.K. Kanjilal, N.K. Aggarwal, Ram Narain, V.D. Sharma, M.K. Balchandani.

STANDARDS OF MASS, VOLUME AND DENSITY

1. SCOPE AND OBJECTIVES

To maintain the national prototype kilogram and to build up and calibrate the transfer standards of mass.

To test and calibrate the standards of mass, volume, density and related parameters for legal metrology and other applications.

To carry out Research and Development in the areas needed for standardisation of mass, volume and density.

2. STATUS AS ON 1.4.1981

2.1 Standard of mass

The unit of mass, its multiple and sub-multiples have been realised through sets of calibrated transfer standards of accuracies of 1 part in 10^7 in the range of 10g to 10kg and $\pm$ 1 μg in the range of 1 mg and 5 g. These standards have been maintained by regular intercomparison by the method of group weighing, using balances of required capacities and sensitivities. Recently two of our 1 kg transfer standards were got calibrated from PTB, West Germany. This was done after a small change in the mass of one of the standards was detected during intercomparison. The values given by PTB and those obtained by us show excellent agreement.

Work has been carried on development of transfer standard masses from indigenous material and of 1 kg standard balances for intercomparison of our transfer standard with the national prototype kilogram. The standard mass pieces were made with the required precision and surface finish from nickel free stainless steel and Ni-Cr alloy supplied respectively by NML, Jamshedpur and DMRL, Hyderabad. The stability of these standards is being studied.

For development of the standard 1 kg balance two alternatives were chosen. An existing 2 kg balance was modified for completely remote operation and its performance evaluated by installing it in a specially designed chamber with 0.001°C temperature uniformity and stability. At the expected sensitivity of 50 µg the performance of the balance was not satisfactory. The remote weight changing mechanism has been redesigned. The second balance being developed is a three knife edge interchangeable pan balance based on NPL, Teddington design. Most of the parts of the balance have been fabricated and the balance partly assembled. However the progress of this work has been delayed due to our inability to get the high precision knife edges either from Indian or from Foreign manufacturers.

2.2 Calibration

High sensitivity balances of capacity ranging from 3g to 10 kg have been installed in stable environmental conditions to provide calibration in term of our transfer standard masses. The accuracies of calibration are 2 prts in 10^7 in the range 10g to 10 kg and ± 2 µg in the range 1 mg to 5 g. Facilities have been established also for calibration of hydrometers and of volumetric measures in terms of our standard masses. The accuracies of both density and volume measurements are 1 part in 10^4. 25 litre automatic pipettes of accuracy 1 part in 10^4 were designed and fabricated for calibration of still higher capacity measures. These pipettes have been supplied to BHEL and Central Water and Power Commission.

3. PROGRESS IN THE YEAR

3.1 Two Pan Interchangeable 1 kg Balance

The blanks of the bearing planes and knife edges were got fabricated by an Indian firm in Varanasi. The final polishing of these knife edges and bearing planes have been completed and found to be satisfactory for the purpose of using these in the subsidiary suspensions. To get an overall idea of the straightness and the thickness of the edge of the knife edge, the microphotograph with magnification 202 were taken. The width of the edge of the knife is found to be of the order of 5 µm. On close scrutiny, it has be seen that there are chippings at various places which may not matter when the knife edges are used only as a suspension device. Further efforts are being made to avoid the chippings and to decrease the width of the edge for obtaining the knife edges for the beam.

3.2 Standard of mass

The further fabrication work of 200 g weights was taken up during the year. Four weights of 200g each of the Nickel-Chromium alloy which was manufactured by the DMRL, Hyderabad have been made. Out of four, two have been finally polished which are awaiting their calibration.

A new 10 kg balance with optical read out has been set up. The balance has a magnetic damping and is able to read upto 0.2mg in 10kg.

3.3 Density standards

The work regarding the setting up of temperature bath with a stability of 0.02°C has been initiated. This hydrostatic bath will be used for calibration of the density hydrometers and later on for realising the artifacts as standards of density.

3.4 Prototype testing for a baby weighing scale

A small scale industry in Tamil Nadu, through the Controller of Weights & Measures, Tamil Nadu, has approached us for the prototype testing of a steelyard type baby weighing scale. This is a new instrument, though based on the existing principle, is supposed to be used in the villages. We have laid down the specific tests, test procedures and the criterion for acceptance for such machines. The machine has been tested and the report has been sent to the manufacturers with a copy to the Controller, Weights and Measures.

3.5 Calibration

Besides the calibration of secondary standards of mass and the capacity measures for States Departments of Legal Metrology, a number of precision weights, volumetric glassware like automatic mercury pipettes, butyrometers etc., and large number of hydrometers of various types have been calibrated for the research and industry. 353 calibration certificates, with Rs.29,696/– as test fee, have been issued this year.

Calibration of travelling standards, received under the Asia/Pacific Metrology Programme

in which several countries like Malaysia, and Australia are taking part, have been completed. Calibration scheme of the two travelling standards together with one standard of our own have been worked out for double substitution method. Necessary arithmatic for calculations of the variances and different statistical tests was also carried out. A random uncertainty of 0.08 mg has been achieved in these measurements.

4. PROJECT TEAM

S.V. Gupta – Project leader.
Mohinder Nath, B.G. Mathur, S.N. Nangia, Tripurari Lal, L.S.Tanwar, Matilal Das, A.N. Bulsara, Mrs. Swaran Varma.

STANDARDS OF FORCE AND HARDNESS

1. SCOPE AND OBJECTIVES

To establish the standards of force and hardness and to provide calibration facilities to the users.

2. STATUS AS ON 31.3.1981

Standard of force is maintained through a dead weight cum lever multiplication machine. It has dead weight capacity of 100 kN with 0.002% accuracy and lever multiplied capacity upto 1 MN with 0.01% accuracy. This machine has been in use for calibration since last year. Earlier the standard of force was maintained by means of a NPL designed and fabricated dead weight machine of 30 kN capacity and 0.004% accuracy

3. PROGRESS IN THE YEAR

3.1 Standard of force and hardness

A hydraulic multiplication system has been designed and installed for calibration of force measuring devices upto 500 kN. The capacity of the machine is being extended upto 1 MN with 0.02% accuracy.

Developmental work on load cells for use as transfer standard has been started and two load cells respectively of 5 kN and 50 N capacity have been made.

Design has been started for a standard hardness machine.

3.2 Calibration

530 force measuring devices were calibrated for various users and the calibration fee of Rs. 1,00,075/– was realised.

4. PROJECT TEAM

M.K. Das Gupta – Project leader
S.S. Nayar, J.K Dhawan, R.S. Sharma, M.K. Chowdhury, Ravi Khanna, 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 10 K bar will be covered.

2. STATUS AS ON 1.4.1981

A detailed study of the equipment and the problems related to pressure standards had been made and the measurement of uncertainties and the limitations of the equipment used in the relevant areas were also studied in detail. The necessary equipment for the establishment of pressure standards upto 10 K bar had been procured. The calibration facilities will be used by the Indian industry in chemical and petrochemical plants, boilers and the manufacture of compressors etc.

3. PROGRESS IN THE YEAR

Work for the erection and commissioning of equipment related to primary and transfer standards for measurement of pressure i.e. controlled clearance piston gauge and dead weight testers upto 10 K bar has been undertaken.

Effect of pressure and temperature on the dielectric and electrical properties has been studied on a series of copolymers. A high pressure dielectric cell has been designed and fabri-

eated to measure the various electrical and dielectrical properties over a wide range of temperature and pressure. The results obtained have been published in international journals [1].

References

1. J.K.N. Sharma and K.K. Jain. J.Phys.D, 15 (1982) 337.

4. PROJECT TEAM

J.K.N. Sharma – Project leader.
K.K. Jain.

STANDARDS OF VACUUM

1. SCOPE AND OBJECTIVES

To establish vacuum standards and facilities for the calibration of vacuum gauges and testing 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 primary standards will be used by the National Physical Laboratory to calibrate transfer standards of the user industry. 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.

Development of vacuum instrumentation.

2. STATUS AS ON 1.4.1981

A standard McLeod gauge [1] using variable compression techniques used as a primary standard of pressure in the range of 10^{-2} - 10^{-5} torr with an accuracy of 2-3% has been established. Vacuum standard from 10^{-3} to 10^{-6} torr using orifice techniques has also been established. A special oil manometer for measuring pressure from 10 torr to 10^{-2} torr has been developed and is being successfully used for calibration in this region.

Calibration of gauges: The standards maintained by the NPL as described above are used for precise calibration of the vacuum gauges as per accuracy of the standard used.

Performance characteristics of rotary pumps: An equipment for measuring characteristics of rotary vacuum pumps has been satisfactorily designed, fabricated and tested as per ISO and ISI specifications.

The apparatus for measuring the characteristics of high vacuum diffusion pumps has been designed and fabricated and the comparative study of the various characteristics of diffusion pump with conductance method and flowmeter under different conditions are going on.

The Penning and Pirani gauges to measure vacuum down to 10^{-5} torr have been satisfactorily designed and developed. Penning and Pirani controllers have been successfully designed and developed for system automation. Automatic electronic sequence control system has also been designed and developed for the vacuum system.

Vacuum Leak Detector based on thermal conductivity principle suitable for vacuum coating, vacuum metallurgy, vacuum drying, vacuum impregnation etc. has been successfully designed and is being commercialised by the local industry through National Research Development Corporation.

A special McLeod gauge using piston and cylinder assembly and a Vacuometer have been developed for industrial use.

The infra-structure in vacuum technology has been used to develop silver impregnated graphite contacts and different types of vacuum valves such as (1) A bakeable glass-isolation valve (2) A two way metal vacuum valve (3) Extra fine control needle valve both line mounting and panel mounting (4) the quarter swing valves of 2", 4" and 6" sizes; and (5) Gate valves.

Ultra high vacuum of 3×10^{-9} torr has been produced by using oil diffusion pump system.

Designed and developed the complete automatic as well as semi-automatic vacuum sys-

tems for the first indigenous scanning electron microscope made in the country.

3. PROGRESS IN THE YEAR

The dynamic method of calibration of vacuum gauges from 10^{-2} - 10^{-7} torr using diffusion pump has been designed and various components are being assembled. This is to improve the accuracy of the existing dynamic system for gauge calibration for the above range.

The work on the study of power consumption of rotary pumps at varying pressure is currently going on.

While studying the performance characteristics of the oil vapour pumps, a fundamental study of molecular flow inside a test dome has been undertaken in great detail resulting in revision of earlier work.

Comparison of two pumping speed measuring methods of oil diffusion pumps has been done to standardise the position of conductance tube.

The vacuum group has received the NPL Merit Award of 1981 for development and establishment of vacuum standards and related techniques for generation and measurement of high vacuum.

References

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4. PROJECT TEAM

J.K.N. Sharma – Project leader.
A.C.Gupta, P.K. Ahwini Kumar, D.R.Sharma, Pradip Mohan.

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 development and maintenance of the fixed points on that scale and the transfer standard instrument and to provide the associated calibration service.

To provide the service for measurement of thermal properties of materials.

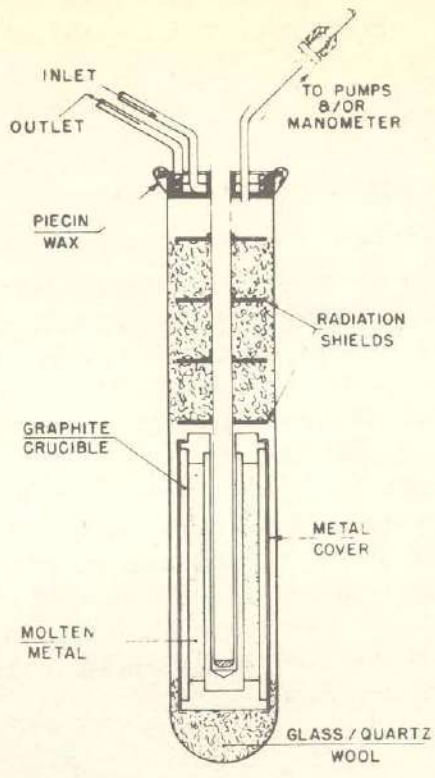

Fig.2 : Melting/Freezing point apparatus for the calibration of Stem-type Platinum-Resistance thermometer.

2. STATUS AS ON 1.4.1981

The unit of temperature has been realised with the accuracy of ± 0.5 m K by establishing and maintaining the cell for triple point of water. Periodic improvements and re-evaluation of the triple point cell have been carried out. A number of fixed points of the IPTS over the range 90.188K to 1337.58K have been established and are maintained. The accuracy of their realisation is 1m K to 2m K upto 693.72 K and 0.1 K for higher temperatures. Platinum resistance thermometers, platinum-irridium thermocouple and optical pyrometer are used as transfer standard instruments for measurement of temperatures. The accuracy of calibration is 0.001°C to 0.005°C over 183°C to 630°C by platinum resistance thermometry, 0.3°C to 0.5°C over 630°C to 1064°C by thermocouple thermometry and 0.5°C to 2°C over 1064°C to 1800°C by optical pyrometry. The standard platinum resistance thermometers used have been designed and fabricated at NPL. Industrial type platinum resistance thermometers have been developed and supplied to other organisa-

tion. Various methods for measurements of thermal conductivity and thermal expansion have been established [1,2].

3. PROGRESS IN THE YEAR

3.1 Standard of Temperature

The fixed points established earlier and transfer standard instruments have been maintained and reevaluated. Improvements have been made to the triple point of water cell. The fixed points of indium, tin and zinc have been established for calibration of thermocouples.

Work has been carried out to develop a platinum resistance standard thermometer suitable upto 962°C (silver point) in order to replace the thermocouple standard in that range. Improvements are being made in the construction technique for ceramic enclosed platinum resistance thermometer.

3.2 Calibration and Testing

The service for calibration of temperature sensors and testing of materials for thermal properties have been continued. During the year 300 calibration and test reports have been issued and Rs.26,888/- were realised as calibration and test fees. Two stem type platinum resistance thermometers have been fabricated and supplied with calibration to BHEL. A fee of Rs.11,000/– has been realised for this service.

References

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5. PROJECT TEAM

K.D. Baveja – Project leader.
V.P.Wasan, R.S.Khandekar, K.N.Bhatnagar, R.K Luthra, N.K. Shrivastava, P.K.Datta, Yash Pal Singh, Mansha Ram, Gurcharanjit Singh, Sukhveer Singh, P.R. Sen Gupta, S.K. Nijhawan, R.P. Chawla, V.P. Sharma.

STANDARDS OF RADIOMETRIC AND PHOTOMETRIC QUANTITIES

1. SCOPE AND OBJECTIVES

To maintain and update the national standards of luminous intensity, luminous flux, illuminance, luminance and other associated parameters and to provide calibration traceable to these standards. To develop and instal an absolute radiometer for realisation of the unit of radiant intensity. To provide service for measurement of optical and calorimetric properties of materials.

2. STATUS AS ON 31.3.1981

The units of luminous intensity (candela), luminous flux (lumen), colour temperature and spectral irradiance have been realised by means of sets of standard lamps, calibrated by BIPM, NPL, UK, PTB, West Germany and NBS, USA. These standards are maintained by mutual and international intercomparisons. Transfer standards for calibration have been derived from these national standards. The accuracies of calibration is 1% to 2% for luminous intensity and flux and $\pm$ 5 K to $\pm$ 10 K for colour temperature.

Facilities have been established for life testing of lamps, gonio-photometric test of luminaires, colorimetric measurement, spectral and luminous transmittance and reflectance measurements and refractive index measurement.

3. PROGRESS IN THE YEAR

3.1 Standards of Radiometry and Photometry

A set of four travelling standard lamps have been calibrated under the Asia Pacific Metrology Programme. For three of these lamps our values agree within 0.8% of the value assigned by the Australian Standards Laboratory. The fourth lamp is showing a difference of 1.7% which is larger than the uncertainty of our measurement. Further measurements are being made on this lamp.

Work is continuing on the design of a electrically compensated thermopile radiometer for absolute measurement of radiant intensity.

3.2 Calibration and Testing

Calibration and testing of lamps, luminaires and optical instruments and components have been

continued. During the year 252 calibration and test certificates were issued and Rs.1,23,020/– were realised as calibration fees.

4. PROJECT TEAM

S.R. Das – Project leader.
K.S. Sharma, K.C. Joshi, Om Prakash, Mrs. S. Manrai, O.P. Bhola, Mrs. S. Mallela, Madan Mohan, Kailash Chand.

STANDARDS OF ACOUSTICAL PARAMETERS

1. SCOPE AND OBJECTIVES

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

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

To test acoustic and electro-acoustic devices and acoustic materials for their performance characteristics and properties.

To render advice, on a consultancy basis, on various problems in acoustics.

To investigate specific roblems arising out of the work described above.

2. STATUS AS ON 1.4.1981

2.1 Standards of Acoustical Parameters

Primary laboratory standard for sound pressure has been maintained.

Standard of hearing threshold by air conduction has been maintained.

Standard for vibration amplitude has been maintained.

Standard replay chains for calibration of magnetic recording tapes (spool and cassette) have been maintained.

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 Testing

Acoustics and electro-acoustic devices, instruments and materials received from outside parties have been evaluated for performance requirements.

2.4 Consultancy

Advice has been rendered to outside parties on various problems in acoustics.

3. PROGRESS IN THE YEAR

3.1 Standards of Acoustical Parameters

Primary calibration of laboratory standard microphones by reciprocity method in a coupler cavity and an accuracy of + 0.2 dB was achieved. Factors contributing to inaccuracy have been identified and efforts are under way to improve the accuracy to better than $\pm$ 0.1 dB. In an international round-robin comparison of transfer standard microphones and piston-phone among national standards laboratories of Australia, China, India, Indonesia and New Zealand under the Asia-Pacific Metrology Programme, transfer standard microphones and pistonphone received from Australia were calibrated.

3.2 Calibration

14 items received from outside parties were calibrated. Calibration fees realised amounted to Rs.1205/–.

3.3 Testing

Performance evaluation of 133 items received from outside parties was carried out and test fees amounting to Rs.11,786/- were realised.

3.4 Investigations

Suitability of some toy guns, pistons and balloons as sound sources for investigations of room acoustics, reverberations and echoes was studied.

4. PROJECT TEAM

A.F. Chhapgar – Project leader
V. Mohan, V.N. Sharma, P.C. John, Omkar Sharma, C.B.L. Gautam.

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 nation and the neighbouring countries.

2. STATUS AS ON 1.4.1981

The time standard at NPL is maintained with the help of two Atomic Cesium Standards - one kept at NPL and the other at ATA (Standard Time Broadcast station). Other secondary standards at NPL include one Rubidium Vapour Frequency Standard and three crystal Oscillators. The accuracy maintained at NPL with regard to frequency or time intervals is 5×10^{-12}. The uncertainty of "Epoch" or "Time Instant" is less than 50 microseconds (upper limit). At present, there is no direct accurate time (Epoch) link between India and other established international laboratories. However, with the help of NNSS satellite receiver at NPL, Epoch can be monitored to about 25 μ seconds.This combined with the monitoring of GBR (16 kHz) signals (NNSS monitoring help in cycle identification of 16 kHz) gives an Epoch accuracy of a few μ seconds. VLF monitoring facilities have also been established [1,2].

The standard Time Broadcast continue to be made on three carrier frequencies viz. 5,10 and 15 MHz [3].

3. PROGRESS IN THE YEAR

3.1 Time Transfer and Time Dissemination Experiments via APPLE

During early 1982, time transfer and time dissemination experiments using Indian Experimental Satellite APPLE were started in collaboration with ISRO. The technique of time comparison via TV, developed at NPL, was tried over long distances, between New Delhi and Madras, taking advantage of broadcast of cricket matches over P & T lines and the results were cross-checked using the same technique via satellite APPLE.

3.2 Rubidium Vapour Frequency Standard

Development work on Rubidium Vapour Frequency Standard is in Progress. Hyperfine resonance and initial locking of crystal oscillator have been observed for the first time [4].

3.3 Contribution to CCIR Volume VII

Two documents, "Time and Frequency Comparisons via 6 kHz Transmissions from GBR,UK" and "Time Dissemination and Time Comparison by means of French-German Satellite Symphonie-1" based on the work done at NPL [5,6] were presented to final meeting of CCIR held in Geneva in September 1981 and were accepted for inclusion in CCIR volume VII.

3.4 Time Dissemination Service via INSAT

Time Dissemination Service via Indian Satellite INSAT, a project submitted to INSAT Coordination Committee, was discussed at Technical Advisory Group of INSAT. Preparatory work in this direction has already been initiated at NPL.

3.5 Calibration of Clocks using NPL Portable Clocks

NPL Portable clock was used to calibrate clocks at SHAR,Sriharikota and Laser Station (STARS) at Kavalur, Madras.

3.6 Installation of NNSS Satellite Receiver

A NNSS (Navy Navigation Satellite System) Satellite receiver was installed and timing accuracies of 25 microseconds order were achieved.

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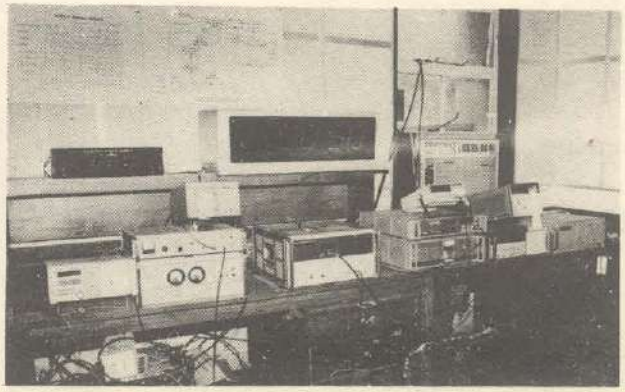

Fig.3: Atomic Standards of Time & Frequency at NPL

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4. 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.Mukherjee (Miss), D.S. Sachdeva, Gurdial Singh, A.K.Suri.

STANDARDS OF DC 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 physical standards of these parameters at international levels of accuracy.

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

To provide apex level calibration service to user organizations.

2. STATUS AS ON 1.4.1981

2.1 Standard of E.M.F.

The primary standard of DC voltage is maintained in the form of a bank of saturated standard cadmium cells kept in constant temperature oil bath and air enclosures. Emf values are assigned to each cell by mutual intercomparison technique using precision Kelvin-Varley potentiometer (precision 1 part in 10^7). Facilities have been created for the measurement of voltage upto 1500 volts.

2.2 Standard of DC Resistance

The primary standard of dc resistance is maintained in the form of a bank of one ohm standard resistors kept in constant temperature oil bath. Mutual intercomparison technique is employed to assign values to each resistor using direct current comparator (precision 1 part in 10^7).

Standard resistors of lower and higher denominations covering the range 10^{-5} to 10^5 ohm are also maintained at constant temperature and assigned values against 1 ohm standard. Facilities have been created for measurement of resistance, in the range of 10^{-5} to 10^{16} ohm.

2.3 Facilities have been created for the calibration of various dc standards and measuring instruments e.g. standard cells, potentiometers, standard resistors, constant current and voltage sources, calibrators, voltage, current and resistance measuring instruments etc.

3. PROGRESS IN THE YEAR

3.1 The as-maintained "ohm" was compared with the absolute "ohm" derived from calculable capacitor. New values have been assigned to the one ohm standard resistors traceable to the calculable capacitor (uncertainty $\pm$ 0.62 ppm).

3.2 E.M.F. Standard

Work on development of dc transfer standard based on Zener diode and that of temperature-controlled air-enclosure for it, was continued.

3.3 Measurement of Low Voltages

Facilities for precision measurement of small voltages (nanovolt) were established.

3.4 Intercomparison of E.M.F.Standards

NPL India acted as the pilot laboratory for intercomparison of dc voltage standard among the countries under the Asia/Pacific Metrology Programme: Intercomparison with Australia based on (i) 'Transvolt' and (ii) Zener diode voltage standard "Cropico", has shown that Indian and Australian standard of emf (one volt level) agree with each other within 0.5 μV.

Intercomparison of VNIIM (USSR) Standard Cells with those of NPL (India) was also carried out.

3.5 Calibration Service Rendered

Calibration work for a large number of agencies e.g. Regional Calibration Centres, Defence

Establishments, various Government Departments, Research Institutes, Public Sector Undertakings and Private Industries was carried out.

4. PROJECT TEAM

V.K. Batra – Project leader.
S.K. Mahajan, T.V. Ganapathy, P.K. Mittal
B. Sircar, Amreek Singh.
K.Chandra

STANDARDS OF CAPACITANCE AND INDUCTANCE

1. SCOPE AND OBJECTIVES

To set up primary standard of capacitance based on calculable capacitor and to realize the units 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 organisations.

2. STATUS AS ON 1.4.1981

2.1 Primary Standard of Capacitance

The vertical model of calculable capacitor based on Thompson-Lampard principle was set up.The accuracy obtained in the realization of the absolute value of capacitance is 5 parts in 10^7. The technique to calibrate a 10 pF quartz capacitor against the calculable capacitor using a specialized transformer bridge was perfected and a 10 pF capacitor was calibrated with an accuracy of 5 parts in 10^7. The setting up of this facility has put NPL on par with major standards laboratories in the world.

2.2 Primary Standard of Inductance

The Maxwell-Wien bridge for capacitance - inductance transfer was evaluated. Preliminary experiments on the realization of inductance from capacitance using Maxwell-Wien bridge and Resonance Technique were completed. Further work to improve the accuracy of inductance transfer is in progress.

2.3 Scale of Capacitance and Inductance was partially built up and calibration facilities for capacitance and inductance standards and impedance bridges were set up.

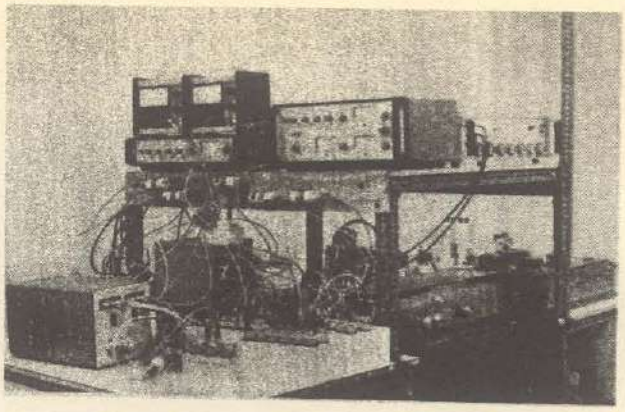

Fig4: Set up for realization of "Absolute ohm" from calculable capacitor.

3. PROGRESS IN THE YEAR

3.1 Primary Standard of Capacitance : [1]

Based on the calculable capacitor the scale of capacitance was built up from 0.001 pF to 10μF with enhanced accuracies varying from 0.5 ppm to 100 ppm. The present accuracies of standards and calibration facilities are given in the following table.

3.2 Primary Standard of Inductance : [2]

The unit of inductance, Henry has been realised from the unit of capacitance with the help of Maxwell-Wien bridge and Resonance Technique. The uncertainty in the realization of a 10 mH inductor at 1 KHz by both the techniques is about 10 ppm. This has brought the standard of inductance on par with other standards laboratories in the world.

The scale of inductance has been built up from 10 μH to 10 H with uncertainties varying from 10 ppm to 500 ppm. The present accuracies of the standards and calibration facilities are given in the following Table.

3.3 Absolute "Ohm" Determination

The unit of resistance "Ohm" has been realized through the calculable capacitor with the help of precision bridges using four terminal-pair techniques and intermediate standards of 1000 pF capacitors, 100 k Ω and 1 kΩ resistors. The components of these bridges and the standards are kept at a steady temperature in an oil bath with a temperature stability of a few milli-degrees. The absolute Ohm was determined with an uncertainty of ± 0.62 ppm. The value of absolute ohm thus determined is

TABLE 1

Standard	Uncertainty	Calibration Facilities	
		Range	Uncertainty
Vertical Model of Calculable Capacitor	5 parts in 10^7		
10 pF and 100 pF quartz capacitor	5 parts in 10^7	10 pF and 100 pF quartz capacitors	1 part in 10^6
10 pF, 100 pF and 1000 pF air capacitors	1-2 parts in 10^6	10 pF, 100 pF and 1000 pF air capacitors	5-10 parts in 10^6
0.001 μF – 1 μF	1-5 parts in 10^5	0.001 μF – 1 μF	5-10 parts in 10^5
10 μF	1 part in 10^4	1 μF – 100 μF	1-2 parts in 10^4
0.001 pF – 1 pF	1 part in 10^4	0.001 pF – 1 pF	2-5 parts in 10^3
		10 aF – 0.001 pF	5 parts in 10^3

Standard	Uncertainty	Calibration Facilities	
		Range	Uncertainty
10 mH, 100 mH realized from capacitance	1 part in 10^5	10 mH, 100 mH	1 part in 10^4
1 mH, 1 H	5 parts in 10^5	1 m H, 1 H	1 part in 10^4
10 H	1 part in 10^3	10 H, 100 H	5 parts in 10^3
100 μH	1 part in 10^4	100 μH	5 parts in 10^4
10 μH	1 part in 10^3	10 μH	1-2 parts in 10^3

$$\Omega_{abs} = (\Omega_{BIPM} + 1.0\mu\Omega) \pm 0.62\mu\Omega$$

3.4 Development of Inductive Voltage Divider

Design and fabrication of 4-dial and 6-dial inductive voltage dividers was completed. The technique to calibrate these IVDs with suitable accuracies was also established.

3.5 Calibration Service Rendered

Calibration of Capacitance and Inductance Standards and impedance bridges from various organisations and laboratories at Echelon I level is carried out.

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4. PROJECT TEAM

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

STANDARDS OF LOW & HIGH FREQUENCY VOLTAGE, CURRENT, POWER, ENERGY, ATTENUATION, IMPEDANCE AND NOISE

1. SCOPE AND OBJECTIVES

The project is aimed to establish, maintain and update the primary and transfer standards for measurement of : Voltage, current, power ratio (20 Hz - 30 KHz) and energy (50 Hz); Voltage, current, power, attenuation noise, frequency and impedance (30 KHz - 1 GHz), and to establish calibration facilities for these parameters.

2. STATUS AS ON 1.4.1981

2.1 A.C. & L.F. Voltage, Current, Power and Energy

Primary standard for A.C. power based on Electrodynamic Watt meters and transfer standard for single and three-phase power and energy based on electronic multiplication circuit have been established.

AC and LF voltage and current standards at transfer level based on thermoelectric comparator, r.f. micropotentiometer and thermal converters have also been established.

2.2 H.F. Voltage

Transfer standards of H.F. voltage based on R.F. micropots, thermal voltage convertors and ATVM have been established.

2.3 H.F. Attenuation

Primary standard of HF attenuation based on WBCO is being established (10 - 100 MHz) to aim an accuracy of 0.001 dB/10 dB. Transfer standard based on IF and RF techniques has been established.

2.4 Frequency Measurement upto 1 GHz

Facilities for frequency measurement upto 1 GHz based on frequency counter locked to cesium clock have been established. Standard frequency signals from 0.1 Hz to 500 MHz have been generated from 1 MHz signal obtained from cesium atomic clock.

2.5 H.F. Impedance

Facilities for lumped circuit impedance parameters based on precision LCR bridge, transformer ratio arm bridge, Twin-tee bridge and RX meter are being established upto 300 MHz.

3. PROGRESS IN THE YEAR

3.1 Primary Standards of AC, LF Voltage and Power [1]

Primary standards of AC and LF voltage and current measurement at 1 KHz based on multijunction thermal converters have been established with AC/DC transfer uncertainty of 2×10^{-6} upto 3 V and 10 mA.

L.F. power measurement facility based on voltage and current measurement and absorption power meter (100 W upto 30 KHz, uncertainty $\pm$ 0.1%) have been established.

3.2 Standards of H.F. Voltage [2]

Compatibility amongst various transfer standards of HF voltage has been established.

Work on primary standard of HF voltage based on calorimeter power head has been started.

3.3 Extension of Calibration Facilities

Calibration facilities have been extended in the following ranges :

a) AC & LF voltage - upto 1000 volts (20 Hz to 100 KHz)
b) AC & LF current - upto 20 Amp. (20 Hz to 5 KHz)
c) AC power and energy - 50 Amp. to 500 Amp, single phase
d) HF voltage - upto 30 volt (1 MHz to 220 MHz) [3]

3.4 International Intercomparison

International intercomparison of thermal converters of VNIIM, USSR with NPL thermal transfer standards has been carried out at NPL at 1 KHz, 2KHz, 10 KHz, 20 KHz, 100 KHz and 1 MHz and 1 volt, 3 V, 10 V, 30 V and 100 V levels.

3.5 Calibration Services

Using the above-mentioned facilities, a large number of instruments e.g. Precision A.C. Voltmeters, A.C. Ammeters, power meters, power factor meters, rotatory sub-standard type energy meters (Single Phase and 3-Phase both), precision calibrators, digital multimeter, signal generators, frequency counters, selective microvoltmeters, attenuators etc. have been calibrated for various user agencies.

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4. PROJECT TEAM

Sharwan Kumar — Project leader (Abroad on Special leave)

Joginder Singh, Suresh Chandra, V.K. Rustagi, Gurmej Ram, S.L. Juneja, Sita Ram, A.K. Govil, Inder Bhan, A.R. Kaushik (Mrs.), Dalip Singh.

K. Chandra

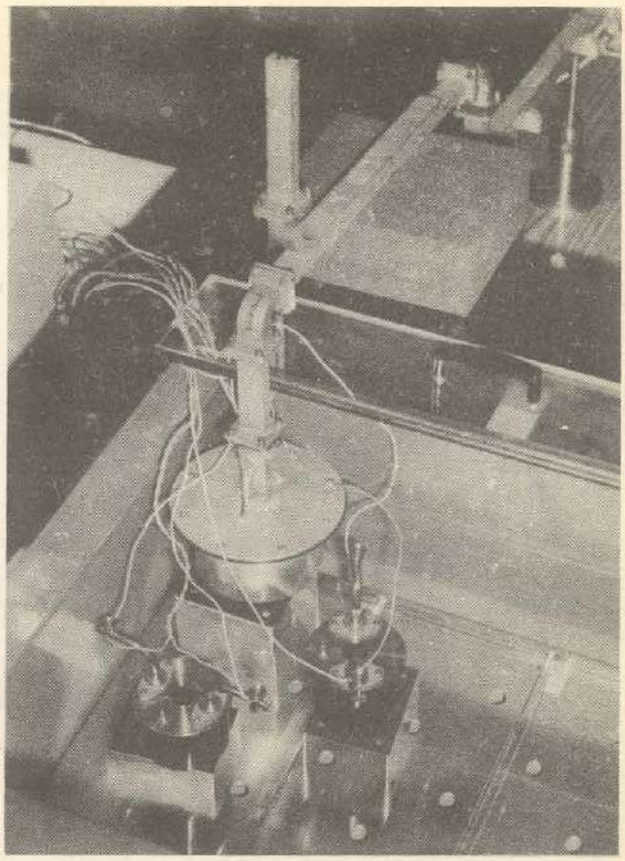

Fig.5: Micro-calorimetric System for accurate Measurement of Microwave Power at 10 GHz kept in constant temperaure oil bath.

STANDARDS OF POWER, ATTENUATION FREQUENCY, IMPEDANCE AND NOISE AT MICROWAVE FREQUENCIES

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) in order to meet the calibration requirements of various Government departments, Defence, Establishment, Regional Calibration Laboratories, Research and Academic Institutes and Public and Private Sector Industries.

2. STATUS AS ON 1.4.1981

2.1 Using thin film bolometer mount as transfer standard of microwave power with ± 0.37% uncertainty in effective efficiency, a feed through power measuring standard was established with an uncertainty of ± 0.8% at 10.0 GHz.Work on micro calorimetric technique was in progress.

2.2 Facilities for measurement of microwave frequencies from 1 GHz to 18.0 GHz have been established. Study of Frequency and Power Stability of different phase locked sources was completed. Standard Microwave Signals had been generated in X and XN bands.

2.3 Parallel IF substitution technique for attenuation measurement upto 100 dB was established in coaxial and waveguide systems with a total uncertainty of ± 0.05 dB/10 dB (± 1.0 dB in 100 dB) in 1—24 GHz range.

2.4 Coupled sliding load technique for VSWR measurement in 2-12.4 GHz range was established with an uncertainty of ± 0.005 in minimum VSWR of 1.02. Tuned reflectometer is being used for measurement of reflection coefficient in X-band.

Precision microwave components such as quarterwave short, moveable precision short circuit have also been developed in X-band.

3. PROGRESS IN THE YEAR

3.1 Microwave Power Standard

Standard bolometer mounts using thin film elements fabricated with the assistance of NPL's thin film group have been developed for use as microwave power standards. These bolometer mounts have been compared and assigned values for their effectie efficiencies at 10 GHz by the Electro Technical Laboratory, Japan. Preliminary measurements on these mounts by microcalorimetric technique showed encouraging results [2,1]

3.2 Microwave Attenuation

The audio substition technique has been established with an uncertainty of 0.02 dB/10 dB with a single step measurement of 30 dB. The total range of the technique is 60 dB with total uncertainty of 0.05 dB/10 dB. The frequency range for both the measurements is 1 to 12.4 GHz in coaxial and waveguide systems [1].

3.3 Microwave Frequency Standard

Power and frequency stability study of the phase locked microwave sources (BWO) was carried out using spectrum analyser, microwave counter and digital power meter with output connected to strip chart recorder [3,4,1].

3.4 Microwave Impedance

A standard mismatch of VSWR 1.10 $\pm$ 0.005 has been developed.

3.5 Microwave Noise Standards

Transver level (Echelon II) equipment for measuring noise parameters, such as noise factor, noise figure, excess noise ratio and equivalent noise temperature, in the frequency range 0.01 GHz to 18.0 GHz has been procured and is being set up.

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4. PROJECT TEAM

V.K. Agarwal – Project leader.

R.S. Yadava, Ram Swarup, P.C. Kothari, H.M. Bhatnagar, Ratinder Agarwal, R.L. Mendiratta, Sadhu Singh, R.C. Bansal.

K. Chandra,

DIVISION OF SPECIALISED TECHNIQUES

AREA COORDINATOR

Dr. V.G. Bhide
Dr (Mrs) S.Z. Ali
(Subsequent to the voluntary retirement of Dr. V.G. Bhide on 31.12.1981)
Dr. Krishan Lal
(Subsequent to the retirement of Dr.(Mrs) S.Z. Ali on 31.12.1982)

INTRODUCTION

The Division of Specialized Techniques was created to establish, maintain and provide facilities for characterisation of materials, to users in the laboratory as well as in other institutions.

At present, this group has facilities for characterization of materials regarding:

(1) Chemical composition including determination of nature and concentration of impurities;
(2) Crystallinity and crystalline structure; and
(3) Crystalline perfection.

Also, facilities have been created to measure some physical properties of materials, such as electrical conductivity and dielectric constant of solids. These facilities are being provided to the scientists working in various groups of the laboratory, users in other research organisations, industries and academic institutions.

The scientists of this Division have also been engaged in basic research in their areas of specialisation.

In addition to the facilities for characterisation of materials, infrastructure has been created for preparation of some poly- and single crystal materials and their characterisation.

In the process of setting up of these facilities, a number of sophisticated equipment have been developed for preparation and characterisation of materials. The expertise developed in the group has, at times, been used to take up development of complete units such as the hot axle box detection equipment for the Indian Railways. A number of sophisticated techniques have also been developed.

In this report, progress of the research and developmental activities of the Division during the year 1981-82 is described project-wise. It covers the following projects :

(1) Characterisation of materials by chemical methods,
(2) Characterisation of materials by spectroscopic methods,
(3) Characterisation of materials by electron paramagnetic resonance spectroscopy,
(4) Characterisation of materials regarding crystalline structure and perfection of X-ray diffraction method and elemental analysis by X-ray fluorescence techniques,
(5) Characterisation of materials regarding microstructure by transmission and scanning electron microscopy and electron diffraction techniques,
(6) Characterisation of single crystals regarding perfection and relevant instrumentation,
(7) Characterisation of materials regarding surface area and porosity,
(8) Development of infrared materials, detectors and systems,
(9) Growth of single crystals, their characterisation and defects in single crystals,
(10) Electronic service unit.

CHARACTERIZATION OF MATERIALS BY CHEMICAL 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 chemical composition.

2. STATUS AS ON 1.4.1981

Facilities are available for materials characterization by chemical methods, flame photometry and atomic absorption spectroscopy. Atomic absorption studies are done on Pye Unicam Model SP 1900 with flameless attachment and forty elements can be analyzed presently by this spectrophotometer.

3. PROGRESS IN THE YEAR

Chemical methods, flame photometry and atomic absorption spectroscopic techniques were used for determination of purity of materials, composition of alloys, steels, minerals, cement, lime, organic compounds, laboratory chemicals and moisture content of the transformer oils. Considerable work has been done for Central Board for Prevention & Control of Water Pollution, on the testing of industrial effluents to enable the various industries to discharge their effluents as per limits laid down by the Indian Standards Institute. Testing facilities have been developed for the analysis of gases.

A method for the micro determination of phosphorus in various steels and water has been developed. In this method phosphorus is converted and water has been developed. In this method phosphorus is converted into phosphoantimonyl molybdate complex. The complex is extracted by methyl isobutyl ketone and determined by atomic absorption spectrophotometer. This method enables for the determination of phosphorus in the presence of vanadium,arsenic, molybdenum and silicon which interfere in the determination of phosphorus by spectrophotometric methods. The sensitivity of detection is 0.02 ppm. Method has also been developed for the determination of arsenic in micro quantities using silver diethyl dithiocarbamate. The lower limit of detection is 0.01 ppm.

Research and developmental work has been carried out for the improvement of indelible ink. The new indelible ink cannot be erased with any chemicals and solvents. R&D work has also been done to develop the process for the manufacture of duplicating ink and stamp cancellation ink using rice-bran-oil which is a waste product and makes the process highly economical. The patents of these processes have been filed with the Controller of Patents. Process has also been developed for making heat sensitive papers and transparencies for thermofax machines. Preliminary work has also been done to develop pressure sensitive paper.

Work has been done on simultaneous determination of thorium and rare earth metals with EDTA using salicyl hydroxamic acid as indicator [1] and synthesis of bisdithiocarbamate complex of bis-p-biphenyl tin (IV) [2].

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4. PROJECT TEAM

D.C. Parashar – Project leader
J.C.Trehan, J.Rai, A.K. Sarkar, Smt. Ramadevi Ramachandran, Smt. Vasantha Raman, Prabhat Kumar Gupta, Mewa Singh, M.S. Dabas. (P.K. Gupta – on deputation to N T P C).

CHARACTERISATION 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 equipment relevant to this area.

2. STATUS AS ON 1.4.1981

Material characterization by infrared spectroscopy in the following spectral regions is being carried out : (a) 2-25 microns using Perkin

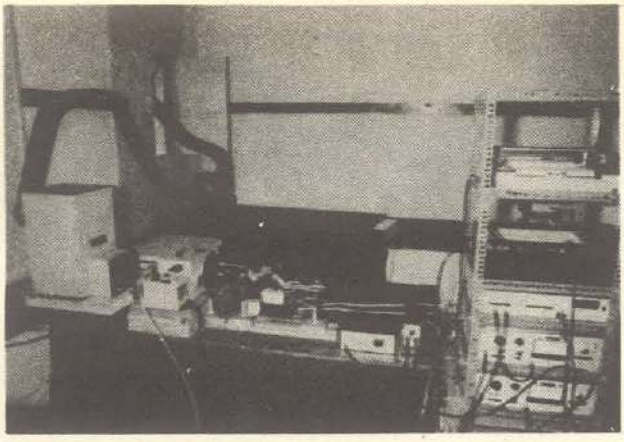

Fig.6(a): Laboratory model of Double Beam Photoacoustic Spectrophotometer.

Elmer model 399 spectrophotometer, (b) 15-300 microns using Far infrared grating spectrophotometer developed at the NPL and (c) 200-300 microns using NPL developed far infrared Fabry Perot type spectrophotometer.

Elemental analysis by atomic emission spectroscopy in the visible and uv spectral regions are being continued. In order to introduce a new technique for material characterization, a single beam Photoacoustic spectrophotometer was developed.

3. PROGRESS IN THE YEAR

Infrared measurements and spectrochemical analysis (uv, visible spectral regions) were carried out on a large number of samples obtained from the research and Development Projects of the laboratory such as Solar Energy: reflectivity and emissivity measurements on selective coatings used for solar collectors, the identification of constituents of these coating materials; carbon fibres; Liquid crystals and vacuum standards: graphite buttons for layerwise copper concentration.

Collaborative research work in the areas of infrared and photoacoustic spectroscopy were carried out together with Chemistry department of Allahabad University; Dairy Technology department of National Dairy Research Institute, Karnal; Chemistry Department of Indian Institute of Technology, New Delhi and Physics department of Banaras Hindu University [1].

Further improvements were incorporated in the laboratory developed single beam Photoacoustic spectrophotometer to use it in the double beam mode so that the normalised Photoacoustic spectra can be recorded directly [2].

Some basic research investigations were carried out in the far infrared [3] in collaboration with Max Planck Institute fur Fest Korperforschung, and atomic emission spectroscopy [4,5]. The feasibility of the development of Photoacoustic microscopy technique was also explored [6].

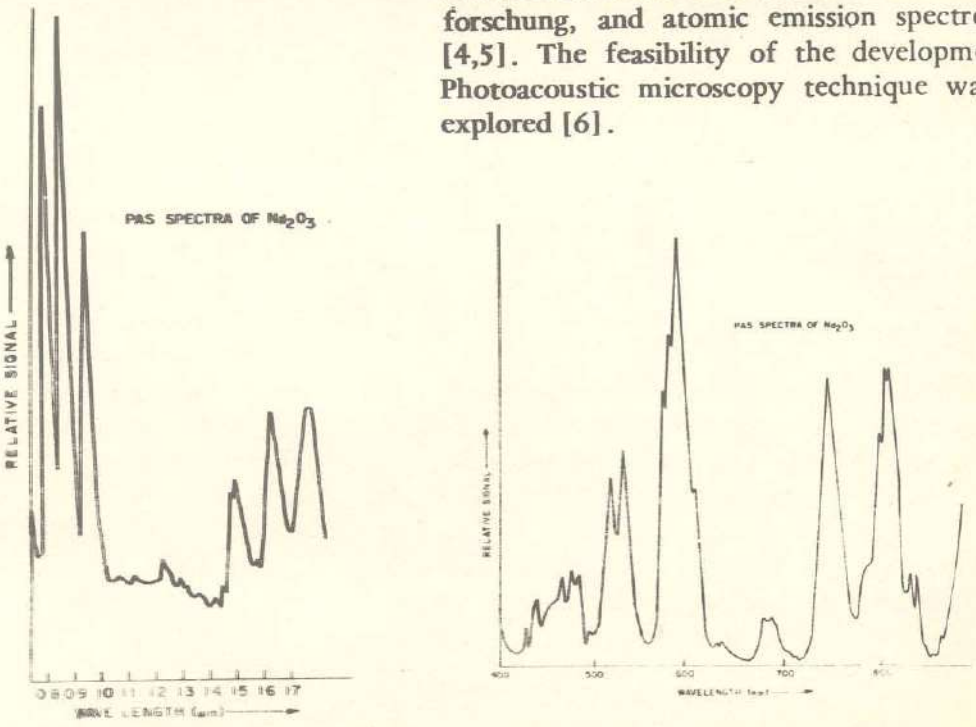

Fig.6(b): Photoacoustic spectra of Nd_2O_3 recorded at NPL developed double beam photoacoustic spectrophotometer. (Spectral range 0.4 to 1.7 microns).

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4. PROJECT TEAM

S.P. Verma – Project leader
Joginder Singh, R.S. Ram, S. Parthasarathy, Devinder Gupta.

CHARACTERIZATION OF MATERIALS BY ELECTRON PARAMAGNETIC RESONANCE SPECTROSCOPY

1. SCOPE AND OBJECTIVES

To establish, maintain and provide to users in the laboratory and outside the laboratory facilities for characterization of materials regarding composition by electron paramagnetic resonance spectroscopy.

2. STATUS AS ON 1.4.1981

Material characterization by Electron Paramagnetic Resonance Spectroscopy using Varian V–4502 X band EPR spectrometer equipped with 100 KHz field modulation unit is being continued. There is provision for EPR study in the temperature range of 77K to 500K and at liquid Helium temperature. Angular rotation work can be done at room temperature only.

3. PROGRESS IN THE YEAR

EPR study of rotational motion of Nitroxides spin probes in the case of nematic liquid crystals u-n-Amylacetophenon-o-(u-n-heptyl benzoyal)-oxime (AAHBO) and u-n-Butoxyphenyl hexyl benzoate (BPHB has been carried out.This study reveals that the probe molecules in these solvents are undergoing slow anisotropic rotational diffusion and has resulted in accurate determination of order parameter and correlation time at different temperatures [1].

The EPR study of kinetic behaviour of oxygen radicals (O_2^-, O^-, O_2^+) adsorbed in Cadmium Sulphide has shown that the number of oxygen radicals decreases above 600°C due to the formation of CdO [2,3].

EPR and magnetic studies of metallocenes have revealed that the coupling between electronic and nuclear motion is important for the understanding of the behaviour of these complexes. Analytical solutions are evolved to these Jahn Teller problems using canonical transformation and variational approach. The variational wave functions are used to calculate the zero-field splitting and EPR g-values which are compared with the experimental results on cobaltocenes [4].

Different superconducting thin films having A-15 structure have been studied and a new mechanism superconductivity was suggested on the basis of conduction electron spin resonance (CESR) [5]. Details of these results are described in report on Superconductivity project.

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4. PROJECT TEAM

S.K. Gupta – Project leader
Ramji Rai, S.R. Singhal.

CHARACTERISATION OF MATERIALS REGARDING CRYSTALLINE STRUCTURE AND PERFECTION BY X–RAY DIFFRACTION METHODS AND ELEMENTAL ANALYSIS BY X–RAY FLUORESCENCE TECHNIQUE

1. SCOPE AND OBJECTIVES

To establish, maintain and provide facilities to NPL scientists and outside 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. STATUS AS ON 1.4.1981

X–ray diffraction techniques such as Debye-Scherrer camera, flat plate camera, Weisenberg and Precession camera, high temperature (upto 1200°C) cameras and X–ray powder diffractometer with X–ray fluorescence attachment have been established in the group. Wide range of materials, both from industry and applied projects of NPL, have been characterized. A back reflection camera for residual strain measurements on large samples (non-destructively) has been designed and fabricated in NPL, and was used to make such measurements on large rotor discs from a Thermal Power Station (BHEL).

Crystal structure of InSe, Bi_2SeTe_2, Thermal expansion of In_2O_3, Bi_2Te_3, Bi_2SeTe_2 and β-In_2S_3 (with phase transformation in the later) and the topotactic reactions in the air oxidation of Bi_2Te_3, Bi_2SeTe_2 and Ga_2Te_3 and Ga_2Se_3 have been studied extensively. X–ray diffraction studies of diamond-like tetrahedral structures: Ga_2Se_3 and Ga_2Te_3 and some of ther solid solutions have shown very special and remarkable diffraction effects due to the presence of vacancies in one-third of metal atom sub-lattice positions.

3. PROGRESS IN THE YEAR

3.1 Characterization of Superhard materials

Crystalline phase analysis studies were carried out over a dozen samples of super hard w-BN compacts made by the HEPP group of NPL under different conditions of high temperature and high pressure. Mixtures of different phases as such as g-BN, w-BN, z-BN, Tic/N (50:50), AlN, TiO_2 and α-Al_2O_3 were identified; and the relative amount of each phase varied from one sample to another.

X–ray Laue photographs of many single crystals of diamond (both GEC and NPL synthesized) were taken. Qualitative comparison revealed that NPL diamonds were in general, comparable to GEC diamonds.

3.2 Characterisation of selective coatings on solar energy absorbers

A large number of chrome black selective coatings prepared at NPL by Solar Energy Group have been analysed and nickel black coatings revealed Cu and Al as main phases and Ni as minor phase.

3.3 Characterisation of Petroleum Coke and Pitch

Petroleum coke and pitch samples were studied in collaboration with Carbon Technology Unit of NPL. Diffraction patterns of pitch coke sample show broad 002 reflection peaks. The petroleum coke samples with small percentage of copper acetate, lead acetate and ammonium molybdate gave varying α_{002} values, the lowest being 3.37A° [1,2]. Theoretical work on vapour adsorption on porous materials have led to an adsorption equation which has been applied to isotherms of type I, II and IV to determine different parameters, such as mesopore area, degree of microporosity, surface area, limiting micropore volume and monolayer capacity etc. [3,4].

3.4 Study of thin films of CdS and other materials

A large number of thin film coatings of CdS and Cu_2S on tin oxide films prepared by scientists of Applied Project, NPL, have shown that structure of CdS is of the normal type in some cases and highly distorted in others, while only the thick and annealed copper sulphide films show prominent lines of some of the $Cu_{2-x}S$ phases.

$CuInS_2$ thin films was found to be cubic phase with diagonistic chalcopyrite lines being absent. Tetragonal and orthorhombic phases were confirmed for two different samples of PbO.

3.5 *Analysis of Ceramic Materials*

The α, γ and δ phases of Al_2O_3 as well as the beta alumina and other ceramic materials have been analysed by X–ray diffraction for the NPL scientists.

3.6 *Analysis of Urinary Calculi from Meerut Region*

In collaboration with LLRM Medical College, Meerut, X–ray diffraction phase analysis studies on large number of urinary calculi revealed that these are mainly composed of relative insoluble crystalline substances laid down layer by layer in organic matrix. Results have been corelated with factors responsible for the formation of stones in the 'stone belt' of North India [5].

3.7 *Study of Cotton and Carbon Fibres [6,7]*

A collaborative work with IARI Delhi on cotton fibres belonging to Gossypium arboreum species has indicated that average angle of orientation (evaluated from Herman's orientation factor) gives better correlation with mechanical properties.

Preliminary X–ray diffraction studies on intercalated carbon fibres from the Carbon Fibre Project, NPL, have been carried out.

3.8 *Study of Crystal Structure of Ga_2Se_3 and other Chalcogenide Materials*

Ga_2Se_3 gave special diffraction effects, that is, the presence of sharp spots accompanied by weak, diffuse, spots for reflections with h+k+l = 4n and completely diffuse broad spots for reflections with h,k,l all odd as well as the presence of streaks along the four (111) reciprocal lattice directions have been found to be due to a disorder in the distribution of Ga and its vacancy along the (111) type of directions in crystal space. These diffraction effects have resemblance to those produced by neutron irradiation in BeO. For sharp reflections of Ga_2Se_3 the Debye-Waller factor 2B was found to be as high as 6, using crystal monochromatised radiation; and of the order of 2 if diffuse components are also included, wherein it fits in with the values for diffuse reflections with h,k,l all odd [8].

A compound with composition $CdGa_2Se_4$ in the system $A^{II}B^{VI} - A_2^{III}B_3^{VI}$ was synthesised and studied by X–ray powder diffraction technique. The value of c-parameter of the tetragonal unit cell was found to be more (i.e. 10.746A°) as compared to that, 10.73A°, reported in literature. Single crystals, chosen from the ingot, were found to suffer from polygonization and twinning.

In the Cu-Ge-Se system, the composition $Cu_2Ge_{1+x}Se_3$ of the type $A_2^IB^{IV}C_3^{VI}$ can tolerate considerable excess of Ge, and this transforms the tetragonal lattice into two phase system, cubic and tetragonal. X–ray diffraction studies on the composition $Cu_2Ge_{1.55}Se_3$ indicated a superlattice structure with an ortho-rhombic unit cell.

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4. *PROJET TEAM*

Mrs. S.Z. Ali – Project leader.
K.C. Nagpal, K.D. Kundra, Mrs. U.Dhawan, D.K. Suri, M.Y.Khan and T.A.K. Ghori.

CHARACTERISATION OF MATERIALS REGARDING MICROSTRUCTURE BY TRANSMISSION AND SCANNING ELECTRON MICROSCOPY AND ELECTRON DIFFRACTION TECHNIQUES

1. SCOPE AND OBJECTIVES

The objective is to establish, maintain and provide facilities of characterisation of materials regarding crystal structure and crystalline perfection by electron diffraction and microscopy methods to support R&D activities of the NPL and help other research and industrial institutions.

To carry out basic research in the areas of material science/solid state physics relevant to the research programme of the laboratory.

2. STATUS AS ON 1.4.1981

We have a Philips EM 200 Transmission Electron Microscope with resolving power of ~6 to 8 A^{o}. A Jeol JSM-35 CF Scanning Electron Microscope, with two major attachments viz. Wavelength Dispersive Spectrometer and Energy Dispersive Spectrometer (EDS) has been added recently.

The study of nucleation, growth and micro-structure of metal films such as tellurium, tin had been carried out. Transport properties of these films were also investigated and explained in collaboration with Indian Association for Cultivation of Sciences, Jadavpur, Calcutta.

3. PROGRESS IN THE YEAR

A large number of powder samples of $CaCo_3$ ferrites, freeze dried samples of various materials, carbon, clays etc. have been examined for the determination of particle size, shape and size distribution.

A few samples of black chrome coatings (selective coating as solar absorber) prepared by a electrodeposition techniques were examined by T.E.M. using bright field and dark field microscopy and electron diffraction techniques. The deposition parameters of these coatings were optimised to achieve high absorption (α) and low emissivity ($\in$).

The study of structure of germanium, tin and tin films covered with germanium films was carried out in collaboration with Delhi University and the results were related with superconducting properties of tin films. Results of study of voids in silver films have been analyzed [1,2].

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4. PROJECT TEAM

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

CHARACTERISATION OF SINGLE CRYSTALS REGARDING PERFECTION AND RELEVANT INSTRUMENTATION

1. SCOPE AND OBJECTIVES

The aim of this project is to establish facilities for characterisation of single crystals regarding perfection, and to provide these to scientists within NPL as well as outside NPL. The sensitivity of the techniques are aimed at the best known level internationally, for industry as well as for research at advanced level. One of the major objectives of this activity has been the development of sophisticated equipment and advanced techniques for characterisation of materials and measurement of physical properties. To carry out basic research on lattice imperfections in crystals.

2. STATUS AS ON 1.4.1981

The following major facilities have been developed within the laboratory: (i) an X-ray diffraction topographic camera; (ii) a microfocus X-ray generator and (iii) a triple crystal X-ray diffractometer for diffuse X-ray scattering measurement and for recording diffraction curves (rocking curves).

Using these equipment a number of research investigations have been carried out in addition to providing these facilities to users

in the NPL and from outside institutions. X-ray diffraction topographic studies of α-Al_2O_3 single crystals grown by different methods have shown that the crystals grown by the chemical vapour deposition (CVD) method have the highest degree of perfection [1].

Systematic detailed measurements of diffuse X-ray scattering (DXS) on silicon (CZ), copper, KCl and KBr single crystals have shown that in these crystals the thermal diffuse scattering is negligible as compared to the diffuse scattering due to defects. This is a new result of considerable fundamental importance. The measurement techniques and the equipment for these measurements have been developed indigenously in the laboratory.

A new area for application of high resolution X-ray diffraction technique has been developed starting with the first experiments performed at the Physikalische-Technische Bundesantalt (P T B) Braunschweig, West Germany One of the NPL scientist during his visit to the P T B established there a triple crystal X-ray diffractometer similar to that developed at the NPL. He also developed a quadruple crystal X-ray diffractometer for observation and characterisation of changes in the atomic arrangement of single crystals subject to high electric fields. For the first time such an experiment was successfully performed and microstructural changes in semiconductors and insulators when a high electric field (ac or dc) is applied to these were directly observed. Remarkable results have been obtained.

3. *PROGRESS IN THE YEAR WITH SUITABLE PHOTOGRAPHS/ILLUSTRATIONS*

3.1 *Characterisation by X-ray Diffraction Topography [1]*

X-ray diffraction topography has been to characterise KCl single crystals grown in the NPL as well as crystals obtained from other scientists. Particular mention may be made of the topographic study of perfection of tin sulphide platelets at the request of scientists of Physics Department, Banaras Hindu University,Varanasi. A preliminary work has been carried out on 7-methoxycoumarine single crystals by the X-ray diffraction topography. These crystals are known to dimerize on irradiation with the ultraviolet light. Attempt will be made to study the mechanism of dimerisation and the role played by defects in this process. Scientists from the Indian Institute of Science, Bangalore had requested for collaboration in this area.

3.2 *High Resolution Diffuse X-ray Scattering Measurements*

Diffuse X-ray scattering measurements have been carried out on silicon single crystals grown by the float zone (FZ crystals) method [2]. As mentioned above a detailed study has already been carried out on silicon crystals grown by the Czochralski method and other crystals [3]. In the FZ crystals, the DXS distribution is not identical with that observed for the Czochralski grown crystals. The diffraction curves have their shape close to that predicted by the dynamical theory. Some structure on the diffraction maximum has been observed. The anisotropy in the DXS distribution and the number of knee points is also very different as compared to those shown by the CZ crystals. Detailed studies are under way.

3.3 *Development of equipment and technique for characterisation of materials*

A new technique for quick evaluation of gross perfection of single crystals has been developed [4]. This involves diffraction with a divergent X-ray beam (divergence of about 10^{-3} radian in the horizontal plane). The diffracted beam is recorded on a film and the structure in the image is a good measure of the perfection. It takes about on hour to estimate the degree of perfection of a crystal. It is a non-destructive method and therefore has advantage over methods like etch pit method.

The angular rotation system of the triple crystal X-ray diffractometer has been improved so that angular motions less than 1 sec of arc can be provided to the specimen.

Work has been started on establishing facilities for observation of electric field induced changes in single crystals. This is aimed at an in-depth study, since the investigations on Si, LiF and CdS crystals [5,6] have been successful.

3.4 *Characterisation of materials regarding physical properties*

Electrical conductivity of KCl single crystals of

DEVELOPMENT OF INFRARED MATERIALS, DETECTORS AND SYSTEMS

1. SCOPE AND OBJECTIVES

Under this project there are two objectives i.e. (i) development of Pyroelectric detectors and systems and (ii) development of thermistor bolometer type infrared sensor and the systems using these sensors. These two activities involve the preparation of suitable materials for pyroelectric and thermistor bolometer type sensors and the development of infrared sensors from these materials. Suitable electronic systems to process and to display the detected signals are also to be designed and developed. Applications of these systems for remote sensing and other similar areas are also to be attempted.

2. STATUS AS ON 1.4.1981

2.1 A self scanned eight element pyroelectric detector array alongwith its multiplexing electronics was developed for thermal imaging. Lithium tentalate crystals were tried for remote sensing of temperature. Earlier, facilities for growth of TGS single crystals from solutions were set up. This activity was continued. Ferroelectric properties of these crystals were studied.

2.2 The followin two ambitious time bound activities were undertaken under sponsorship from outside agencies : (a) development of Hot Axle Box Detection System for Indian Railways and (b) development of a system for the measurement of temperature of armature conductor and commutator riser part of 165 M DC traction motor. The first of these was sponsored by the Department of Science & Technology and the second was sponsored by Bharat Heavy Electricals Limited, Bhopal.

The Thermistor bolometer type infrared sensor was developed from its raw materials. Optics for this equipment was designed and germanium lenses of required specifications were fabricated complete with an anti-reflection coating. The preamplifier, the low noise Bias supply and the main electronic processing unit in Bread Board form were designed, developed and tested The system so developed was tested on simulated experiments and the necessary modifications were incorporated. The Printed Circuit Board (PCB) layouts and PCBs were made for various such systems and these wired up boards were subjected to environmental and vibration tests according to ISI specification 2106.

After rigorous trials a prototype of Hot Axle Box Detection System was fabricated and was subjected to extensive laboratory trials under simulated conditions.

The feasibility of taking up the development of a system for the measurement of temperature of armature conductor and commutator riser part of 165 M DC traction motor was worked out.

3. PROGRESS IN THE YEAR

3.1 Work on the electricically balanced pyroelectric radiometer (EBPR) was carried out for absolute measurement of low level optical radiation. The pyro-electric detector was so designed that the operating frequency lies between thermal relaxation frequency and electrical cut off frequency [1]. By utilising the principle of EBPR, a system for remote sensing of temperature has been designed and tested for targets with temperature varying from 45^{o} to 160^{o}C kept at a distance of 210 mm. Measurements carried out at various ambient temperatures with analog meters showed an accuracy better than + 1^{o}C [2]. A monodomain LATGS crystal was used to construct sensitive infrared detector with sensing element of 5 x 5 mm and Noise Equivalent Power (NEP) of 5×10^{-8} Watt/$Hz^{1/2}$ and absolute measurements of near infrared radiation were carried out. Eight element pyroelectric detector array made earlier was further modified. A Television camera alongwith a monitor has been procured for development of infrared vidicon. Work on growth of single crystals of TGS, LATGS, deuterated TGS & KDP was continued.

3.2 After the successful trials of the laboratory model of Hot Axle Box Detection System for various simulated train speeds, the system was modified to make it suitable for field trial on the track itself. A site was selected near Sahibabad railway station about 40 Km from Delhi on Calcutta – Delhi route of Northern Railway to monitor the temperature of axle boxes of trains approaching New Delhi/Delhi railway station. All the precautions were taken

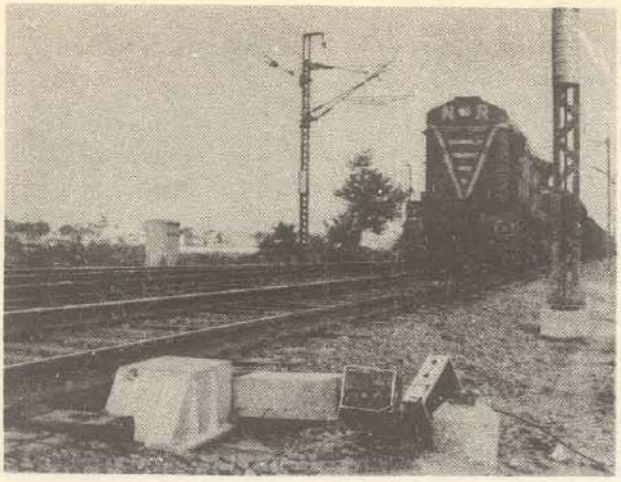

*Fig. 7(a): **Hot Axle Box detection system** under field trial at Sahibabad.*

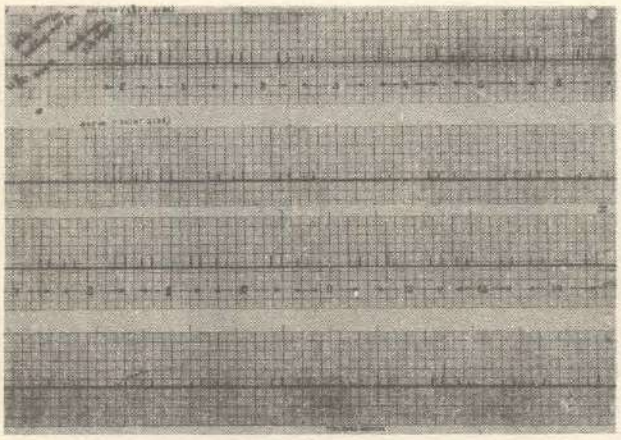

*Fig. 7(b): **Two channel record on Hot Axles** Box detection system installed at Sahibabad railway station.*

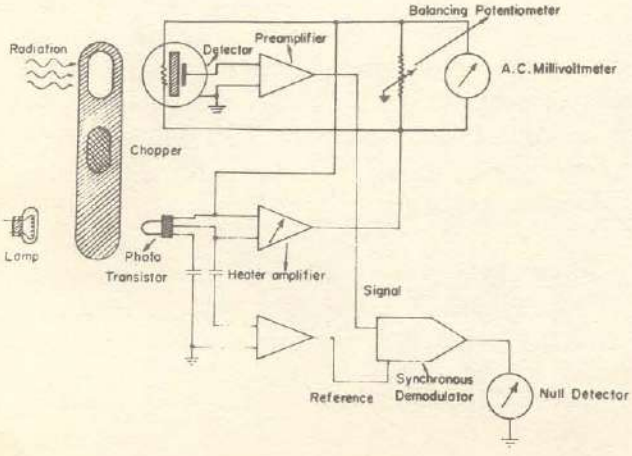

Fig. 8: Schematic diagram of electrically balanced pyroelectric radiometer (E.B.P.R.)

regarding its installation on electrified track in different seasons of the year were carried out by monitoring the temperature of axle boxes of superfast-passenger and goods trains.

Based on the feedback obtained from these trials, fabrication of a new dual channel prototype of Hot Axle Box Detection system has been started. This system will record heat signal data of axle boxes on both sides of the running train. Scanners of Hot axle box detection system comprising of optics, infrared sensor and pre-amplifier will be installed at the track side and will work automatically and unmanned. The electronic processing unit alongwith recorder and audio-visual alarm will be located at a station approximately 40 Km from the installation side.

The developmental work on the remote detection of temperature of the commutator riser part and the contact temperature measurement on armature conductor of traction motor have been taken up and started simultaneously. While the scanner (optics, sensor, preamplifier and bias supply) for the remote detection has been fabricated, the suitable sensors have been embedded in the conductor alongwith leads and sealing compounds to withstand the temperature and the voltage insulation for the contact measurement. The electronic tachometer for both the measurements have been developed and most of the printed circuit boards after their completion were subjected to continuous laboratory trials. An experimental unit was thus fabricated based on the modular construction. This unit will be capable of recording heat signal data from the commutator riser part of the DC traction motor rotating at 3000 RPM.

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4. PROJECT TEAM

M.M. Pradhan – Project leader and R.K. Garg for the activity on Pyroelectric detector and systems.

S.P. Varma – Project leader and Joginder Singh, V.V. Shah, S.P. Suri (Smt) Madhu Bahl, H.K. Maini for the activity on thermistor sensor and systems.

GROWTH OF SINGLE CRYSTALS, THEIR CHARACTERIZATION AND DEFECTS IN SINGLE CRYSTALS

1. SCOPE AND OBJECTIVES

This project aims at producing well characterised single crystals. It is proposed to develop most of the equipment like crystal pullers for crystal growth by Czochralski method, furnaces, controls etc. within the laboratory and also to develop suitable techniques to grow single crystals of high degree of perfection.

2. STATUS AS ON 1.4.1981

Two versatile crystal pullers have been developed for growth of single crystals from the melt by the Czochralski method. Special care has been taken to eliminate the effect of vibrations on the crystal growth. The vibrations generated within the pulling system as well as those transmitted from the surrounding environment have been isolated with the help of special anti-vibration mountings. The pulling motion is provided with the help of a screw and nut assembly which has been guided by a rod of square cross-section and a rod of circular cross-section. Both these rods have been made with care and special precision. For example, the rod with square cross-section is flat within $\pm$ 5 μm over its entire length of nearly one metre. The total length of pull is around 70 cm. Different seed rotation rates are possible. The rate of pulling can be continuously varied electronically in the range of 2 mm per hour to 20 mm per hour.

Fig.9. A versatile crystal puller designed, developed and fabricated at the NPL. It is being used for growth of nearly perfect single crystals from melt by the Czochralski method.

Resistance heated furnaces with well-controlled temperature profiles have been developed. The system conveying heat to the melt has been optimised. So far, the crystals are being grown in air. Some work has been started on the development of a vacuum chamber for growth of single crystals under controlled environment.

Single crystals of KCl, KBr and NaCl of different diameters have been grown. The maximum diameter is around 55 mm.

These crystals have been characterized by using X-ray diffraction topography and triple crystal X-ray diffractometer. It has been found that the rocking curves of these crystals have a half width in the range 10-30 sec of arc. In the topographs, dislocations can be resolved. Detailed studies of diffuse X-ray scattering on KCl and KBr crystals have been carried out.

Facilities for growth of single crystals of materials like CdS from the vapour phase have also been established. These include a crystal pulling device having a rate of pull of about 10 mm per 24 hours. Crystal growth can take place under desired atmosphere as well as under desired temperature gradient. Several crystals of CdS of 10 mm diameter have been grown under different pressures of H_2S and with different temperature gradients.

3. PROGRESS IN THE WITH SUITABLE PHOTOGRAPHS/ILLUSTRATIONS

3.1 Growth and Characterisation of Alkali Halide Single Crystals [1,2]

During the current year experiments have been started on the growth of pure LiF crystals as

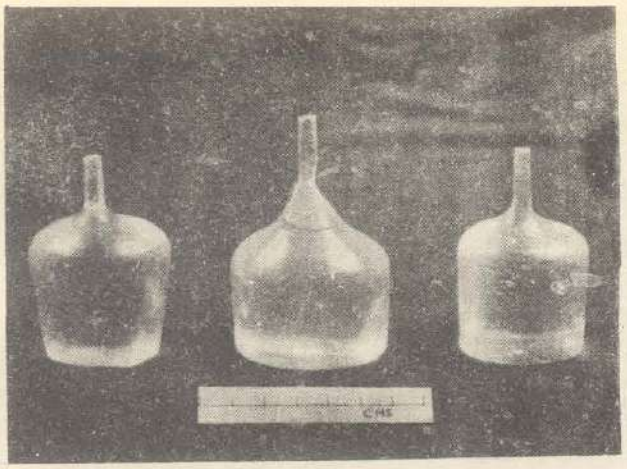

Fig.10(a): A few large size (diameter of more than 50mm) Potassium chloride single crystals grown with the crystal puller developed in the laboratory. Rate of pulling was 10mm/hr. and the rate of seed rotation was 30 RPM.

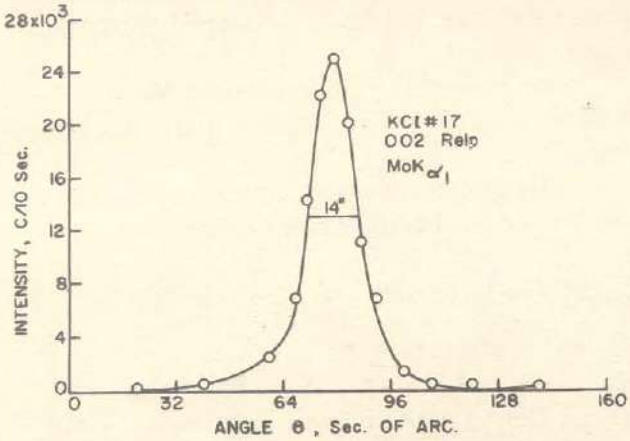

Fig.10(b): A typical rocking curve of a (001) potassium chloride single crystal obtained on the triple crystal X-ray diffractometer developed at the NPL. [002] reciprocal lattice point and $MoK_{\alpha 1}$ radiation were used. The half-width 14 seconds of arc of the curve shows a high degree of perfection of these crystals.

well as on the growth of calcium doped NaCl crystals.For the later we have a specific request from Reactor Research Centre, Kalapakkam (Department of Atomic Energy). NaCl crystals containing different concentration of calcium have been grown. Preliminary experiments on LiF crystals show that for better diameter controls some more experiments are required which are under way.

A new lapping facility based on an indigenously available lapping machine has been established. Several crystal plates of diameter

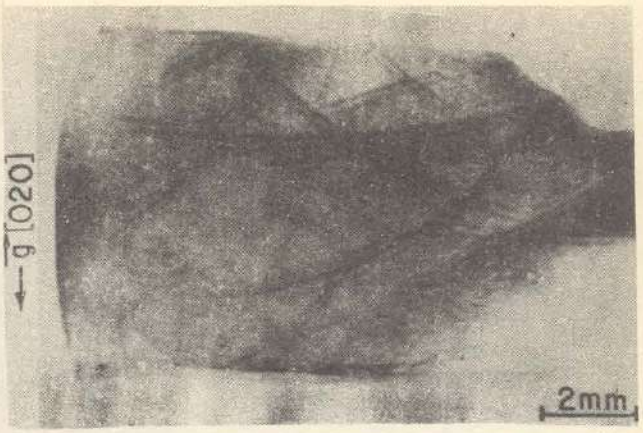

Fig.10(c): A typical projection topograph of a (001) potassium chloride single crystal recorded by using $MoK_{\alpha 1}$ radiation and [020] diffraction vector. The images of dislocations are seen well resolved.

about 30 mm and thickness about 5 mm have been successfully lapped on this system.

The chamber of growth of crystals under conttrolled atmosphere is under fabrication. The stainless steel dome, the base plate and flanges etc. have been machined.The tubes for cooling fluid are to be welded to the chamber and the metallic gaskets and the heating elements of graphite are to be fabricated.

Fabrication of a furnace for growth of single crystals by the flux method has been started. It will have silicon carbide heating elements and will be used to grow single crystals of materials like yttrium iron garnet (YIG).

The quick X-ray diffraction technique developed in the NPL for evaluation of perfection has been used to characterize a number of KCl and LiF crystals grown by the Czochralski method. Some of the good quality KCl crystals have also been characterized on the X-ray diffraction topographic system. These show low density of dislocations.

Work on growth of CdS single crystals was continued.

Single crystals have been supplied to different scientists in the country.

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4. PROJECT TEAM

Krishan Lal – Project leader.
R.V. Anantha Murthy, Vijay Kumar,S.D.Sharma S.K. Halder, Nathi Singh (left NPL), S.N.N. Goswamy.

ELECTRONICS SERVICE UNIT

1. SCOPE AND OBJECTIVES

The objective of the project is the maintenance of specialised electronic equipments and design development and fabrication of electronic instruments/systems required from time to time by various R&D groups in the laboratory.

2. STATUS AS ON 1.4.1981

2.1 The group is closely associated with the development of Hot Axle Box Detection System and is responsible for the design and deveopment of all the electronic sub systems. The full account is available under the project 'entitled, "Development of Infrared Materials, detectors and systems".

2.2 The group is closely associated with the development of a system for temperature rise measurement in armature conductor and commutator riser part of 165M DC traction motor and is responsible for the design and development of all the electronic sub-systems. The full account is available under the project entitled "Development of Infrared Materials, detectors and systems".

2.3 A microprocessor system based on Intel 8085 CPU was set up and number of simple soft ware programmes were developed.

3. PROGRESS IN THE YEAR

As mentioned this group is actively associated with the development of (1) Hot Axle Box Detection System and (2) the delopment of a system for temperature rise measurement in armature conductor and commutator riser part of 165M DC traction motor the progress on the project is described at one place namely under the project "Development of Infrared Materials, detector and systems".

It is planned to use microprocessor in combination with the equipment on temperature rise measurement being developed for Bharat Heavy Electricals Limited, Bhopal and some soft ware has been developed pertaining to this work.

Sophisticated equipment like Varian V–4502 X–band EPR spectrophotometer has been maintained.

Electronics component stores Reclaimation Service has been provided to the laboratory.

4. PROJECT TEAM

S.P. Suri – Project leader.
S.C. Garg, S.K. Singh, A.C. Prabhakar, K.C. Taneja, (Smt.) Madhu Bahl, H.K. Maini, Y.P.S. Negi.

different degrees of perfection was measured as a function of temperature.

Work of this project has received considerable attention and invited papers have been arranged at several national/international meetings/events [7-14].

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4. PROJECT TEAM

Krishan Lal – Project leader.
D.R. Pahwa, Vijay Kumar, S.D. Sharma, S.N.N. Goswami.

CHARACTERIZATION OF MATERIALS REGARDING SURFACE AREA AND 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.

2. STATUS AS ON 1.4.1981

Porosity of the finely divided and porous materials is determined using displacement densities by mercury and kerozene. Specific surface of such materials (if 5 m^2g^{-1}) is determined using volumetric adsorption apparatus fabricated in NPL. A standard Orr Surface Area Pore-volume Analyser, Micromeritics Model – 2700 D, has been used to determine the specific surface (5 m^2g^{-1}) of PAN base Carbon fibres.

3. PROGRESS IN THE YEAR

Surface area of a number of samples of fine powders, prepared by cryochemical techniques in the laboratory was determined. This has helped in assessing the suitability of this technique for the preparation of substrates for thick and thin film devices.

Surface area measurements were also carried out on activated carbon samples received from industry.

Samples of carbon fibres were prepared from viscose rayon yarn under various conditions of pyrolysis [1] Part of this work was carried out at the surface Chemistry Laboratory of Brunel University, U.K. by one of the NPL scientists.

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4. PROJECT TEAM

J.N. Bohra.

DIVISION OF MATERIALS

AREA COORDINATOR

Dr. G.C. Jain

Dr. V.N. Bindal
(Subsequent to the
demise of Dr. G.C.
Jain on 10.5.1982)

INTRODUCTION

The Division of Materials continued its R&D activities in the following areas :

1. Silicon Solar-Cells
2. Carbon Products & Glassy Carbons
3. Carbon Fibres
4. Ferrites & Conducting Ceramics
5. Ultrasonics and Electro-ceramics
6. Phosphors/Luminescent Materials & Devices.

The choice of the various projects undertaken was based on the national requirements in view. The special emphasis was on the use of indigenous raw materials and the fabrication of equipment, instruments, devices and components.

R&D efforts for reducing the cost of fabrication of solar cells starting from Ferro-silicon were continued as an attempt towards the development of alternate sources of energy. The aviation grade carbon brush blocks were developed using indigenous raw materials for Defence applications. The production of carbon electrodes, used for dry batter industry, was started by the licencee. The carbon-composites for biomedical applications and carbon fibre felt were developed on laboratory scale utilising carbon fibre developed earlier. A special grade of Ni-Zn ferrite ions were developed for the Atomic Energy applications. A new grade of piezoelectric ceramic materials was developed for pilot plant production. Copper activated monochrome phosphor developed earlier was tested successfully for TV industry.

A sonic balance to be used by the blind persons and a device for parametric generation of low frequency for underwater applications were developed.

STUDIES ON DEVELOPMENT OF POLYCRYSTALLINE SILICON FOR PHOTOVOLTAIC SOLAR ENERGY CONVERSION

The details are given under "Utilization of solar energy".

RESEARCH & DEVELOPMENT ON CARBON PRODUCTS

1. SCOPE AND OBJECTIVES

Indigenous technologies for the development of pitch coke as a substitute for petroleum coke, aviation grade brushes for air crafts and graphitized electrodes are desired to be developed. The objectives of research and development activities are:

i) To investigate the behaviour of coal tar and coal tar pitches and develop a batch process for the production of pitch coke.
ii) To study the surface properties of carbon materials.
iii) To develop certain grades and varieties of brush materials conforming to specifications of high altitude brushes.
iv) To develop 1" diameter graphitized electrodes.

2. STATUS AS ON 1.4.1981

Pitch coke was made from commercial coal tar pitch and coal tar on a 2 kg batch by carbonization and followed by calcination at 1200°C. The coke yield was over 80% and it had comparable physical and chemical properties to petroleum coke. Impregnating and extra hard pitches were made from coal tar using techniques of distillation, thermal treatment and solvent fractionization. The quinoline insoluble content was found less than 5% for the impregnating pitch. Sulphur treatment of the pitch gave sulphuretted pitch which had softening point above 130°C. Surface groups were studied on pitch coke, petroleum coke and low ash metallurgical coke by oxidizing the cokes in air at 300-450°C.

Two grades of aviation grade brush for Hindustan Aeronautics Limited, Nasik, were characterised and their friction and wear rates were determined. In house tests on the two varieties (PR–72–003 and 004) were carried out and subsequently tested at HAL, Nasik, under simulated conditions of high altitude.The results indicated comparable performance and type approval were obtained by Directorate of Aeronautics (R&D), Ministry of Defence, 1" electrode obtained by extrusion were made for primary cells.

3. PROGRESS IN THE YEAR

3.1 The coal tar was distilled under varied conditions of thermal treatment to produce pitches with softening point ranging from 50 to 150°C. The original tar and benzene insoluble 7% and quinoline insoluble content was 3%. The ash of the tar being 0.07% and coke yield 25%. The pitch processed from the tar and softening point 60°C (R&D), quinoline insoluble 3.2%, benzene insoluble 16.0%, ash 0.16%, carbon content 40% and real density 1.254 g/cc.

The pitch was separated into solvent fractions by extractions with benzene, toluene, quinoline, xylene, dioxane and trichloro ethylene. The insoluble and soluble fractions were thermally [1] treated in nitrogen and air. It was found that benzene, xylene, toluene fractions behaved similarly while the quinoline fraction differently. The results are useful for further processing the pitches. Chemical treatment of the pitch was done with elemental sulphur from 2-20% by weight of the pitch. The effect on softening point, benzene solubility, coke yield and weight loss at temperatures 150-350°C studied.

The sulphur additions preferentially attack the groups containing hydrogen and remove them in the form of hydrogen sulphide. Three reactions take place simultaneously – (1) Thermal decomposition of the pitch leading to weight loss, (2) Dehydrogenation by sulphur interaction and (3) Establishment of crosslinks and hardening.

Structural studies involving X-ray diffraction on sulphuretted carbons were done subjecting the materials to heat-treatment at 850-2000°C. From the diffraction profiles it was learnt that 5 additives reduces the crystallinity of the resulting carbons as indicated by increase in 'd' spacing. Studies on sulphuretted cokes are important as high 5 crudes are likely to be

available in considerable quantities and their use for anode carbon is to be investigated. A Ph.D. thesis has been compiled on the investigations.

Pitches have been used in composites processing on account of their high degree of thermal plasticity and coke yield. A project on use of pitch for carbon-carbon composites has already been taken at NPL. Composites were made using carbon fibre as filler and Rourkela based pitch as matrix by wet winding techniques The mechanical properties of the composites were determined. The work is intended for biomedical applications ofcarbon-carbon composites using coal tar pitch.

Pitch coke, low ash metallurgical coke and petroleum coke were oxidised in air at temperatures 250-550°C and their weight losses recorded. The oxidised cokes were degassed in nitrogen and CO_2 determined by titrations against $Ba(OH_2)$. Surface groups on the cokes were determined by titrations with NaOH, Na_2CO_3 and NaH CO_3 to estimate differential surface groups. The results indicate that pitch coke is a better anode material as far as its anode loss is concerned [2].

TABLE 1

Properties of Pitch Coks Vs.Petroleum Coke

Density	Pitch coke: 0.76 g/cc	Petroleum coke : 0.70 (-52+100 mesh) g/cc
Strength	26.6%	34.2% (-do- on 10 ton)
Ash	0.3%	0.6%

TABLE 2

Properties of Carbon-Carbon Composites

Fibre volume	40%
Flexural strength	690 MN/m2
ILSS	17.2MN/m2
Softening point of pitch used	104°C
- resins of the pitch	24%

3.2 Natural graphite and metal graphite powders containing metal powder additives were oxidised in air at various temperatures and hydrophilic surface groups formed during this treatment were detected. The results indicate the increased reactivity and consequent formation of hydrophilic surface groups which increase water vapour adsorption on graphite in presence of lead. This may be helpful in graphite lubrication during the process of sliding against a counterface [4].

The graphite debris film formed on sliding on the contact surfaces affects the sliding behaviour and its topography depends on the conditions of sliding such as load, speed, temperature, current density as well as nature of the bulk composite and the counter face material. The rubbed surface of the composite against copper counterface at a current density of $10A/cm^2$ and peripheral speed of approximately 10 m/sec indicates a relatively strong, coherent and continuous film formation. The damage to the film indicates that it has arisen due to crack formation and subsequent flaking off the film from the surface. It appears from topographical considerations that low wear conditions exist under the sliding conditions. This has been confirmed

TABLE 3

Surface Groups on Cokes

Material	Acidity, meq/g			
	NaOH	Na_2CO_3	$NaHCO_3$	Degassing
Pitch coke	0.5176	0.3336	0.1237	0.837
Petroleum coke	0.4111	0.1480	0.2531	1.950
Low ash metallurgical coke	0.7645	0.4075	0.3194	3.802

TABLE 4

	Contact volt drop	Average Wear rate x 10^{-11} (g/cm) +ve brush	-ve brush
1. Cu 70%, G 20%, Pb 10%	0.8	27.2	4.75
2. Cu 70%, Sn 10%, Pb 10%	0.8	51.8	5.5
3. Cu 80%, G 20%	0.6	82.6	58.9

by actual mechanical tests on rates of wear given below on copper, lead and graphite composite material [3]:

At the instance of HAL, Nasik, investigations were conducted on developing aviation grade brushes for performance at high altitude. Certain grades of brushes corresponding to PR-72-003, 004 and 005 were made and they have undergone rigorous simulated high altitude tests at their works and shown performance comparable to the imported brush components. The tests include measurement of their physical properties and wear out rates under (i) ambient conditions, (ii) high temperatures, (iii) high altitude (-56°C and pressure corresponding to an altitude of 15 km (pressure 90 mm Hg), (iv) vibration test under specified frequencies ranging from 20-200 C/s, amplitude, from 0-05 mm and vibration overloads 0.8 - 4 'g'.

3.3 Number of compositions of the filler materials were evaluated to improve the apparent density of the electrodes. The values of flexural strength and electrical resistivity were studied. A graphite furnace using indigenously available resistor tubes and carbon black as packing material was installed for graphitising of the baked electrodes under controlled atmospheres. This furnace may give better controls over the laboratory Acheson furnace.

A number of compositions using petroleum coke as the filler material were tried using extrusion followed by baking at 1000°C . .e rods were 1.55 g/cc density. Further work s in progress.

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4. PROJECT TEAM

Dr. R.L. Seth – Project leader.
Dr. O.P. Bahl and Group, S.K. Kapur, K.K.Datta C.L.Verma, Chhotey Lal and C.V.M. Das.

DEVELOPMENT OF GLASSY CARBONS AND CARBON PRODUCTS

I. SCOPE AND OBJECTIVES

i) To develop phenol formaldehyde resins compositions for subsequent conversion to glassy carbons.

ii) To develop carbon cements from indigeneous raw materials for low and high temperature applications.

iii) To modify pitches for their use in carbon products and carbon-carbon composites.

iv) To develop clutch carbons and to provide assistance in manufacture of carbon bricks in a study sponsored by M/s Siddharth Carbochem Products, Baroda.

2. STATUS AS ON 1.4.1981 :

Some compositions of phenol formaldehyde resins were made and these were casted into artefacts of various shapes and sizes and were finally carbonised in inert atmosphere

to produce glassy carbons. Investigations on carbon mixes were undertaken to study the electrical resistivity of carbon powders used in making various carbon products.

3. *PROGRESS IN THE YEAR*

3.1 Glassy Carbons :

Phenol was reacted with formaldehyde in the molar ratio of 1 : 1.3 in presence of suitable catalysts. These resins were shaped into artefacts of various shapes such as plates, discs, crucibles, tubes, rods by moudling as well as casting techniques. The green glassy carbons were heat treated to 1000°C and 1800°C in inert atmospheres and the following typical characteristics were obtained.

Green density	1.25 g cm^{-3}
Carbonised density	1.50 g cm^{-3}
Yield	64%
Volume shrinkage	46%
Flexural strength	21,000 psi
Shore hardness	(90-100)

Experiments were in progress to improve the characteristics of glassy carbons and to use glassy carbons in semiconductor and thin films applications.

3.2 Carbon Cements :

Carbon cements were prepared by using modified coal tar pitches, thermo-setting resins, solvents and carbonaceous particles.The cements were used joining carbons sections and were tested for the bonding strength. Different compositions were formulated ranging from those applied cold to those applied hot or low and high temperature applications.

3.3 Modification of Pitches :

The coal tar pitches were modified by thermal and chemical treatments. The modified pitches prepared from various soluble portions of coal tar pitches lead to extended mesophase micro-structures [1]. This is very useful for the production of needle cokes and supreme cokes in modern ultra high powder carbon electrodes. Suitable pitches were made and supplied for the R & D on carbon-carbon composites. Further improvements are necessary.

3.4 Sponsored Project :

A project was sponsored by M/s Siddharth Carbochem Products, Baroda to develop clutch carbons and to provide assistance in R&D on carbon bricks. The dies for making clutch carbons were fabricated and suitable compositions of clutch carbons were worked out and passed on to the party. Assistance was also given in the R&D on carbon bricks. The dense carbon bricks with bulk density of 1.56 g cm^{-3} and crushing strengths over 650 kg cm^{-3} were developed [2].

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4. PROJECT TEAM :

Dr. G.C. Jain — Project leader

Gopal Bhatia, R.K. Aggarwal, O.P. Bahl, L.M. Manocha and R.L. Seth.

FEASIBILITY STUDIES ON SETTING UP OF AN EXPERIMENTAL PILOT PLANT FACILITY FOR CARBON FIBRES

1. SCOPE AND OBJECTIVES

(i) To characterize various polyacrylonitrile fibre samples developed by IPCL, Baroda and to optimise processing parameters for converting these precursors into carbon fibres.

(ii) To try various chemical treatments of PAN fibres for improving the mechanical properties of resulting carbon fibres.

(iii) To give surface treatment to carbon fibres on continuous scale.

(iv) To make model composites with surface treated carbon fibres and hybrid composites and to study their fracture behaviour.

2. STATUS AS ON 31.3.1981

Until 31.3.1981, carbon fibres had been developed from imported special grade acrylic fibres. Preliminary experiments on indigenous acrylic

fibres produced by IPCL were carried out. Encouraging results were obtained but the need for a detailed and systematic work was established.

Surface treatment of carbon fibres was completed on batch scale with Conc.HNO_3 and by anodic treatment.

Facilities for making model composites with carbon fibres and epoxy resins were created in the preceding year.

Carbon fibre felt had been developed by normal padding method.. It has to be tried.

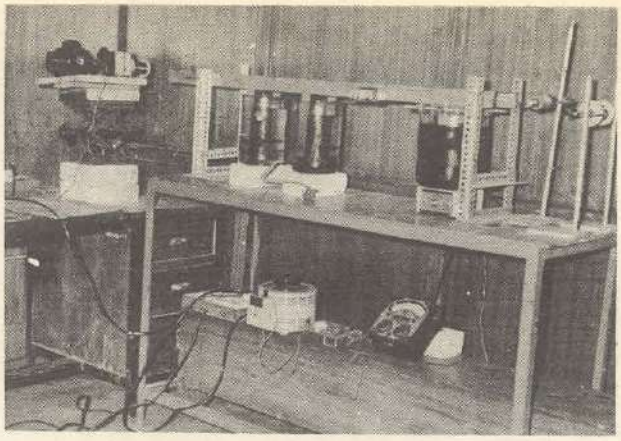

Fig.11: Electrolytic Cell for Surface Treatment of Continuous Carbon Fibres.

3. PROGRESS IN THE YEAR

3.1 *Processing of Carbon Fibres*

The important characteristics of different imported special grade acrylic precursors meant for making carbon fibres were compiled (ref.2) and sent to the Indian Petrochemicals Corporation Ltd., Baroda, who have the responsibility to develop suitable acrylic precursor for us. On the basis of the suggestions given by the laboratory, various samples of acrylic precursors were received from IPCL. These were analysed for mechanical properties, density etc. and were then converted into carbon fibres. The processing parameters involved in conversion of these acrylic precursors to carbon fibres were optimised and the resulting carbon fibres were thoroughly characterised. The mechanical properties of some typical acrylic precursors alongwith the carbon fibres developed therefrom are compiled in Table 1. This work is still continuing.

3.2 *Chemical treatment of Acrylic Fibres*

Stabilization step involved in the process of making carbon fibres controls the mechanical properties of ultimate carbon fibres and also the economy of the process. Efforts have been made to improve this step. Chemical impregnations of PAN fibres with various chemical reagents such as Cucl, Benzoic acid etc. have been tried which have shortened the oxidation time thus saving energy and have resulted into fibres with good mechanical properties. An improvement of 40% in the mechanical properties of carbon fibres was achieved.

3.3 *Surface Treatment of Carbon Fibres*

Bench scale apparatus for continuous anodic treatment of carbon fibres was designed and installed (Fig.11). Anodic treatment of carbon fibres was given using various electrolytes such as Sodium Hydroxide, Sulfuric acid/Potassium Dichromate, Sodium Hypochlorite etc.etc.

3.4 *Model Composites with Carbon Fibres*

3.4.1 Model composites were made with surface treated carbon fibres and their mechanical properties were evaluated. It was found that the mechanical properties specially flexural strength and Interlaminar shear strength increase significantly.

3.4.2 Composites were made with following different apoxy resin systems to evaluate CFRP. (i) Araldite LY 558 + HT 976; (ii) Araldite MY 720 + HT 972 and (iii) Araldite LY 556 + HT 972.

Araldite MY 720 systems have better properties and can be used at higher temperature than LY 556 system.

3.4.3 Two dimensional carbon fibre reinforced ultrahigh molecular weight polyethylene composites were made for bio-medical application. Ultra high molecular weight polyethylene is best bio-compatible material. When reinforced with carbon fibres it yielded composites with escellent impact strength and flexural strength matching the properties of natural bone.

3.4.4 Hybrid composites were made with Kevlar /Carbon fibres in epoxy resins. Different lay up systems were tried to have composites with good impact strength and interlaminar shear strength.

3.5 *Development of Carbon Fibre felt*

Carbon fibre felt is the best insulating material for higher temperature applications in metallurgy. In continuation to previous work, further experiments were done on different weave patterns to have good insulating felt. As a result a special weave pattern has been identified which is suitable for making carbon fibre felt. Felt has been made on lab scale with dimensions 30cm x 30cm x 4mm. Efforts are being made to scale it up to bench scale.

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4. PROJECT TEAM

Dr. G.C. Jain – Project Coordinator.
Dr. O.P. Bahl – Project leader.
L.M. Monocha, R.B.Mathur, S.S. Hanspal, Tarsem Lal Dhami, S.K. Rai, R.L. Seth, K.D. Kundra, J.N. Bohra, Chhotey Lal, Devendra Gupta and Avtar Singh Kalsi.

DEVELOPMENT OF FERRITES AND CONDUCTING CERAMICS

1. SCOPE AND OBJECTIVES

The aim of the project was to do investigatory studies on preparation of various ceramic materials for use in electronics and energy sectors.

2. STATUS AS ON 1.4.1981

Various grades of high quality Mn-Zn ferrites with initial permeability greater than 10,000 had been prepared. The sintering kinetics and magnetic properties of nickel zinc ferrites with V_2O_5 as additive were studied. Magnetic tape for audio C-60 cassettes had been coated and calmdered to meet electroacoustic requirements. Beta alumina ($Na_20.5\ Al_2O_3$) powders were synthesised and sintering studies on these ceramics were started. Various grades of silver cements for use in electronics had been developed and were in pilot production.

3. PROGRESS IN THE YEAR

The various products investigated during the year are professional grade ferrites, audio magnetic tapes, and gamma iron oxide, Beta alumina solid electrolytes, zinc oxide based varistors, $LaCrO_3$ ceramics, alumina and silver cements.

3.1 Ferrites

A microprocessor controlled furnace has been designed and various subsystems have been procured. The total system is now being assembled. A B-H loop plotter for soft ferrites has been designed and fabricated. It measures the B-H loop at 0.5 KHz and displays it on an X-Y Recorder. Effect of various additives like SiO_2 and Sb_2O_5 on properties of Ni-Zn ferrites have been studied [2]. Fine Mn-Zn ferrite powders have been synthesised by hydrothermal oxidation of a solution of Sulfates of Mn-Zn and Fe. To meet the requirement of the VEC project of BARC, a special grade of professional Ni-Zn ferrite ions were developed and supplied as torroids of size 100mm OD x 50mm ID x 12mm for use in high power RF transformers in the frequency range of 1-15 MHz (Fig.12) [1].

3.2 Magnetic Tape and Gamma Iron Oxide

A small plant for preparing 500 gms of gamma iron oxide per day had been fabricated. The gamma ferric oxide sample from DMRL,Hyderabad was processed in the coating plant and magnetic tape thus produced was calendered and tested for various electrical and magnetic properties. Cobalt coated gamma iron oxide powders were prepared.

3.3 Beta Alumina

The repeatability of preparation of B"-Al_2O_3 by the Zeta process was tried out. Some tubes of beta alumina were also isostatically pressed. Reactive alumina powder suitable as raw material for the process were synthesised starting from ammonium alum. With this powder, it was possible to obtain a density of 3.25 g/cc in B" Al_2O_3 bodies.

3.4 Varistors

Sintering kinetics of zinc oxide based varistors with n 20 ($I = KV^n$) and voltage rating of 50-100 V/mm had been studied. Zinc oxide varistors containing three oxides besides zinc oxide

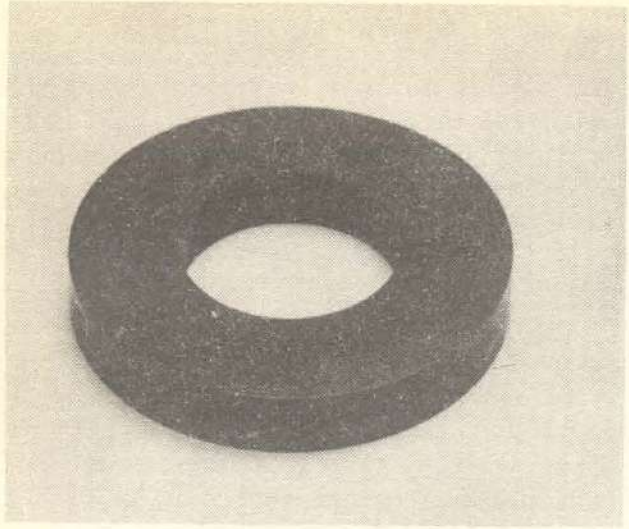

Fig.12: Special grade Ni-Zn ferrite torodial core for BARC-VEC project.

were prepared with n as high as 35 ($I = KV^n$). The metallisation procedure for these have now been standardised and varistors have been batch produced.

3.5 $La(Sr)CrO_3$ Ceramics

Strontium doped $LaCrO_3$ ceramics with electrical conductivity better than 0.05 $ohm^{-1}cm^{-1}$ had been prepared. The a.c. electrical conductivity, infrared characteristics and dielectric properties of $LaCrO_3$ ceramics prepared in the laboratory were studied [3,5,6]. The sintering kinetics i.e. the grain growth and densification were also studied in the ceramics [4].

3.6 Alumina

Using reactive alumina powder (99.95% pure) of mean particle size 0.7 um prepared in the laboratory, alumina bodies with densities as high as 3.96 g/cc were prepared by sintering at 1550°C. The effect of additives like MgO and La_2O_3 is under study.

3.7 Silver Cement

Various grades of silver cements, e.g. air-dry, oven curing type and fire on types, had been produced. A total of 13.59 Kgs of silver cements of various grades costing Rs.52,469/- have been pilot produced and supplied to actual users. Silver cement suitable for screen printing contacts on-to silicon solar cells is under development.

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4. PROJECT TEAM

B.K. Das – Project leader.
V.K. Amar, G.Govindaswami, A.K. Mehrotra, Ram Pal Tandon, R.B. Tripathi, Rahul Kumar, S.M. Khullar, H.S. Kalsi, Satbir Singh, B.S. Kurana, R.C. Goel, S.K. Sharda, A.P. Gera, T.R. Pushpagadan, K.P. Shankaran Nair, Mukul Sharma, G.C. Jain, Santosh Kumari, Balbir Singh and T.Podikunju.

ULTRASONIC TRANSDUCERS MATERIALS AND DEVICES

1. SCOPE AND OBJECTIVES

The objectives of this project are to develop ultrasonic instruments, transducers, techniques and materials for various technologically important applications, such as :

i) Ultrasonic Instrumentation
ii) Non Destructive Testing
iii) Standardisation and Transducer Characterisation
iv) High Power Ultrasonics
v) Underwater Acoustics
vi) Piezoelectric Materials
vii) Physical Ultrasonics

2. STATUS AS ON 1.4.1981

In Instrumentation, targets achieved were (i) a complete laboratory model of ultrasonic A-scan opthalmoscope, (ii) powerful ultrasonic transducer for air (125 dB re 2 x 10^{-4} ub) working from high amplitude drive using indigenous ferrite elements, (iii) studies on ultrasonic transducer using corona charged mylar, (iv) transducers/chamber for CO_2 relaxation apparatus.

In NDT, a miniature surface wave probe for ultrasonic NDT was developed. The facility of circule diagram plotting was added to help in the investigations on evaluating the effect of environment on adhesive bonded joint nondestructively, as well as for underwater acoustics work.

In Transducer characterisation, (i) a technique was suggested for designing halfwave resonators for ultrasonic transducers; effects of mismatch were also studied, (ii) a method was developed which gives information about the backing of the transducers through help of absorption measurements.

In High Power ultrasonics, studies of nonlinear effects produced by it have been carried. A new phenomenon of subharmonic vibrations emanating from a membrane has been observed[17].

In Underwater Acoustics, work has been concentrated on characterisation of underwater transducers for transmitting response and sensitivity and studies on the parametric phenomenon initiated.

In the Materials Development programme, the material NPLZT–5H1 having high dielectric constant and higher charge sensitivity has been developed for low power applications. Work on PZT–4 is being continued for high power applications.

3. PROGRESS IN THE YEAR

3.1 Ultrasonic Instrumentation

Developmental work on the following two new instruments has been initiated :

i) Air Doppler System : A laboratory purpose ultrasonic Doppler System[11] for use in air has been successfully developed. The system using hybrid transducer has sufficient sensitivity to detect targets as well as a falling drop of liquid. Flow rate studies of liquids have been made in a non contact manner using the method. Detection of large speeds is possible.

ii) Measuring Scales for Blind : Exploiting the effect of acoustic radiations on a membrane in frame, a sonic balance has been developed for the blind for weighing an article or quantity upto 1.5 kg. The system does not need weights to be placed and the balance point is detected by the turn of the frequency dial till a sharp change in sound level is heard. The accuracy of present tests is better than 10g in 300gm.

In addition, improvements have been made in the laboratory model of ultrasonic opthalmoscope and performance of CO_2 relaxation[5] system. Characteristics of piezoelectric ceramic transformer[16] for high voltage low current gain requirements and ultrasonic transducers for air borne operations, have also been studied.

3.2 *Ultrasonic Non-Destructive Testing (NDT)*

Magnetic crack detection facility for testing of ferromagnetic materials has been installed in order to make a comparative study of detection capability of the ultrasonic methods with the magnetic methods of crack detection and surface inspection.

In addition, the feasibility of a technique for evaluation of adhesive bond strength has been experimentally established. The transducer response to the loading by the bonded specimen is viewed on the oscilloscope and a shift in the response peak seems to be suggestive of the index of the bond strength[18]

A method of evaluating mechanical quality factor Q_m of piezoelectric discs directly from ultrasonic flow detector, was devised[10].

3.3 *Standardisation and Transducer Characterisation*

The laboratory has developed a method of ultrasonic power measurement based on the study of motional impedance characteristics[13] of transducer. The ultrasonic power is evaluated in terms of voltage, efficiency and real part of impedance. The method is rapid, reproducible and does not need alignments or adjustments. Comparison of the results with the radiation pressure measurements have been satisfactory. A laboratory model of ultrasonic power meter using strain gauge mounted on a diapharagm has also been developed[19].

A method has been set up using a capacitance probe for vibration estimation in pulsed ultrasonic systems. In this preliminary system amplitudes upto $1A^{o}$ could be measured. The method would be useful in characterising transducers in ultrasonic diagnostics.

Work has been done on characterisation of variety of transducers, such as used in ultrasonic nebulisers, ultrasonic theraphy equipments and fish finding equipments by motional impedance measurements and using strain gauge technique.

Resolution measurement[14] in ultrasonic diagnostic apparatus has been studied and a two wire method has been found most suitable.

3.4 *High Power Ultrasonics*

Further studies have been made on the subharmonic vibrations[1] from membranes. It has been shown that the subharmonic emission has a threshold, which varies as a function of membrane tension.[17]

Work is in progress towards the development of the sources and electronic high power modules. A cogged wheel emulsification system has also been designed and is under study.

3.5 *Underwater Acoustics*

A facility for measuring directional response of transducers has been added. Work on evaluation[2] of underwater vibrators has been continued. Parametric generation of low frequency vibrations was studied using a single transducer of high frequency. The need for using higher levels of excitation has been identified.

3.6 *Piezoelectric Ceramic Materials*

Work on the development of lead zirconate titanate based materials is in progress, such as :

(a) NPLZT–5H1 : Material properties have been standardised and pilot produced for consumer acceptability tests.

(b) NPLZT–5H2 : Piezoelectric material with $d_{33} \sim 450$ and k_3^T 3000 has been developed. The standardisation of pilot production is in progress.

(c) Work on optimising the properties of NPLZT–4 series material for high power applications, particularly tanδ is in progress.

(d) An improved method[14] of poling of piezoelectric material has been developed in which the piezoelectric discs are maintained in vibrating condition during poling

(e) Work on flexible piezoelectric material for transducer application based on composite materials has been initiated.Lanthanum doped lead zirconate titanate ceramic powder embedded in epoxy resin has been fabricated[12] and the effect of particle size of the ceramic material on the dielectric and electro-mechanical properties have been studied.

(f) An experimental muffle furnace suitable for loading alumina crucible has been fabricated.

Data on some of the piezoelectric materials developed at NPL are described in Table I.

TABLE 1

Typical Room Temperature Data (Low Signal) of the Piezoelectric Material Developed at NPL

S.No.	Parameter	NPLZT—4 Series				
		NPLZT-5H$_1$	A	B	C	D
1.	Belative Permittivity K_3^T	2500	750	880	1150	1300
2.	Dielectric Loss Factor Tan - δ	0.02	0.004	0.0055	0.007	0.0075
3.	Piezoelectric charge Constant $d_{33} \times 10^{-12}$ C/N	380	170	225	280	310
4.	Piezoelectric Voltage Constant $g_{33} \times 10^{-3}$ V-m/N	17.2	25.6	28.8	27.5	26.9
5.	Planar Coupling Factor k_p	0.52	0.45	0.51	0.52	0.54
6.	Frequency Constant N_{3t}	1900	2050	1900	1900	1900
7.	Mechanical Quality Factor Q_m	70	350	500	500	500
8.	Curie Point ^oC (c)	195	300	310	300	300
9.	Density x 10^3 kg/m^3	7.5	7.5	7.5	7.5	7.5

3.7 Physical Ultrasonics

Fundamental studies in absorption measurements in liquids have been carried out using shock excitation[9*] on various transducers with and without backing. Effect of transducer backing on absorption has been observed in all the cases. The theoretical expression relating deviated in absorption to pulse width, has been experimentally tested[15].

Besides contributing to elucidation of the mechanism of effect of backing on absorption, work has important bearing in transducer characterisation.

Work is going on for establishing the measurement facilities for velocity, attenuation, viscoelastic and high viscosity measurements. Investigations in ultrasonic properties of carbon fibre reinforced plastics have been carried out.

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V.N. Bindal – Project leader.
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LUMINESCENT MATERIALS AND DEVICES

1. SCOPE AND OBJECTIVES

Preparation of II–VI compounds from indigenous raw materials and development of opto-electronic device using these materials.

2. STATUS AS ON 1.4.1981

The development work on Cu-activated TV phosphor as required by BEL was continued. Prototype X-ray image intensifier panels made by group were sent to NTI, Bangalore for tests.

3. PROGRESS IN THE YEAR

The first in a series of large scale trials of Cu-activated monochrome TV phosphor produced in NPL had been conducted at BEL in February 1982, on the basis of a prototype approved earlier by BEL. This test has confirmed the uniformity of material being produced in bulk by the NPL's pilot plant. This has also provided a basis for setting out the specifications of the indigenous phosphor (ref.1) as a first step to transfer of NPL's know-how for TV phosphor.

3.1 X-ray Image Intensifier

A meeting was convened at ICMR Headquarter in November 1981 to evaluate the progress and take measures to expedite the panel testing. It was attended by experts in the field of radiography. The recommendation was that NPL should take up this work as a major thrust area with the collaboration of AIIMS.

3.2 CdS Screen Printed Solar Cells

This activity was continued. The efficiency achieved so far is about 1%. Various parameters such as conductivity, porosity, grain growth etc. are being studied for improvement of the efficiency as much as to make the device cost-effective. This is considered possible inspite of low efficiency, since the fabrication cost is much less and problems of construction of large area cells are simpler than the vacuum evaporated type of CdS-solar cells.

3.3 Basic Research

By means of thermally stimulated luminescence (TL) technique the trapping parameters and order of the kinetics in TL process in the CaS: Ce, Cl luminophor are investigated. In the temperature range 300-450 K, two glow-peaks are observed showing the presence of two group of traps in this luminophor whose trap-depths are 0.66 + 0.16 eV and 1.13 + 0.11 eV respectively as determined by three different methods. The order of the kinetics in TL processes in this luminophor comes out to be first order for the

first group and second-order for the second group of traps.

A technique for thermoluminescence studies was developed in which TL is measured as a function of temperature of excitation. The results show added structure in TL spectrum.

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P.K. Ghosh – Project leader.
H.P. Narang, Virendra Shankar, Harish Chander and G.C. Jain.

RADIO SCIENCE DIVISION

AREA COORDINATOR

Dr. A.P. Mitra

INTRODUCTION

The main areas of activities of the Radio Science Division have for sometime been oriented towards the following major areas :

i) Radio communication through the ionosphere and the troposphere over frequencies from a few kiloherts to many gigahertzs,

ii) Studies of the atmospheric environment from the surface to many thousands of kilometers,

iii) Space research activities.

While major activities were undertaken in all three areas, the most significant new effort was the Division's involvement in the preparation, planning and initiation of the Indian Middle Atmosphere Programme (IMAP). In the IMAP, the NPL plays a dominant role and its activities include use of rockets and balloons for studies of middle atmospheric ionisation and minor constituents (mainly ozone); use of groundbased systems like solar UV-B reception and lidar for minor atmospheric monitoring; and largescale modelling of the middle atmospheric parameters. The total IMAP plan and the NPL's contribution to this are indicated in the following Tables [1,2,3,4].

As a part of the consolidation of the IMAP Programme, models of the electron density profiles for the middle atmosphere for the entire Indian sub-continent were prepared and have now been issued by IMAP as consolidation report. A package of balloon carrying sensors for measurement of positive and negative ions in the stratosphere has been flown on 23rd March, 1982 at 0028 IST from the National Balloon Facility at Hyderabad. The balloon went upto a height of 33 kms and measurements were available for a period of approximately 5½ hours. At the Department of Physics, University College of Wales, London, one of our scientists fabricated, jointly with E.R. Williams, a dual hotwire temperature probe which is expected to be flown in a rocket soon and will measure neutral temperature in the altitude range of 65-100 km, an important new activity in view of the currently existing uncertainties in the mesospheric temperatures.

Rapid strides were made in parameterising the tropospheric and ionospheric media towards design of high reliability communication systems The total capability covers a study of the propagation characteristics of radio waves from a few kilohertzs to many gigahertz and their applications to a wide variety of practical systems. The major thrust this year has been in widening the network of monitoring of TV stations for studying anomalous VHF propagation and for microwave links. Tropospheric scintillations and multipath effects on digital communication received special attention. The microwave radiometer which had in the past provided some very valuable information on the water vapour content have now conclusively shown that the radiometry – deduced water vapour concentration is some 10–20% larger than in-situ measurements - a result that has been interpreted in terms of water clusters.

Other new activities are the development of new techniques to derive C_N^2 parameters from available links, total parameterisation of a large number of HF links proposed by the Indian Navy, and development of short-term solar activity prediction techniques. An experimental earth station in the GHz range was set up to receive C-band signals of the "Apple" satellite and subsequently INSAT–1A transmissions. Much of the atmospheric environment monitoring continued to be based on equipments located on the ground. Amongst these, the micro-

TABLE 1

Specific Details of Balloon Payloads for IMAP

Sl. No.	Experiment	Instrument Weight kg.	Telemetry Weight kg.	Orientation platform wt. kg. accuracy required	Support instrumentation wt., kg.	Pay-load weight, kg.	Altitude required, km.	Time of launch	Float duration	Time of observation	Class of Balloon required
(A)	RADIATION STUDIES										
1.	UV Scattering PRL	5	7	60, AZ ∠1°	154	226	30	night flight	1 hr	morning twilight	100 kg.
2.	Radiation Experiment PRL/NPL	10	7	60, AZ ∠1°	154	231	30	Night flight	2 hrs	morning twilight	100 kg.
3.	O_2 and OH, Poona University	15	7	60, AZ ∠1°	154	236	30	night flight	7-8 hrs	morning twilight	100 kg
4.	Optical Aerosol Scattering, VSSC/ Poona University	20	7	60, AZ∠1°	154	241	25	around sunrise	6-8 hrs	day time	100 kg.
5.	Optical/IR Aerosol Scattering NPL	20	7	60, AZ ∠1°	154	241	25	around sunrise	ascent & descent flight	day time	100 kg.
6.	Upgoing/Down-coming radiation flux (IR/optical), VSSC	20	7	60, AZ ∠1°	154	241	25	around sunrise	ascent & descent flight	day time	100 kg.
(B)	ATMOSPHERIC DYNAMICS										
1.	Puff Release Experiment, PRL	60	..	..	154	214	30	night flight	ascent only	2 hrs	100 kg.
(C)	IONISATION AND ELECTRODYNAMICS										
1.	Ion Density (D.C.probe), NPL	20	7	..	132	159	35	day & night	ascent & descent	3 hrs	30 kg.
2.	Ion Density (Gerdien Condenser), NPL	5	7	..	132	144	35	day & night	ascent & descent	3 hrs	30 kg.
3.	Ion Density (Blunt Probe), PRL	15	7	..	132	154	30-35	day & night	ascent & float	3 hrs	30 kg.
4.	Electric Field (Double Probe) vertical/horizontal, PRL	20	7	..	132	159	30	morning, 0500 hrs	3 hrs	3 hrs	30 kg.

TABLE 2

Details of rocket payload, year-wise distribution of rocket types for WG on Radiation

Rocket Type	No. of Rockets/Payload description				Total No. of rockets
	1982-83	1983-84	1984-85	1985-86	
RH-200	..	..	..	..	..
	(See table on Minor Constitutents-as some measurements are common)				
M-100	lyman α, MUV & 1.27 μ radiation (NPL/PRL) 2	lyman α, MUV & 1.27 μ radiation (NPL/PRL) 1	..	..	3
RH-300	..	lyman α, MUV, 1.27 μ, UV scatter, (NO (NPL/PRL) 2	lyman α, MUV, UV scatter, 1.27 μ, No.(NPL/PRL) 2	..	4
Total	2	3	2	..	7

TABLE 3

Details of rocket payloads, year-wise distribution of rocket types for WG on Atmospheric Dynamics

Rocket Type	No. of Rockets/payload description				Total No. of Rockets
	1982-83	1983-84	1984-85	1985-86	
RH-200	Chaff payload for winds April-December 36	Chaff payload for diurnal variation 20	Temperature payload for stratospheric warming (IITM) 10	..	66
RH-300	Chemical Release Experiment for wind shear, (PRL) 2	..	..	..	2
RH-560S	..	..	..	Chemical Release payload for winds upto thermosphere (~200 km) 2	2
Total	38	20	10	2	70

TABLE 4

Details of rocket payloads, year-wise distribution of rocket types for WG on Minor Constituents & Atmospheric Chemistry

Rocket Type	No. of Rockets/payload description				Total No. of rockets
	1982-83	1983-84	1984-85	1985-86	
RH-200	Optical ozono sonde (NPL) 4	Optical ozono sonde (NPL) 5	Optical ozono-sonde (NPL) 10	Optical ozono-sonde (NPL) 2	21
M-100	Ozonosonde, 1.27nm, UV scatter, NO (PRL) 3	..	OOzonosonde(PRL), 1.27nm, UV scatter, NO (PRL) 4	..	7
RH-300	..	Test flight for NO, O, OH etc. (NPL) 2	Ozone, NO, $O_2(1\Delta_g)$, UV scatter, GC, HNO_3, OH etc. (NPL/PRL) 7	Ozone, NO, UV, GC, HNO_3, OH, $O_2(1\Delta_g)$ etc. PRL/NPL 3	12
Total	7	7	21	5	40

barographs and the dopplometers have led to some interesting observations relating to passage of cyclone centres. These results are preliminary and need to be confirmed, but, if true, are of major significance.

Another major activity was to study the effect of aerosol contamination in the estimate of ozone concentration from groundbased Dobson measurements. Such estimates are necessary since the effects of human influences that one looks for is only around 1 Dobson unit.

In the area of space research, measurements with satellite radio beacon transmissions have continued. For the study of medium scale irregularities, a number of receiving systems were installed in Hyderabad, Bangalore, SHAR and Warangal in collaboration with research institutions and universities. A new study was introduced for evaluating atomic oxygen density profile in the height range of 90-120 kms using groundbased night airglow measurements.

A major effort was devoted to the building of models for the atmospheric environment, both of ionisation and of neutral parameters. For the entire Indian sub-continent Reference Ionospheres have been prepared from 60—1000 kms. Neutral density models have been derived using MSIS inputs. Electron temperature models for different conditions of solar activity have been developed. Models of ion composition are also available.

Much work has been done on the question of human influences on the changing environment. The relative roles played by aerosol sprays nitrogenous fertilizers, supersonic aircrafts,space shuttles and other man-made systems vis-a-vis the natural events like solar proton events and volcanic eruptions have been examined. Attention was concentrated on two primary effects: (a) global climatic changes and (b) UV—B dosage increases.

The sodar system was operated in the forward scatter mode to study windshear in the boundary layer.

GROUND BASED FACILITIES FOR ENVIRONMENT MONITORING

1. SCOPE AND OBJECTIVES

To study the different regions of the upper atmosphere with ground based instruments to monitor the minor constituents in the middle atmosphere with particular reference to IMAP programme; to have a solar flare patrol.

2. STATUS AS ON 1.4.1981

Routine measurements with existing instruments like Ionosonde, Microbarograph, VLF receiver etc., were continued.

3. PROGRESS IN THE YEAR

3.1 Observation of Gravity Waves Generated by Cyclone Centres

Development of cyclone centres in the Bay of Bengal, well before their striking the coast,could be noted in microbarographs deployed at Delhi, Hyderabad and Madras and dopplometer in the Delhi-Calcutta circuit as wave patterns [1].

3.2 Laser Heterodyne System

The design of a laser heterodyne system for measurement of atmospheric minor constituent has been completed and preliminary work on the construction has started. The system will operate in the 10 micron band. This system is being developed as a part of the IMAP programme [2].

3.3 Ozone Variation Trends and Measurement Inaccuracies

A thorough study was made on the effect of aerosol contamination on total ozone variation from ground based Dobson measurements. The error estimates were found to be the same order as the day-to-day changes [3]. Such estimates are necessary since the effects of human influences that one looks for in Dobson measurements is only around 1 Dobson Unit in the last decade.

3.4 Ultraviolet Extinction During Geological Times

Based on 3 separate models of oxygen and ozone building during geological times, possible effects of damaging ultraviolet radiations on the life-patterns during geological times have been discussed in another paper presented at Space Science Symposium.

3.5 Some Additional Activities

VLF receivers and a field strength meter were provided in working condition for the Antarctic expedition.

Three solid state radiometers at 20, 25 and 30 MHz have been procured. Installation work is going on. Portable aerial system for all the 3 units have been designed.

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4. PROJECT TEAM

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STUDY OF ENVIRONMENTAL HAZARDS BY SODAR AND SOLAR UV–B MONITORING AT GROUND

1. SCOPE AND OBJECTIVES

To study the wind shear and refractive index structure parameter by monostatic sodar and develop a Doppler Sodar facility.

To monitor solar UV–B radiation at ground on long term basis and to study ozone depletion in the atmosphere and variation of erythemal dose over Indian Subcontinent.

2. STATUS AS ON 1.4.1981

The observation on solar eclipse of February 16, 1980 were processed. Stratified/elevated layers observed on the sodar echograms within the atmospheric boundary layers were analysed. Forward scattering Sodar system was operated during the month of December, 1980 and January, 1981.

A solar UV–B photometer is in operation since 1979 at NPL. The UV radiations were recorded at three wavelengths 280 ± 1 nm, 290 ± 1 nm and 310 ± 1 nm. The seasonal variation of UV radiation has been studied.

3. PROGRESS IN THE YEAR

3.1 Atmospheric Studies using Sodar

In addition to the monostatic mode in operation till now, sodar system was introduced in December, 1980. It has been demonstrated [1] that in this mode, the component due to wind shear in the elevated layer can be clearly defined, offering a potential study of the wind shear in the atmosphere boundary layer by sodar.

The refractive index structure parameter values have also been computed both for optical and radio waves at a height of 200 m using the sodar data [2]. It has been seen that during the monsoon, the value of the parameter under stable condition are substantially different.

3.2 Study of UV–B Radiation

Observations on UV–B radiation taken during the period were analysed for diurnal, monthly and seasonal variations of solar UV–B reaching at ground.

The correlation between diffuse component of UV radiation recorded at 50° zenith angle is being related to the actual ozone measurement of IMD by Dobson Spectrometer at Delhi. It has been found that 20% ozone variation gives approximately 45% changes in UV radiation. However, at higher value of ozone, above 280 DU the changes in UV radiation is comparatively low. It has also been observed that the variation of UV with ozone shows different trend in different season. This is due to the fact that the atmospheric condition and aerosols contents are different in different seasons.

3.3 Estimation of Erythemal Doses over the Indian Sub-continent

Solar UV–B radiation intensity reaching ground level in the erythemally hazardous wavelength range of 290 to 325 nm has been estimated at different locations in India based on total ozone measurement data available for about two decades. Daily erythemal dose has been computed for Delhi, Kodaikanal and Srinagar. Contour plots of seasonal dose variation have also been made for these stations based on averaged measured ozone values [3].

The solar UV–B measurement has been correlated with ozone measurement over Delhi and a computer program has been developed to calculate the erythemal dose over various Indian Stations based on actual ozone measurement.

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4. PROJECT TEAM

A. S.P. Singal – Project leader.
B.S. Gera, Ram Dass.

B. B.N. Srivastava – Project leader.
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ROCKET, SATELLITE AND BALLOON EXPERIMENTS

1. SCOPE AND OBJECTIVES

The main objective of this project is to study the lower and topside ionosphere using rockets, balloons and satellite radio beacon experiments (with special reference to electron, ion and neutral number density; scintillations; large and medium scale irregularities etc.) and to use the ionospheric study for various space applications such as refraction errors, in satellite ranging and position fixing, effects of irregularities in communications etc.

2. STATUS AS ON 1.4.1981

Monitoring of ETS–II signals have been conti-

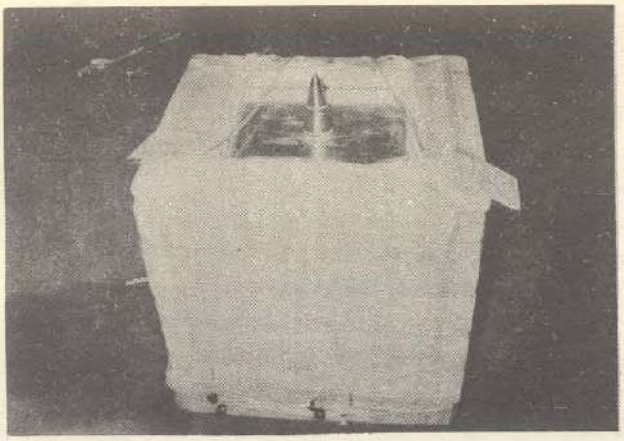

Fig.13: Balloon 1

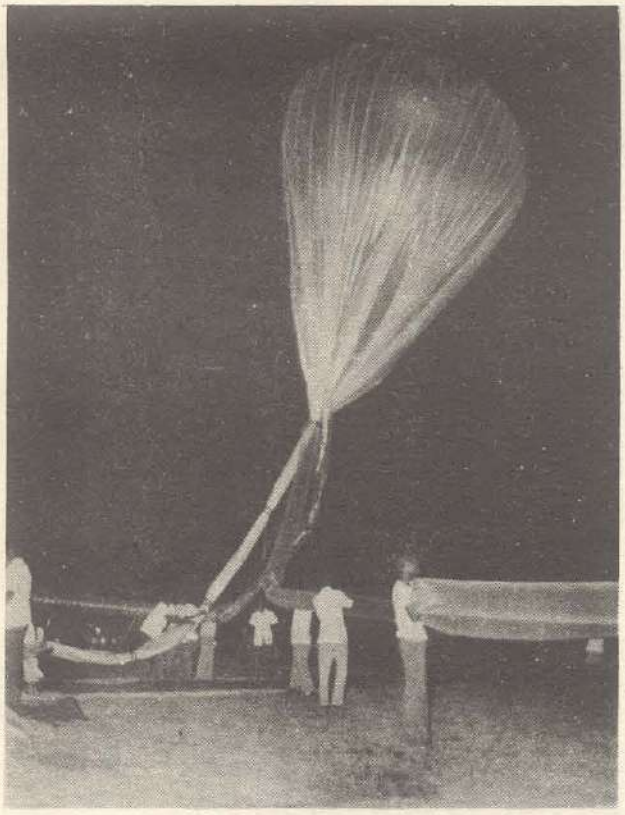

Fig.14: Balloon 2

nued at Delhi and Hyderabad. Regular rocket experiments were planned.

3. PROGRESS IN THE YEAR

3.1 Satellite Beacon Experiments

A detailed study of the night-time scintillations for the period January-February 1980 at a number of stations viz. Delhi, Hyderabad, Bangalore and Nagpur reveals that the scintillation producing night-time F-region irregularities appear first over the magnetic equator and then spread out to low latitudes [1].

A study of the Fresnel-type fading patterns on amplitude records has been undertaken. Results show that these patterns were most frequently observed in the time interval between local sunset and mid-night hours mainly in summer months [2].

Ionospheric Electron Content (IEC) has been studied over the period starting from low solar activity to high solar activity for the stations Gauhati and Delhi [3].

For a detailed and comprehensive study of medium scale irregularities, a number of receiving systems have been installed at Hyderabad, Bangalore, SHAR and Warangal in a collaborative programme with other research institutions and universities.

3.2 Rocket and Balloon Experiments

The space group of Radio Science Division has taken up a comprehensive programme of balloon and rocket experiments to study the stratosphere and lower mesosphere in connection with the Indian Middle Atmosphere Programme (IMAP). This is in addition to the regular rocket experiments.

A scientific proposal for the measurement of ion composition in the stratosphere by Quadrupole Mass spectrometer has been submitted to National Balloon Board for the allocation of balloons. This experiment is tentatively scheduled around the end of 1982. This proposal has also been presented in a seminar-cum-workshop on 'Opportunities for high altitude balloon experiments in India' held at Hyderabad in January, 1981.

A balloon-borne payload for the measurement of stratospheric positive and negative ion densities was developed and was successfully launched on March 23, 1982 at 0028 hours IST from the National Balloon Facility at Hyderabad Fig.13,14. This experiment, which incidentally is the first balloon experiment under IMAP, had a MOSFET input electrometer amplifier with logarithmic characteristics between 5×10^{-11} and 5×10^{-7}A for positive ions and 5×10^{-11} and 5×10^{-8}A for negative ions. The balloon ascended at the rate of 200m/min and reached an altitude of 33 km.

A NPL–Bulgarian collaborative rocket

programme for the post-sunset measurements of E & F regions of the ionosphere is being worked out. A scientific proposal for the above will be sent to ISRO soon for the allocation of rockets. This programme is scheduled in the early 1983.

A NPL—Japan collaborative rocket experiment for the study of D-region of the ionosphere in detail is in the final phase of planning. The scientific proposal has already been submitted to ISRO.

Further the space group is going to participate in two separate inter-comparison rocket compaigns — one for electron density and another for ozone measurements.

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4. PROJECT TEAM

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STUDY OF STRATOSPHERIC IONIZATION

1. SCOPE AND OBJECTIVES

To investigage the ionization, temperature, composition, energetic particles and aerosols in the ionosphere using rockets, balloons satellites and ground based techniques.

2. STATUS AS ON 1.4.1981

During the solar eclipse of 16 February, 1980 five Gerdien condenser rocket payloads have been flown; three in Centaur rockets from Thumba and two RH-200 rockets from Balasore.

Surface barrier silicon detectors were flown on RH-560 rocket on 1.10.1980 from Sri harikota to measure the energy spectra of protons and electrons in the range of 15-250 Kev.

Electron temperature probe was flown on the same RH-560 rocket to measure the temperature profile below 350 km.

Ground based night airglow photometer, measuring the airglow intensities of 5577A, 6300A and OH(8,3) band, is being operated at Visakhapatnam from January, 1980 and data is being analysed.

A new method of deducing the atomic oxygen density profile in the height range of 90-120 km using these ground-based night airglow measurements is successfully developed and it is published as RSD Scientific Report No.110 in February 1981.

3. PROGRESS IN THE YEAR

3.1 Rocket Studies on Neutral Temperature

In collaboration with the Department of Physics, University College of Wales, Aberystwyth, England, a dual-hot-wire temperature rocket probe was developed which can measure neutral temperature in the altitude range of 65-100 km. Incidentally this is the region where conventional thermistor bead or resistance thermometers fail to give reliable temperature data due to unavoidable large time lags. Several of our dual hot wire temperature probes are expected to be flown during the IMAP programme.

3.2 Study of Lunar Tidal Component of (OI) 5577A

Lunar tidal component of 5577A line intensity has been investigated [1]. A technique of deriving the eddy diffusion coefficient in the lower thermosphere from the night airglow measurements has been developed.

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4. PROJECT TEAM

M.N.M. Rao — Project leader.
Ravi Mohan Khanna, C.B. Tandel,K.L.Gulati.

IONOSPHERIC STUDIES USING INCOHERENT SCATTER RADAR

1. SCOPE AND OBJECTIVES

To design and develop a National Incoherent Scatter Radar Facility in India.

Incoherent Scatter Radar studies of the upper atmosphere and ionosphere with data obtained from various observatories.

2. STATUS AS ON 1.4.1981

A programme was initiated to study the electron cooling rates and solar EUV fluxes during sunspot cycles 20 and 21 by using the incoherent scatter measurements from Arecibo.

3. PROGRESS IN THE YEAR

A detailed study of electron and ion temperature and electron concentration obtained from the incoherent scatter measurements at Arecibo for the period August, 1966 to May, 1977; have shown a remarkable difference in the behaviour of electron cooling rates in the two sunspot cycles 20 and 21 [1]. This behaviour, however, is consistent with the EUV measurements during the two sunspot cycles. Coefficients linking the dependence of electron temperature on electron concentration and solar activity were also obtained by using Arecibo incoherent scatter radar measurements thereby improving the current empirical model of electron temperature [2].

The new coefficients obtained for the electron temperature dependence on electron concentration and solar activity will be our major input on the improvement of the International Reference Ionosphere. With these coefficients, it would be possible to obtain electron temperature in the ionospheric F-region for any level of solar activity.

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4. PROJECT TEAM

K.K. Mahajan – Project leader.
A.R.Jain, V.K. Pandey, Ramesh Kohli, B.C.N. Rao, Risal Singh, M.K. Goel.

TROPOSPHERIC AND IONOSPHERIC COMMUNICATIONS

1. SCOPE AND OBJECTIVES

The major responsibility of the project is to conduct research on our radio environment and use the properties of the environment, the troposphere and the ionosphere in particular, for optimising design of radio links in the entire radio spectrum currently used for communication purposes.

i) It is aimed to explore the terrestrial atmosphere with special emphasis on troposphere and ionosphere with a view to obtain information on characteristics affecting radio waves;
ii) study of the physics of the troposphere and ionosphere with special emphasis on radio communications,
iii) characterise the earth's radio environment for use in a wide spectrum of frequency bands;
iv) advise Indian Civil and Military communication organisation on optimum operational Parameteres for their radio links;
v) advise defence organizations on anamolous radar and microwave propagation;
vi) predict solar and geomagnetic activities with several appropriate time intervals in advance; and
vii) data collection and interpretation of radio refractivity morphology in the boundary layer at various representative regions in India.

2. STATUS AS ON 1.4.1981

The short and long term predictions on ionospheric parameters, and solar and magnetic activity conditions have continued.

3. PROGRESS IN THE YEAR

3.1 Long-term Solar Activity and Ionospheric Predictions

This group continued to provide long-term pre-

dictions on solar activity and ionospheric parameters to various Civil and Defence organizations during this period.

The decaying part of the present solar activity cycle number 21 has been predicted by choosing appropriate cycles of the past and the predicted sun spot values are shown in Fig.15 along with error bars.

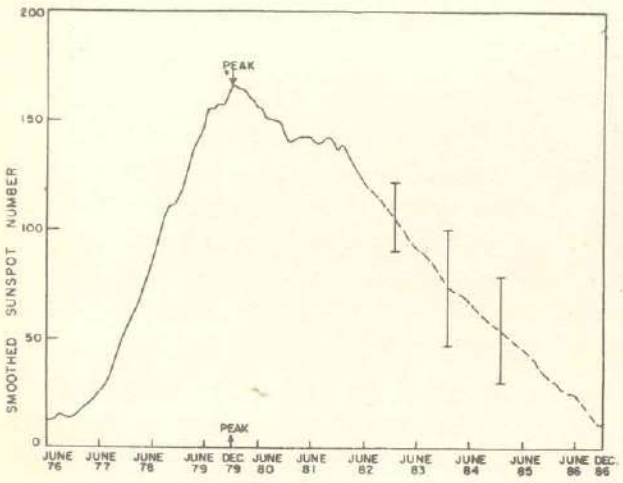

Fig.15: Predicted Solar Cycle 21 along with the error bars. The zurich observed values are also indicated.

(Error bars for 90% probability)
- Zurich observed
— Predicted cycle

The prediction accuracy of ionospheric parameters for HF communications has been improved by taking into care the 2nd degree variations of these parameters with smoothed sunspot-number.

During 1981, a complete guide was prepared to aid HF communicators in planning high reliability point-to-point links [1]. Magnetic storm modelling to aid prediction of short-term variations in HF communication parameters has also been completed for Indian zone [2].

3.2 *Short-Term Solar and Magnetic Activity Forecasts*

Predictions on 10.7 cm flux on twice-a-week basis to ISRO were provided in response to their request during June-July 1981 when Rohini satellite was launched by SLV-3 from Sriharikota. This was in addition to their once a week predictions on 10.7 cm flux. Special forecasts on magnetic conditions were provided to research institutions to aid in rocket compaigns for the study of spread F, electrojet phenomena and also served Middle Atmospheric Programmes.

3.3 *Prediction of F_2 – Region Variability*

Studies conducted on day-to-day variability in F–region parameters have shown that the general extent of variability over their monthly median values is largest during low solar activity periods. These results on distribution of daily parameters are being used while predicting the higher and lower order supports of HF communications for different user requirements.

3.4 *An Evaluation of Indian HF Link Performance*

One of the major jobs undertaken during this year was to conduct a survey of various HF links that are being operated in the country by both Defence and Civilian Organizations, to evaluate the performance of the links and also to identify the specific problems relevant to HF communications at low latitude. This is the first such survey ever conducted in the country and was coordinated through JCEC. Information pertaining to more than 200 HF links was obtained.

3.5 *VHF Propagation Characteristics*

At the request of AIR a study was undertaken at various parts of the country to define the morphology of anomalous TV propagation [3]. An example of the stations studied at Patiala is given.

3.6 *Marine Microwave Communications*

A study has been undertaken to determine the thickness of the evaporation duct over sea, using climatological summaries which included data on surface temperature, and pressure, deck-level temperature and dew point and wind velocity at several locations in Indian Ocean [4]. This study is important in characterising the propagation conditions upto wave lengths of a few tens of a centimeter.

3.7 *Experimental Studies to Aid Tropo-Communication*

Using Delhi-Sonepath LOS link data at 7.6 GHz, it has been found that scintillation index is higher during post sunrise and post sunset periods because of building up of refractivity perturbations due to layered structures in the atmosphere [5].

Transmitting Station	Distance from Patiala (km)	Transmitted Power (KW)	Frequency MHz	Antenna Height (Meters)	Path Loss Max/Min db
		Recording Station : Patiala			
Karachi	1075	50	62.25	100	200/135
Lahore	240	50	175.25		175/130
Amritsar	204	10	189.25	100	170/125
Jullunder	132	10	201.25	200	165/123
Mussorie	196	10	208.25	91	172/128

A study has been undertaken to improve the performance of P&T microwave link between Madras and Tirupati. The study showed that the design of the link did not take into consideration several factors including first Fresnel zone clearance for at least 99% reliability and it was suggested that Receiver/transmitter antenna height at Tirutanni should be increased for achieving better reliability.

3.8 Experimental Studies to Air Satellite-to-Ground Communications

The advent of Satellite Communication Systems (in GHz band) as the prime mode of communication has hign lighted the need to account for scintillations in predicting system performance, particularly in the case of high speed digital communications. The purpose of the experimental earth station at NPL is to collect data on GHz scintillations and in future to correlate the characteristics of scintillation with the bit error rate in digital communication.

3.9 Solid State Digital Microwave Refractometer.

Fabrication of an airborne solid state digital microwave refractometer has been undertaken during this year. The refractometer provides information on real time vertical refractive conditions affecting microwave systems performance.

3.10 Rain and Water Vapour Attenuation

Microwave attenuation due to rain and water vapour has been studied by using a multi-frequency radiometer as well as from LOS data. The mixing ratio profiles were calculated by using the radiometric studies and compared with the experimental data obtained from radiosondes.

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4. PROJECT TEAM AS ON 1.4.1982

Dr. B.M. Reddy – Project leader.

S.B.S.S. Sarma, G.S. Uppal, Santosh Aggarwal (Mrs.), D.R.Lakshmi (Mrs.), P.K. Banerjee, H.N. Datta, A.B. Ghosh, P.L. Malhotra, P.K.Pasricha, S.K. Sarkar, Raj Singh Dabas, M.V.S.N.Prasad, M.K. Raina, Mohendra Mohan, Shashi Kala Suresh Shastri (Mrs.), M.K. Dua, K.G.M.Pillai, Shiv Kumari Kalra (Mrs.)

IONOSPHERIC AND 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. STATUS AS ON 1.4.1981

Some empirical and theoretical models of electron density, electron temperature and ion composition were developed earlier which are being continuously updated using the latest available information. Recently, a method was developed to calculate the percentage occurrence of Sporadic-E above any specified frequency. Scientillation model has been prepared for Indian zone.

4. PROGRESS IN THE YEAR

The neutral atmospheric models based on MSIS model, are prepared for different solar activities and times of the day [1]. (example illustrated in Fig.1).

From an analysis of foF2 and (M3000)F_2 parameters over 3 solar cycles it is shown that a second degree curve of the type $a + bR + cR^2$ (R = Sunspot number) represents the solar activity variation.

From a study of the magnetic storm time data of the above parameters in the Indian Ozone, model storm time variations are given for equatorial, low and midlatitudes [2].

International Reference Ionosphere models have been generated for a few Indian Stations.

Empirical relations of the electron temperature (Te) versus electron density (Ne) is given which includes the effect of solar activity.

The empirical relation observed between T_e vs N_e is calculated from theoretical models.

The day to day variability and storm time variations are generated from theoretical models.

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4. PROJECT TEAM

B.C.N. Rao – Project leader.
Y.V. Ramanamurty, M.K. Goel, N.K. Sethi, Abdul Hamid, A.K. Saha, Y.V. Somayajulu, B.M. Reddy, K.K. Mahajan, M.N.M. Rao, A.R. Jain, T.R. Tyagi, R.C. Saksena, S. Aggarwal (Mrs.), D.R. Lakshmi (Mrs.), A.B. Ghosh, Lakha Singh, P.K. Pasricha, R. Venkatachari, K.S. Zalpuri, V.C.Jain, V.K. Pandey.

HIGH PRESSURE TECHNOLOGY

PILOT AND DEMONSTRATION PLANT IN HYDROSTATIC EXTRUSION & MATERIAL SYNTHESIS

1. SCOPE AND OBJECTIVES

1) To establish (a) 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 in the following ferrous and non-ferrous metals and alloys: ETP copper, silver bearing copper, admiralty brass, aluminium brass, 90/10 copper-nickel, phosphor bronze, stainless steel 302,304, 316, duralumin, titanium, zirconium, tantalum, covar (b) laboratory facilities in cold forging of steel.

2) To determine the process parameters for the extrusion of composite materials such as copper-clad aluminium,copper clad steel,copper-nickel clad titanium etc.

3) To batch-produce extruded products and cold forged components for trial runs by the industry.

4) To establish laboratory facilities in the synthesis of superhard materials and to develop the process technology for the synthesis of superhard materials.

5) To promote the development of production equipment in metalforming and material synthesis.

2. STATUS AS ON 1.4.1981

The erection and commissioning of 500-ton vertical hydraulic press was completed. In the absence of a proper induction furnace with a conveyor system, some trial runs were carried out, at the time of commissioning, using a muffle type resistance furnace, on the hot extrusion of Cu-Ni billets. About 10 billets were extruded. The extrusion was found to be satisfactory.

Preliminary trials on the shear spinning of tube hollows in inconel, incoloy and different grades of stainless steel tubings were carried out to establish the capability of shear spinning process to produce high dimensional tolerance wall thickness tubing.

A large number of samples of tubes,shapes and profiles including spline shafts, finned solids and finned tubing both in ferrous and non-ferrous materials had been extruded.

Some of these shapes were exhibited and extrusion demonstrations made at the International Symposium in Modern Metalforming Techniques held at the NPL from March 23 to March 28, 1981.

Work on the development of w-BN and c-BN sintered compacts to be used as tool tips was initiated in the synthesis of superhard materials programme of the project.

3. PROGRESS IN THE YEAR

Design of tooling consisting of dies, mandrels, bolster, back-up ring, die holders and ejectors for the hot extrusion of ferrous and non-ferrous metals and alloys in 75 and 100 mm diameter containers was taken up and completed. These components have since been fabricated in the pilot plant workshop and are awaiting heat treatment and final grainding. Talks were initiated with Guest Keen & Williams for a collaborative project for the development of cold/warm forging technique for the manufacture of 4 components required by Scooters India Ltd., Lucknow.

New roles with different angles and land were designed and fabricated for shear spinning. Samples of Ti, inconel, incoloy and stainless steel tubes were shear spun to establish various experimental parameters. Simultaneously the design of a modified version of shear spinner has been completed.

Samples sent by ISRO for cold extrusion were extruded. Since the pressure available in 85 mm chamber is not adequate for the extrusion of materials at the desired extrusion ratio a

programme was initiated to change 85 to 55 mm tooling.

In the material synthesis programme,work on the compaction of c-BN to make tool tips is being done. The initial results have been encouraging.

4. PROJECT TEAM

B.K. Agarwala – Project leader.

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UTILIZATION OF SOLAR ENERGY

THERMAL CONVERSION

1. SCOPE AND OBJECTIVES

i) Development of solar collectors and solar thermal devices

ii) To evolve national test procedure for testing flat plate collectors and setting test facilities.

The aim of the project is to generate the necessary know-how and promote utilization of solar energy.

2. STATUS AS ON 1.4.1981

Solar Energy Group in NPL has been working on the problem of utilization of solar-energy by thermal conversion since 1975 and has acquired sufficient capabilities in development and fabrication of solar collectors and solar thermal devices. Flat plate collectors with different absorber materials such as Aluminium,MS,G.I. and Copper with different designs like bonduct aluminium, sheet-Tube configuration etc. with thermal efficiencies ranging from 30%-55% were developed. One of the first major utilization of solar energy was the installation of space heating system at BHEL, Haridwar under technical guidance and supervision of NPL. An arry of $105m^2$ flat plat collector was used to heat water from 50^oF ambient temperature to 130^oF. The hot water was stored underground and circulated through fan coil radiators to provide space heating. The other installation was swimming pool heating system at Hotel Mauraya.

Facilities for fabrication of concentrating collectors were created. $2m^2$ parabolic concentrating system with focal axis at the centre of gravity of the system with aperture 57 cm and geometrical concentration ratio 22 capable of providing steam at 150^oC was developed. Based on the experience gained large size concentrating collector system with an aperture of 75 cm and geometrical concentration ratio : 20 was fabricated and installed to assess the feasibility of process heat. The results obtained are quire encouraging.

A simulated 1 tonn capacity solar refrigeration unit using water amonia vapour absorption cycle was designed and fabricated. The coled produced using this chiller can be used to provide space cooling and cold storage.

A solar House demonstrating the solar space heating and water heating was designed and constructed. In this system the solar heat that is collected using $12m^2$ solar air collectors is used for active space heating in an area of 50' x 15' during winter. With passive heating design features it is possible to obtain passive heating in the range of $20\text{-}22^oC$ when the ambient temperature is around $8\text{-}10^oC$ whereas with active heating the temperature is in the range of $30\text{-}35^oC$. An array of 32 m^2 solar flat plate collectors installed on the slanting roof provides hot water and also pre-heated water to aqua amonia vapour absorption chiller.

Solar drier capable of drying 100 kg of grains per day was designed and fabricated. This drier has been used for drying potato-chips, vegetables, fruits etc. Since this is an indirect solar drier the colour and quality of the dried product is retained to a great extent.

A noval spiral expander 1.4 kW capacity with low rpm (1500) suitable for direct coupling to the water pump has been designed and fabricated.

A solar still of 12m in length and 1.5m width capable of delivering 50 litres of distilled water per day has been installed and is in operation.

Keeping in view the importance of selective coatings for better efficiency, development work undertaken on black chrome and black nickel has yielded valuable results. Work is in progress to optimize the various parameters affecting the selectivity.

3. PROGRESS IN THE YEAR

The progress made during the year is indicated below :

3.1 Development of Flat Plate Collectors

The various parameters on which thermal performance and efficiency depend were investigated to optimise the efficiency, keeping in view the cost, ruggedness, ease of fabrication, life etc. A large number of collectors were fabricated and tested. The technology of flat plate collectors Al-Cu, Cu-Cu etc. has been well established.

The completion report on "Flat plate collectors suitable for delivering water at 60°C" a project financed by DST has been submitted to DST.

3.2 Development of test facilities for solar collectors

Under a project funded by DST test procedures, have been evolved for testing flat plate solar collectors and test rigs comparable to international standards have been set up. Being a National Test Facility Centre, flat plate collectors manufactured by various parties within the country have been tested for thermal performance,test fees realised and test reports issued.

To obtain absolute value of the collector efficiency factor, indoor test facility similar to German Group has been created to measure the heat loss co-efficient.

Beckman UV, VIS, NIR and IR Spectrophotometers have been acquired for evaluating physical parameters such as absorptance and emittance of absorber materials and transmittance of glazing materials. Also a calorimetric method has been set up to measure the total hemispherical emittance of the absorber coating.

3.3 Development of Selective Coatings

The Group is actively engaged in the development of various types of selective coatings suitable for solar absorber panels. Black chrome and Structured Nickel selective coatings have been developed. The effect of various process parameters on the optical properties like absorptance, emittance has been studied. The black chrome coating can be deposited on copper, aluminium and mild steel substrates. The solar absorptance of the coating is about 0.95-0.97 while thermal emittance is in the range of 0.27 to 0.40. The coating is stable under thermal cycling upto 250°C and is very adherent, acid resistant and long lasting. The absorptance and emittance values for structured Nickel coating on aluminium can be varied from 0.85-93 and 0.12-0.50 depending on actual requirement.

Electroles's black Nickel Selective Coating has been developed. This coating has solar absorptance 0.90-0.93 and thermal emittance in the range 0.10-0.40. The coating is stable upto 250oC and can be easily applied.

The black chrome and electroless black nickel selective coatings have been found to be ideal for flat plate and low concentration collector system.

3.4 Development of $25m^2$ Cylindrical Parabolic Concentration Collector System

$25m^2$ cylindrical parabolic concentrating collector system having 4 module structures with an aperture area of $6.3m^2$ each, total span 175m, and geometrical concentration ratio : 46 has been designed to provide working temperatures upto 200°C for catering process heat requirement. All the components of the systems, the parabolic glass moulded reflectors, fibre glass back up structure, selectively coated copper tube absoorbers, (3.5 cm dia), self tracking electronic unit have been fabricated. Work is in progress to fabricate the remaining parts.

3.5 To promote Solar Energy utilization solar thermal devices developed at NPL were exhibited in various exhibitions at Gurgaon, India International Trade Fair and at Amethi and Jais (Rai Bareilly) under DST pavilion. The pavilion got the first and the Second prizes, at Amethi and Jais respectively.

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STUDIES ON DEVELOPMENT OF POLYCRYSTALLINE SILICON FOR PHOTOVOLTAIC SOLAR ENERGY CONVERSION

1. SCOPE AND OBJECTIVES

The objectives were :

To prepare polycrystalline silicon suitable for fabrication of solar cells starting from ferrosilicon/metallurgical grade silicon and to make research/development efforts to reduce the cost of materials;

To prepare polycrystalline silicon ingots with columnar grains to be used for the fabrication of silicon solar cells for terrestrial applications;

To develop cheap methods of fabrication of silicon solar cells on the substrates.

2. STATUS AS ON 1.4.1981

The process for the generation of trichlorosilane has been optimised to produce trichlorosilane of solar grade purity. Using the float zone method, polycrystalline silicon rods upto 25mm diameter with columnar grains have been produced. Methods to cast silicon ingots inside graphite crucibles had been tried [10]. P—N junction solar cells were fabricated on wafers prepared from the above ingots by using simultaneous diffusion techniques [2]. A cheap method for putting on an auto reflection coating by a unique photoelectrochemical method was in vogue [7]. The contacts used on the silicon solar cells were Ti-Ag and Ti-Pd-Ag.

The NPL process has demonstrated that it is possible to prepare silicon solar cells with an average AM1 efficiency of 7-8%, using NPL polycrystalline silicon with columnar grains [2].

Various fundamental studies[1,5,8,11-16] were carried out to study the effect of resistivity and grain size of the wafer on the efficiency [4]. Other studies included the effect of annealing on resistivity and photoconductivity [3], effect of diffusion temperature [9], study of metal silicon interface after metallisation of the silicon solar cells.

3. PROGRESS IN THE YEAR

3.1 Production of Silicon

During the year a total of 197 Kgs of trichlorosilane has been prepared and 7.3 Kgs silicon has been obtained from it by the thermal decomposition. These have been used for various experiments. A joint programme to scale up the production of trichlorosilane of solar grade purity was pursued in collaboration with the DCM Chemicals, Delhi. A plant has been set up at the DCM Chemical Works. 80 Kgs of Trichlorosilane has been supplied by DCM and 3 Kgs of silicon has been thermally decomposed from this trichlorosilane and evaluated for the production of solar cells.

3.2 Growth of Polycrystalline Silicon Ingots

A number of silicon ingots with columnar grains of few mm grain size have been cast inside graphite crucibles of 45mm dia. The ingots obtained from these have been upto 38mm dia.Fig.16 illustrates typical ingot and Fig.17 shows the grain structure of substrate and solar cell made from it. 18mm dia polycrystalline silicon ingots were also prepared by using a Float Zone apparatus. The silicon rods obtained were used for the fabrication of solar cells and various fundamental studies.

3.3 Fabrication of Solar Cells

About 2000 solar cells of 16mm dia have been fabricated using simultaneous diffusion technique and Ti-Ag contacts. These cells have been assembled into panels. Various grades of silver cements prepared at the laboratory were tried for screen printing contacts onto the solar cells. Although, at present these types of contacts show high contact resistance, they show a promise for a cheaper technology.

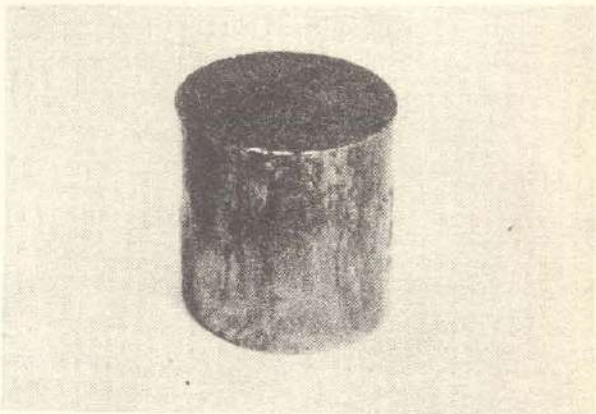

Fig.16: Polycrystalline Silicon Ingot grown by Directional Solidification of Silicon in Graphite Crucible, (38mm dia).

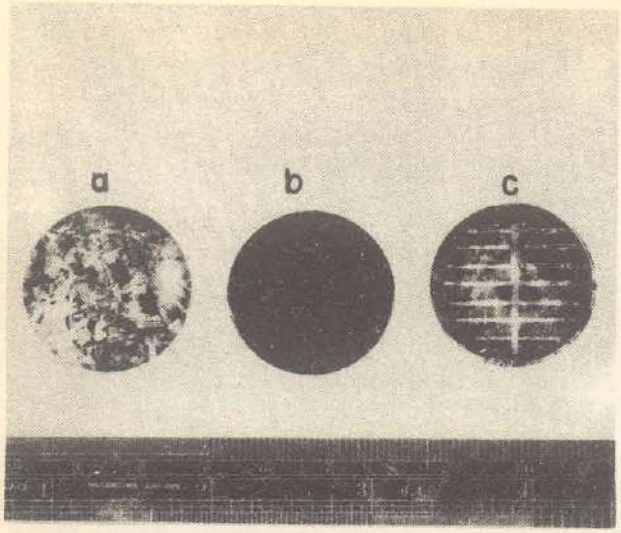

Fig.17: *(a) Etched Poly-Si Wafer*
(b) Diffused and AR-coated Poly-Si Wafer
(c) Finished Poly-Si Solar Cell

More fundamental investigations to understand the effect of process parameters on the solar cell properties were carried out during the year. Some of these are :

1. Effect of grain size on diffusion length and spectral response of solar cells.
2. Effect of temperature on diffusion length and spectral response and diode parameters of polycrystalline silicon solar cells.
3. Optimisation of junction depth of spectral response of polycrystalline silicon solar cells.
4. Effect of high level conditions on open circuit voltage of silicon solar cells.
5. Use of tin oxide as an AR coating on solar cells.
6. Grain boundaries segregation of impurities in NPL polysilicon using AES and SIMS.
7. Dependence of short circuit current and minority carrier diffusion length of polysilicon solar cells.

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5. PROJECT TEAM

Dr. G.C. Jain – Project Coordinator
Dr. B.K. Das – Project leader.

P.K.Gupta, P.V.N. Ramanathan, V.D.P.Sastri, Y.R. Anantha Prasad, Shiv Nath Singh, S.C. Kant Misra, Santosh Kumari, N.P. Singh, Mohan Lal, Bal Ram Awasthy, Balbir Singh, N.S.Bhangari, S.B. Manmohanan, N.K. Arora, Ram Kishore, B.C. Chakravarty, H.P. Gupta, Prem Prakash, Ravi Kumar, T. Podikunju and Manjit Singh Pawar.

DEVELOPMENT OF THIN FILM CdS SOLAR CELLS

1. SCOPE AND OBJECTIVES

To carry out basic and applied research leading to the development of low cost thin film CdS Solar cells.

2. STATUS AS ON 1.4.1981

Technology of fabrication of front wall type thin film CdS:Cu_2S solar cells have been developed. These cells formed over ordinary window glass substrates in which component semiconducting layers in polycrystalline form are built up using vacuum deposition and chemical processes are totally encapsulated to withstand vagaricity of the terrestrial conditions. To evaluate the reproductibility of the technology and the controls over to process variables, a laboratory level batch production facility has been established. More than one thousand cells have been fabricated on this facility. The conversion efficiency of these solar cells ranged between 5-6%. A unique feature of these cells is that they have shown remarkably stability over a period of more than four years. Several solar cells modules have also been fabricated and their utilization in energising several electrical devices such as a communication receiver set etc. have been demonstrated. This achievement has been possible through several planned basic investigations on photo-electronic properties of pure and Al-doped CdS, oxygen chemisorption effects, structural optical and electrical investigations on Cu_2S films, growth kinetics of Cu_2S layers and effect of process variables of the chemiplating process, compositional depth profiles of the cells as obtained by ESCA and AES investigation etc. These have not only enriched basic understanding of the field but in turn also provided valuable feed back to the technology development and eventually in finding the solution to a number of problems. Besides these, during the project a number of innovative techniques and jigs have also been developed which have been key performance of our technology development. For example, a high rate CdS evaporator, controlled deposition of hetro-junction, an integrated fine metallic grid contacting and encapsulating process and press for the same etc.

3. PROGRESS IN THE YEAR

During the course of further investigation in the project four new short-term activity were planned. These are aimed at i) to inhibit growth of Cu_2S along the CdS grain boundaries without disturbing the other advantageous features of the chemiplating process; ii) to study the composition of the CdS cells across its depth by using ESCA and AES particularly to find the rationale behind the air-heating process and also effect of Cd, Cu and S migration and oxide formation; iii) to develop inexpensive electroplating of CdS layers for solar cell applications and; iv) to study of growth kinetics of Cu_2S layers in CdS solar cells; and v) to find another suitable p-type material for use in conjunction with CdS with the aim of improving efficiency and ease in fabrication.

The progress in each of these activity is discussed separately.

3.1 A Novel Field Assisted Chemiplating Process for Fabricating Improved CdS; Cu_2S Solar Cells by Inhibiting Vertical Junctions

A novel field assisted chemiplating process (FAC) for barrier formation which is capable of modifying the structure of the junction interface have been developed. By exerting controls over the diffusion of the ionic species taking in the reaction, a predominently rapid volume diffusion reaction is altered to a parabolic surface diffusion one and thus narrow pointed p-type Cu_xS growth intrusions across the cell, along the CdS grain boundaries have been prevented. Since for several reasons the intrusions are potential shorting paths cause increase in shunt conductance lower fill factor and reduce open circuit voltage, their inhibition has resulted in cells of improved performance and life expectancy. Over a small area 1 cm^2, the conversion efficiency of about 7.5-8% have been achieved. A detailed study of various field strength and plating variables over the photovoltaic performance of cells have been undertaken which convincingly demonstrate the efficacy of the new process. As inferred from the XPS and AES investigations on these cells, a kinetics model of growth of Cu_xS layers has also been developed. Presently, work is in progress: (i) to further understand the physical processes in

the cells fabricated with this novel technique from basic point of view and (ii) to extend the technique to larger area cells currently being produced in the laboratory (Ref.1).

3.2 *Electron Spectroscopic Studies on CdS Solar Cells*

Surface composition and depth profile studies of chemiplated thin film CdS solar cells have been carried out using X-ray photo-electron spectroscopy (XPS) and Auger Electron Spectroscopy (AES) techniques. These have indicated that the junction is fairly diffused in 'as-prepared' cells and the air heat-treatment of all at 210°C relatively sharpens the junction by inducing relative migration of unreacted Cu^+ ions towards the Cu_xS and Cd ions out of the Cu_xS layer. This appears to be rationale behind the improvements in the cell performance. Using Cu(2p 3/2)/S(2p) ratio, as well as Cu (LVV)/(LMM) Auger intensity ratio, it is inferred that nominal valency of Copper in the layers above the junction is in Cu^+ and it essentially in the Cu_2S form. Cu signals originating in the deeper layers have been shown to be from grain boundary region, XPS and AES studies also show that in these regions copper sulphide is partly in the form of CuS and partly some Cu^{++} are trapped in the lattice. It is significant that nominal valence state of copper changes rather abruptly across the junction interface. These investigations have been most useful in providing clue to several outstanding problems related to interface in these cells (Ref.2).

3.3 *Electro-plated Thin Film CdS Solar Cells*

Investigations were undertaken on the electro-deposition technique for deposition on CdS and Cu_xS layers in the nonacqueous electrolytic medium onto stainless steel, Cr^+Ag coated and conducting glass substrates. Effect of deposition parameters such as plating current, composition of both and also the structural and electrical properties of the respective semiconducting layers constituting the hetero-junction were studied. This helped identifying the precise process parameters for solar cell fabrication. The efficiencies achieved are low at present, however considering the simplicity of the technique and that considerable scope exists for further optimisation of film properties, the possibility of achieving better efficiencies in cells processed by this technique are many. Work in this direction is continued (Ref.3).

3.4 *Studies of Growth Kinetics of Cu_2S Layers in CdS Solar Cells*

The kinetics of growth of chemiplated $Cu_{2-X}S$ films on thermally deposited and chemically etched CdS layers were investigated. Scanning electron microscopy examination of parent films revealed the usual columnar growth and pyramidal tops as in typical high efficiency cells, with an enhanced area factor of 2.5. During chemiplating, $Cu_{2-X}S$ growth occurs and conformal to the grain surface but deep penetrations results along the grain edges. In the present studies, quantitative estimates of such growth behaviour are obtained by varying the ion exchange reaction parameters, particularly the dip period and the pH of the CuCl bath. Results suggest that for a pH value of 4.6 the growth is parabolic in nature whereas in solutions of lower pH (about 3.4) a fast linear growth mechanism dominates. The textured morphology of the grain yields an expression for net $Cu_{2-X}S$ growth from which grain surface thickness and grain boundary penetration depths are evaluated. Resultant changes in junction area affect the open circuit voltage of the cells. The studies show that pH of the solution plays an active role in controlling the $Cu_{2-X}S$ growth process and also in obtaining superior cell characteristics (Ref.4).

3.5 *Exploratory Work in Ternary Compound Cells*

As an alternative to Cu_xS layer, work on new materials such as the copper based chalcopyrites such as a $CuIn(S,Se)_2$ was initiated. After establishing the initial feasibility of the spray pyrolysis process for making thin films of ternary compounds for reproducible and repetitive coatings a new spray pyrolyser equipment was installed. Further work is in progress (i) to study the structural and optical properties of these layers as a function of spray parameters and (ii) to fabricate solar cells in back wall configuration over conducting transparent glass substrates.

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CRYOGENICS & SUPERCONDUCTIVITY

SUPERCONDUCTIVITY, SUPERCONDUCTING MATERIALS, SUPERCONDUCTING MAGNETS, JOSEPHSON TUNNELLING AND ITS APPLICATIONS

1. SCOPE AND OBJECTIVES

Understanding the phenomenon of superconductivity, superconducting materials, development of superconducting magnets, study of the phenomenon of Josephson tunnelling and its applications including Josephson voltage standard and study of non-equilibrium superconductivity.

2. STATUS AS ON 1.4.1981

Conduction electron spin resonance studies carried out for the first time ever on superconductors led to an important conclusion that superconductivity is an ordered magnetic state in the conduction band resulting from exchange interactions of antiferromagnetic type. These studies were based on varieties of A-15s possessing different Tc values. It was shown that the results of others relating to NMR and ESR of Aluminium could be better explained in terms of the new model.

Growth kinetics studies of A-15 formation, systematically carried out led to an improved understanding of structural dependence on T_c of Nb_3Sn and V_3Ga. Also, insitu technique yielded V_3Ga and V_3Si, two A-15 high T_c phases.

Various types of Josephson junctions such as clarke solder blob junctions, Nb-Nb point contacts and Pb-Pb_xO_y-Pb tunnel junctions were fabricated and extensively investigated for dc and ac Josephson effects. Effect of microwave radiations on the junction current-voltage characteristics were thoroughly investigated so as to produce a large number of constant voltage steps required for voltage standard work. Various components/parts of the Josephson volt standard set-up were tested. The time base of the synthesized signal generator which forms a part of 10 GHz stabilized microwave system used to irradiate the Josephson junction was calibrated against the atomic clock frequency of the Time and Frequency Standard of NPL.

3. PROGRESS IN THE YEAR

3.1 Superconductivity (Phenomenon) - Basic Research Programme [1-6]

Extensive experimental work with ESR technique continued to extend our previously reported studies for new superconductors and under different conditions. During the last 6 months, we have studied the Chevral phases and also pure metal Re, both before and after irradiation with heavy ions. The results support our previous work on A-15s and the contention that electron pairing may be the manifestation of exchange interactions of antiferromagnetic type in the conduction band. The experiments are in progress which attempt to look at the conduction band close to T_c.

Exhaustive critical analysis of pressure induced superconductivity of lanthanides and actinides and their alloys has been carried out in the light of our model. It has been shown that various results hitherto unexplained by any theory or mechanism of pairing can be readily understood if one involves our model that exchange interactions play a creative role in superconductivity.

3.2 Superconducting Materials [7]

Growth kinetics studies of multifilament-Nb_3Sn with 2000 to 10,000 filaments is being investigated. Microstructures are studied using scanning electron microscopy. The results show that growth of Nb_3Sn takes place by solid state diffusion with Sn atoms diffusing through grain boundaries. Inductive T_c probe is developed and interestingly, T_c transition of Nb_3Sn is found to be very broad. In-situ technique has also been used for making Cu-V_3Ga composites. Melt spin-

ing apparatus has been set up to form A-15 phases which are metastable.

3.3 Superconducting Magnet

DST sponsored programme has been started to design and fabricate a superconducting magnet producing a field of about 130 koe. This will have outer windings of Nb-Ti and the inner ones of Nb_3Sn.

3.4 Josephson Effect and Non-equilibrium Superconductivity-Basic Research [8-13]

Extensive experimental work to understand non-equilibrium superconducting state using Pb-Pb_xO_y-Pb type thin films junctions and solder blob type junctions have been carried out. Self-injection induced periodic switching between positive and negative resistance regions beyond gap voltage is observed in I–V curves of Pb-Pb_xO_y-Pb junctions. It is explained due to formation of a two energy gap state comprising of a gap with usual value for equilibrium state and the suppressed value to the spatially inhomogeneous non-equilibrium state.

In the case of Nb-Sn blob junctions, zero voltage pair current region has been observed even upto 0.2K above the transition temperature of Sn and is explained due to quantum phase fluctuations. When both the materials are superconducting, an entirely different type of I–V characteristic has been observed in several SLUGs. A typical I–V curve shows usual zero-voltage supercurrent upto a critical current, I_c, above which a resistive region whose differential resistance $R_d < R_N$, the normal resistance, is observed. At a second critical current, I_2, it switches to quasi-particle region through a plateau region. This low differential resistance region is found to behave like pair current region and is attributed to enhancement of superconductivity by non-equilibriun distribution of quasiparticles.

3.5 Josephson Volt Standard

A Josephson volt standard is in operation. This makes use of a niobium point contact which when irradiated by microwaves at liquid helium temperatures gives constant voltage-current steps at one mv level. The frequency used for irradiation is about 10 GHz and is stabilised. This is measured accurately to a few parts in 10^8. With suitable electronics it is possible to choose the correct voltage step for comparision with standard cell volt and this is done with the help of an accurate resistance divider. A few such comparisons show that it is possible to compare standard cell volt to the Josephson volt to an accuracy of a few parts in 10^7.

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4. PROJECT TEAM

A.V. Narlikar - Project leader.
A.K. Gupta, R.G. Sharma, N. Shankar Natarajan, S.N.Ekbote, N.D. Kataria, (Mrs.) Madhu Prasad (on deputation to IISc, Bangalore), B.V.Reddy, V.S.Tomar, Man Mohan Krishna, V.S. Yadav, S.K.Agarwal.

Part-time associates

S.K. Gupta, S.B. Samanta, K.C. Nagpal, V.K. Batra, S.P. Suri, A.C. Prabhakar.

DEVELOPMENT OF LOW TEMPERATURE LIQUEFACTION PLANTS, SYSTEMS AND DEVICES

1. SCOPE AND OBJECTIVES

The research and developmental work under this project aims at development of equipment such as liquefaction plants, containers for liquefied gases and other devices in the area of cryogenics.

2. STATUS AS ON 1.4.1981

2.1 Cryoprobes for Medical Surgery

NPL has developed cryoprobes for cataract, detachment and glaucoma operation of the eye and has successfully used them at various hospitals.

2.2 Liquid Nitrogen Containers

NPL has developed 20 litre liquid nitrogen containers, superinsulated, ultra low loss type with a loss rate of 2% per day for dairy husbandry for freezing bull semen after several years of R&D.

2.3 Sterling Cycle Liquid Air Plant

The thermodynamic and engineering design of this plant was completed and various drawings prepared. Some fabrication job has been completed on this plant. This is a very difficult area.

2.4 Liquid Helium/Hydrogen Plant

The work on the engineering design of this plant was undertaken during this year.

3. PROGRESS IN THE YEAR

3.1 Cryoprobes for Medical Surgery

A new cryoprobe has been developed on the refrigeration capacity for the treatment of cancerous and noncancerous tumours in the ENT area [1-3]. The machine was given to Dr. Prem Kakkar, Head, ENT Department of Lok Nayak Jaiprakash Narayan Hospital, Delhi. The system had been tried for about 50 cancerous and benign tumours over the last one year, out of which about 25 cases were of the cancerous tumours and the rest the benign tumours.There has been reported no failures in the benign tumours, while in the case of malignant tumours only three cases have been reported which were not successful by this technique. This has established to a certain degree the utility of cryosurgery and the effectiveness of the system developed by the NPL for the treatment of cancerous and benign tumours. All the patients chosen were considered hopeless and had been already treated unsuccessfully by all the other existing techniques. It, thus, establishes that the cryosurgery is now regarded to be one of the best techniques for the treatment of various kinds of tumours.

3.2 Liquid Nitrogen Containers

During 1981-82, some efforts have been made to get various systems developed for developing a liquid nitrogen container with a loss rate in the range of 1% or better [4]. This work is expected to be continued during the next year. This will help in the preservation of bull semen and other biological products [5-6].

3.3 Sterling Cycle Liquid Air Plant

The work on this plant has been going on for the last 2½ years or so and was continued during the current year. The fabrication of the most of the parts of the machine was completed during 1981-82 and various sub-assemblies were assembled and the snags removed. Work on the assembly of the total system may be started during 1982-83.

3.4 Liquid Helium/Hydrogen Plant

Design and development of this plant has been going on for the last one year at NPL. The engineering design is mostly complete and some fabrication job has been started. The plant is designed to deliver 3-4 litres helium per hour.

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4. PROJECT TEAM

A.P. Jain – Project leader.
N.K. Babbar, S.C. Gera, Hari Kishan, Kasturi Lal Y.S. Reddy, R.B. Saxena, S.C. Vashishth and M.L. Sharma (part-time).

PREPARATION OF A VARIETY OF FINE CERAMICS BY CRYOCHEMICAL AND SPRAY DRYING TECHNIQUES, THEIR CHARACTERISATION AND APPLICATIONS

1. SCOPE AND OBJECTIVES

To prepare a variety of fine ceramics like Al_2O_3, Fe_2O_3, NiO, Mn_3O_4, CoO, $LiFe_5O_8$, Other ferrites, PZT, PLZT, etc. having electronic applications by cryochemical and spray drying techniques, characterise the materials prepared by these two methods for surface area, particle size and size distribution, dopant distribution, phase identification by the B.E.T. techniques,electron microscopy, atomic absorption technique and X-ray analysis technique, respectively.

2. STATUS AS ON 1.4.1981

Most of the ceramics mentioned in Section 2 have been prepared at NPL in laboratory scale. These have been characterised for the various parameters mentioned in Section 2. A phase diagram study was made for NiO and Mn_3O_4 system in order to establish the condition of formation of $NiMn_2O_4$ [1], which is used as a thermistor infrared detector for the detection of rise in temperature in the axles of fast moving railway carriages. Some preliminary investigations have been made for the preparation of β–Al_2O_3 using λ and γ–Al_2O3 made by the above two techniques.

3. PROGRESS IN THE YEAR

Considerable amount of work has been done in the field of bi-phase ferroelectric composites using $BaTiO_3$ as the matrix and $NaNbO_3$, B_2O_3 and PbB_2O_4 as the dispersed phases. Various ferroelectric parameters from these composites have been measured at room temperature and upto 75°C. Of the various properties measured, dielectric break down voltage was one of prime interest. Some very interesting results have been obtained from these composite studies. Some theoretical calculations were also made for a number of systems with $BaTiO_3$ as the matrix and the concentration of the dispersed phases varying between 2 to 10 mole %, in order to calculate the variation of the ferroelectric properties as a function of concentration of the dispersed phase. $BaTiO_3$ and $NaNbO_3$ solid solutions have been studied at 1100°C and 1200°C and various properties measured.

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4. PROJECT TEAM

A.P. Jain –.Principal Investigator.
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Part time associates

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APPLIED PROJECTS

ELECTROSTATICS AND ELECTROPHOTOGRAPHY

1. SCOPE AND OBJECTIVES

i) To develop xeroradiographic unit for medical radiology.
ii) To develop newer materials for electrophotography.
iii) To develop electrostatic dust collectors.
iv) To develop electrostatic separator for agricultural applications.

Development of the technology in the above areas is undertaken to create the necessary know-how transfer for fabrication within the country and thereby achieve self reliance.

2. STATUS AS ON 1.4.1981

Know-how for the processes mentioned below have already been developed and released to several firms and continuous R&D is in progress:

i) Electrophotographic machines (manual and semi-automatic) using Selenium plates.
ii) Sensitized ZnO coated paper for Electrofax machines.
iii) Electrofax machines.
iv) Electrostatic dust precipitators using polymer media.
v) Sensitized polymers/binder layers as photoreceptors in electrophotography.

In respect of the following activities preliminary studies have been made :-

Xeroradiography
Electrostatic dust collectors
Electrostatic separators
Development of newer materials.

3. PROGRESS IN THE YEAR

Besides continuous R&D for the toners and photoconductive coatings, renewed efforts have been made for developing cheaper and superior conductive base for the electrofax paper. Achievements during the year are described below.

3.1 Xeroradiography

An equipment has been set up for the measurement of parameters such as surface charge decay, x-ray induced conductivity, fatigue, etc., related to the characterisation of photoreceptors for use in xeroradiography using Medical X-ray equipment.

A number of materials such as selenium, lead monoxide, polymers, etc. have been investigated for their performance as X-ray sensitive photo-receptors. [1-10]. Lead monoxide seems to be a very promising material for this purpose [2-4].

A few compositions have been investigated for the development of high contrast toners. A process has been developed for making the same and a patent is being filed. The design of the cloud chamber is completed and its fabrication is underway.

3.2 Newer Materials for Electrophotography

The charge storage and decay characteristics of various polymeric materials have been investigated with a view to their application in electrophotography both as photoreceptors as well as in toners [1-10].

3.3 Electrostatic Dust Collectors/Separators

A corona type dust collector has been developed A test bench is set up for the measurement of the efficiency of various types of dust collectors using ASHRAE Standard. New electrode configuration is being developed for better corona emission and collection efficiency.

3.4 Consultancy services rendered during the year (party, problem, terms).

Consultancy was provided to M/s Chaudhary Traders for investigating the properties for new resins and polymers which could be used in toners and to M/s Hindustan Reprographics Ltd. New Delhi for the evaluation ofclays and polymers used in special conductive coatings.

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4. PROJECT TEAM

P.C. Mehendru - Project leader.
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THIN FILMS AND AMORPHOUS MATERIALS

1. SCOPE AND OBJECTIVES

i) To develop certain optical coatings like multi-cavity and very narrow band interference filters, achromatic beam splitters, multilayer AR coatings, dichroic mirrors etc., specially for space applications.

To develop low cost chemical dip and spray pyrolysis methods for fabrication of optically active films.

The scope and objective of the project not only involves the development of the above devices but also to cater to the needs involving custom design, supply and consultancy undertaking. This will help in import substitution.

ii) To optimise deposition parameters for the fabrication of doped amorphous silicon films for use in solar cells.

To develop a low cost technology for the fabrication of amorphous Silicon Solar Cells for terestrial applications.

2. STATUS AS ON 1.4.1981

This Film Group in the NPL has been working on the problems of optical coatings since last several years and has acquired sufficient capabilities in the design and fabrication of various types of optical coatings. The development made in these areas have been reported earlier. Like the know-how for hard sun glass coatings (in different shades) released to various vendors earlier and the know-how for the manufacture of Film Thickness mointor and controllor jointly developed in collaboration with Electronic Services Section and released through NRDC is being marketed by the Licencee. Consultancy services were made available for the production of consumer items like pearlised coatings and coatings on bangles etc.

Antireflection coatings in the IR region for Germanium lenses for Hot-axle detection project of the laboratory were developed and field tested.

Design and fabrication of a large number of multi-cavity interference filters were undertaken and supplied to ISRO.

Optical coatings like Gun Sight Reflector, collimating Sight Glass etc. were developed under Sponsorship of HAL, Nasik.

Preliminary experiments were undertaken with imported formulations to Antireflect glass flats by spinning and subsequent heat treatment.

Work on hard optical coatings by R.F. sputtering of suitable dielectric materials was initiated. It is now possible to deposit and monitor in a programmed fashion constituent layers involved in a multilayer system. Efforts are being made to deposit low loss films by this method for the layers involved.

ii) The group has undertaken the work on fabrication of amorphous silicon films by R.F. Sputtering in Argon-Hydrogen.' Some initial studies have been completed.

3. PROGRESS IN THE YEAR

The progress made during the year on Thin Films and amorphous materials is indicated below :—

3.1 *Optically Active Films of Conducting Transparent Coating*

A few formulations involving organic vehicles for spray pyrolysis and spin-dried optically active thin films were prepared in collaboration with Liquid Crystal Group and films of conducting Transport coatings required for one of the products to be developed for HAL, Nasik tried. Similarly, films of TiO_2 have also been prepared and evaluated using our own formulation.

3.2 *Development of Thin Films Bolometer for Microwave Power Measurement*

Thin film bolometer mounts for microwave power measurement prepared by this group in collaboration with the Microwave standards group have been compared and assigned values for effective efficiency at 10 MHz by the Electro technical Laboratory, Japan.

3.3 *DHW Films for ISRO Ahmedabad*

Large number of DHW Films, costing about Rs.1.5 lakhs were supplied to ISRO, Ahmedabad for their ground based Radiometric investigations.

3.4 *Development of Space Qualified Interference Filters for ISRO, Ahmedabad*

To meet the long term requirement of ISRO for Space Qualified Interference Filters requiring high degree of sophistication in design, fabrication' and testing a project was submitted to ISRO and the same has been approved under ISRO's RESPOND Programme. The first instalment of Rs.5.97 lakhs out of a total of 10.5 lakhs has been received. The work on the project is in progress.

3.5 *Development of Achrometic Beam Spilters and Dichroic Mirrors etc., for IRS Satellites (ISRO)*

To meet the requirement of Achrometic Beam Splitters and Dichroic mirrors etc. to be used in the optical system of IRS series of satellites, a project proposal has been submitted to ISRO to carry out these development activities. The coatings sought to be developed under the contract, amongst other things, require that they are polarisation insensitive, which, indeed, is a very stringent requirement.

To meet this and other requirement of space qualified coatings, a detailed computer assisted design work was undertaken and limits of performance of various coatings defined. Designs of DHW filters have also been refined and this has become the work horse for various optical coating designs. A particularly significant achievement utilising the refined DHW design has been the complete elimination of the coloured glass filter otherwise required for supression of longer wavelength side bands.

3.6 *Development of Amorphous Materials*

R.F. Glow discharge system for decomposition of silance for the deposition of Amorphous Silicon Films was set up.

The main S.S. Reactor which can accommodate upto 125 mm dia.substrates was entirely in house fabricated. The system incorporates Mass Flow meters for control of reacting gases and precision controller for substrate temperature. Amorphous Silicon Films so deposited have been characterised by IR spectroscopy, electrical and photoconductivity measurements and are found to be of device quality. In absence of gaseous dopants no device structure could be attempted. However, the same should be available by the end of 1982.

4. PROJECT TEAM

V.V. Shah - Project leader
R Bhattacharya, B S, Verma, P N Dixit, Meenakshi Kar (Miss), R Marwah (Mrs.), U C Uprethi

DEVELOPMENT OF DIGITAL DISPLAY DEVICES

1. SCOPE AND OBJECTIVES

a) Development of a variety of alpha-numeric display devices namely :

i) Black and white and

ii) Coloured Liquid Crystal
iii) Electro-chromic
iv) Planar gas discharge display devices.

b) Basic studies on the physico-chemical behaviour of new electro-optic materials.

Development of these display devices involving basic and applied research is undertaken to create the necessary know-how transfer for fabrication within the country and thereby achieve self-reliance.

2. *STATUS AS ON 1.4.1981*

Liquid crystal digital display devices (Black digits on white background) in a variety of sizes and shapes have already been developed. These devices consume extremely low power (~1 micro watt/cm^2) and operate at voltages less than 3 volts. The know-how for fabrication of LCD's suitable for digital systems such as electronic watches, clocks, pocket calculators, multimeters etc. has been passed on to industries for commercial production.

A unique feature of the transfer of this know-how has been that scientists of this group helped in setting up of the infra structure and initial production at the entrepreneurs' factory sites. One Scientist was deputed to PDDL (Chandigarh)—a state undertaking and one Scientist to Krystronics Pvt.Ltd., Jaipur, to promote indegeneous self-reliance in this area.

3. *PROGRESS IN THE YEAR*

Significant progress has been made during the year in (i) development of Coloured LCD's, (ii) Studies on polymorphism in liquid crystals, (iii) Mossbauer spectroscopic investigations on anistropic molecular diffusion in liquid crystals, (iv) development of electrochromic display devices, (v) development of new organic electrochromic materials and (vi) synthesis and characterization of organometallic compounds of indium and tin. Some of the achievements are described below :—

3.1 *Development of Coloured Liquid Crystal Digital Display Devices*

An entirely new type of coloured liquid crystal display device have been developed. In this, coloured digits appear against a colourless background (positive mode coloured displays). This has been achieved through development of an unconventional electrode pattern and subsequently employing a new voltage scheme based on dye-phase changes and guest-host interaction effects in high pitch cholesteric liquid crystals.

3.2 *Studies on Liquid-crystalline and Solid Crystalline Polymorphism in Liquid Crystals*

Investigations undertaken on polymorphism in liquid crystalline materials using thermal, infrared and Raman scattering and X-ray diffraction data, suggest that the whole sequence of polymorphism is a continuous process of step-wise liberation of molecular degrees of freedom. It appears that the ability of these materials to show such a large number of polymorphism is inherent in the structure of their molecules.Solid crystalline polymorphism appears to arise out of different molecular arrangements in the lattice network and the 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.

Studies on 4-Cyano-4' - octyloxy biphenyl (M-24) using Infrared absorption, differential scanning calorimetry, microscopic and X-ray diffraction techniques, has brought out clearly s solid polymorphism in this compound. There are at least three solid crystalline forms SC_I, SC_{II} and SC_{III} with the following transitions :

$$SC_I \xrightarrow{40^oC} SC_{II} \xrightarrow{51^oC} SC_{III} \xrightarrow{54.5^oC} \text{Smectic A} \xrightarrow{67^oC} \text{Nematic} \xrightarrow{80^oC} \text{Isotropic liquid.}$$

The appearance and the preponderance of these solid crystalline forms depend critically on the manner in which liquid crystalline melt solidifies [1].

3.3 *Anisotropic Molecular and Particle Diffusion Studies Using Mossbauer Spectroscopy.*

Studies on liquid crystals in smectic as well as nematic phase at low temperatures using Mossbauer Spectroscopy have given valuable information about the order and glass transitions in oriented supercooled nematic and smectic liquid crystals. Following Singwi-Sjolander expression $\Delta E - \Gamma = 2hK^2D$ and using the data on broadening of the Mossbauer lines arising out of anisotropic molecular and particle diffusion in such

liquids, the diffusion coefficient parallel D_{11} and perpendicular $D_{\perp}$ to the director in the various phases of the liquid crystals computed, show that $D_{11}/D_{\perp} > 1$ in the nematic phase whereas $D_{11}/D < 1$ in smectic phase [4].

3.4 *Development of Electrochromic Display Devices*

Efforts are being made to develop tungsten trioxide based electrochromic display devices (ECD's) using both solids as well as liquid electrolytes. Because of relatively higher peak current densities involved in ECD's (specially at the onset of colouration), a new segment configuration design was evolved which makes maximum usage of available area (for a given digit separation) and also minimizes both the IR drop across a segment and the equalized RC time constant to each segment. A suitable opacifier has been developed which provides the desired white background to the activated electrodes without affecting the motion of protons (H^+) or Lithium (Li^+) ions involved in the electrochromic colouration of the WO_3 films.The contrast (blue on white) is quite good.Investigations are underway to understand the two persistent challenging problems of switching speeds (colouration and erase times) and that of operational life of electro-chromic cells. Realizing that the surface morphology of WO_3 films and the interface between electrochromic films and the electrolyte play dominant roles in controlling the speeds, two entirely new approaches have been introduced namely (i) the idea of ion charge transfer amongst the turning "ON", and "OFF" segments in addition to the conventional charge injection mechanism for initial blue colouration, (ii) modifying the surface of WO_3 films so that faster diffusion of H^+ or Li^+ can take place along the grain boundaries involved in the colouration. It is expected that the methods based on these approaches which are under development would lead to relatively faster ECD's with longer life.

3.5 *Colouration Properties of Organic Electrochromic Materials*

Electrochemical and Electro-optical studies on a series of alkyl substituted bipyridinium dibromides (Viologens) to assess their suitability for electrochromic display devices have made it possible to have activated digits having good contrast appearing in pink colour against a white background in a digital display cell.

3.6 *Synthesis and Characterization of New Organometallic Compounds*

A number of organometallic compounds of tin and indium have been synthesised and they are characterized by elemental analysis, IR spectroscopy, proton magnetic resonance and Mossbauer spectroscopy. These compounds include dicyclopentadinyl dichloride of tin and indium as well as carboxylates and dithiocarbamates of Sn(IV). Some of these materials have been utilized in making transparent electrically conducting coatings on glass substrates used for electrode configurations in electrochromic and liquid crystal digital display devices [2,3,5].

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4. *PROJECT TEAM*

Subhas Chandra - Project leader
S.C. Jain, S.S.Bawa, S.A. Agnihotry (Mrs) C.P.Sharma, A.M. Biradar, N.S. Verma, D.Chand.

DEVELOPMENT OF VACUUM SYSTEM FOR SCANNING ELECTRON MICROSCOPE

1. *SCOPE AND OBJECTIVES*

The long term objective of this project is to develop a sound, scientific and technological base for future development of sophisticated instrument such as Scanning Electron Microscope so

that they may be manufactured in India with indigenous know-how. It is a multi-institutional project where the following institutions are collaborating with NPL :

i) M/s. Central Electronics Ltd.,Sahiabad (UP)
ii) GSIO, Chandigarh
iii) CEERI, Pilani
iv) IIT, Delhi and
v) BHU, Banaras.

2. *STATUS AS ON 1.4.1981*

The semi-automatic vacuum system with various interlocking arrangements has been successfully developed and fitted to the first commercial model of the scanning electron microscope assembled at CSIO, Chandiragh.

Two vacuum systems, one with semi-automatic and the other with automatic electronic control system, has been supplied to M/s Central Electronics Ltd., Sahiabad (UP) who will manufacturing scanning electron microscope in the country on behalf of the Department of Science and Technology.

Ultra-high vacuum of the order of 3×10^{-9} torr has been achieved in glass vacuum system of 17-20 litre of capacity above the mouth of the pump.

3. *PROGRESS IN THE YEAR*

Two more automatic vacuum systems are being assembled and tested which are finally going to be fitted with sputter-ion-pumps to incorporate the LaB_6 cathode gun. In view of this an all metal ultra-high vacuum system using liquid nitrogen trap and sputter-ion pump have been fabricated and tested. These observations will finally help in achieving the vacuum system to incorporate Lanthanum hexaboride gun cathode in replacement of the usual tungsten hair pin cathode in the electron gun stage.

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PROJECT TEAM

J.K.N. Sharma - Project leader A.C. Gupta, D.C. Sharma, B.R.Chakraborty, T.R. Choudhury.

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 new experimental observations recently made in charge transfer compounds like TTF-TCNQ. Superconductors driven away from thermal equilibrium by external fields hold promise of raising the transition temperature.

2. STATUS AS ON 1.4.1981

During the last few years, the theoretical research programme pursued in the laboratory was in condensed matter physics:

1) Dilute Magnetic alloys with special reference to Kondo Effect.
2) Superconductivity, including influence of magnetic impurities in superconductors and nonequilibrium superconductivity.
3) Phase transition in quasi one-dimensional systems.

The results obtained from theoretical investigations done in the above mentioned areas have been reported earlier and published in the Journal of Low Temp. Physics (USA).

3. PROGRESS IN THE YEAR

3.1 Phase Transition in Quasi One-dimensional System

This problem was investigated using the bosonization technique which is non-perturbational. In this method, matrix elements of fermion operators are calculated in boson representation.Work is in progress to obtain soliton and bound soliton states. Related problems like the massive Thirning model and the Baxter model are also being studied.

3.2 Non-equilibrium Superconductivity

Analytical solutions of the non-linear differential equation which was derived last year to describe the charge imbalance dynamics in a non-equilibrium superconductor were obtained. An important finding is that the localized phase slip centre through which the current-induced breakdown of superconductivity occurs can now be analytically linked to a Josephson oscillator. This result could be obtained only by considering the non-linear dynamics of the charge imbalance.

3.3 Kondo Effect in Superconductors

Since the Kondo Hamiltonian for normal metals has been diagonalized exactly by using a modified Bethe ansatz (N. Andrei Phys. Rev Letters 45, 379, 1980), the problem of Kondo Effect in Superconductors needed a fresh investigation. This was taken up and calculations are in progress to reduce the Hamiltonian to the Gross-Nevue form and to use the Bethe ansatz.

3.4 Contribution in International Forum

Was an invited delegate to the International Conference was on Theoretical Physics (Jan 4-7) held at Physics Department of Delhi University.

4. PROJECT TEAM

R Sundaram - Project leader

DESIGN AND DEVELOPMENT OF OPTICAL SYSTEMS

1. SCOPE AND OBJECTIVES

To do research relevant to indigenous manufacture of optical instruments and devices not already undertaken by the other agencies in India

and to work for establishing a modern optical industry in the country.

2. STATUS AS ON 1.4.1981

Use of computer was made for understanding the basic nature of optical systems and on the basis of this, research theories of computer simulation of lens systems, understanding of basic genetics of these systems and their classification into a Mendeleev type classification and demerit reduction by the method of evolution, were developed. As the response from the existing optical industry to utilize the results of this research was limited because of the basic weakness of the existing infrastructure, a new strategy has been suggested in the shape of "Setting up a technological nursery for optical components in the hills of U.P.". A new concept of technological nursery has been suggested to solve the existing problems. Associated concepts of industrial seeds, industrial plants and industrial orchards have also been proposed.

3. PROGRESS IN THE YEAR

Apart from the research work continued in the areas indicated above, a number of prospective manufacturers of optical components were provided with information on problems of optical instrument manufacture in the Indian as well as the global context and these have been highlighted in the articles published in the "Optical Digest".

Setting of Technological Nursery of Optical Components in U.P. Hills

To establish an industrial complex of small optical factories for the hills of U.P. on the pattern of the Swiss Watch Industry through the catalytic role of the technological nursery. A proposal has been made for the annual plan 1983-84. At the centre of the proposal is the concept of the "technological nursery" seeking a synthesis of scientific, technical, technological and managerial knowledge and skills for an optimum utilization in production. This nursery will train young apprentices in a team under a team of experienced supervisors engaged in the fabrication of prototypes upto the stage of sample production at an international level of standardization. This team of young trainees, regarded as an "industrial seed", will work as a nucleus for development into one of the factories of the future industrial complex. Initial follow-up work with the Garhwal Development Corporation, Government of U.P. and other agencies was undertaken.

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4. PROJECT TEAM

Ram Prasad - Project leader

INSTRUMENTATION SERVICES

SCOPE AND OBJECTIVES

i) Maintenance and Calibration of scientific laboratory-type, medical, electrical, electronic and electro-optical instruments and apparatus. Besides rendering this service to the Laboratory, work from other institutional users for sophisticated instruments is also undertaken.

ii) Advice on instrumentation problems and also on the availability of Indian-made instruments and components; and

iii) On-the-spot consultancy service for
- a) assessment of damage to equipment,
- b) technical advice on maintenance of equipment, and
- c) inspection reports for initiating write-off, calibration or repairs.

PROGRESS IN THE YEAR

During the year 1981-82, assistance was rendered in servicing of 61 instruments of which 30 were from within the Laboratory, 16 from outside organisations in the country, and 15 from Tanzania.

Instrumentation consultancy and technical information requests attended to during the year numbered 92 of which 30 were from Tanzania.

Assistance was also rendered to the Tanzania Research & Development Organisation in the planning of a sophisticated Instrument Maintenance Centre.

STAFF AS ON 1.4.1982

S K Suri.

APPENDICES

CENTRAL WORKSHOP

The Workshop plays a vital role in the successful completion of the R&D projects by way of fabricating prototypes, test jigs etc. wherever necessary. It is assisted by a Drawing & Design Section.

The work of the Workshop is organised in the following Sections :

(a) Machining & Turning, (b) Fitting, (c) Sheet Metal, (d) Welding, (e) Carpentry, (f) Smithy, (g) Painting, (h) Mechanical Maintenance, (i) Electroplating, (j) Foundry, (k) Glass Fibre Moulding and (l) Electrical Maintenance.

The Foundry Section has sub-sections for pattern making, moulding and melting.

The Workshop is equipped with a variety of machine tools and a sub-store. It also assists the industry and other government departments.

During the year, 2745 jobs were processed and completed for various R&D projects of the laboratory. The estimated cost of these jobs amounts to Rs. 10.8 lakhs. The major jobs completed during the year were :—

Project/Group	Job
Length Standards	i) Lapping Machine; and ii) Fabrication of Mirror Mount for Stabilized He-Ne Laser
Vacuum Standards	i) Fabrication of parts and assembly of Rotary Pump; ii) Machining of High Precision Stainless Steel Parts; and iii) Fabrication of Angle Prism.
Acoustical Standards	Fabrication & Assembly of Microphone Stand
Solar Energy Utilization	i) Fabrication of Rotating Assembly; ii) Moulding of Fibre Glass Tank; iii) Machining of Massive Cast Iron Pieces; and iv) Moulding of Fibre Reinforced Plastic Parabolic Reflector Panels
Cryogenic Plants & Facilities	Fabrication of precision parts for the Liquid Air Plant
Stratospheric Ionization	Fabrication of ten Gerdien Condensers.

The Drawing & Design Section rendered assistance to various R&D projects and undertook drawing jobs for publications, seminars, exhibitions etc. About 340 jobs were completed during the year. Some of the major design jobs completed related to :

Mount for Stabilised Laser and Iodine Cell
Solar Tracker
Hydraulic Multiplication Unit
Device for Testing Tachometer
Moveable Carriage for Microwave Apparatus
Polishing Machine
Jig for Standardisation of Electromicrophone
Parabola Generating Machine for Solar Concentrators.

STAFF AS ON 1.4.1982

J.R. Anand, In-Charge (on Deputation)
S.K. Kapur - Officiating In-Charge.
C.S. Dua, M.K. Chhiber, S.L. Thind, J.N.Ojha, Raghukul Tilak Sharma, Gurdial Singh Bhamra, Kartar Chand, T.R. Marwaha, Ram Swarup, J.P.

Fig.18: General view of the Workshop

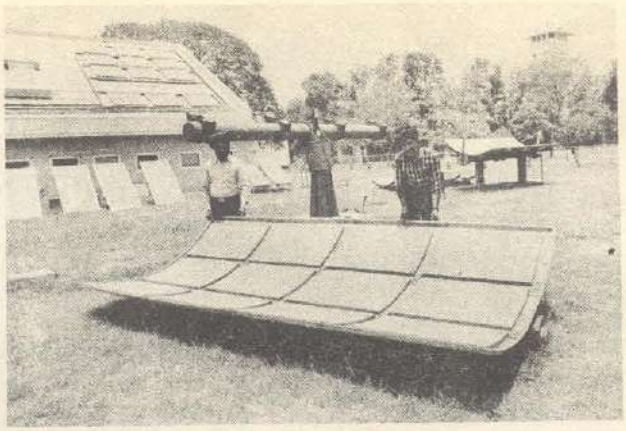

Fig.19: FRP Parabolic reflector panel for solar power station

Saini, Bhupinder Singh, Khazan Singh, Sham Singh, P.D. Aggarwal, Harish Chand, M.L.Nagpal M.G. Sehgal, Ganpat Singh, Kewal Krishan Sharma.

LIBRARY

The Library continued to provide library, documentation and reprographic services. Its important activities and products included literature search especially on analysis of calculi, anti-reflection coatings, and plastic glass; compilation of a core list of titles on solar energy; and a directory of learned societies and research institutions in radio science and space science. A compilation of a directory of current journals in NPL is underway. Measures were introduced to make document retrieval activity expeditious and trouble-free.

433 books were added to update the collection. The prestigious titles were the Annual Book of ASTM Standards for 1981, and the JCPDCS Cards.

Plans were drawn out for resource sharing among science libraries to provide the users of the Library the benefit of access to publications held in the collections of other libraries and to meet the mounting demands for information within the budgetary constraints. The actual implementation of the plans would take effect in the coming years.

A total of 105 m^2 floor area was added to expand the library space. It would now enable the Library to plan a room each for housing reference publications and abstracting journals, microfilm and microfische readers, and journals for binding.

Library data on books, journals, photocopies, translations etc. during April 1981—March 1982 are given below :

Publications holdings as on 31.3.1981	98,881
Books & Journals accessioned during 1.4.1981 to 31.3.1982	1,572
Standard Specifications added during 1.4.1981 to 31.3.1982	983
Journals subscribed during 1981-82	313
Journals added during the year	4
Journals dropped during the year	17
Photocopies accessioned	34
Translations Accessioned	36
Publications issued (including inter-library loan)	24,000 (approx)
References provided in SDI Service	2,500 (approx)
Bibliographies prepared on demand	10
Xerox copies supplied	10,000 (approx)
New Members enrolled	39

The library is recognised as a Patents inspection centre and on this account it continues to receive Indian Patents.

STAFF AS ON 1.4.1982

S.M. Dhawan In-Charge
S.K. Phull, Sudarshan Kumar, Ashok Kumar, S.K. Sharma, S.P. Jain, G.S. Srivastava, Sawanti Lal, Hasan Haider, J.S. Dhama.

PLANNING, MONITORING & EVALUATION GROUP

The responsibilities of this Group are Preparation of Laboratory's Five-Year Plans and Annual Plans; Project Monitoring & Evaluation; Project Budgeting & Costing; Manpower Planning; Planning & Coordination of Inter-Laboratory & Inter-Agency Project Group Meetings; Supported Projects; Project Report Writing; Publication of various Technical Reports & Adhoc Reports; and Miscellaneous jobs related to various activities of the Group.

During the year, the document "Annual Plan 1982 and Project Budget Statement, Revised Estimates 1981-82 and Budget Estimates 1982-83 and Sixth Five Year Plan Projection (1980-81 to 1984-85); Part I-Financial Statements", was compiled.

A document entitled "R&D Programmes 1982-83" describing the status of the various R&D Projects in the NPL, as well as the proposed research programmes for the year 1982-83, was compiled.

The Group also compiled the document "Major Achievements & Significant Highlights 1981-82", forming input for the CSIR Annual Report for the year.

A document "Spotlight on Resource Utilization During 1978-81 and Proposed Deployment of Resources During 1981-85" was brought out in January 1982.

Another document entitled "Current Research Projects : 1981-82" was compiled as an input for a compilation by the INSDOC.

Creation of a data-base on Human resources to assist in manpower planning and to provide information on project personnel was started.

STAFF AS ON 1.4.1982

G.K. Arora, In-Charge

M K D Rao, Shikha Mandal, Mrityunjay Karfa, S S Bhakri.

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73. Puntambekar (PN) and Dahiya (HS): Frequency stabilization of two mode He-Ne laser using a passive cavity. Tenth Symposium on Optics, IIT, Madras, Jan 8-10, 1982.
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on Reactivity of Solids, Guru Nanak Dev University, Amritsar, Oct 13-15, 1981.

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4. Reference atmosphere for Indian sub-continent from 120 to 1000 km. M.K. Goel, V.C. Jain & K.K. Mahajan. RSD Scientific Report No.116, Sept. 1981 (Mimeographed).
5. Modelling of Indian F-region for HF communications during disturbed conditions. D.R. Lakshmi, S. Shastry, Shiv Kumari & K.G.M. Pillai. RSD Scientific Report No.117, Oct 1981 (Mimeographed).
6. Energy deposition by precipitating KeV range protons and neutral hydrogen atoms into the equatorial atmosphere: Dependence on the neutral atmosphere model. M.N.M. Rao, B.C.N. Rao & V.C. Jain. RSD Scientific Report No.118, Jan 1982 (Mimeographed).
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9. Transhorizon propagation characteristics over North -West India. S.K. Sarkar, H.N. Dutta, D. Narayanan Rao & B.M. Reddy (CENTROP Report No.37, Sept 1981 (Mimeographed).
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BOOKS

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LECTURES

1. Crystal growth and lattice imperfections-Interferometric and X-ray diffraction studies: Reminiscences (Guest of Honour). A.R.Verma. International School on Synthesis, Crystal Growth and Characterization of Materials for Energy Conversion and Storage, NPL, New Delhi, Oct 12-23, 1981, (Printed).

1981 KRISHNAN MEMORIAL LECTURE

The 1981 Dr.K.S.Krishnan Memorial Lecture was delivered by Dr. R. Ramanna, Director, Bhabha Atomic Research Centre, Bombay and Secretary, Department of Atomic Energy, Government of India, New Delhi. on "Some Recent Advances in Nuclear Physics" on 21st January, 1982. Dr. Ramanna recalled emotionally his close association with Dr. Krishnan. Dr. Krishnan was a member of the Atomic Energy Commission for several years and took great interest in the affairs of the Commission and gave good support to Dr. Homi J. Bhabha in the early days of decision making. He recalled the deep understanding of physics which Dr.Krishnan possessed and due to which even nuclear physicists considered it a pleasure to discuss their problems with him.

Dr.Ramanna reviewed some recent exciting work in nuclear physics which has been possible due to newer developments in the theory and exciting possibilities of experiments at recently established powerful particle accelerators. He surveyed different aspects of fission of nuclei and nuclear reactions in heavy ion physics.

He gave the background of the physics of fission on the basis of the liquid drop model. In recent years, it has been realised that with the inclusion of the nuclear shell effect on the potential energy map of the nuclei with regard to changes in the shape during fission, several interesting possibilities occur theoretically. One of these is that the fission barriers of the actinide nuclei have a double-humped shape. The other is that very heavy nuclei which were expected to have vanishingly small fission barrier on the basis of the liquid drop model and therefore were unstable, can become stable if the shell structure is a closed one. This consideration has raised the hope that there may be an island of super-heavy nuclei which is stable enough to be observed experimentally.

The discovery of double-humped barrier due to the effect of nuclear shell structure has proved to be very useful to the reactor physicists. It is hoped that this knowledge will help the designers of a 1000 MW reactor to increase the breeding ratio appreciably and decrease the fissile fuel inventory and also decrease the number of control rods. Obviously, this would lead to a considerable saving in the expenditure.

Eventhough any super heavy nucleus has yet to be discovered, the theoretical predictions of the properties of these, particularly the fission properties have been worked out in detail. It is expected that in comparison to the 2.8 neutrons released in the fission of ^{240}Pu nearly 10 neutrons may be released in the fission of a super heavy nucleus $^{296}_{114}X$. This has obviously many very interesting implications. Dr. Ramanna mentioned that due to these and similar considerations, there has been an intense scientific activity in search of these elements in nature as well as attempts have been made to produce them in the laboratory. Obviously, the laboratory experiments have concentrated on heavy ion reactions. Theoretical investigations carried out at Trombay have shown that the shell effect which could produce stable nuclei would disappear when the nuclei are excited even with moderate energies. Therefore, this may come in the way of producing these nuclei in laboratory experiments.

Dr. Ramanna reviewed the recent advances in heavy ion reactions and described some of the most valuable results and discussed some of the outstanding problems. It has been observed that when the particle energies during heavy ion reaction are low (15 - 20 meV/n) an unexpected phenomenon Deep Inelastic Collision (DIC) takes place. The colliding partners in a reaction time of 1 - 10×10^{-22} sec exchange nucleons amongst each other. In different collision conditions, the two colliding nuclei may even fuse to form a larger nucleus which would be a hot rotating system due to conservation of energy and angular momentum. The rotation tends to stabilize the newly formed nucleus against fission. Another possibility during collision and the resulting heavy nucleus is the evaporation of a large number of neutrons due to its excited state. After giving out neutrons the residual nucleus will be highly proton rich. Similarly, by varying experimental conditions different types of exotic nuclei can be produced. He mentioned about the recent discovery of a nucleus with ground state proton radioactivity, reported by the Darmstadt group.

Dr.Ramanna also discussed some recent results obtained in the area of heavy ion reactions when beam energies of 2 GeV/n are used with facilities like Bevalac. Head-on collisions at these energies are expected to produce a complete nuclear overlap leading to increase in nuclear density. Some theory suggests that nuclear matter under such high compression can result in a new stable phase having much higher density. Experiments in this direction are just starting. The basic ideas in these studies and those aimed at understanding of the nature of neutron stars have a lot in common.Dr.Ramanna discussed some more aspects related with Deep Inelastic Collisions (DIC). He mentioned that recent work has shown that complete fusion of nuclei and direct interactions during collisions are only two extreme limits. A sizable cross-section appear for the intermediate process of DIC. This partitioning of the cross-section between fusion and DIC is basically determined by the potential energy and the energy dissipation which can be pre-determined by using the concept of friction.

A variety of experiments have been performed in recent times to understand different possibilities during collisions. The theoretical description available till now can broadly explain most of these results. However, there are several important issues which are yet to be resolved. One of these relates to the degree of

neutron–proton correlation in the exchange process. Another interesting problem is regarding the correlation of the transfer of angular momentum into the individual fragment spins with observables such as energy loss. Newer experiments are being designed in this area. One of the interesting experiments is aimed at measuring spins of fragments through measurements of gamma ray multiplicity. The Heidelberg and Darmstadt group is setting up a large γ-ray detector facility known as the NaI crystal-ball project. It is hoped that results of this work will clarify several important issues.

Dr. Ramanna surveyed the studies of decay of vacuum through heavy ion collisions. Theoretically, it is expected that when the atomic number Z increases the critical value of 173 the binding energy of an electron in the $^1S_{1/2}$ orbital is equal to or greater than the rest mass of two electrons. This leads to creation of an electron-position pair without any expense of energy. The electron is expected to be bound in the $^1S_{1/2}$ state and the positron is expected to escape due to Columbian repulsion of the nucleus. Therefore, a super heavy nucleus can cause the empty space around it to become unstable and produce matter and anti-matter. Experimentalists are struggling to discover collisions which can result in the observation of decay of vacuum. So far no conclusive results have been obtained. Nevertheless, future experiments should be able to provide a definite answer to this problem.

Dr. Ramanna also reviewed recent work in the area of heavy ion collisions with projectile energies in the relativistic and ultra-relativistic regions. He particularly mentioned that the range of energy from 10 meV/n to 200 meV/n is still an open field. Some accelerators are being constructed to fill this gap as it is clear that this energy region may contain information about several newer transitions in the reaction modes. Experiments have just started on relativistic heavy ions. The collisions in this case can result in the two nuclei just brushing against each other and leading to fragmentation,or the two may have head-on collisions also leading to fragmentation. The experimental results will show under what conditions the two situations occur. It is hoped that during some of these collisions the shock front may produce nuclear matter with much higher density than usual and which may become stable or metastable. At such higher densities a pion condensate may be formed. Dr. Ramanna mentioned that when the energies/n exceed several GeV (ultra relativistic domain) the collisions may produce densities of nuclear matter higher than that exist even in side a nucleon. Such a system can no longer be understood in terms of the usual nucleons and one may have to consider quark and gluon degree of freedom. It is hoped that in future such experiments will be performed and it will be possible to test the quantum chromodynamic theory. Dr. Ramanna ended his lecture by mentioning that all these studies are aimed at eventually understanding the ultimate reality of matter itself.

NPL MERIT AWARDS - 1981

Hot Journal Box Detection System

The problem of remote detection of an overheated journal box in a running train at a speed of 16 km/hr was posed to the Laboratory. Intense vibrations near the running train-track side, low infrared energy emitted by an overheated journal box, high speed of the train, perfect operation of the system in adverse weather and climatic conditions, automatic operation of the system without any false signal in the presence of hostile electrical interferences, all these factors made the problem difficult and challenging. Through a multi-disciplinary approach the Laboratory had developed a fast, free-from-microphonics, rugged, sensitive and room-temperature infrared sensor; an optical system with suitable anti-reflection coating; a low-noise, low-ripple sensor-bias supply, and high performance signal-processing electronics and digital display locator.

The entire work was carried out under the supervision and guidance of Dr. V.G. Bhide.

The team had developed a prototype of the system under a programme sponsored by the Department of Science & Technology, and the Central Electronics Ltd. was associated as the production agency for it.

Awardees:

Dr. S.P. Varma, Shri S.P. Puri, Shri Joginder Singh, Shri H.K. Maini, Dr. S.K. Sarkar, Dr. V.V. Shah, Shri Kanji Lal, Dr. K.C. Nagpal, Shri M.L. Sharma, Shri H.L.B. Bhaskar, Dr.(Mrs.) S.A. Agnihotry.

Temperature Measurements and Evaluation of Thermal Properties of Materials

The team had established national standards and calibration facilities for temperature measurements. The work involved the setting up of several thermal equilibrium states i.e. fixed points on the International Practical Temperature Scale such as gold point, silver point, zinc point, tin point, and triple point of water with accuracies comparable to those of international standards. Optical pyrometer, thermocouples and platinum resistance thermometers used as reference standards designed and fabricated at NPL cover the temperature range from 1800°C down to -183°C. International intercomparison of thermocouples amongst countries of the Asia/Pacific region was successfully carried out. Techniques for evaluation of the thermal properties of materials and refrigerating appliances had also been established. These calibration and evaluation facilities are extensively utilized by government departments and public and private sector undertakings and industries.

Awardees:

Shri K.D. Baveja, Shri V.P. Wasan, Shri R.S. Khandekar, Shri K.N. Bhatnagar, Shri Ram Krishan, Shri N.K.Srivastava.

Vacuum Standards and Related Techniques

The team had set up reference manometers and bakeable Mcleod gauges, and calibration facilities for vacuum gauges and developed techniques for evaluation of leak detectors and vacuum pumps. The study of the noise of mechanical pumps had proved helpful in specifying internationally acceptable noise levels for the pumps. The fundamental study of molecular flow inside a test dome, carried out by this team, had given a deeper insight into the effect of gauge tube on pressure measurements. Gauges and vacuum controller for process control, developed by this team, are being commercially manufactured.

The team had also designed and developed the vacuum system with various interlock and safety devices for the scanning electron microscope, developed as a multi-institutional project supported by the Department of Science & Technology.

The team had also successfully developed silver-impregnated graphite contacts for relays which are extensively used by the Indian Railways and have also substantial export potential.

Awardees:

Shri A.C. Gupta, Shri Desh Raj Sharma, Shri D.C. Sharma, Dr. B.R. Chakraborty, Shri Pradeep Mohan, Shri P.K. Dutta, Dr. J.K.N. Sharma.

Indian Expedition to Antarctica

The sole representative of NPL in the Indian scientific team which landed on Antarctica on 9 January 1982, Dr. Amitava Sen Gupta (Awardee), had in the past contributed to the development of time and frequency programme of the Laboratory. During the mission to Antarctica, he had the primary responsibility of undertaking experiments in radio communication under difficult and often adverse conditions. He undertook experiments on a wide variety of radio communication studies all along the cruise path and at near Antarctica; the experiments included measurements of time delay of standard frequency transmissions, of field strengths at a wide variety of frequencies, and Omega transmissions at very low frequencies.

Ph.Ds AWARDED

Awardee	Title of Thesis	University	Supervisors
J.N. Bohra (Scientist)	Characterisation of the pore structure of carbonized rayon yarn	Brunel University, UK	Prof. S. Brunauer, Prof. K.S.W. Sing, and Dr. S.S. Chari (NPL).
R.K. Aggarwal (Scientist)	Characteristics of carbon mixes	Meerut University	Dr. G.C. Jain (NPL), and Dr.A.N. Pandey.
Suresh Chand (Scientist)	Charge storage and transport phenomena in pure and doped PVF_2 and PVF films.	Delhi University	Dr. A.R. Verma (NPL), and Dr. P.C. Mehendru (NPL).
N.P. Gupta (UGC Fellow)	Electrical, dielectric and optical studies in organic polymers.	Meerut University	Dr. P.C. Mehendru (NPL), and Dr. V.K. Agarwal.
Saji Salkalachen (Res. Fellow)	Studies of the photoelectronic properties of composit copper sulphide thin films in CdS:Cu_2S solar cells.	Delhi University	Some aspects of work carried out at NPL under the guidance of Dr. V.G.Bhide

OTHER HONOURS & AWARDS

1. Dr. A.R. Verma, Director, NPL was awarded the 'Padma Bhushan' for his contributions to science and technology.
2. International Union of Radio Science (URSI)
   i) Dr. A.P. Mitra was re-elected as Vice-President for a second three-year term.
   ii) Dr. A.K. Saha was elected as a member of the Ionospheric Network Advisory Group (INAC).
3. Indian Middle Atmosphere Programme (IMAP) (1982-85)
   i) Dr. A.P. Mitra was nominated as Chairman, Scientific Advisory Committee.
   ii) Dr. Y.V. Somayajulu was nominated as a Member, Scientific Advisory Committee.
   iii) Dr. A.K. Saha was nominated as a Coordinator for the Working Group on 'Minor Constituents & Atmospheric Chemistry'.
4. Dr. V.G. Bhide, Scientist (Director's Grade) was elected as the Director of the International Solar Energy Society.
5. Dr. B.M. Reddy was elected as Vice-Chairman of the URSI Working Group on "Ionospheric Knowledge Needed to Improve Radio Communications".
6. Dr. Krishan Lal was invited to act as a Consultant to the Commission on Crystal Growth and Material Characterization of the International Union of Crystallography.
7. Dr. P.C. Kothari, Shri H.M. Bhatnagar, Dr. V.K. Agrawal and Dr. K. Chandra won the J.C. Bose Memorial Award for their research paper entitled "A feed-through microwave power measuring transfer standard at 10.0 GHz" published in Journal of the Institution of Electronics and Telecommunication Engineers, Vol 26 (1980) 579-83 .
8. In the exhibitions on alternative sources of energy held at Amethi (Uttar Pradesh) and Jais, Rai Bareilley (Uttar Pradesh), NPL's displays were adjudged first and second, respectively. The items put on display at the two exhibitions included (i) Domestic Solar Water Heating System, (ii) Solar Still and (iii) Variety of Solar Collectors, as also some photographs of solar grain drier and solar cookers etc.

SIGNIFICANT EVENTS

1. *Appointment of Dr A.P. Mitra as Director, NPL*

Dr A.R. Verma, retired as Director, NPL on 31st March 1982 after about 17 years of distinguished service to the Laboratory in this capacity. In his place, Dr A.P. Mitra assumed charge as the Director of the Laboratory with effect from 1st April 1982.

2. *Expedition to the Antarctica*

NPL, through its scientist Dr Amitava Sen Gupta, participated in the Indian expedition to the Antarctica. The role assigned to the Laboratory was to conduct radio propagation and communication studies both enroute as also while on the continent. These experiments included (i) VLF propagation studies, (ii) HF propagation time delay, (iii) VHF long distance propagation, (iv) Measurement of the HF radio noise level and (v) Communication experiments.

Monitoring of the signals from the NPL's standard time broadcast under the call sign 'ATA' was done periodically. It was found that the signal was very well received in the Arabian Sea and the Indian Ocean upto the equator. The reception continued on 15MHz upto about 10^{o}S. On a few occasions the ATA signals on 15 MHz were heard at Mauritius (20^{o}S).

3. *NPL Science Week*

NPL observed 21-25 September 1981 as a Science Week to celebrate the 60th Birthday of Dr Ajit Ram Verma, Director, NPL. The highlights of this were:

   i) A lecture on 'Physics and Reality' by Prof. D.S. Kothari, Chancellor, Jawahar Lal Nehru University on 21 September,1981.Prof M G K Menon presided over this function.
   ii) Presentation on major achievements of NPL during the last decade, by the senior NPL scientists.
   iii) Release of the special volume on 'Crystallography', brought out by the PID as a special issue (Vol 19, No 9, September 1981), of the Indian Journal of Pure and Applied Physics, in association with the Indian National Science Academy, New Delhi. It carries 20 invited articles by eminent crystallographers from India and abroad, covering different aspects of crystallography. The volume was released by Prof. S. Nurul Hasan, Vice President, CSIR, on 21 Sept. 1981. The coordination work was done by Dr Krishan Lal of NPL.

Special popular lectures were delivered by Prof. D.S. Kothari on the nature of force fields, and by Dr A R Verma on monomolecular films, for the

benefit of the young science students on the 22nd September, 1981.

A special feature of the Science Week was that the NCERT's National Science Talent Scholars studying in M.Sc. Physics at the various universities were specially invited at NPL-expense to stay for the week and visit various activities of the Laboratory. In addition to them, one young Ph.D.,winner of the INSA medal award was also invited to spend this week at the NPL. Students from the University of Delhi and other educational institutions also attended the lectures.

Dr G S Sidhu, DGSIR presided over the function on the 22nd September, and also declared the Laboratory open to the public till 25 September 1981.

Screening of films and slides on the NPL activities; display of video tapes of scientific matters on TV monitors; periodic planetarium shows with commentaries; and exhibition of equipment, instruments, devices, photographs etc. depicting the activities and achievements of the Laboratory, constituted other attractions.

4. Dr V G Bhide

Dr V G Bhide, Scientist (Director's Grade) took voluntary retirement from NPL on 31 December 1981 to join as Chairman, Energy Studies, University of Poona, Pune.

5. Test, Evaluation & Calibration Centre.

The Test, Evaluation and Calibration Centre of the Laboratory which had been set up at the NPL with financial support from the Department of Electronics to (i) act as a national laboratory facility for environmental testing, calibration and evaluation of electronic and electrical products, and (ii) operate field exposure stations and to carry out studies in tropicalization, was taken over by the Department of Electronics, and was shifted to its new site in Okhla Industrial Area. Dr. R.P. Wadhwa, Scientist-in-charge of the Centre, and some other scientists were released on deputation to help the Department of Electronics in setting up the Centre, now termed as the Electronics Regional Testing Laboratory (North).

PATENTS FIELD, ACCEPTED AND SEALED IN INDIA DURING THE PERIOD 1.4.1981 to 31.3.1982

(A) Indian Patents Filed :

Sl No	Application No.	Date of Filing	Title	Inventors
1	358/DEL/81	4.6.1981	Process for coating of solar cell with anti-reflection film	Dr A. Prasad Mrs. S. Balakrishnan Dr. S.K. Jain Dr. S.N. Singh
2	408/DEL/81	25.6.1981	An improved diffusion boat for simultaneous diffusion of P & N dopants into silicon wafers	Dr. S.N. Singh Mr. N.K. Arora Dr. A. Prasad Dr. G.C. Jain Mr. V.K. Sharda
3	821/DEL/81	31.12.1981	Improved process for the manufacture of carbon fibres from polyacrylonitrile fibres (This is a further improvement over the sealed patent under the same title bearing specification No.146912)	Dr. G.C. Jain Dr. O.P. Bahl Dr. L.M. Manocha Dr. R.B. Mathur Mr. S.S. Hanspal
4	51/DEL/82	23.1.1982	Process for in-situ preparation of indelible ink for making a permanent identification mark on a substrate	Dr. P.K. Gupta Mr. B.G. Mathur Dr.(Mrs.) Vasantha Raman

(B) Indian Patents Accepted :

Complete Specification Number	Application Number	Date of Acceptance	Title of the Patent at Acceptance	Inventors
148663	474/DEL/78	2.5.1981	A powder sprayer	Dr. D.C. Parashar Mr. Narendra Kumar Mr. V.K. Bahl Mr. J.R. Anand

(C) Indian Patents Sealed :

Complete Specification Number	Application Number	Date of Sealing	Title of the Patent at Acceptance	Inventors
148429	520/DEL/78	3.10.1981	A process for making photo receptors to be used in electrophotography	Dr. P.C. Mehendru Dr. S. Radhakrishnan Dr. N.L. Pathak Dr. M.N.Kamalasanan
148663	474/DEL/78	26.12.1981	A powder sprayer for spraying air borne powder material on earthed objects	Dr. D.C. Parashar Mr. Narendra Kumar Mr. V.K. Bahl Mr. J.R. Anand
146912	192/DEL/77	8. 1.1982	Improved process for the manufacture of carbon fibres from polyacrylo-nitrile fibres	Dr. O.P. Bahl Dr. L.M. Manocha

PROCESSES RELEASED FOR COMMERCIALIZATION DURING 1981-82

Sl No	Process Title	Party	Terms of Release		
			Premium Rs.	Royalty	Nature of Licence
1.	Colour Coatings of the Sun Glasses	M/s KVR Optical Industries, Jamshedpur	5,000	3.5%	Non-Exclusive
2.	Silver Impregnated Graphite Contacts for Relays	M/s Jyoti Refinery, Bombay	15,000	5%	Non-Exclusive for 10 years
3.	Construction Technique for Ceramic Enclosed Sensors for Industrial Platinum Resistance Thermometers	1) Process Control, Roorkee	3,500	2.5%	Non-Exclusive for 10 years
		2) M/s R J Industrial Corporation, Roorkee	3,500	2.5%	Non-Exclusive for 10 years

PROCESSES THAT WENT INTO PRODUCTION DURING 1981-82

Sl No	Process Title	Party	Years of Release	Terms of Release		
				Premium Rs.	Royalty	Nature of Licence
1.	Constant Stress Viscometer	M/s Associated Instruments Manufacturers (India) Ltd., New Delhi	1971	2,000	2.5%	Non-Exclusive
2.	Midget Electrodes	M/s Shreyas Engineering & Chemical Industries Ltd., Mysore	1975	10,000	3%	Non-Exclusive
3.	Film Thickness Monitor	M/s Vacuum Instruments Co. Ltd., New Delhi	1978	2,000	7%	Non-Exclusive for 14 years

SYMPOSIA/SEMINARS/TRAINING COURSES

INTERNATIONAL

An International School on Synthesis Crystal Growth and Characterisation of Materials for Energy Conversion and Storage was held at the NPL during October 12-23, 1981. The Commission on Crystal Growth of the International Union of Crystallography (IUCr) had invited Dr Krishan Lal to organise this School at the NPL. Dr G S Sidhu, DGSIR and Secretary to the Government of India, inaugurated the School. The IUCr announced the School in honour of Dr Ajit Ram Verma's 60th birthday.

Twenty-eight eminent scientists delivered sixty lectures covering different topics of current interest in this area. 18 of the speakers were from abroad covering countries in Europe, USA and Japan. 140 scientists were registered participants of the School. 11 of these were from abroad. Besides the scientific programme, a special lecture by Prof. D.S. Kothari on 'Physics and Reality' was also organised during the School. Cultural programmes were also organised on this occasion. Proceedings of the School are being published by North-Holland Publishing Co., Amsterdam, jointly with the NPL.

NATIONAL

1. A training course on Recent Advances in NDT of Materials was organised in collaboration with the Delhi Productivity Council on 16-18 September 1981, at Maurya Hotel, New Delhi.

2. The Sixth National Symposium on Cryogenics (SNSC-81) was held at the NPL on 27-28 January 1982. It was followed by a Workshop on 'Applications of Cryogenics in Medicine, Surgery, and Agriculture and Life Sciences' on 29 January 1982. An exhibition of cryogenic instruments and equipment manufactured in the country was also arranged on this occasion.

3. The Second National Symposium on Ultrasonics (NSU-82) was held at the NPL on 23-24 February 1982. It was attended by about 200 delegates and 42 papers were presented. An exhibition of ultrasonic instruments manufactured by various firms was also arranged on this occasion.

4. A Refresher Course on Activated Carbons was held at the NPL in March 1982. This was organised by the Indian Carbon Society. About twenty participants from industry and research institutions attended.

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DEPUTATION ABROAD

(AF)-Air Fair
(LH)-Local Hospitality

Name of Scientist	Period of Deputation	Countries visited	Purpose of Visit & Scheme/Programme	Agency funding the visit
1	2	3	4	5
Dr.B.K. Agarwala	Aug.-Sept. 1981	UK,USA,FRG & Japan	Tour of leading countries of research and development and concerned industrial houses to study the latest advancement in hydrostatic extrusion and material synthesis, and to identify experts & institutions who could assist in the development work of the UNDP Project on Pilot & Demonstration Plant in Hydrostatic Extrusion & Material Synthesis.	UNDP
Dr.B.K. Agarwala	20-27 Nov. 1981	Indonesia	For participation in the Workshop of Directors of Metallic Industries in Developing Countries	RCTT of CSGAP, Bangalore
	28-29 Nov. 1981	Singapore	To visit Department of Mechanical Engineering, University of Singapore	CSIR (NPL)
Mrs. Santosh Aggarwal	29 June-6 Oct 1981	Czechoslovakia	To study the techniques of data collection, scaling and interpretation in terms of radio communication parameters, at the Regional Warning Centre, Prague, under CSIR-CSAV Exchange Programme for Solar and Ionospheric studies.	(AF)-CSIR (NPL) (LH)-Czechoslovakia
Dr.(Mrs.)S.Z. Ali	16-25 Aug.1981 & 7Sep.-11 Oct.1981	Canada France	To participate in the 12th Congress of the International Union of Crystallography, Ottawa. To see the X-ray work and have discussion on Crystal Defects at a) University of Paris, and b) Crystallographic Laboratory of the CNRS, Grenoble under CSIR-CNRS Exchange Programme.	CSIR (NPL) (LH) - CNRS
Dr.O.P.Bahl	Sep.1981-Mar.1982	Brazil	UN Assignment as Chief Technical Adviser to Centro Technico Aerospacial, Brazil, on Carbon Fibres.	UNIDO
Dr.V.G.Khide	Aug.1981	UK & France	Solar Energy Research at CNRS	(AF)-CSIR (NPL) (LH) - French Government
Dr.V.N. Bindal	28 June-4 Aug.1981	England	(i) To attend (a) the 'Ultrasonics International-81 Conference & Exhibition', Brighton,(30 June-2 July), (b) Tenth L.H. Gray Memorial Conference on 'Biological Action of Radiofrequency, Microwave and Ultrasonic Radiations',Oxford (13-16 July), Radiations', Oxford (13-16 July), and (c) 'Acoustic Emission & Photoacoustic Spectroscopy Meeting', Chelsea College (21-23 July); and (ii) To work with Dr. R.W.B.Stephens at Chelsea College of Technology, University of London.	(i) CSIR (NPL) (ii) Chelsea College

1	2	3	4	5
Dr.V.S. Tomar	1 Nov. 1981 to 4 July 1982	Japan	To gain experience in Josephson Voltage Standard, non-equilibirum superconductivity, DC SQUIDS etc., at ETL & University of Tsukuba, Japan, under INSA-JSPS Exchange Programme	INSA & JSPS
Dr.Tuhi Ram Tyagi	Nov. 1980 to Aug 1981	USA	To make a Satellite Radio Beacon Study of the Ionosphere, on invitation from the University of Illinois.	University of Illinois
Dr.A.R. Verma	8-20 June 1981	USA	To participate in the Second International Conference on Precision Measurements & Fundamental Constants at Gaithersburg, and to visit Pennsylvania and New Jersey.	CSIR (NPL)
Dr.A.R. Verma	27 Oct. to 3 Nov 1981	Japan	To attend the International Symposium on Metrology & Measurement Standards, and to visit the National Institute for Research in Materials, Tokyo.	Agency of International Science & Technology, Japan
Dr.R.S. Yadava	4-29 Oct 1981	USA	To aquaint with the microwave standards work at NBS, Boulder, under CSIR-NSF Exchange Programme.	(AF)- CSIR(NPL) (LH)- NSF Authorities
Dr. Kailash Chandra	21-23 Oct. 1981	Indonesia	To attend on behalf of India, the Fourth Meeting of the Steering Committee of the Asia/Pacific Metrology Programme of the Commonwealth Science Council	Commonwealth Science Council
Dr.N.D. Kataria	9 June 1980 to 15 Mar. 1982	FRG	To work on fabrication of small area tunnel junctions for voltage standard and SQUIDs at PTB, Braunschweig, under CSIR-DAAD Exchange Programme	(i) CSIR (NPL) (ii) GAES
Dr. Krishan Lal	9-28 Aug. 1981	i) USA	To visit and deliver lectures at the IBM Thomas J.Watson Research Centre & IBM East Fishkill Laboratory, New York	INSA & CSIR
		ii) Canada	To participate in the 12th Congress of International Union of Crystallography, Ottawa, and to attend meeting of the International Steering Committee of 'International School on Synthesis, Crystal Growth & Characterization of Materials for Energy Conversion & Storage'	
Dr.B.S. Mathur	7 Sept. to 21 Oct. 1981.	i) Switzerland	To attend the meeting of the International Radio Consultation Committee (7-16 Sept.)	(AF)-CSIR(NPL) (LH)-Countries/ Laboratories visited.
		ii) France	(a) To visit laboratories on invitation (16-25 Sept.) and (b) to attend the third Symposium on Time & Frequency (12-16 Oct.)	
		iii) FRG	Visit to laboratories on invitation (26 Sept.- 11 Oct.)	
		iv) Italy	Visit to Laboratories on invitation (17-20 Oct.)	

1	2	3	4	5
Dr. P.C. Mehendru	6 Mar.to 4 Apr. 1982	Japan	To discuss the work being carried out in the fields of electrostatic precipitators at Prof. Masuda's Laboratory in Tokyo University, and on newer materials such as polymers, electrets etc. at Prof. Ieda's Laboratory in Nagoya University, under INSA-JSPS Exchange Programme	INSA & Japanese Society for Promotion of Science.
Dr.A.P. Mitra	24-30 May 1981	USA & Sweden	To attend the meetings of the Scientific Committee on Problems of the Environment (SCOPE), and General Assembly of URSI	URSI
Dr.A.P. Mitra	10-28 Aug. 1981	USA & FRG	To attend the 20th URSI General Assembly and the meeting of the International Association on Meteorology and Atmospheric Physics (IAMAP)	URSI & INSA
Dr.A.P. Mitra	Nov. 1981 (one week)	USSR	As a member of INSA delegation	INSA
Dr.A.V. Narlikar	15May to 13 July 1981	FRG	Visit to the Basic Physics Institute of the University of Karlsruhe to interact with Prof. W.Buckel in in the area of superconductivity - new mechanism, under CSIR-DAAD Exchange Programme	(AF)-CSIR (NPL) (LH)-University of Karlsruhe
Dr. M.N.M.Rao	22 Sept.1981 to 22 Feb. 1982	UK	To develop a temperature probe which can measure neutral temperature in the altitude range of 65-100 km, at the University College of Wales, under INSA-Royal Society Fellowship.	INSA & Royal Society, London
Dr.A.K.Saha	10-24 Aug.1981	USA	To attend 20th URSI General Assembly at Washington D.C., (Aug 10-19), and to visit NASA	INSA & CSIR (NPL)
Dr.Debabrata Sen	16-28 Nov.1981	Italy	To attend a Workshop on Quantum Metrology and Fundamental Constants.	(AF)-CSIR(NPL) (LH)-Organizing Committee of the Workshop.
Dr.Amitava Sen Gupta	10-26 Aug.1981 i)	USA	To attent URSI Meeting, and to visit USNO and NBS Laboratories.	(AF)-URSI & INSA Other Expenses CSIR (NPL) & COSTED
	ii)	UK	Visit to NPL, Teddington.	
Dr.R.G. Sharma	1 Feb. to 15 Aug 1981	Finland	To work on Superfluid ^{3}He - Ultra low temperature Josephson, at the Low Temperature Laboratory, Helsinki, University of Technology, Under Finnish Fellowship.	(AF)- Low Temperature Laboratory (LH)-Finnish Government
	15 Aug to 10 Sept.1981	USSR	To work on superconducting materials in Kapitza's Institute, under Indo-Soviet Collaborative Programme.	(LH)- USSR Academy of Sciences
Dr.S.K. Sharma	5-23 Oct.1981	Japan	Training at JEOL Factory in Tokyo for the operation of scanning electron microscope, and WDS attachments.	M/s JEOL,Japan & M/s Toshniwal Bros (P)Ltd., New Delhi.
	Oct. to Nov.1981	USA	Training at Kevex Corporation, California, for operation of EDS.	

1 Portion of Materials Division

COLLABORATION WITH OTHER AGENCIES/INSTITUTIONS

(Includes Programmes Supported by Outside Agencies)

2 Dr.K.Lal.

Sl. No.	Group/Project Activity	Collaboration/Programme	Nature of Collaboration
1	2	3	4
		A. DIVISION OF STANDARDS	
	International		
A.1.	Standards- Various Groups.	i) Asia/Pecific Metrology Programme. ii) Indo-Soviet Collaboration Programme.	The Laboratory took part in international intercomparisons of standards of physical measurements. During the year, travelling standards of mass, time and frequency, illuminance, dc voltage, hf voltage, and standard microphone were calibrated at the NPL under these programmes.
A.2.	Standards of Mass, Volume and Density.	i) Weights & Measures Department, Trinidad. ii) Weights & Measures Department Tobago.	Advice was given on testing of precision balances, calibration of weights, volumetric measures and hydrometers.
A.3.	Standards of Pressure and Vacuum.	National Bureau of Standards, USA.	Establishment of pressure and vacuum standards.
	National		
A.4.	Calibration.	Programme on National Coordination of Testing and Calibration Facilities, coordinated by the Department of Science & Technology.	Department of Science & Technlology is providing financial support for setting up a National Calibration Service Cell at the NPL.
A.5.	Electrical & Electronic Standards.	Department of Electronics (DOE).	DOE is providing financial support for augmentation of the primary electrical & electronic standards at the NPL.
A.6.	Standards of Mass, Volume and Density.	i) Directorate of Weights and Measures, Government of India. ii) State Departments of Weights and Measures.	Advice was given on selection of equipment for Regional Reference Standard Laboratories. Advanced training in metrology was given to three weights and Measures Officers.
A.7.	Standards of Accustical Parameters.	i) Central Food Technological Research Institute. ii) Border Security Force Academy.	Auditoria were examined and corrective measures recommended.
		iii) Central Public Works Department, New Delhi.	Lectures on acoustical measurements and acoustic materials were delivered at a referesher course for architects and engineers.
		iv) Archaeological Survey of India.	Measurements were made on Noise & Vibration due to aircrafts flying over buildings during landing and take-off.
		v) Rashtrapati Bhawan, New Delhi.	Measurements were made in Ashoka Hotel to quantify the adverse acoustic environment and improve the listening condition.

1	2	3	4
		vi) Administrative Training Institute, Nainital.	Acoustic design of the Institute's auditorium was worked out.
A.8.	Vacuum Standards.	i) Central Scientific Instruments Organisation, Chandigarh.	NPL has been assigned the task of developing vacuum systems for Scanning electron microscope.
		ii) Central Electronics Engineering Research Institute, Pilani.	
		iii) Banaras Hindu University, Varanasi.	
		iv) Central Electronics Ltd., Sahibabad.	
		These four agencies and the NPL are having a callaborative programme on development of scanning electron microscope, coordinated and financially supported by the Department of Science & Technology.	
		B. DIVISION OF MATERIALS	
National			
B.1	Carbon Fibres	Setting up of an experimental pilot plant facility for processing of carbon fibres.	Department of Science & Technology is providing financial support for the project.
B.2	Development of Carbon Products using Pitch Coke.	Evaluation of Pitch as a Resin for Carbon-Carbon Composites; Silane Coupling Agents	This forms a part of a multi-institutional project on Development of Resins, Moulding Compounds, Curing Agents etc. for use in Composite Industry, coordinated and financially supported by the Department of Science & Technology
B.3.	Ferrites & Conducting Ceramics.	i) Bhabha Atomic Research Centre, Bombay.	The variable Energy Cyclotron Project was supplied special ferrites as per their requirements as an import substitution effort.
		ii) Defence Metallurgical Research Laboratory, Hyderabad. (DMRL)	Evaluation of gamma ferric oxide received from DMRL.
		C. DIVISION OF SPECIALIZED TECHNIQUES	
International			
C.1.	Transmission and Scanning Electron Microscopy.	Department of Metallurgy, Centre for Nuclear Research, France.	Collaborative work on the study of voids and their growth in thin silver films.
C.2.	Characterisation of Porous Materials for Surface Area and Porosity.	Brunel University, UK.	Characterisation of Carbonized rayon yarn at the Brunel University.
C3	Growth of Single Crystals & Characterization of Single Crystals Regarding Perfection.	i) Physikalisch-Technische Bundesanstat, Braunschweig, Federal Republic of Germany (Professor Dr. V.Kose's Division)	Microstructural changes in semiconductors and insulators subject to high electric fields by triple and quadruple crystal X-ray diffractometers.
		ii) Institute for Technical Physics, (Hungarian Academy of Sciences), Budapest, Hungary, (Dr.L.Zsoldos's group)	Characterisation of defects in Crystal by X-ray topography and diffuse X-ray scattering methods.
		iii) Clarendon Laboratories, Oxford University, Oxford, U.K. (Dr.B.M.Wanklyn's group on Crystal Growth).	Characterisation of flux grown crystals by X-ray diffraction topography.

1	2	3	4
		iv) Institute of Meterology, Goss Standart, Moscow, USSR.	On 'Properties of Materials and Physical Constants' being coordinated by the Indian Standards Institution, New Delhi.
		v) Institute of Crystallography, Moscow, USSR.	On 'Crystal Growth and Lattice Imperfections' being coordinated by the Indian National Science Academy, New Delhi.
C.4.	Modular Automatic Multi-purpose Solvent Extractor.	Georgia University, USA.	Collaboration work was started on nematicidal characteristics of groundnut skin extract on pigs.
National			
C.5.	Chemical Analysis.	i) Geological Department, Jawaharlal Nehru University, Delhi.	Analysis of rock samples.
		ii) Lady Irwin College, Delhi.	Analysis of metals in food extracts.
C.6.	Transmission and Scanning Electron Microscopy.	Physics Department, University of Delhi.	Collaborative work on study of microstructure of tin, Ge, and Ge covered tin films.
C.7.	Growth of Single Crystals & Characterization of Single Crystals for Perfection.		Several crystals have been supplied to scientists in universities and other institutions for research in solid state physics and material science. Physics Department of the Banaras Hindu University, Varanasi, and the Indian Institute of Science, Bangalore, have also been rendered help in characterization of crystals regarding perfection.
C.8.	Infrared Spectroscopy and Spectrochemical Analysis.	i) Dairy Technology Division, Indian Dairy Research Institute, Karnal.	Nearly 200 samples of icecream mix and milk powders in different proportions were analysed by infrared spectroscopy, with the objective of finding out interaction between different constituents to yield efficient cream mix powders.
		ii) Chemistry Department, Allahabad University	Nearly 300 soil samples were analysed by infrared spectroscopy for Ph.D. work of a student.
		iii) Physics Department, Banaras Hindu University, Varanasi.	Photoacoustic & infrared spectroscopic facilities were extended.
C.9.	Infrared Detectors & Systems.	i) Physics Department, University of Delhi.	Two Ph.D. students were given the necessary help regarding group theoretical calculations of infrared and Raman frequencies in the study of ferroelectric properties of TGS and KLP and measurements.
C.10.	Infrared Detectors & Systems. Jointly with Electronics Service Unit	i) Central Electronic Ltd., Sahibabad, (CEL).	An engineering model of hot axle detection system based on the laboratory model will be developed by the CEL in collaboration with NPL. The project is supported by the Department of Science & Technology.
		ii) Bharat Heavy Electricals Ltd., Bhopal (BHEL).	Development of system for the temperature measurement on traction motor in collaboration with BHEL.

1	2	3	4
C.11.	Modular Automatic Multi-purpose Solvent Extractor.	Indian Agricultural Research Institute, Delhi.	Collaboration work was started on nematicidal characteristics of the groundnut skin extract.
		D. DIVISION OF RADIO SCIENCE	
National			
D.1	Rocket, Satellite and Balloon Experiments.	i) Usmania University, Hyderabad ii) Indian Institute of Science, Bangalore. iii) ISRO Rocket Range at Sriharikota (SHAR). iv) Regional Engineering College, Warangal.	Study of medium scale irregularities.
D.2	Tropospheric & Ionospheric Communications.	i) Anomalous Microwave Propagation & Prediction of Radar Performance over India.	Department of Electronics is providing financial support for the project.
		ii) Defence R&D Organisation, Directorate of Electronics, Ministry of Defence.	Research & Training Scheme with financial support provided by Defence.
		iii) Institute of Radio Physics and Electronics, Calcutta University.	Monitoring of civil aviation microwave links.
		iv) Srivenkateswara University, Tirupati.	Monitoring of Madras - Tirupati P & T microwave link.
		v) Regional Engineering College, Warangal.	Monitoring of Hyderabad - Vijayawada microwave link.
		vi) Punjabi University, Patiala.	Study of anomalous VHF propagation.
		vii) All India Radio. viii) Department of Post & Telegraphs, New Delhi.	Study of VHF communication problems in digital communication.
		ix) RCPO, New Delhi.	Radar Communication.
		E. HIGH PRESSURE TECHNOLOGY	
International			
E.1.	Pilot and Demonstration Plant in Hydrostatic Extrusion & Material Synthesis.	Tokyo Institute of Technology, Japan.	Prof. A. Sawaoka visited NPL to advise on the programme of developing c-BN compacts.
		F. APPLIED PHYSICS PROJECTS	
National			
F.1.	Thin Films and Amorphous Materials.	i) Space Application Centre, Trivandrum.	Advice was given on the design of a dichroic beam splitter for the multi-spectral camera system being developed for the infrared remote sensing satellites.
		ii) Indian Space Research Organization.	Supply of sophistical optical coatings.
		iii) Hindustan Aeronautics Ltd. Nasik.	
F.2.	Electrostatics & Electrophotography.	i) All India Institute of Medical Sciences, New Delhi. ii) Dr. Ram Manohar Lohia Hospital New Delhi. iii) National Tuberculosis Institute, Bangalore.	Collaboration in development of xeroradiography.

1	2	3	4
		iv) Indian Council of Medical Research, New Delhi.	
		v) World Health Organisation, New Delhi.	
		vi) M/s Advani-Oerlikon Ltd., Bombay.	Development of electrophotographic machines.
		vii) M/s Modi-Xerox Machines, Modinagar.	
		viii) Indian Institute of Technology, New Delhi.	Development of new materials for electrophotography.
		ix) Meerut University, Meerut.	
		x) National Environmental Engineering Research Institute, Nagpur.	Development of electrostatic dust collectors.
		xi) Central Mechanical Engineering Research Institute, Durgapur.	
		xii) Bharat Heavy Electricals Ltd., Hyderabad.	
F.3	Development of Display Devices.	Department of Electronics (DOE).	DOE is providing financial support for development of (i) Electrochromic Display Devices, & (ii) Coloured Liquid Crystal Display Devices.
		G. CRYOGENICS & SUPERCONDUCTIVITY	
National			
G.1	Cryogenic Plants & Facilities.	Department of Electronics. (DOE)	A project on 'Development and Production of Small Powders for Variety of Ceramics, using Cryo chemical and spray Drying Techniques' with financial support from DOE.
G.2.	Superconductivity, Superconducting Materials, Systems & Devices.	Department of Science & Technology.	The Phase II of a project on Structure and Properties of A-15 Superconductors, in continuation with the first phase, has been taken up with financial support from the Department of Science and Technology.
		H. SOLAR ENERGY	
International			
H.1.	Thin Film CdS Solar Cells	i) Bulgarian Academy of Sciences, Bulgaria.	Exchange of scientists.
		ii) University of Stuttgart, West Germany.	
National			
H.2.	Solar Energy - Thermal Conversion.	Department of Science & Technology.	DST is providing financial support for projects on (i) Development of Flat Plate Solar Collectors suitable for Delivering Hot Water at 60°C, and 9ii) Setting up of Test Facilities for Solar Collectors.
H.3.	Thin Film CdS Solar Cells.	i) Tata Energy Research Institute, Bombay, (TERI).	TERI is providing financial support for a project on development of CdS-Cu_2S Solar Cells.
		ii) Physics Department, University of Rajasthan, Jaipur.	Training to researchers.
		iii) Physics Department, University of Kashmir, Srinagar	
		iv) Birla Institute of Technology & Science, Pilani.	Assistance in project work of engineering students.

SCIENTIFIC & TECHNICAL STAFF OF THE RANK OF SCIENTIST 'A' OR EQUIVALENT AND ABOVE (As on 1.4.1982)

Designation (As per New Nomenclature)	Engaged in		Total
	R&D	Infra-structural Activities	
Director	1	-	1
Scientist (Director's Grade)	1	-	1
Scientist 'F'	2	-	2
Scientist 'EII'	16	-	16
Scientist 'EI'	22	1	23
Scientist 'C'/Engineer 'C'	68	1	69
Technical Officer (C)	9	2	11
Workshop Superintendent (C)	-	1	1
Library Officer (C)	-	1	1
Documentation Officer(C)	-	1	1
Information Officer (C)	-	1	1
Industrial Liaison Officer (C)	-	1	1
Scientist 'B'/Engineer 'B'	84	1	85
Technical Officer (B)	21	-	21
Technical Officer (B) (Glass Blowing)	-	4	4
Documentation Officer(B)	-	1	1
Design Engineer (B)	1	-	1
Scientist 'A'	16	-	16
Technical Officer (A)	26	2	28
Refrigeration Engineer(A)	-	1	1
Electrical Engineer (A)	1	-	1
Civil Engineer (A)	-	2	2
Total	268	20	288

Note: Includes scheme posts, and also posts against which persons are on deputation to other organizations.

STAFF STRENGTH AS ON 1.4.1982*

Area of Activity		Scientific & Technical Staff		Administrative Staff		Other Supporting Technical Staff (Excluding Class IV)	Class IV Staff (Technical & Non-Technical)	Total Staff
		Officers	Assistants	Officers	Assistants & other Administrative Staff (Excluding Class IV)			
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)
(A) R&D Activities								
A.1	Standards	83	55	-	14	37	8	197
A.2	Materials	51	39	1	6	88	21	206
A.3	Specialized Techniques	31	12	1	5	12	5	66
A.4	Radio Science	43	23	3	9	17	5	100
A.5	High Pressure Technology	10	16	-	3	21	5	55
A.6	Applied Projects	29	14	-	2	13	2	60
A.7	Cryogenics & Superconductivity	21	10	-	3	11	-	45
	Total (A)	268	169	5	42	199	46	729
(B) Infrastructural Activities								
B.1	Technical Infrastructure	13	50	-	13	121	9	206
B.2	House Keeping—Technical Service	4	14	-	3	65	27	113
B.3	House Keeping—Administrative Services	3	2	12	107	26	133	283
	Total (B)	20	66	12	123	212	169	602
	Grand Total	288	235	17	165	411	215	1331

*Note : Includes scheme posts, and also posts against which persons are on deputation to other organisations.

ACTUAL EXPENDITURE DURING 1981-82

(Rs. in lakhs)

Budget-Head	Non-Plan			Plan	Grand Total
	NPL	TEC	Total (2)+(3)		
1	2	3	4	5	6
(A) RECURRING					
P1-Pay of Officers	35.000	0.374	35.374	4.530	39.904
P2-Pay of Establishment	43.893	1.512	45.405	2.338	47.743
P3-Allowances	74.998	1.777	76.775	12.427	89.202
P4-Contingencies	31.000	4.195	35.195	2.997	38.192
P6-Maintenance	3.495	-	3.495	-	3.495
P7-Chemicals, Apparatus & Equipment	28.950	0.409	29.359	16.000	45.359
Total Recurring(A)	217.336	8.267	225.603	38.292	263.895
(B) CAPITAL					
P5(1) - Works	-	-	-	9.060	9.060
P5(2)-Services	-	-	-	11.631	11.631
P5(3)- Apparatus & Equipment	25.665	-	25.665	109.762	135.427
P5(4)(i)- Furniture	-	-	-	0.977	0.977
P5(ii)- Library Books & Journals	8.200	-	8.200	-	8.200
P5(iii)- Vehicles	0.697	-	0.697	-	0.697
Total Capital (B)	34.562	-	34.562	131.430	165.992
Grand Total (A)+(B)	251.898	8.267	260.165	169.722	429.887

MEMBERSHIP OF THE RESEARCH ADVISORY COUNCIL
(12 February 1980 — 30 June 1982)

Dr B D Nag Chaudhuri, — Chairman
Saha Institute of Nuclear Physics,
92, Acharya Prafulla Chandra Road,
CALCUTTA 700009.

Dr N A Narasimham, — Member
Head, Spectroscopy Division,
Bhabha Atomic Research Centre,
Trombay
BOMBAY 400085

Dr S S Jha, — Member
Professor,
Tata Institute of Fundamental Research,
Dr Homi Bhabha Road,
Colaba,
BOMBAY 400005

Dr A K Gupta, — Member
Director General,
Indian Standards Institution,
Manak Bhavan,
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NEW DELHI 110002

Prof. A K De, — Member
Chief Controller (R&D),
Ministry of Defence,
Room No 204, C-Wing,
Sena Bhavan,
NEW DELHI 110011

Dr S Ramaseshan, — Member
Director,
Indian Institute of Science,
BANGALORE 560012

Maj.Gen.K K Mehta, PVSM(Retd.), — Member
Advisor (STQC),
Department of Electronics,
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Near Khan Market,
NEW DELHI 110003

Shri V Narayana Rao, — Member
Director,
Defence Electronics Research Laboratory,
Research & Development Organization,
Ministry of Defence,
HYDERABAD 500005.

Prof S N Mitra, — Member
Visiting Professor,
Department of Electronics &
Communication Engineering
University of Roorkee,
ROORKEE 247672 (UP)

Director General, — Member
Scientific & Industrial Research, — (Ex-officio)
OR his nominee

Director, — Member
NPL, New Delhi — (Ex-officio)

Chairman, — Member
Coordination Council for Physical & — (Ex-officio)
Earth Sciences Group of CSIR Laboratories

Dr R P Wadhwa*, — Member-Secretary
Scientist 'F',
NPL, New Delhi
(also a member of the Executive Committee, NPL)

Dr Krishnan Lal*,
Scientist 'E-II'
NPL, New Delhi
took over as Member-Secretary consequent upon Dr Wadhwa's deputation to the Department of Electronics.

MEMBERSHIP OF THE EXECUTIVE COMMITTEE
(12th February 1980 — 30 June 1981)

Dr A R Verma, — Chairman
Director,
National Physical Laboratory,
Hillside Road,
New Delhi 110012

Dr A K Gupta, Director General, Indian Standards Institution, 'Manak Bhavan' 9-Bahadur Shah Zafar Marg, New Delhi 110002	Member	Dr P C Mehendru, Scientist-E II National Physical Laboratory, Hillside Road, New Delhi 110012	Member
Maj.Gen. K K Mehta, PVSM (Retd.) Advisor (STQC), Department of Electronics, Lok Nayak Bhavan, 3rd Floor, Near Khan Market, New Delhi 110003.	Member	Sr Finanace & Accounts Officer, National Physical Laboratory, Hillside Road, New Delhi 110012.	Member
Dr N A Narasimham, Head, Spectroscopy Division, Bhabha Atomic Research Centre, Trombay, Bombay 400085	Member	Chairman, Coordination Council for Physical and Earth Sciences Group of CSIR Laboratories	Permanent Invitee
Dr. R.P. Wadhwa, Scientist-F, National Physical Laboratory, Hillside Road, New Delhi 110012	Member	Director General Scientific & Industrial Research, or His Nominee	Permanent Invitee
		Administrative Officer, National Physical Laboratory, Hillside Road, New Delhi 110012.	Member-Secretary

* Dr. Krishan Lal, Scientist-E II, National Physical Laboratory took over as Member consequent upon Dr. Wadhwa's deputation to the Department of Electronics.