NPL REPORT
1976

NATIONAL PHYSICAL LABORATORY
Hillside Road, New Delhi

CREDITS

Chairman, Library & Publication Committee	Krishan Lal
Compilation, Editing & Production	G K Arora S P Verma M G Goswami M K D Rao P N M Menon (PID)
Technical and Secretarial Assistance	S S Bhakri R C Dhawan Amar Nath Khural Inderjeet Taneja Ram Swaroop Joginder Singh
Cover Design	S K Das Gupta (PID)

National Physical Laboratory,
Hillside Road, New Delhi-110 012

Printed at ARUNA PRINTING PRESS, B-78, Naraina Industrial Area, Phase-II, New Delhi-110028.

CONTENTS

DIVISION OF STANDARDS

STANDARDS

One of the important objectives of the Laboratory is the establishment, maintenance and up-dating of the national standards of physical measurements at internationally accepted accuracies. This activity, which is a statutory obligation, demands continuous research on standards and on techniques of measurements, utilizing latest techniques, very close to the frontiers of knowledge.

The report presents the activities on the following standards :

(i) Length standards ;

(ii) Mass standards ;

(iii) Photometric and radiometric standards ;

(iv) Temperature standards ;

(v) Force standard ;

(vi) Low pressure and high pressure standards ;

(vii) Acoustical standards ;

(viii) Time and frequency standards ; and

(ix) Electrical and electronic standards.

CALIBRATION & TESTING

Another objective of the Laboratory attended to by this Division is the periodic calibration of standards of measuring instruments and equipment used by various governmental and other testing authorities, industries, Defence etc., against the national standards, and supply of standards to various agencies, to ensure uniform scientific, industrial and commercial measurements. As a corollary to this, the Division also undertakes the calibration of instruments and testing of industrial products and appliances for performance, life, and for effect of environmental conditions.

The report presents this activity under the following categories :

(i) Length metrology ;

(ii) Mass, volume and hydrometers ;

(iii) Photometry, colorimetry and radiometry ;

(iv) Heat ;

(v) Engineering materials ;

(vi) Low pressure and high pressure ;

(vii) Acoustics ;

(viii) DC calibration ;

(ix) AC & high frequency calibration ;

(x) Microwave calibration & testing ; and

(xi) Test, Evaluation & Calibration Centre.

1. STANDARDS

1.1 LENGTH STANDARDS

Scope and Objectives

(i) Maintenance and upgrading of the standard of length and its utilisation for standardization and for other precision linear measurements ; and

(ii) Research on improvement of the standard, and development of instruments and techniques for precision measurement of length.

The existing standard of length at the NPL is the National Prototype Metre which is a copy of the International Prototype Metre.

The technical objectives are :

(1) Periodic calibration of the Laboratory Standard Metres against the National Prototype Metre ;

(2) Development of iodine absorption stabilized He-Ne lasers and installation of Kr^{86} lamp, for use as primary standards ;

(3) Development of laser frequency inter-comparison system, for maintenance of the standards by frequency stability determination ;

(4) Development and calibration of He-Ne lasers stabilized at the peak of the power output curve, for use as transfer standard ;

(5) Development of an interference comparator and other measuring systems, for standardization of gauges in terms of the wavelengths of laser and Kr^{86} radiations ; and

(6) Development of longitudinal comparator.

Progress

For iodine absorption stablized He-Ne lasers, design and fabrication of the resonator system, gain tube, absorption cell and phase sensitive feed-back control system were completed, and assembly of the system was started. Plasma instabilities and noise of He-Ne laser tube were studied to determine the optimum excitation condition for frequency stabilization.

The design of a longitudinal comparator and fabrication of most of its components was completed.

Scattering of laser light by liquid crystals was examined for making a coherence spoiling device. New and interesting scattering properties were observed and investigated.

A Fourier transform spectro-radiometer was designed, and its fabrication was started in collaboration with the Photometric and Radiometric Standards Section.

1.2 MASS STANDARDS

Scope and Objectives

(i) Design and fabrication of 1 kg balances (including interchangeable pan balance) for the comparison of 1 kg standards against the National Prototype Kilogram with precision commensurate with the internationally accepted accuracies ;

(ii) Design and fabrication of weights in multiples and sub-multiples of 1 kg, and to establish their values in terms of the National Prototype Kilogram ;

(iii) Intercomparison of the NPL 1 kg standards against the standards of other nations ; and

(iv) Design and fabrication of other high precision balances, and to conduct research pertaining to weighing designs and development of standards of unit of mass.

Progress

1 kg Interchangeable Pan Balance: During the period under report, pattern for the base of the balance was given the final finish, and gun metal required for casting the base was obtained.

1 kg Modified Balance : Work on the installation of a modified 2 kg capacity Oertling balance, with initial sensitivity of 1 mg per division without lamp and scale, was continued, and the design of the weight changer was improved.

Fabrication of Standard Weights : The sample of the Niomonic-75 nickel-chromium alloy received from DMRL, Hyderabad, was found suitable for making standards of mass, and since the material was available in rods having sections upto 55 mm × 55 mm, it was decided to make 10 sets of weights from 1 g to 1 kg in the first instance.

Recalibration of Standard Weights: Ten 5 kg weights, nineteen 2 kg weights, and one set of weights from 1 mg to 100 g, were recalibrated during the period under report.

1.3 PHOTOMETRIC AND RADIOMETRIC STANDARDS

Scope and Objectives

Establishment and maintenance of scales for luminous intensity, luminous flux, colour temperature and reflectance standards.

The main objective is to bring all photometric, colorimetric and radiometric measures under a consistent measurement system, traceable to the national standards maintained at the NPL.

Status Prior to the Period Under Report

Units of candela and lumen were so far being maintained through a set of six lamps each, which were got calibrated from the BIPM in 1957-58 for luminous intensities at two temperatures and for luminous flux at two temperatures. The scale of distribution temperatures was being maintained in the range 2000 K to 3000 K through another set of calibrated lamps.

Progress

International intercomparison to take stock of the variations in the values of the units of candela and lumen was made. Activities were specially geared towards establishing standards based on radiometry and spectroradiometry in line with the recommendation of the Consultative Committee on Photometry and Radiometry of the CIPM made in September 1975.

An absolute radiometer based on electrically compensated radiometers, with thermopile and pyroelectric film as the transducers, was designed.

Work on photoelectric pyrometer was started for transferring the scale of distribution temperatures from one standard lamp to a working standard.

Preparation of working standards and laboratory standards of luminous intensity, luminous flux and colour temperature was continued, with special emphasis on working standards for a number of miniature lamps.

1.4 TEMPERATURE STANDARDS

Scope and Objectives

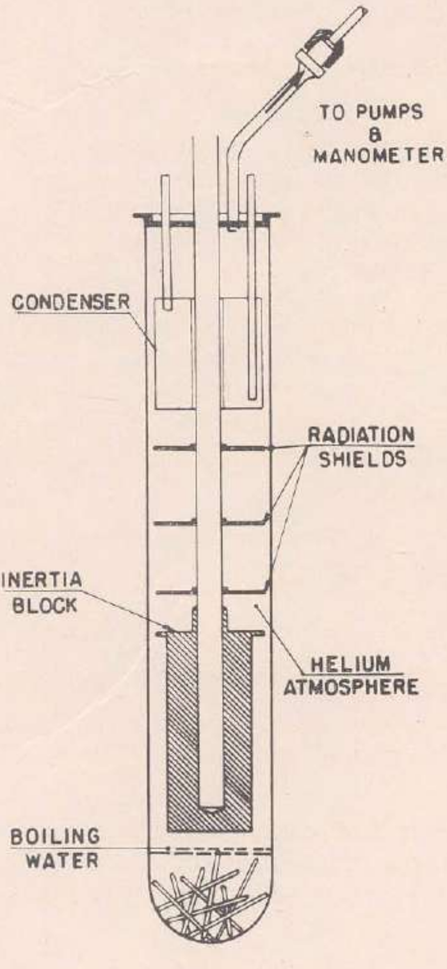
To realise the International Practical Temperature Scale 1968, or as it may stand amended under the authority of the General Conference on Weights and Measurures, Sèvres, France, for ensuring uniformity in temperature measurement in science and industry.

Progress

1.4.1 PLATINUM RESISTANCE THERMOMETRY (TEMP. RANGE 630°C TO -259°C)

Power Projects Engineering Division of the Department of Atomic Energy, Bombay, sponsored a programme on development of ceramic enclosed sensors. A few pieces were developed and sent to the Instrumentation Ltd., Kota for testing.

Some new standard platinum resistance thermometers were constructed and calibrated at the various fixed points. One such thermometer was



BOILING POINT APPARATUS

Fig 1 Water boiling point apparatus incorporating a heavy thermal inertia block and a radiation shield.

delivered to the CSIO, Chandigarh, and two were supplied to the Instrumentation Ltd., Kota.

Two new triple-point-of-water cells were constructed. A new apparatus for condensation point of steam (B P of water) was set up, incorporating a heavy thermal inertia block and a radiation shield to achieve better stability in temperature around the sensor of the platinum resistance thermometer (*Fig 1*). The continuous recorder (Linseis) and the precision pressure gauge (Texas), received as aid from the PTB, West Germany, were incorporated in the oxygen-point set-up. The cryostat for B P of oxygen and triple point of oxygen was redesigned.

1.4.2 Thermo-couple Thermometry (Temp. Range 630°C to 1064°C)

Both the wire method and the ingot method were perfected to realise the silver point. It was found that freshly drawn silver wire is good for realising the silver point, but when kept for a long time, it tarnishes, and the melting point may be lowered by 5°C to 10°C. However the ingot method gave reproducible results to within 1 μV (0.1°C). The wire method was set up to realise the gold point also.

A small thermo-couple annealing unit was fabricated. It incorporates AC electric current heating, with simultaneous facility for measurement of wire temperature in the range 0—450°C from the DC thermal emf generated in the thermo-couple. The arrangement is helpful for final annealing at 450°C for the platinum wire which cannot be seen by an optical pyrometer.

Drawing and design of a calibration bath for reversing thermometers was completed during the year.

1.4.3 Optical Pyrometry (Temp. Range 1064°C to 1800°C)

Work relating to the fabrication of photoelectric optical pyrometer was continued.

1.5 FORCE STANDARD

In order to verify material testing machines, force measuring instruments are required. These proving devices are to be calibrated at regular intervals.

The Laboratory maintains the unit of force 'Newton' to an accuracy of 4 in 10^5. A 3 ton dead-weight machine designed and developed at the Laboratory is used to calibrate testing machines for the industry and various R & D and other organisations. Beyond this, and upto 20,000 kgf, a universal testing machine modified at the Laboratory, using a hydraulic multiplication system of approximately 1 : 100 ratio, was established for calibration of devices at various steps of load with an accuracy of 0.1%.

With the fabrication of the measuring cylinder and some parts of the loading frame during the period under report, work relating to the development of a hydraulic multiplication system of 100,000 kgf (1 MN) registered significant progress. The system consists of a main cylinder assembly, a load frame, straining unit and measuring cylinder with a dead weight. The ratio of the areas of the two cylinders was about 300 and, as such, a multiplication factor of 300 was obtained. A test rig was also fabricated for testing the main cylinder assembly. The system was tested for 0.5 MN without any appreciable leakage of oil.

Work on setting up of a primary standard of force using a dead weight of 100 kN, together with 1 : 10 liver multiplication to get 1 MN was initiated. The equipment is being received as an aid from the PTB, West Germany. Construction of a special building to house this equipment was started.

1.6 LOW PRESSURE AND HIGH PRESSURE STANDARDS

Scope and Objectives

The emphasis, for the present, has mainly been on the establishment, maintenance and updating of standards for low pressures from one atmosphere down to 10^{-8} torr, and to undertake development of vacuum instruments and systems, with a view to help the vacuum instruments industry in upgrading the quality of their instruments. Scientific research in surface science and in allied fields forms another major objective of this activity.

Progress

During the period under report, a dynamic system for gauge calibration in the range 10^{-3} torr to 10^{-6} torr was fabricated, using the orifice method (*Fig 2*). The calibration gas purification system was also designed and fabricated and the associated flow measuring system was also designed.

Vacuum System for Scanning Electron Microscope : With the financial assistance offered by the Department of Science & Technology for the development of a scanning electron microscope—an inter-institutional project identified by the Coordination Council for the Physical & Earth Sciences Group of CSIR Laboratories—, the task of development of a high vacuum system for the instrument assigned to the Laboratory, received a boost. The design of the high vacuum system capable of producing a vacuum of 10^{-6} torr was completed, and the various components of the system were fabricated. Testing of these components was also

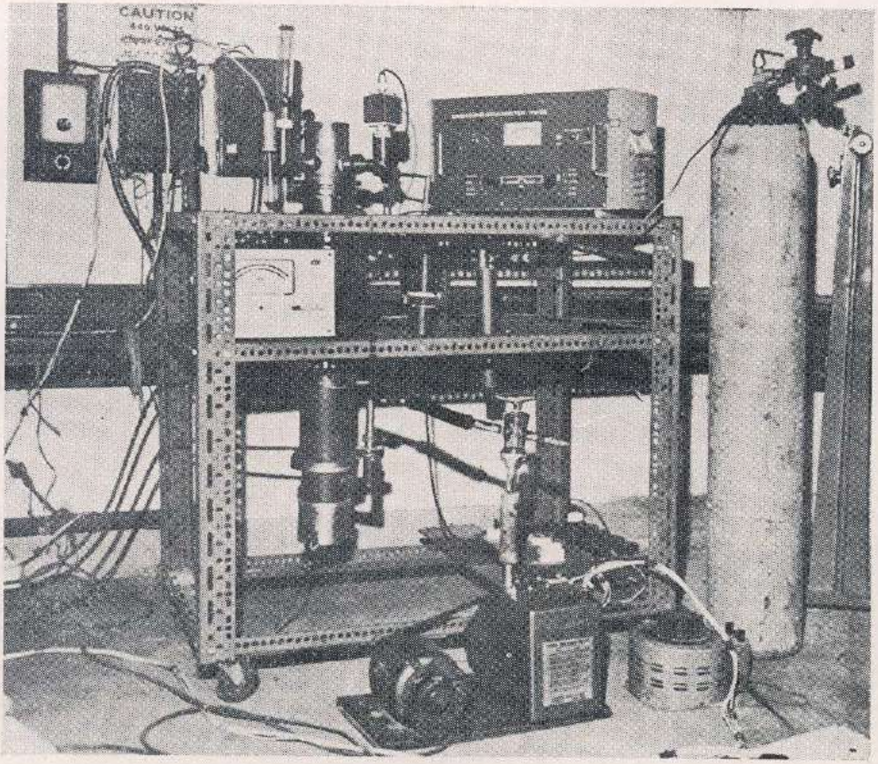


Fig 2 Set-up for calibration of gauges in the range 10^{-3} torr to 10^{-6} torr using the orifice method, fabricated and installed at the NPL.

undertaken, and initial attempts were made to make the system semi-automatic.

1.7 ACOUSTICAL STANDARDS

Scope and Objectives

To maintain primary/derived standards relating to measurements in acoustics such as sound pressure, vibration acceleration and displacement, hearing thresholds for air and bone conduction, and audio frequency voltage .

Progress

Standard replay chain for calibration of cassette tapes and cassette tape recorders was established.

Equipment for up-dating standards received as aid from the PTB, West Germany, was set up.

An investigation on the sensitivity and frequency response of piezo-ceramic phonograph cartridges under different load terminations was carried

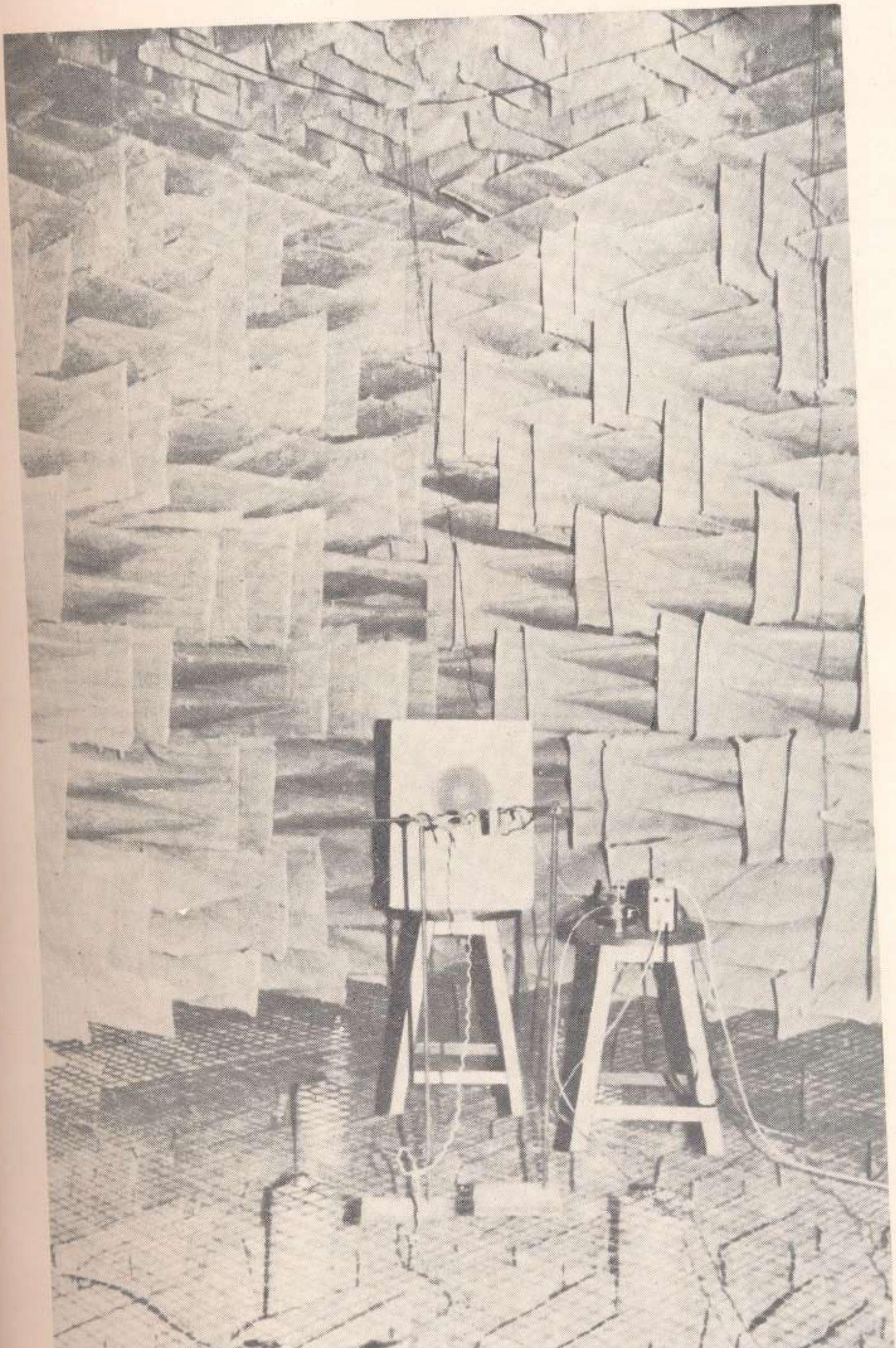


Fig 3 A view of the anechoic room with set-up for electro-acoustical measurements.

out for the ISI. The results were useful for laying down standards on the performance characteristics of such pick-ups.

In addition to the reverberation room commissioned in the previous year, the anechoic room was fully commissioned (*Fig 3*).

1.8 TIME AND FREQUENCY STANDARDS

Scope and Objectives

Updating and maintaining the base units of time and frequency, and disseminating standard time and frequency signals to the nation and the neighbouring countries, constitute the objectives of this activity. The aim is to have standard time and frequency broadcast round the clock at different frequencies, to increase the accuracy of transmission, and to develop atomic time standards.

Progress

Rubidium Vapour Atomic Standards : The Laboratory continued its effort on development of a laboratory model rubidium gas cell frequency standard in collaboration with the Advanced Centre of Electronics Systems, IIT, Kanpur.

Time & Frequency Dissemination Service : Since January 1975, NPL had been disseminating standard time and frequency signals under the call sign ATA from a 10 MHz (2kW peak envelope power) transmitter, for 6 hours per day on all working days, and these signals were directly based on the cesium atomic clock housed at the NPL. The power of transmission at 10 MHz had been increased to 8 kW (peak envelope power) in August 1975.

The year 1976, recorded the following more land marks in the process of further improvement of this service :

1 January 1976	Transmission on a second frequency of 15 MHz was also started on a powerful (8 kW peak envelope power) transmitter. The transmission time was increased from 6 hours per day to 8 hours per day on all working days.
1 April 1976	Transmission time was increased still further from 8 hours per day to 11 hours per day on all days excepting Sundays and gazetted holidays.
1 May 1976	Transmission was started for 4 hours per day on all Sundays and second Saturday of the month also.
15 September 1976	The set of quartz crystal oscillators of 100 kHz (accuracy better than 5 parts in 10^{10}), which had so far been used for transmission of time & frequency standards, were replaced by a commercial atomic cesium clock.
18 November 1976	Transmission on a third frequency of 5 MHz was also started.

Fig 4 gives a view of the Time & Frequency dissemination station of the NPL.

LF/VLF Monitoring : Intensive studies were initiated on LF/VLF monitoring with the help of a Tracor LF/VLF receiver model 599 K. VLF stations tracked were GBR (England) and NWC (Australia). The local frequency standards at the NPL were calibrated against GBR and NWC, and an accuracy of better than 1×10^{-9} was achieved. As a typical example, an HP 105 B oscillator as received had an accuracy of 5.43×10^{-9} (a

Fig 4 NPL transmits standard time and frequency signals under the call sign 'ATA' from its broadcasting station at Greater Kailash, for the benefit of Defence, Posts & Telegraph, All India Radio, Overseas Communication Service, Indian Space Research Organisation etc. A cesium atomic clock which has an accuracy of $\pm 7 \times 10^{-12}$ and a stability of $\pm 3 \times 10^{-12}$ has been installed, to meet the requirement for more accurate signals than was possible by the set of 100 kHz quartz crystal oscillators used earlier, and the signals are now broadcast for 11 hours per day at frequencies of 5 MHz, 10 MHz and 15 MHz. This service also caters to the requirement of other countries in the South and South-East Asia.

drift of 88 μ sec over an observation period of $4\frac{1}{2}$ hours). After settin against GBR, an accuracy of 5.16×10^{-10} (a drift of 13 μ sec over a observation period of 7 hours) was achieved.

Time Synchronisation : As a part of the time synchronisation programm development of a portable clock was taken up to calibrate clock which are far away from the NPL and cannot be either physically broug or otherwise linked to the NPL, for calibration.

Interface Logic Unit : A time link between the atomic cesium clock Greater Kailash, and the All India Radio 'Time-Pips', was establishe during the year.

Time Correction : The atomic clock of the NPL was stopped for a secon at the midnight of 31 December 1976, in order to bring the India Standard Time in unison with the other international times.

1.9 ELECTRICAL AND ELECTRONIC STANDARDS

Scope

The programme on establishment, maintenance and updating of th primary & transfer standards of various parameters such as voltag current, capacitance, inductance, power, attenuation, impedance, freque cy, noise etc., covering DC, AC, high frequency and microwave range was continued as an area of thrust. Nine rooms in the groun floor of the main building of the Laboratory were renovated to provid the prescribed environmental conditions of temperature, humidity, du and vibration-free atmosphere etc. The ten-year programme of work su mitted to the Electronics Commission for financial support was scruti zed by a Working Group on 'Guidelines for Funding Projects on Standa disation, Testing and Evaluation', set up by the Commission, and aft extensive discussions with this Working Group, the programme w approved, and an ad-hoc budget provision of Rs. 21.52 lakhs was made f capital equipment. Full details of the equipment were worked out, takin into account the traceability charts prepared for each parameter.

1.9.1 Standard of DC Voltage and Resistance

Objective

Realization of the national standard of electric current [ampere] b maintaining the national standards of electromotive force [volt] an electrical resistance [ohm]. This is achieved through :

(i) Mutual inter-comparison of emfs of the national bank of stab Weston cadmium cells, by measuring their differences with a vernie potentiometer to a precision of 1 part in 10^6 ; and

(ii) Mutual inter-comparison of resistances of the national bank of standard resistors by substitution method, and measuring their differences using modified Wheatstone shunt bridge housed in the same oil bath as the one containing the 1 ohm standard resistors, to an accuracy of 5 parts in 10^7.

These standards are internationally cross-checked from time to time to ensure their accuracies.

Progress

Twenty six sets of readings of one-ohm standard resistors and twenty six sets of readings of emf standard comprising of forty cadmium cells, were taken under controlled conditions of temperature.

1.9.2 Realization of the Unit of DC Voltage through Josephson Effect

Objective

To undertake work on Josephson Effect for realization of the unit of DC voltage, following the international trend.

Progress

Josephson junctions are very sensitive to magnetic field and also to a wide range of radio frequencies. A shielded room (3m $\times$ 2m $\times$ 2m) was therefore constructed. The outer walls of this room were covered with high permeability silicon steel sheets (μ = 2000 at 1 kHz). The inside lining was made of 1 mm thick copper sheets. The room was also provided with a shielded door arrangement with similar linings. Work on a cryostat for irradiation of SLUGS with microwaves in a waveguide under controlled conditions was initiated to study in detail the variation of critical current and step height with microwave frequency and power.

Work was also initiated to assemble a microwave system to generate X-band radiations and to couple it efficiently to the Josephson junctions.

This work pertains to the group working on Josephson tunnelling. (*See* Section 2.8 on pages 44-45).

1.9.3 Capacitance & Inductance Standards

Objective

To realise the unit of capacitance [Farad] based on the calculable capacitor, to realise primary unit of inductance [Henry] in terms of Farad, and to determine the absolute value of ohm from the calculable capacitor.

Progress

Work on the setting up of a horizontal type calculable capacitor based on Thomson Lampard theorem was initiated during the year. The value to be realised by the horizontal capacitor, conforming with the internatio practice, is 1pF with an accuracy of ± 1 part in 10^6.

A chamber for housing the standard was fabricated. This is evacuat by a rotary pump and a diffusion pump to get a vacuum of the ord of 0.03 torr which is sufficient for this purpose. Work relating to procur ment of precision reference grade bars, spacers and insulators etc. requir for the setting up of the standard, was started.

Facilities for calibration of capacitances and inductances in the frequen range 20 Hz to 10 kHz, were set up.

1.9.4 AC & High Frequency Standards

Objective

Development, maintenance and up-dating of AC and high frequenc standards for electrical parameters like voltage, current, power, attenua tion, impedance, frequency and noise etc. in the frequency range 30 H to 1000 MHz.

Progress

A transfer standard based on non-portable electro-dynamometer was s up for measurement of voltage (10 mV—1000 V), current (10 mA—5 A and power (1 mW—5kW) at 50 Hz. The measurement uncertainty fo voltage was established to be within ± 0.1%.

A set of working standards based on thermal voltage converter was fabri cated in the voltage range 100 mV to 100 V, for the frequency range 20 H to 10 MHz. The range of the existing set-up based on thermal converte was extended to 50 V upto 30 kHz with an accuracy of 0.2% to 0.5%.

Work on establishing transfer standard based on rf micropotentiomete (100 μV—100 mV), in the frequency range DC to 500 MHz, was initiated

Work on the development of Bolovac as the primary standard of HF Vo was started.

1.9.5 Microwave Standards

Objective

Development, maintenance, and up-dating of microwave standards o measurement for attenuation, power, impedance, frequency and noise.

Progress

Microwave Attenuation: Work on audio substitution technique wa carried out, and an accuracy of 0.02—0.05 db/10 db was established i the range 0 to 50 db. Facilities were established for calibration of microwave attenuators in co-axial and waveguide configurations upto 12.4 GHz in the range 0 to 40 db.

Microwave Power : Improvement of the accuracy of power measurement in X-band, using a DC self-balancing bridge procured from the NBS, USA, was continued. The overall accuracy of the system was estimated to be 1% to 2% in the range 2.6 GHz to 12.4 GHz, power being in the range 10 μW to 10 W.

Microwave Impedance : Standard reflectometry technique was established for measurement of return loss. The accuracy of return loss measurement achieved was 0.02—0.05 db/10 db in wave guides (8.2 GHz to 12.4 GHz) and coaxial lines (1.0 GHz to 12.4 GHz) for a range of return loss of 40 db. Perfect $\lambda/4$ short circuits for frequencies in the X-band were fabricated by electro-forming techniques. Development of some other precision fixed short circuits, moveable terminations and multi-stub tuners was started.

Microwave Frequency : Microwave frequency measurement facilities were established in the range 1.0 GHz to 18.0 GHz with the precision of 1 part in 10^{10}, traceable to the Cs atomic standard. Investigations on frequency locking of reflex klystrons in X and XN bands were initiated. Complete circuit diagrams of measurement set-ups to cover all microwave parameters were prepared, based on the traceability charts.

2. CALIBRATION & TESTING

2.1 LENGTH METROLOGY

Scope and Objectives

(i) Calibration of precision engineering gauges for linear, thread and angle measurement ;

(ii) Testing of measuring instruments, equipment, tools and materials for linear dimensions (length, angle, straightness, flatness, etc.) including prototype testing ;

(iii) Development of methods and instruments for calibration and testing ; and

(iv) Calibration and certification of standard length measures for the Directorate of Weights and Measures.

Facilities exist for making linear measurements to the accuracies detailed below :

(a) Line standards upto 1 metre length with precision of 0.5 μm ;

(b) End standards upto 4 metre length with precision of 1 μm per metre ;

(c) Length of smaller gauges upto 100 mm (slip gauges) in terms of wavelength of Hg^{198} radiations with accuracies ranging from ± 0.03 μm to ± 0.1 μm ;

(d) Testing of surface plates and straight edges for flatness in sizes of 100×100 mm^2 to 1000×1000 mm^2 as per standard specifications ;

(e) Various dimensional measurements including thread measurements involving precision finer than 0.01 mm ; and

(f) Angle measurement with precision of 1″.

Progress

Testing and calibration of secondary length standards, and of various types of engineering gauges and other products was undertaken. About 600 test reports were issued during the year 1976-77, and about Rs. 36,000 were realized as test fee.

Particular mention may be made of the calibration of the reference slip gauge set for CMTI, Bangalore, and reference standard metre bars for the Directorate of Weights and Measures. Based on this calibration, a new specification for the Reference Standard Metre Bar was drawn up, and it was accepted by the Directorate of Weights and Measures.

Calibration procedures for reference and secondary standard metre bars and for slip gauges were also drawn up.

An improved method was developed for calibration of camel-back type straight edges.

2.2 MASS, VOLUME AND HYDROMETERS

Scope and Objectives

(i) Testing and calibration of (a) precision weights including standards for Weights & Measures Enforcement Departments of the country, (b) volumetric glassware, (c) hydrometers of various types, and (d) butyrometers ;

(ii) Testing of balances and weighing machines ;

(iii) Supply of authenticated copies of standards of mass to the industry, research institutions and to the Departments of Legal Metrology; and

(iv) Supply of standard measures of capacity to the state departments for enforcement of weights and measures.

Progress

About 360 test reports were issued during the year 1976-77 and about Rs. 70,000 were realised as test fee.

Five balances used for calibration work were serviced and re-set.

2.3 PHOTOMETRY, COLORIMETRY AND RADIOMETRY

Scope and Objectives

(i) Testing and calibration of lamps, luminaires, materials for light and colour control, optical instruments, systems and components, photometric instruments etc. ;

(ii) Measurement of optical properties of materials, *viz*. colour, spectral reflectance and transmittance, optical density, opacity etc. ; and

(iii) Supply of NPL-made integrating spheres.

Progress

During the year 1976-77, 145 test reports were issued to outside parties and an amount of about Rs. 84,000 was realised as test fee. Besides, substantial testing work for other activities of the Laboratory was also done.

2.4 HEAT

Scope and Objectives

(i) Testing and calibration of platinum resistance thermometers, thermocouples, optical pyrometers, and mercury-in-glass thermometers ;

(ii) Testing of domestic refrigerators and refrigeration appliances as per ISI specifications ; and

(iii) Providing facilities to the industry in the development of their insulation products, and to develop new methods for determination of their thermal properties *viz*. thermal conductivity, linear expansion etc.

Progress

During the year 1976-77 about 190 test reports were issued, and an amount of about Rs. 18,000 was realised as test fee.

Calibration of thermo-couples (type R & S) by difference method was taken up. This method has been found to save calibration time by 2 to 4 days.

A 12″ guarded hot plate was designed and fabricated for determination of thermal conductivity at temperatures above 200°C upto about 500°C.

A method was devised for determination of linear expansion of conducting materials in the form of wires and fibres. Linear expansion of materials by dilatometer method was studied.

Work on setting up of facilities for testing of evaporative air coolers was initiated.

2.5 ENGINEERING MATERIALS

The following testing facilities for engineering materials exist at the Laboratory :

(i) Tensile strength measurement, compression tests on metals and concrete cubes, plotting stress strain curves (Maximum load — 100,000 kgf) ;

(ii) Hardness tests — Rockwell, Brinell & Vickers Pyramid — on metals ;

(iii) Bend test ;

(iv) Izod and Charpy impact test ;

(v) Torsion test on wires upto about 4 mm diameter ;

(vi) Transverse tests ;

(vii) Load tests on materials handling machines, e.g. jacks, hoists, chain pulley blocks etc. ; and

(viii) Calibration of proving rings, universal testing machines, impact testing machines and hardness testing machines.

Progress

About 340 test reports were issued to outside parties, and an amount of about Rs. 79,000 was realised as test fee during 1976-77.

2.6 LOW PRESSURE AND HIGH PRESSURE

Scope and Objectives

(i) To set up calibration facilities for various types of pressure/vacuum gauges for the ranges (i) 760 torr to 1 torr, (ii) 1 torr to 10^{-2} torr, and (iii) 10^{-2} torr to 10^{-6} torr ; and

(ii) To test the performance characteristics of vapour diffusion pumps and oil rotary pumps according to standard specifications.

Progress

The equipment for measuring vapour diffusion pump characteristics was modified to study its characteristics by direct flow measurement technique. Preliminary work on measurement of the critical backing pressure of vapour diffusion pump was also carried out.

A series of rotary vacuum pumps of different makes and capacities were tested, and the pumping speed versus pressure characteristics curves were drawn for each case. By modifying certain parameters, it was possible to improve the speed characteristics of indigenous rotary vacuum pumps.

M/s. ESCO Ltd., were provided consultancy service for the development of a suction abortion apparatus. BHEL, Hardwar was advised in regard to the functioning of their bitumen impregnation plant. Consultancy services were also rendered to M/s. Swadeshi Polytex, Ghaziabad, and the Cable Corporation of India, Faridabad, in connection with their vacuum problems.

2.7 ACOUSTICS

Scope and Objectives

(i) To calibrate instruments used for acoustic and electro-acoustic measurements in terms of the acoustical standards ;

(ii) To test acoustic and electro-acoustic devices and acoustic materials for their performance characteristics and properties, to measure noise produced by machines, and to check complete electro-acoustic systems and acoustic performance characteristics of auditoria ;

(iii) To render advice on problems of noise reduction, acoustic design and treatment of auditoria, hearing protection etc. ; and

(iv) To investigate specific problems arising out of the work done in standardization, calibration, testing and consultancy.

Facilities exist for testing items like motion picture projectors, magnetic recording tapes, audiometers, hearing aids, ear defenders, automobile horns, electric sirens, sound absorbing materials, sound insulating materials, tuning forks, vibration generators, sound level indicators, tachometers, ultrasonic therapy units, loudspeakers, microphones, amplifiers, sound reproducing equipment etc.

Progress

Periodic calibration of laboratory measuring instruments was continued.

The anechoic room of the Acoustics Block was completed and put into commission. Tests on the performance of the room were carried out.

Tests were carried out on more than 70 items received from the outside parties. 10 cases of consultancy were also handled. The cases included acoustic treatment of auditoria, noise suppression from air-conditioning systems, design of sound recording studios, and noise insulation for speech secrecy in a defence briefing room.

2.8 DC CALIBRATION

The group working on the establishment of DC standards, undertook calibration work also.

Progress

Calibration of standard cells, standard resistors, potentiometers, voltage dividers and current shunts etc. from various public and private sector undertakings, including Defence laboratories, was undertaken, and about 100 test reports were issued.

2.9 AC & HIGH FREQUENCY CALIBRATION

The group working on the establishment of standards for AC, and high frequency measurements, undertook calibration work also.

Use was made of the following existing facilities for rendering calibration service to outside parties including the public sector undertakings, Defence laboratories and other organisations :

(i) Calibration of 50 Hz power meters from 10 μW to 5 kW with improved accuracy of $\pm$ 1%, and RF Power meters from 10 μW to 10W with improved accuracy of $\pm$1% to $\pm$2% in the frequency range 10 MHz to 1 GHz ;

(ii) Calibration of VTVMs, signal generators, etc. (frequency range extending upto 100 MHz) in the voltage range 5 mV to 100 V ;

(iii) Calibration of current measuring instruments from 1 mA to 5 A in the frequency range 30 Hz to 30 kHz with improved accuracy of $\pm$1% ;

(iv) Measurement of characteristic impedance of coaxial cables upto 1000 MHz ; and

(v) Measurement of various parameters of transistors and diodes upto 1000 MHz.

Progress

Following are certain improvements made during the year :

(1) The range of voltage measurement for calibration of the voltage measuring devices at 50 Hz was extended upto 300 V with an accuracy of $\pm$0.1%.

(2) Calibration facility for current at 50 Hz (Upto 5A) was generated with an accuracy of 0.1%.

(3) A facility for measurement of cut-off frequency of the HF transistors upto 500 MHz was established.

(4) Measurement of characteristic impedance of coaxial cables in VHF and UHF was initiated.

2.10 MICROWAVE CALIBRATION & TESTING

The group working on the establishment of standards for microwave measurements undertook testing and calibration work also.

Progress

Calibration and testing of microwave components and instruments was continued for both private and public sector undertakings. Radome points were evaluated for Defence. About 250 test reports were issued, and an amount of about Rs. 12,000 was realised as test fee.

2.11 TEST, EVALUATION AND CALIBRATION CENTRE

The Test, Evaluation and Calibration Centre was formally inaugurated by Prof. M.G.K. Menon, Chairman, Electronics Commission on 2 February 1976 (*Fig 5*).

In his inaugural address, Prof. Menon underlined the importance of an integrated programme of development in electronics. He observed that with a 20% growth-rate, the electronics industry is the healthiest sector

Fig 5 Prof. M.G.K. Menon, Chairman Electronics Commission, formally inaugurating the Test, Evaluation and Calibration Centre of the Laboratory on 2 February 1976. Behind him is Dr. Y. V. Somayajulu, Scientist-in-charge of the Centre. Prof. Y. Nayudamma, Director General, Scientific & Industrial Research is at the extreme right. The Centre acts as a national laboratory facility for environmental testing, calibration and evaluation of electronic and electrical products.

of industry in India today. It has now achieved a considerable degree of self-reliance, and in a decade from now, it would have the strongest base in the country.

He said that 60% of production of electronics industry was in the field of professional electronics which served a wide spectrum of the national economy like defence and communication. Production figures had gone up from Rs. 4.35 crores in 1966 to a figure of Rs. 300 crores last year. This year's production figures were between Rs. 360 crores to Rs. 380 crores.

Prof. Menon also talked about the proposal of the Electronics Commission to assist in the establishment of national test and evaluation centres at Delhi, Bombay, Bangalore and Calcutta. He said that there would be a number of regional test centres also, in addition to the testing facilities set up by public sector undertakings like the Bharat Electronics Ltd., and the Electronics Corporation of India Ltd.

Dr. A.R. Verma, Director, NPL said that components and equipment are frequently called upon to function in environments far beyond human capabilities to withstand. Such conditions may include extremes of heat and cold, vibration and shock, damp, sand, salt and other unpleasant conditions. He said that the environment under which a component or an equipment has to operate reliably has a profound influence on the manufacturing process and the product manufacture, and that the modern testing techniques are key to their reliability. In this connection he observed that in its efforts to improve the quality of products, the Department of Electronics has funded each state to establish developmental and test laboratories. It has also funded different agencies to establish Regional Test and Evaluation Centres. It is in the fitness of things that the Test, Evaluation and Calibration Centre is located at the National Physical Laboratory, which was founded to maintain the national standards for physical measurements.

Scope

(i) To act as a national laboratory facility for environmental testing, calibration and evaluation of electronic and electrical products ; and

(ii) To operate field exposure stations and to carry out studies in tropicalization.

The Test, Evaluation and Calibration Centre serves as a national facility for the northern zone, on lines similar to two other centres—one at the Bhabha Atomic Research Centre (BARC), Bombay, and the other at the Chief Inspectorate of Electronics (CIL), Bangalore—for encourging the growth of the electronics industry by meeting the demand for developmental and type testing.

Objectives

(i) To provide quick and efficient test facilities to electronic and electrical industry and other user organisations such as Defence, Civil Aviation, DGS&D, ISI etc. ;

(ii) To carry out primarily developmental and type testing according to the Indian Standards Institution (ISI) specifications or any other national specifications required by the user ;

(iii) To analyse the performance of components and equipment to acquire failure-rate data, and to carry out failure analysis studies to evaluate the reliability in order to advise the industry to improve its products and the users in the planning of systems ;

(iv) To carry out correlation studies between the accelerated laboratory tests and the performance of the products under actual environmental conditions, through setting up of several stations representing different climatic and other environmental conditions, and to make this information available to all interested parties—both national and international ;

(v) To carry out systematic studies in tropicalization of components and equipments ;

(vi) Based on the test data, studies and experience, to suggest and advise revision and/or updating of the IS specifications ;

(vii) To offer calibration facilities, with established traceability to the national standards of physical measurements of the NPL ; and

(viii) To perform such other specialized services or render advice, as may be required from time to time.

Progress

About 330 test reports were issued during the year 1976-77. These included environmental, electrical and mechanical tests performed on a variety of electronic and electrical equipments and components, and helmet testing etc. A sum of about Rs. 88,000 was realised as test fee.

TABLE—I

Statement of Receipts on account of Calibration and Testing Work done by the Division of Standards during 1976-77

Activity	*No. of Test Reports*	*Test Fee (in Rs.)*
Length Metrology	602	36,449.00
Mass, Volume and Hydrometers	358	69,995.00
†Photometry, Colorimetry and Radiometry	145	84,195.02
Heat	187	17,777.67
Engineering Materials	341	79,340.00
Low Pressure and High Pressure	5	585.00
Acoustics	76	7,180.00
*DC, AC & HF Calibration	19	8,258.50
Microwave Calibration & Testing	250	12,030.00
Test, Evaluation and Calibration Centre (including helmet testing)	324	88,450.40
Total	2,307	4,04,260.59

†Includes the receipts of the Spectro-Chemical Analysis Section of the Division of Specialized Techniques (*See Table-III on Page 46*).

*Represents the receipts of the erstwhile Electronics Division.

to achieve reliability and reproducibility of any device, it is extremely essential to characterize materials very precisely for purity, perfection and their relevant physical properties. With further increase of sophistication in industry, the stringency of materials characterization is great and, in fact, as industry becomes more and more science-based, it requires extremely well characterized materials.

The Specialized Techniques Group not only undertakes the testing of materials for purity, crystallinity and perfection, but also undertakes precise measurements of the physical properties of materials.

Objectives

The main objectives of the Group are :

(i) To cater to the needs of the various groups in the Laboratory for testing of materials for purity, perfection, crystallinity and physical properties ;

(ii) To extend its services to other research institutions/laboratories and to the industries in the country, for characterization of materials ;

(iii) To undertake jointly or individually, programmes for understanding the relationship between the composition, structure, imperfection and other relevant physical properties ; and

(iv) To undertake certain R & D programmes in the frontiers of science.

1.1 ANALYTICAL CHEMISTRY SECTION

The activities of this Section included chemical analysis of materials (minor and major constituents), development of newer and better methods of analysis, and preparation of specialized chemicals not available in the country.

Progress

Chemical analysis for purity and composition was carried out for different groups of the Laboratory and for the industries in and around Delhi. During the year, about 220 test reports were issued to outside parties, and an amount of about Rs. 35,000 was realised as test fee.

The samples analysed included water, different kinds of steels, aluminium, pig lead, cement, quartz, fly ash, organic & inorganic chemicals, chromium and silver plated materials, brass, bronze, lime, transformer oil, ferrites, ceramics, phosphors, iron, manganese and copper ores, com-

DIVISION OF SPECIALIZED TECHNIQUES

The activities of the Division of Specialized Techniques are organized into three major groups *viz.*,

1. Specialized Techniques Group ;
2. Cryogenics Group ; and
3. Solar Energy Group.

The Specialized Techniques Group undertakes the testing of materials for purity, crystallinity and perfection, and also carries out investigations in the frontiers of science in the respective fields of work. The Group also undertakes investigations on the precision measurements of some of the physical properties of the vast variety of materials in bulk as well as in thin film state.

The Cryogenics Group directs its attention to the study of the peculiar phenomena that occur at low temperatures e.g. Josephson Effect, Kondo Effect etc., development of cryogenic plants, study of superconducting materials and systems, and preparation of fine powders by cryo-chemical techniques etc. The Group also renders cryo-technical advisory services to the other groups of the Laboratory and to the outside institutions and organisations.

The Solar Energy Group constituted in 1975 for intensifying efforts in harnessing solar energy, concentrates on development of devices using thermal solar energy conversion through use of flat plate solar collectors and concentrators, and has also undertaken investigations on development of photo-voltaic devices for solar-energy conversion into electricity, using some promising materials other than silicon.

1. SPECIALIZED TECHNIQUES GROUP

Introduction

With the over all fast development of science and technology on the one hand and the industry on the other, the demand for materials with precise specifications & newer and newer materials is growing equally fast. In order to fulfil this requirement, increasing efforts are being made to study why materials behave as they do, and whether we can tailor materials to the required specifications. It has been clearly established that

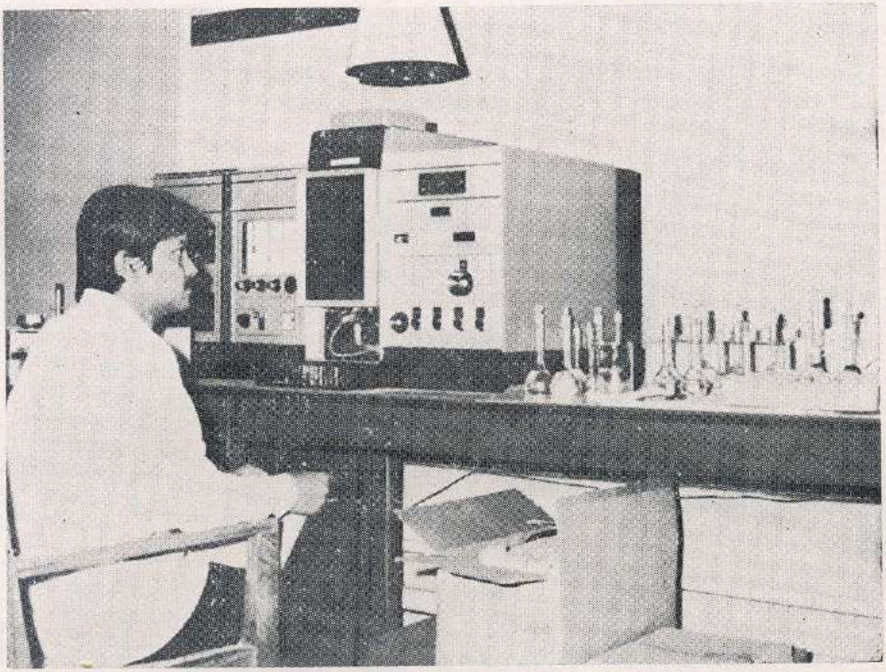


Fig 6 Atomic absorption spectrophotometer set up at the Laboratory.

pressed gases, fertilizers, inks etc. In the course of chemical analysis a few problems of developmental nature were also undertaken.

Atomic Absorption Spectrophotometer : With the installation of an atomic absorption spectrophotometer in the Section (*Fig 6*), the evaluation of trace impurities in different materials has been greatly facilitated. Trace elements in phosphorus, ceramics and silicon, prepared in the Divison of Materials of the Laboratory, were evaluated by this technique. Similarly large number of trace elements were determined in water and industrial effluent samples as per requirements of the Central Board for the Prevention and Control of Water Pollution, New Delhi.

Determination of Phosphorus in Water and Other Materials by Atomic Absorption Spectrophotometric Method : Direct determination of phosphorus by atomic absorption spectrophotometric method was not possible as the emission line of phosphorus lies in the extreme ultra-violet region. Phosphorus was converted into phospho antimonyl molybdate complex. The complex was extracted into methyl iosbutyl ketone. Since phosphorus and antimony are present in 1 : 2 molar ratio, the determination of antimony was carried out using antimony emission line, and it was correlated with the phosphorus content.

Determination of Phosphorus in Steel using Phospho Antimonyl Molybdate Complex : A method for the spectrophotometric determination of phosphorus in steel using phospho antimonyl molybdate complex was developed. Reduction of phosphomolybdate complex with ascorbic acid and antimony was found to be advantageous over other methods. The molybdate complex formed was found to have maximum absorption at 802 mμ and the molar extinction coefficient was 23,000. The method was found to be specially suitable for determination of low level phosphorus in steel. Effects of acidity, reagent concentration, and diverse ions were studied with a view to finding optimum conditions of the complex formation and estimation of phosphorus in steel.

Stamp Cancellation Ink : This work was undertaken at the instance of the P & T Department for improvement in the quality of the stamp cancellation ink used by them. Earlier the ink used by the Department was a homogeneous mixture of mineral oil and carbon black. A new formulation using vegetable oil, a thickening agent and carbon black was prepared. This formulation, besides showing better performance, was found to be 30 to 40% cheaper as the cost of the oils used is much less as compared to mineral oils. P & T Department approved the quality of the ink.

DTA & TGA Studies : Thermograms of forty samples supplied by different groups of the Laboratory and outside parties were scanned. These included samples of ferrous ammonium sulphate , ferric oxalate and aluminium sulphate prepared by cryochemical techniques ; cholesteryl nonanoates, cholesteryl oleates and cholesteryl carbonates used as liquid crystalline materials; leather, chitosin, algin and preoxidised PAN fibres for study of their carbonisation behaviour; organometallic complexes like butyrates, benzoates, and fermates of cerium ; isonicotinic acid derivative of transition elements etc.

Heat Sensitive Sheets for Thermofax Machine : An effort was made to develop the coating composition of the sheets used in thermofax machines for document copying. The coating is usually a heat-sensitive material which decomposes into black product only above a desired temperature.

1.2 SPECTRO-CHEMICAL ANALYSIS SECTION

Progress

Samples of such diverse nature as phosphors, ceramics, piezo-electric materials, superconducting materials, carbon products, ferrites, silicon and quartz were received by the Section for characterization during the year. About 450 determinations for elemental constituents in different kinds of samples received from the various R & D groups of the Laboratory and from other CSIR laboratories and industries, were made.

Some of the significant achievements of the Section during the period under report were :

Stenheil spectrograph was set up for the regular analysis of samples with complex spectra, where spectral interference is an important factor.

Master spectra of common elements with major and minor concentrations were recorded for quicker interpretation of analysis spectra.

A spectrometric set-up was developed for the characterization of yellow, red and far red lines of alkali metals, since the sensitive lines of Na, K, Rb etc. lie in this region where the sensitivity of photographic plate is low.

The sensitive detection lines of elements are often interfered by spectral lines of other elements present as major or minor in the matrix. To enable a correct identification of an element to be made, it is important to have a precise knowledge of such interferences. A comprehensive survey of the spectral interferences was undertaken for many of the common elements, e.g. Ca, Sr, Ba, B, Bi, Cr, Ni, Fe, Al, As etc.

1.3 INFRARED SECTION

One of the main objectives of this Section is to develop and provide a sensitive, selective and reliable characterization facility by infrared spectroscopy.

Progress

Grating-Type Far Infrared Spectrophotometer : Assembly of the various parts of the grating-type far infrared spectrophotometer designed, developed and fabricated at the Laboratory, was completed, and the instrument was calibrated and commissioned (*Fig 7*). This instrument covers the spectral region of 15 to 300 μm. Some minor alterations in the optics of the instrument were also made to improve its sensitivity and resolution in the energy-starved region of 200 to 300 μm. The feasibility of extending the spectral range of the instrument upto 600 μm was also examined.

1 to 3 μm *High Resolution Spectrometer :* The assembly of the spectrometer was completed and the calibration spectra were recorded.

Fabry-Perot Type Far Infrared (200—400 μm*) Spectrophotometer :* A new housing for the Fabry-Perot type far infrared spectrophotometer in which vacuum can be created, was designed and fabricated. A crystal for low temperature measurements was also designed and fabricated.

Hilger H-800 Spectrophotometer : The commercial Hilger H-800 spectrophotometer, which is an expensive but obsolete model, covers the

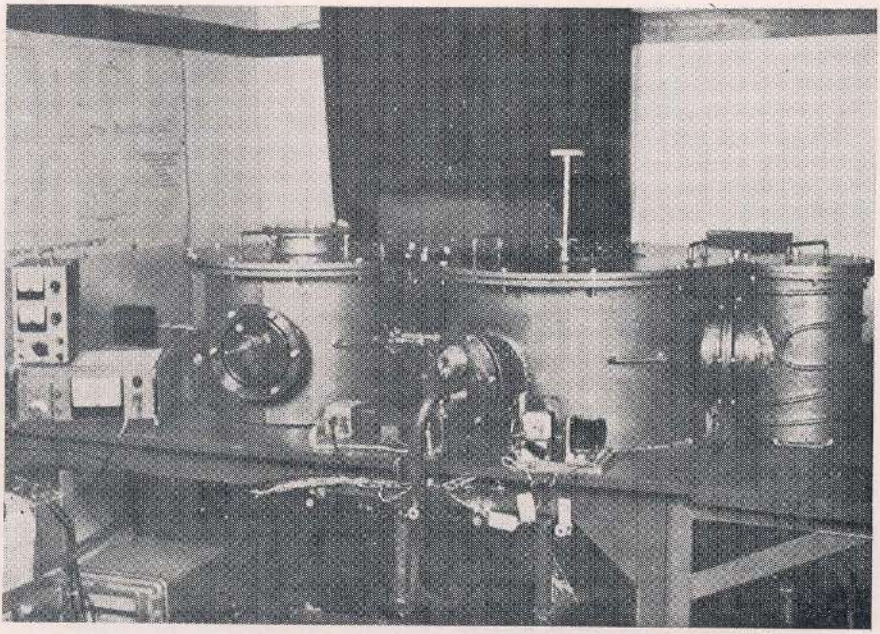


Fig 7 Grating-type infrared spectrophotometer for the range 15 to 300 μm, designed, developed and fabricated at the Laboratory.

spectral range of 2 to 15 μm. Considerable effort was put in to maintain it in working order, and a number of samples were characterized with this instrument.

Fourier Transform Infrared Spectrophotometer : Preliminary studies on the feasibility of the design, development and fabrication of a Fourier transform infrared spectrophotometer were completed.

Crystal Growth : Large-size single crystals of TGS were grown, using the apparatus designed and fabricated at the Laboratory. Doped crystals of TGS were also grown.

Infrared Thermometer : Work on the development of an infrared thermometer was undertaken. A two-element detector was fabricated with a view to neutralising the effect of variation of ambient temperature on the net output from the pyro-electric detector.

Study of Domain Pattern of Ferro-electric Crystals : A new method was developed for the study of domain pattern of ferro-electric crystals. It consists of laser irradiation on the surface of the crystal plate and measuring the pyro-electric signal thus developed in an AC millivoltmeter. It is found that the pyro-electric signal from different regions of the surface is not uniform and depends upon the domain pattern of the crystal. Pyro-electric signal observed by scanning the crystal plate under focussed laser beam could be used to determine the domain pattern of the crystal. Theoretical expression regarding the electric field created by hot hemisphere on the crystal surface, was derived and used to explain the additional signal from different regions.

Study of Polarity, Intensity of Pyro-electric Signal, and its use to obtain Domain Pattern : Study of pyro-electric signal by laser irradiation with the help of phase sensitive detection technique and automatic recording of the signal was undertaken. Necessary scanning and recording instruments were also designed and developed. It was observed that this method helps to obtain not only the domain pattern but also the polarity and intensity of the pyro-electric signal. The technique was used for the study of ferro-electric crystals.

Relative Emissivity Measurement : The intense radiation from the sun has a wavelength maxima at approximately 2 μm. One of the requirements for effective tapping of this energy from the sun is to have a material which has a selective absorption for the infrared radiation. To test the efficiencies of these selective surfaces, a set-up for the relative emissivity measurement at different temperatures, higher than the room temperature, was designed and fabricated.

Theoretical Studies on Far Infrared Filters : Further work on transmission characteristics of multi-element reciprocal grid filters was carried out, and theoretical expressions were derived to explain their properties in the far infrared.

1.4 X-RAY DIFFRACTION AND FLUORESCENCE SECTION

Progress

This Section carried out X-ray analysis of a wide variety of materials received from government departments, industries, universities, ISI, and other groups of the Laboratory. Many a short-term problems of this type required long-term research for a proper elucidation of the particular difficulty.

X-ray analysis for crystalline phase-identification, orientation determination by X-ray Laue techniques, solid solution formation etc., were carried out for the following types of materials :

> Red mud samples from the aluminium industry sent by the Central Building Research Institute, Roorkee, metallurgical coke samples, microphonic carbon granules, SiC, PAN precursor (homopolymer and copolymer), coal tar and petroleum pitch, materials prepared under high-pressure and high temperature conditions, molybdenum

target material used in X-ray tubes, Fe_2O_3 and Fe_3O_4, pyrophyllite, Bi rods, surface layers on solar collector plates, synthetic diamond grits, lead zirconate-titanates, ferrites, jarosite, splatt-quenched Bi-Pb sheets, CdS single crystal for orientation determination, $LiNbO_3$, calcined aluminium hydrates, gallium phosphide, electro-ceramics, and zinc—manganese ferrites prepared by hydrothermal oxidation.

Structure and Phase Transformations in Semiconductor Chalcogenide Materials: The work aims at synthesising chalcogenide materials (sulphides, selenides and tellurides) and obtaining complete knowledge about the crystal structure, thermal expansion, temperature range of stability and transformation into the high-temperature phases for fabrication of devices based on these materials, as also a full understanding of the nature of extended defects in crystals, annealing behaviour, topotactic reactions, line-profile analysis for crystalline size determination etc.

The investigations conducted during the year include :

1. Finalization of the X-ray data on the structure and nature of extended defects in InSe.
2. Finalization of the X-ray fluorescence data on the air-oxidation of Bi_2Te_3 and Bi_2SeTe_2 and of the crystal data on the fully-oxidised phases.
3. X-ray studies of the nature of extended defects in alpha Ga_2Se_3—a cubic zinc-blend type of structure.
4. Formation and studies of the super-lattice structure of beta Ga_2Se_3, using single crystal and powder data.
5. X-ray studies of the gamma Ga_2Se_3 phase.

X-ray Fluorescence Analysis: X-ray fluorescence analysis of core materials of cinema arc carbons, microphonic carbon granules, gadolinium gallium garnet, oxidised Bi_2Te_3 and Bi_2SeTe_2 was undertaken. Also X-ray radiographic work on thin foils of copper beryllium used in diaphrams was carried out.

1.5 ELECTRON MICROSCOPY AND ELECTRON DIFFRACTION SECTION

The Section undertakes electron microscopic and electron diffraction studies of materials to characterize them for their particle size, size distribution, shape, crystallinity, phase identification, defects etc. Surface topography and surface defects can also be studied by replication technique.

Progress

Testing of the samples from within the Laboratory and from outside organizations was continued. About 90 samples were tested during the year. This included investigation of about 70 samples of γ-Fe_2O_3, soft ferrite powder, spray-dried and freeze-dried powders of alumina, α-Fe_2O_3, and thin films of Cu-S system for phase identification, which was undertaken for the other R & D groups of the Laboratory. Examination of various samples of γ-Fe_2O_3 revealed that about 50% of the runs showed γ-Fe_2O_3 formation, and that further improvement in the conditions of preparation of the material were necessary.

Metal-Polymer Films : Development of metal-polymer films was undertaken. Copper particles were embedded in Nylon 66 obtained from BASF, West Germany, by evaporating them simultaneously from two different sources under vacuum of the order of 10^{-5} torr. Micrographs of the Copper-polymer films so prepared showed micro-polycrystalline/amorphous structure and the diffraction patterns revealed broad haloes. The necessary arrangement for making electrical resistivity measurements was made and a few films were tested.

Nucleation and Growth of Thin Films of Tin : A programme on the study of nucleation and growth of tin films was undertaken with the aim of establishing the conditions of growth of a particular phase of tin. A large number of tin films having thickness ranging between 10Å and 1000Å were prepared at room temperature, 100°C and 150°C, and were examined by electron microscopy and electron diffraction.

Gold-Copper Thin Films : Work on the electrical and structural properties of gold-copper thin films was undertaken in collaboration with the Physics Department of the Indian Association for the Cultivation of Science (IACS), Calcutta. IACS made the electrical resistivity measurements, and this Section carried out structural investigations of the films by electron microscopy and electron diffraction. It was observed that with change of composition of copper, the ordered phase changed to disordered phase , and simultaneously a difference in particle size was also observed.

Thin Films of Bi_2O_3 : Another collaborative work undertaken related to the investigation of thin films of Bi_2O_3. The Physics Department of the Bareilly College, Bareilly, grew the thin films and made dielectric measurements on them, while this Section examined the structure of the films to identify whether a particular phase had been grown. It was observed from electron microscopy and diffraction measurements that Bi_2O_3 films prepared by heating Bi films in O_2 atmosphere at 175°C for 50 hours showed α-phase of the bismuth oxide.

1.6 X-RAY DIFFRACTION TOPOGRAPHY SECTION

X-ray diffraction topography is an important tool for fundamental research as well as for routine testing of crystal perfection in some industries. X-ray topography is used to detect and characterize (i) grain boundaries , (ii) low angle boundaries , and (iii) dislocations. For grain boundaries and low angle boundaries, it is even possible to determine their angle. The dislocations can be resolved in good single crystals , and their nature i.e. whether they are edge or screw dislocations , and their Burgers vector , can also be determined. Besides , the method is non-destructive.

Progress

The X-ray diffraction typography camera was used to characterize a large number of crystals regarding their perfection.

Sapphire single crystals received from the PTB , West Germany , were characterized regarding their perfection. An investigatory study on neutron irradiated single crystals of silicon was also undertaken at the instance of the Indian Institute of Technology, Kharagpur.

Microfocus X-ray Generator : Developmental work on microfocus X-ray generator was continued, and the electron gun and the anode housing were perfected. Work was also started on another unit of microfocus X-ray generator for the Department of Physics & Astrophysics of the University of Delhi.

Triple Crystal X-ray Diffractometer : Diffraction curves for silicon single crystals obtained by the modified X-ray topography set-up developed earlier had exhibited half-widths of about 40-60″ as against the half widths of 5-10″ expected from theoretical considerations for ideally perfect crystals. This was due to the fact that the monochoromatisation and collimation of the radiation was not perfect. To overcome this constraint, a triple crystal X-ray diffractometer was developed. In this instrument the X-ray beam from a microfocus X-ray source is first monochromated and collimated by diffraction from a set of two nearly perfect single crystals of silicon. At this stage it is possible to get well resolved $K\alpha_1$ beam which is isolated from the direct residual beam and $K\alpha_2$ beam (which is only present when a line X-ray source is used). This $K\alpha_1$ beam is used as the exploring beam. The specimen crystal is mounted on a special turn-table developed for this instrument. This turn-table gives rotations of about 1″ to the crystals. With this system, typical diffraction curves of nearly perfect silicon single crystals exhibited half-widths of about 5″ (*Fig 8*). Some investigations of diffuse X-ray scattering were made by using this system, which confirmed the earlier findings that the conventional theory developed for explaining diffuse

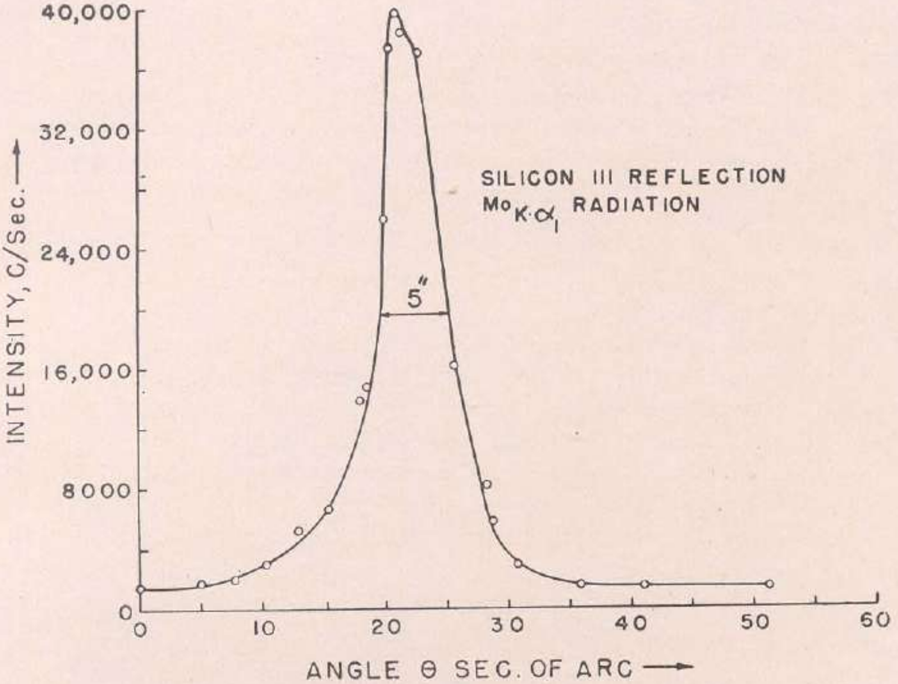


Fig 8 A typical diffraction curve of a dislocation-free silicon single crystal, recorded on the triple crystal X-ray diffractometer developed at the Laboratory.

X-ray scattering in terms of X-ray scattering from phonons was inadequate as it did not explain the results for all values of phonon wave vectors.

Growth and Characterization of Single Crystals of Opto-electric Materials : The design of a versatile crystal puller for growth of single crystals of opto-electric materials by Czochralski technique was completed, and the work on fabrication of various parts of this equipment was also taken up by the Central Workshop of the Laboratory.

The existing facilities for growth of alkali halide crystals from melt were used for growing several crystals for supply to outside institutions. Work on growth of cadmium sulphide crystals from vapour phase was also started and some preliminary runs were made with a view to perfecting the technique.

Dielectric and Electrical Conductivity of Insulators : Methods for accurate measurement of dielectric constant of insulators were developed. This work established that the effect of change in stoicheometry, gross lattice imperfections and impurities, can be measured as a change in dielectric constant. A sample holder for measurement of dielectric and electrical conductivity of insulators was built for the Baroda University.

1.7 ELECTRON PARAMAGNETIC RESONANCE SECTION

The activity of this Section essentially involves the detection and measurement of paramagnetic centres/impurities in various materials of technological importance, using electron paramagnetic resonance spectroscopy.

Progress

A variety of samples from industries and various groups in the Laboratory were investigated. Some of the interesting studies undertaken are reported below :

EPR Absorption in Pulses and Oil-Seeds : EPR studies were undertaken on various pulses like black gram, rajmaha, lentil, soyabean, pigeon-pea, green gram, and oil-seeds like sunflower, mustard and groundnut etc. Most of the pulses and oil-seeds showed a seven-line EPR absorption spectrum. On close examination of the spectrum, it was found that the central line was due to some free radical present only in the husk of the seeds whereas the other six lines were characteristic of Mn^{2+} ion present in the kernel of the seeds. Super hyperfine structure due to the interaction of Mn^{2+} ion with the surrounding nuclei was also observed in some cases.

Photovoltaic Properties of Cadmium Sulphide : Photovoltaic properties of cadmium sulphide can be increased many folds by incorporating Cu by firing in the lattice. Some experiments were conducted on CdS : Cu : Cl samples to find the effect of O_2 firing on the Cu centre. It was observed that heat treatment is conducive for manganese to go into the lattice as Mn^{2+}. Work on O_2^- centres formed in the CdS lattice was continued.

Study of Liquid Crystals : A monotropic smectic B liquid crystal *viz.* p-n-hexyloxybenzylidine-p-toluidine (HBT) doped with vanadyl acetylacetonate which serves as a paramagnetic probe, was investigated, using EPR technique. All the phase transition points, and variation of order parameter with temperature were studied. Work on other liquid crystals was also initiated.

1.8 MÖSSBAUER SPECTROSCOPY

The order parameters, the transition temperatures, various transition phenomena including the glass transition phenomenon etc. of various liquid crystals of smectic and nematic type were studied using tin and iron as the Mössbauer probes. These studies revealed that there is a continuous decrease in the order parameters with increasing temperature. The line width of the absorption peak and the area under resonance of the Mössbauer peak suddenly change drastically at the transition points particularly at the glass transitions. It was found that this is due to the diffusion of the Mössbauer probe in the liquid crystalline matrix at and near the transition points.

1.9 STANDARD REFERENCE MATERIALS

Introduction

Development of sophisticated materials is an activity that can be divided into two parts *viz.* (1) production of materials, and (2) characterization of materials.

Characterization of materials is an activity which, on the one hand, is meant to satisfy the user, and on the other, to get a feedback regarding the quality of the materials produced. This feedback essentially is vital for producing materials having properties closer to specifications.

With the large number of facilities for characterization of materials already available at the Laboratory, it was considered appropriate to initiate work on Standard Reference Materials.

Scope & Objectives

(i) Maintenance of the existing facilities & creation of new facilities for characterization of materials regarding chemical composition, crystalline structure, crystalline perfection, and characterization regarding user-oriented physical properties ; and

(ii) Development of Standard Reference Materials (SRMs) relevant tos the needs of the industry and R & D institutions.

Progress

As per ISI-Handbook 1972, there are about 200 specifications of irons and steels. A study of these revealed that of these, there are about 70 specifications in which the composition has been specified, and that there are in all 27 elements which occur in different concentration and composition ranges in these specifications. A survey was carried out for the steel industry regarding the use of SRMs by their laboratories. From the information received from different steel plants, it seems that about 14 specifications are generally being produced in these plants.

1.10 SULFAMPHTHALEIN INDICATORS

Scope and Objectives

Introduction of a new series of indicators for chemical analysis, and the related dyes for animal fibres and medicinal purposes, has been going on for the past few years. This work aims at the synthesis of sulfamphthalein indicators, purifying them to the chromatographic grade, and examining their physico-chemical characteristics, *viz.*, melting point, formation constants, IR, Visible and UV absorption spectra, and pH of colour transformation which would comprise of the characterization of colour change in terms of (i) SCD for sensitivity of colour change;

(ii) pH_{mcc} correct to 0.01 pH units ; and (iii) half band-width of change of SCD in pH units as a measure of the rapidity of colour change.

Progress

Synthesis and Purification of Sulfamphthalein Indicators : o'Cresol-sulfamphthalein, Phenol-sulphamphthalein, and Xylenol Orange Analogue indicators were synthesised and purified to chromatographic grade by using the multipurpose solvent extractor already developed at the Laboratory. The chromatograms of the purified indicators were developed in different eluants.

The nitrogen and sulphur contents of the chromatographic grade of phenol- and o'Cresol sulphamphthalein indicators were also determined.

Evaluation of Colour Changes of the Phenol-& o'Cresol Sulfamphthalein Indicators : The colour changes of the Phenol- and o'Cresol sulfamphthalein indicators with the change of pH were evaluated in terms of pH, SCD, $pH_{1/2SCD}$, pK, and (pH_{mcc}—$pH_{1/2trf}$). The last is a newer characteristic in search of an ideal indicator. The results are given in Table II.

Table—II

Colour changes of Phenol- and o'Cresol Sulfamphthalein Indicators Synthesised and Purified at the NPL

Indicator	*Range of colour change*	*pHmcc*	*SCD at maximum colour change*	*Half band-width of change of SCD in pH units pH ½ SCD*	*pK at 27°C*	*Buffer medium*	*pHmcc − pH ½trf*
Phenol-Sulfamphthalein	Acidic	0.60 1.35	7.6 11.2	0.50 0.70	1.28±.02	(KCl+HCl buffer bet. pH 0.75—2.5)	+.07
	Alkaline	7.65	25.4	1.10	7.82±.02	(KH_2PO_4 as buffer bet. pH 7.8—8.9)	
		8.15	32.6	0.55	7.96±.03	(Glycine as buffer bet. pH8.1—9.0)	+.19
o'Cresol Sulfamphthalein	Acidic	0.50 1.30	12.6 17.4	0.65 1.07	1.31±.02	(KCl + HCl buffer bet. pH 1.0—2.4)	—.01
	Alkaline	8.05 8.20	36.0 39.0	1.57 0.70	8.22±.02	(KH_2PO_4 as buffer bet. pH 7.6—8.9)	—0.2

Micro-determination of Mercury : Work on the use of Xylenol Orange Analogue (XOA) synthesised at the Laboratory, was extended for micro-determination of mercury and zinc, in continuation of the work on micro-determination of lead, done earlier.

Oxygen Flask Method for Determination of Sulphur in Steel : Work relating to the determination of sulphur was continued. The effect of various parameters to obtain appropriate conditions for complete ignition of the steel, and achieving correct end-point was investigated. The results obtained for different samples of steel compared very well with the reported results. Recovery of platinum used in the process was also investigated.

1.11 ELECTRONICS SERVICE UNIT

Scope and Objectives

(i) Design, development and fabrication of specialized electronic equipments/systems needed by the other R & D groups of the Laboratory and by the industry ;

(ii) Maintenance of sophisticated electronic equipments/instruments of the Laboratory ; and

(iii) Consultancy service in electronic circuit design.

Progress

Digital Line Frequency Monitor : A 3-digit line frequency monitor was developed and fabricated for the AC & HF Standards Group of the Laboratory. The instrument gives an accuracy of $\pm$ 0.1 Hz.

Time Marker Unit : A time marker unit was developed for the Project on Ground-Based Facilities for Environment Monitoring, of the Division of Radio Science of the Laboratory. This unit provides short pulses of 3 sec duration once in every minute. There is also a provision to identify hourly pulses.

Precise timing pulses were obtained from a quartz crystal oscillator which will subsequently be synchronized with the national time signals broadcast by the Time & Frequency Standards Section of the Laboratory, under the call sign 'ATA'.

Digital Frequency Counter with Liquid Crystal Display : A 3-digit digital frequency counter using liquid crystal display was developed and fabricated to serve essentially as a demonstration unit, using liquid crystal displays developed at the Laboratory.

Digital Clock with Liquid Crystal Display : A $3\frac{1}{2}$ digit clock using liquid crystal display was developed and fabricated. This was also meant to serve as a demonstration unit, using liquid crystal displays developed at the Laboratory.

Fig 9 Electronic monitor for vaccum deposited thin films, designed and developed at the Laboratory.

Thin Film Thickness Monitor : This instrument was redesigned and developed, using the modern trends in electronic circuitry. The complete technical know-how was handed over to M/s Vacuum Instruments Co., New Delhi, who had sponsored the development of this instrument earlier (*Fig 9*).

Maintenance Service : In addition to the above R & D activity, the following equipments were repaired during the year :

1. Hilger Infrared Spectrophotometer, for the Infrared Spectroscopy Section.
2. DTA — TGA (X-Y recorder) and Electrolyser, for the Analytical Chemistry Section.
3. X-Ray Diffraction Unit, for the X-ray Diffraction & Fluorescence Section.
4. Variable Temperature Regulator Type V-4540, for the Electron Paramagnetic Resonance Section.
5. Carl Zeiss Spark Generator for the Spectro-Chemical Analysis Section.

Stores Reclamation Service : The condemned/unserviceable electrical and electronic equipment from the individual scientists, before being returned to the Central Stores, were tested, and in many cases reconditioned.

2. CRYOGENICS GROUP

Introduction

The field of cryogenics is no more a preserve of the research scientist. Apart from its applications in industries such as chemicals , steel , fertilizers , metal working , food preservation etc. , cryogenics has another important and very useful phenomenon to offer , and that is , that many materials behave in a peculiar way at very low temperatures.

The Cryogenics Group of the Laboratory has been engaged in doing fundamental as well as developmental research work in this area of great potential applications.

2.1 CRYO-TECHNICAL SERVICES

This Section has an obligation to maintain and operate various liquefiers such as air, nitrogen & helium liquefiers. These croyogens were supplied to the various groups of the Laboratory and also to outside research institutions and industrial undertakings. Valuable assistance by way of technical advice to various scientists from within the Laboratory as also from outside was also given regarding design of cryostats, and techniques of low temperature measurements etc. Liquid air vessels from outside the Laboratory were also taken up for repairs.

2.2 CRYO-PROPERTIES OF MATERIALS

Progress

Fibrous material such as mineral wool bonded and 'loose-fill' was found to be another thermal insulant useful at cryogenic temperatures for super-insulation. The facilities already developed for the measurement of thermal conductivity of such materials between 300 K to 77.4 K were modified to perfect them from a commercial testing point of view. The system was made capable of measuring thermal conductivity under different gas atmospheres and under varying pressures, densities and temperatures.

2.3 CRYOGENIC PLANTS AND FACILITIES

Progress

Super-insulated Dewars : Super-insulated dewars using pyrex glass with maximum capacity of 5 litres were made. The radiation losses were reduced through multiple reflections by the introduction of very fine (0.006 mm thick) aluminium foils in the evacuated double-wall. Glass fibre for insulation was inserted between these aluminium foils. The vessels are very effective for storage of liquid air.

Dewars for the Dairy Industry : Dairy industry requires large size dewars of about 10—20 litres capacity. Development of aluminium dewars was started to meet this requirement. This work required development of welding techniques for getting vacuum-tight joints over large areas. A technique was developed for welding of aluminium with aluminium. A high current rectifier was also designed for converting an available argon arc welding set operating in AC mode, into a DC set.

2.4 CRYO-PROBES FOR MEDICAL APPLICATIONS

Progress

The team of scientists working on the development of cryogenic devices for medical applications, works in close collaboration with the All India Institute of Medical Sciences, New Delhi, and other local medical institutions. Development of cryo-probes for cataract removal and retinal reattachment was the first programme which this team had successfully completed, but with the inflow of feed-back information from the medical institutions, further improvements in the device were undertaken to make it more versatile for other medical applications as well. Provision was made for fast de-freeze in case the probes accidentally touched the unwanted parts. Copper-constantan thermocouples were used externally in the unit. The unit can also be used for curing Parkinson's disease for which some of the nerves in the head which cause this disease, have to be deadened. Work relating to the application of this technique for curing diseases of the ear, nose and throat, removal of tumours, and treatment of gynaecological disorders etc., was also taken up.

2.5 CRYO-CHEMICAL TECHNIQUES FOR SMALL POWDER PREPARATION

Progress

Pure lithium ferrite powders ($LiFe_5O_8$) without dopants, for computer memory cores, were made in quantities, using the spray drying technique, and samples were sent to the Central Electronics Ltd., for trials. Fe_3O_4 powders for ferro-fluids were also made by the spray-drying technique. The particles were of about 150Å diameter, and fairly uniform. Work on the development of ultra-fine powders for magnetic seals in high speed water-pumps and other machinery was also initiated at the instance of the National Productivity Council. A furnace for 1300°C was installed for firing large samples.

A solution technique which has certain distinct advantages over spray-drying and freeze-drying techniques was developed for making Mg-Mn-Zn ferrite powders. These powders were also characterized.

Work on development of tungsten carbide for use in machine tool industry was initiated.

2.6 SUPERCONDUCTING MATERIALS AND SYSTEMS

Superconducting materials and systems are assuming an ever increasing technological importance, and form a challenging area of basic research. About three years back, a research and development programme on superconducting materials and systems was initiated. The programme consisted of the development of (i) superconducting materials such as Nb-Ti, Nb_3Sn and Pb-Bi, (ii) superconducting magnet systems, and (iii) superconducting cavities.

Progress

Superconducting Materials: Solid state diffusion process with tin bronze matrix containing niobium filament is followed for making Nb_3Sn. This method is ideally suited to make multi-filamentary Nb_3Sn conductor at low temperature. Since the reaction temperature, time, and the concentration of tin in the matrix determine the final superconducting properties of Nb_3Sn, a systematic study was undertaken to understand the influence of these variables. Scanning electron microscope was used to follow the changes occurring in the layer, growth, and the grain structure of Nb_3Sn. Fine grain size of the order of 400Å was observed in Nb_3Sn layer. This fine grain structure is essential for enhancing the current-carrying capacity of the conductor through the effective interaction of magnetic flux lines and the grain boundaries.

Micro-structure of splat quenched lead alloys was also studied with the help of optical microscope.

Superconducting Magnet: Under this programme, design and fabrication of a superconducting magnet system of a maximum field strength of 60 kOe was completed during the year. The same was fitted with a superconducting switch which enabled the operation of the magnet in a persistent mode.

To energise a superconducting magnet, a low voltage/high current DC power supply with a high degree of stability is essential. Such an energiser, developed earlier, was successfully tested during the year.

The development of a high homogeneity superconducting system with a maximum field of 70 kOe was also taken up jointly with the Bharat Heavy Electricals Ltd.

Superconducting Microwave Cavity: Superconducting microwave cavities have very large Q values of the order of 10^{11}, which make them ideal for a variety of microwave applications. Since 1974, superconducting oscillators have introduced a new dimension in time and frequency standards. They offer an unprecedented stability of 10^{-16} as compared to 10^{-12} of the atomic beam standard. Development of a superconducting cavity stabilized oscillation system, in collaboration with the Time and Frequency Standards Group of the Laboratory was undertaken. Tunable lead cavities were made for 9 GHz, and were tested at liquid air and ambient temperatures. Developmental work on a suitable system for testing at liquid helium temperatures was started.

2.7 THEORETICAL INVESTIGATIONS IN LOW TEMPERATURE PHYSICS

Progress

In an earlier investigation, it was shown from the renormalization group theory that the invariant coupling, and therefrom the vertex function for a one-dimensional system, diverge at a finite temperature, indicating the possible superconducting behaviour at a finite temperature. This possibility was further examined by calculating the response functions *viz.* Cooper-pair fluctuation and density fluctuation from the renormalization group theory. The solutions of the non-linear Lie equations for these response functions in the second order renormalization were obtained . These solutions explicitly reveal the possible singular behaviour of these functions at a finite temperature. The conditions for a possible period-doubled superconductor were derived. The relevance of these new results to Frohlich model of one-dimensional superconductivity in general, and to a real system like the organic molecular solid TTF-TCNQ in particular, was discussed.

In a second investigation, the possible superconducting behaviour of a quasi one dimensional system like TTF-TCNQ was further examined by introducing some kind of inter-chain coupling which will enable the development of long-range order in the transverse direction and lead to a real phase transition. An electronic dispersion which is dependent on the ratio of the intra-chain to the inter-chain coupling tranfer integrals was introduced, and modified Lie equations for the invariant coupling and the vertex function and their solutions were derived. These exhibit finite temperature singularity which is dependent on the inter-chain coupling.

2.8 JOSEPHSON TUNNELLING

Progress

Systematic studies of both the AC and the DC Josephson effect were conducted on Clarke solder blob junctions (SLUGS) with a view to fabricating devices based on Josephson effect, and to set up a standard of emf. Solder blob junctions were selected due to their ease of fabrication, magnetometric applications , and their similarity to DC SQUID. A thorough study was also made to understand the quantum interference properties.

A comparative study of non-hysteretic and hysteretic junctions was made in detail, as hysteresis is undesirable for many devices. Fabrication techniques for hysteretic as well as non-hysteretic junctions were also developed. In particular, the following aspects were studied :

Temperature Modulation : Temperature Modulation studies on non-hysteretic junctions gave an estimate of the junction asymmetry parameter, and inductance of the superconducting loop. Hysteretic junctions showed a prominent periodic variation of critical current with temperature which was markedly different from the temperature variation of critical current for non-hysteretic junctions.

Quantum Interference Effect : Magnetic field modulation was studied in SLUGS by passing a current through the niobium wire in the forward and the reverse direction. For non-hysteretic junctions the periodic variation in critical current with magnetic field was demonstrated. Hysteretic junctions showed a variation of the critical current with the magnetic field without well defined periods. The modulation for hysteretic junctions was studied at various temperatures.

Biasing Effects : Hysteretic junctions showed a variation in the critical current with subsequent sweep cycles, while the non-hysteretic junctions showed no variation with sweep cycles. All the experimental results showed that hysteresis leads to a net trapping of magnetic flux in the course of making a measurement.

3. SOLAR ENERGY GROUP

Progress

Solar Space Heating System : Encouraged by the first major solar energy application in development of a solar space heating system for the Hardwar factory of Bharat Heavy Electricals Ltd., which underwent the first successful run in December 1975, the Laboratory prepared a computer programme for the design of solar space heating systems for developing other such systems.

Solar space heating was also provided in a room in the NPL. In this case a row of collectors was mounted on the top of the building. Water is heated in these collectors and the heated water is circulated through a fan coil unit placed in the room.

Solar Cooling System : There are essentially three approaches that can be followed to achieve space cooling. These are (a) vapour absorption cycle , (b) vapour compression cycle , and (c) de-humidification and evaporative cooling. Detailed analysis showed that vapour absorption cycle was best suited for solar space cooling. For variety of reasons, the

A comparative study of non-hysteretic and hysteretic junctions was made in detail, as hysteresis is undesirable for many devices. Fabrication techniques for hysteretic as well as non-hysteretic junctions were also developed. In particular, the following aspects were studied :

Temperature Modulation : Temperature Modulation studies on non-hysteretic junctions gave an estimate of the junction asymmetry parameter, and inductance of the superconducting loop. Hysteretic junctions showed a prominent periodic variation of critical current with temperature which was markedly different from the temperature variation of critical current for non-hysteretic junctions.

Quantum Interference Effect : Magnetic field modulation was studied in SLUGS by passing a current through the niobium wire in the forward and the reverse direction. For non-hysteretic junctions the periodic variation in critical current with magnetic field was demonstrated. Hysteretic junctions showed a variation of the critical current with the magnetic field without well defined periods. The modulation for hysteretic junctions was studied at various temperatures.

Biasing Effects : Hysteretic junctions showed a variation in the critical current with subsequent sweep cycles, while the non-hysteretic junctions showed no variation with sweep cycles. All the experimental results showed that hysteresis leads to a net trapping of magnetic flux in the course of making a measurement.

3. SOLAR ENERGY GROUP

Progress

Solar Space Heating System : Encouraged by the first major solar energy application in development of a solar space heating system for the Hardwar factory of Bharat Heavy Electricals Ltd., which underwent the first successful run in December 1975, the Laboratory prepared a computer programme for the design of solar space heating systems for developing other such systems.

Solar space heating was also provided in a room in the NPL. In this case a row of collectors was mounted on the top of the building. Water is heated in these collectors and the heated water is circulated through a fan coil unit placed in the room.

Solar Cooling System : There are essentially three approaches that can be followed to achieve space cooling. These are (a) vapour absorption cycle , (b) vapour compression cycle , and (c) de-humidification and evaporative cooling. Detailed analysis showed that vapour absorption cycle was best suited for solar space cooling. For variety of reasons, the ammonia—water system was selected. Its refrigeration capacity is fairly high and the system can be operated at temperatures which can be attained with simple flat plate solar collectors. System design of a solar cooling system was completed, and fabrication of its first proto-type of about one tonne capacity, was started.

Photo-voltaic Solar Energy Conversion: Efforts were made to develop CdS : Cu_2S solar cells, and initial success was achieved in making a few solar cells with efficiency of 3-4 percent.

TABLE—III

Receipts from the Testing work done by the Division of Specialized Techniques

The various specialized techniques were utilized by the other groups of the Laboratory also. With the spare capacity available, this service was also made available to outside parties on payment of nominal charges. The receipts from this work during 1976-77 are given below :

Activity	*For other groups of the Laboratory*		*For outside parties*	
	Number of Test Reports	*Test Fee (in Rs.)*	*Number of Test Reports*	*Test Fee (in Rs.)*
(1)	(2)	(3)	(4)	(5)
Analytical Chemistry	45	7,090	224	35,200
Spectro-Chemical Analysis	63	15,365	□	□
Infrared Spectroscopy	30	10,405	—	—
Electron Microscopy	16	7,950	2	—
X-ray Spectroscopy	23	17,470	6	1,390
EPR Spectroscopy	15	1,300	—	—
Low Temperature Group	—	—	2	2,840
Total	192	59,580	234	39,430

Note 1 — The figures indicated in column (3) represent the test fee that could have been charged, had the work been done for some outside parties.

Note 2 — A number of jobs done for outside parties are not reflected in the above table as the service was rendered free of charge, and no test reports were issued.

Note 3 — □ The receipts of the Spectro-Chemical Analysis Section are included in the receipts for Photometry, Colorimetry & Radiometry activities of the Division of Standards. *(See Table-1 on page 24).*

DIVISION OF MATERIALS

The Division of Materials pursued R & D work in the areas of semiconductor materials and devices, magnetic materials, ferroelectric and dielectric materials and devices, low loss ceramic insulators, and carbon products. These R & D activities are complementary to the activities of the two experimental pilot plants *viz.* (i) Development-cum-Production of Electronic Components Unit and (ii) Carbon Pilot Plant.

The Division continued the time-targetted programmes of work on development of silicon controlled rectifiers, high frequency ferrites, high permeability ferrites, magnetic tapes, steatite and high alumina ceramics, high voltage ceramic capacitors, and carbon fibres, and also on establishment of a pilot production facility for monochrome TV phosphors.

1. SEMICONDUCTOR MATERIALS AND DEVICES

The Laboratory has been engaged in the area of semiconductor technology for the past few years. Research and development in this area incorporates activities in (i) silicon technology , and (ii) luminescent materials and devices.

1.1 SILICON TECHNOLOGY

The activities in silicon technology include preparation of poly-crystalline silicon , growth of single crystal silicon , and development of high power silicon devices.

Progress

Poly-crystalline Silicon : During the year, the quality of poly-crystalline silicon produced in the Laboratory by the trichlorosilane method was further improved. The purity corresponding to 100-200 ohm cm N-type material was tested within the Laboratory and in the outside industry.

A dome-type cracking unit of quartz, where two rods of silicon can be grown at a time, was fabricated.

Single Crystals of Silicon : The work envisages development of indigenous know-how for growth of single crystals of silicon, both by the Czochralski method as well as by the float zone method. Samples of silicon single crystals grown within the Laboratory , were sent to the outside industry for their acceptability trials. Towards the end of the year, the technology for the growth of single crystals of silicon by the Czochralski method was transferred to M/s Semiconductors Ltd., Bombay, for commercial exploitation.

Silicon Controlled Rectifiers : In an effort towards the development of 400A SCRs, technology for producing 4-layer devices (p-n-p-n) with a single diffusion was developed successfully. Single emitter SCR pellet with emitter shorting had already been developed. Test apparatuses for measurement of leakage current in forward and reverse directions, latching and holding current, and gate-triggering voltages and currents, were also fabricated.

1.2 LUMINESCENT MATERIALS AND DEVICES

Progress

The work envisages development of group II-VI compound phosphors of sulphide and selenide type particularly of Zn and Cd, and the setting up of a pilot plant for upscaling production of monochrome TV phosphors to about 800 kg per year with financial assistance from the National Research Development Corporation of India, New Delhi.

During the period under report, the following jobs were done in order to set up the pilot plant facilities for TV phosphors :

Design and fabrication of reaction vessels, filtration vessels, air-tight furnaces, H_2S generator, activation furnaces etc.

Testing and standardization of phosphors, using the cathodo-luminescence unit set up at the Laboratory.

Renovation of premises, and commissioning of pilot plant facilities.

Fig 10 shows a part of the pilot plant for production of monochrome TV phosphors.

2. MAGNETIC MATERIALS

In the area of magnetic materials, the Laboratory has been working for the past about two decades, and has developed the entire spectrum of oxide magnetic materials *viz.* ferrites—both for the entertainment industry as well as for professional use in the communication industry.

Upto the year 1975, various grades of ferrites for use in the frequency range 1 kHz to 300 MHz were developed for use as components in radio and TV industry. As a result, the Government of India floated the Central Electronics Ltd.—a public sector undertaking—which has on its production programme, professional ferrites of various forms.

Work was concentrated on the development of high permeability ferrites and high frequency ferrites. These ferrites find use in making a variety of devices like invertors and pulse-transformer cores.

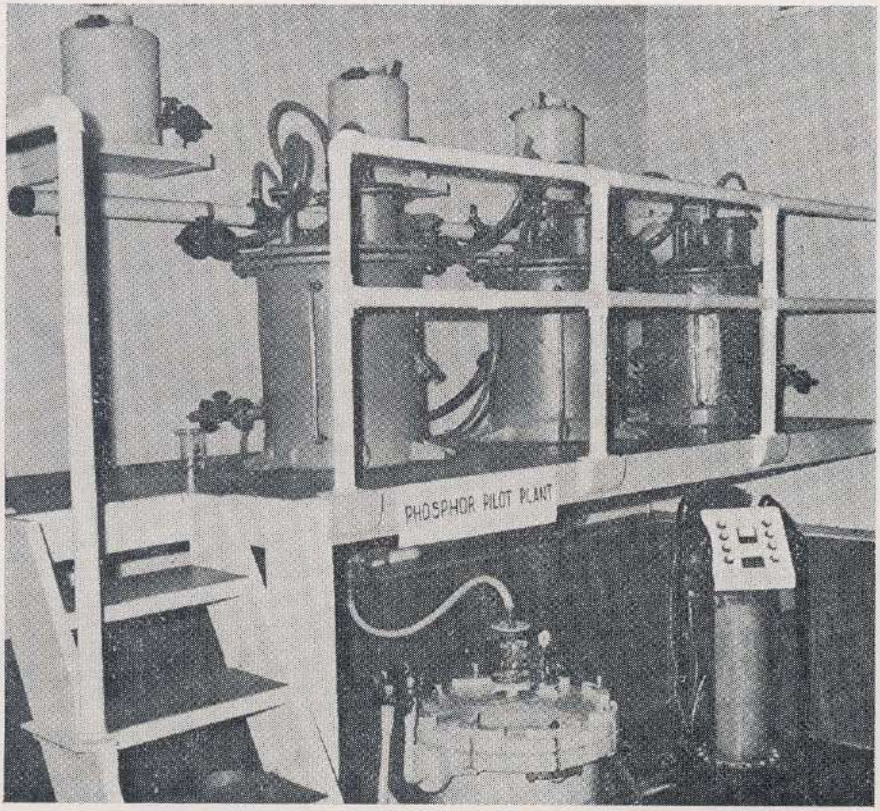


Fig 10. Part of the phosphor pilot plant, housing the chemical unit. The plant has been designed by the scientists of the Laboratory for up-scaling the laboratory process for production of monochrome TV phosphors, with financial support from the National Research Development Corporation of India, New Delhi.

Progress

High Permeability Ferrites : Using Bayer's ferric oxide and S. Merc manganese and zinc oxide, Mn-Zn ferrites of $\mu_i = 8000 \pm 20\%$, $\rho > 10$ ohm cm, and Tc $> 130°C$ were developed. This is the upper-most limit of μ_i which is possible with the presently available materials ($SiO_2 < 0.02\%$). Effect of grain diameter and silica content on permeability was studied. The maximum grain size without intra-granular pores was found to be around 30 microns if the present raw materials are used. Also the permeability was found to achieve a maximum value with increase in silica content upto a certain stage, whereafter it dropped. Studies on the effect of additives like Nb, Mo, V etc. on grain growth of Mn-Zn ferrites were continued further.

High Frequency Ferrites : Further work on the development of Ni—Zn based ferrites resulted in the development of ferrites equivalent to Siemens' K1 (except for temperature factor), for making pot cores for operation upto 10 MHz, using the high purity grade raw materials. The temperature factor ($TF \times 10^6$ at 23°—55°C) achieved was < 10 against < 6 of Siemens' K1. Blocks of high frequency ferrites (5 to 30 MHz) were also made during the year for making high power ($>$ 100 W) RF transformers. The material development for torroidal shape was completed, and processes of pressing and sintering were perfected.

Magnetostrictive Ferrites : Transducers suitable for ultrasonic cleaners, drillers and sonars were completely developed and found to compare very well with those of the Japanese origin. These find applications in low-voltage and low-impedance devices. Pilot production of these transducers was taken up to meet the demand of the Naval Oceanographic Research Laboratory, Cochin, and the National Institute of Oceanography, Goa.

Magnetic Tape Technology : The objective has been to develop a small-scale magnetic coating unit with indigenous raw materials and equipments. Utilising indigenous materials, magnetic tape for C-60 cassettes, meeting all specifications (except variation in intensity), was prepared on the prototype magnetic tape coating plant fabricated within the Laboratory. The manufacturing process involved thorough mixing of the ingredients like gamma-iron oxide, binders, resins & solvents in a ball mill to prepare smooth magnetic paint, continuously stirring it inside the coating chamber, and uniformly coating it on the base material, such as mylar, passing through the chamber. The coated film was magnetically aligned and dried. The material conformed to IS 4377-1967, IS 4479-1967 and IS 4480-1967.

TV Deflection Yoke Cores : A special type of jig was made for putting notches on the TV deflection yoke cores. This was expected to improve the yield for ATI 040 type yoke for which the yield was poor.

Ferrite Powders : Ferrite powder preparation by hydro-thermal oxidation for hard ferrites as well as for low-loss Mn-Zn ferrites was attempted. The powder size was 100-2000Å. A calcination study of spray-dried Mn-Zn ferrites was also completed.

Environment controlled thermo-gravimetric analysis was started during the year. It was possible to analyse the composition of various ferrite materials to ensure consistency in the processing. Oxidation/reduction reaction in ferrites was studied at temperatures upto 1400°C in controlled atmosphere.

3. FERROELECTRIC & DIELECTRIC MATERIALS AND DEVICES

Efforts were concentrated on the development of suitable materials for making different types of piezoelectric transducer elements and high voltage ceramic capacitors.

The activities can be grouped under the following major areas :

1. Piezoelectric ceramic materials ;
2. Lithium niobate single crystals ;
3. High voltage ceramic capacitors ;
4. Technical ceramics ; and
5. Ultrasonic instrumentation and piezoelectric devices.

3.1 PIEZOELECTRIC CERAMIC MATERIALS

Progress

A piezoelectric material (NPLZT-6), based on lead zirconate titanate, was developed for use in ceramic filters. It has good frequency stability with temperature and low ageing factor as compared to NPLZT-5 developed earlier. The various electrical and piezoelectric parameters of this material are listed in Table-IV.

TABLE – IV

Typical Properties of NPLZT-6 Piezoelectric Material

Property	*Symbol*	*Unit*	*Value*
Piezoelectric Charge Constant	d_{33}	10^{-10} Coloumb/newton	1.8
Piezoelectric Voltage Constant	g_{33}	10^{-2} Volt-meter/newton	2.88
Planar Coupling Factor	k_p		0.40
Dielectric Constant	K_3^T		700
Dielectric Loss Factor	tan δ	$\times 10^{-2}$	2.5
Curie Temperature	Θ	°C	280
Frequency Constant (Thickness Mode)	N_3t	metre-Hz	2100
Frequency stability (−25°C to + 85°C)			± 1%
Density	ρ	10^3 kg/m^3.	7.5

A systematic exploratory work on piezoelectric materials based on lead zirconate titanate and suitable additives, suitable for high power applications, was carried out. The preliminary investigations based on lead zirconate titanate with Fe_2O_3 as additive showed encouraging results. Further work on optimization of various piezoelectric parameters was also taken up. Experimental facilities for ceramic processing, and testing and measurement facilities for material characterization, were also supplemented.

3.2 LITHIUM NIOBATE SINGLE CRYSTALS

Progress

Crack-free single crystals of lithium niobate of 1 cm dia. were grown. Work relating to characterization of the crystals and standardization of growth parameters, was initiated during the year.

3.3 HIGH VOLTAGE CERAMIC CAPACITORS

Progress

Standardization of pilot production of ceramic capacitors in 1 kV—4 kV working range using two standard compositions (MKD and TCD) was completed successfully, and know-how for the same was transferred to M/s. Oblum Electrical Industries, Hyderabad, and M/s. Dielectro Magnetics Ltd. Palghat.

High K ceramic materials having dielectric constant of 1800, based on the composition $BaTiO_3$, $CaZrO_3$ and $PbZrO_3$ were standardized. Further work on development of still higher K materials ($\sim$ 5000) was taken up.

Fabrication process for power capacitors was successfully completed. A few samples were sent to the Bharat Heavy Electricals Ltd., Hardwar, and the All India Radio, New Delhi, for consumer acceptability tests. Exploratory work on the composition of dielectric material suitable for high frequency applications was taken up.

Manufacturing process of grading capacitors used in lightning arresters was successfully demonstrated at the site of M/s. Oblum Electrical Industries, Hyderabad.

3.4 TECHNICAL CERAMICS

The programme involves the development of low-loss insulating ceramics for use at high frequencies, and this essentially envisages work on alumina and steatite substrates and bodies.

Progress

Alumina Ceramics: Experiments were initiated to sinter 98% alumina to full density at temperatures below 1600°C. However, it was possible to sinter 95% alumina bodies with the following parameters :

Sintering Temperature	1550°C
Dielectric Constant	9.1
Dielectric Loss Factor	1×10^{-4}
Dielectric Strength	$>$ 22 kV/mm
Resistivity	$> 10^{14}\ \Omega$ cm
Water Absorption	0.28%
Density	3.5×10^{3} kg/m^{3}

Steatite Compositions : A new steatite composition (Steatite A—4) was developed and standardized for electronic and physical characteristics. This composition had a broader firing range ($\pm$ 20°C) than the Steatite-I composition ($\pm$ 5°C) developed earlier, and, as such, it could be fired in a production type furnace. The new composition had the following properties :

Firing Temperature	1260° $\pm$ 20°C
Dielectric Constant	6—9
Dielectric Loss Factor	$< 1 \times 10^{-3}$
Dielectric Strength	>22 kV/mm
Water Absorption	0
Density	2.9×10^{3} kg/m^{3}

3.5 ULTRASONIC INSTRUMENTATION AND PIEZOELECTRIC DEVICES

The objective is to develop various types of piezoelectric devices using NPL-developed material, and to develop ultrasonic instrumentation.

Progress

Ultrasonic Power Generator : Piezoelectric ceramic (equivalent to PZT-4) for high power generation, under development at the Laboratory, was used for trials. A 100 W power generator was fabricated for conducting studies on sandwich transducers in particular.

Medical Therapy Unit : Improved type of probe-heads in the frequency range 870 kHz, for medical therapy units, were developed and supplied to the industry. Piezoelectric ceramic equivalent to PZT-5, developed earlier at the Laboratory, was used in these probe heads.

Scour Detection at Bridge Piers : Feasibility studies were conducted for scour detection at bridge piers by means of ultrasonic transducers embedded in the bridge piers at the time of the construction of the bridge, by simulated laboratory experiments. Success was achieved in cases where the foundation has been eroded and the transducer exposed to the water. However, problems were faced when there was a slurry formation in the vicinity of the transducer. These problems were under investigation.

Ultrasonic Non-destructive Testing Probes : Three different types of probes, *viz.* (i) normal beam probes , (ii) angle beam probes, and (iii) surface wave probes of various standard frequencies had already been developed prior to the period under report. Normal twin probes (*Fig 11*) were developed during the year under report, using all indigenously available materials. These are used for ultrasonic non-destructive testing and thickness gauging. Single probes of ordinary type have the dis-

Fig 11 Twin normal prote (dead zone 2—6 mm) for ultrasonic non-destructive testing and thickness gauging, developed at the Laboratory.

advantage of having a dead zone of the order of 6—12 mm which, in this case, was overcome by using separate transducers for transmitting and receiving. The dead zone in this case was around 2—6 mm. Some of the developed probes were supplied to the actual users and were reported to be satisfactory.

Air Transducers for Out-door Use : The design of the air transducer already developed and released to the industry, was improved for overcoming the observed short-comings.

Another air transducer with a solid angle of 60° and having a much larger range than that covered by the first model was also designed and developed.

Piezoelectric Ceramic Filters : Piezoelectric ceramic filters were made using NPLZT-6 material developed at the Laboratory, and the same were used in radio receivers to improve selectivity. The filter consists of a thin piezoelectric ceramic disc of NPLZT-6 provided with concentric ring and dot electrode configuration on one side, and a full electrode on the opposite side. The filter developed has sharp selectivity, high stability and low ageing effects, and it can be used as a separate unit.

Under-water Acoustics : Work relating to setting up of facilities for acoustic power measurement of the transducers developed, was initiated. A 5 W transducer for under-water applications was developed. With the radiation pressure balance developed, it was possible to measure power with about 10% accuracy. A set-up for the calorimetric method of acoustic power measurement was also designed and fabricated.

A control room for carrying out under-water acoustics experiments/investigations in a concrete tank was constructed. A set-up for distance measurement under water, using the NPL-developed transducer, was also designed and developed. *Fig 12* shows a view of the concrete tank for under-water transducer calibration & standardization.

Production/Repair of Ultrasonic Instruments & Devices : The group also undertook production and repair of ultrasonic instruments and devices for outside parties. The foreign exchange saving as a result of this service was to the tune of about Rs. 0.5 lakh during 1976-77.

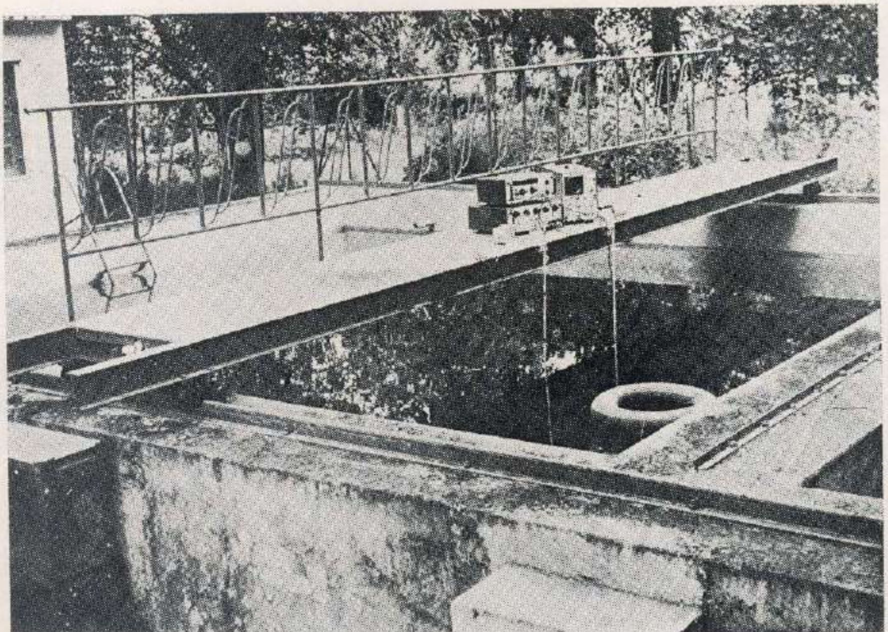


Fig 12 Facility for calibration and standardization of under-water acoustic transducers, set up at the Laboratory.

4. CARBON PRODUCTS

Activities in the area of carbon technology covered research and development work on (i) carbon fibres, (ii) arc carbons, (iii) midget electrodes, (iv) electrographitized grades of brushes, (v) carbon mixes, and (vi) carbon microphone granules.

4.1 CARBON FIBRES

Progress

Carbon fibres were developed using PAN (Poly Acrylo Nitrile), viscose rayon, and pitch precursors.

PAN : Efforts were directed towards drawing of carbon fibres in continuous stretches, and encouraging success was achieved in development of fibres using PAN precursor. Two imported PAN precursors were carbonised, yielding the following results :

PAN-Courtella, UK	Strength : 300×10^3 psi
	Modulus : 30×10^6 psi
PAN-Beslon, Japan	Strength : 250×10^3 psi
	Modulus : 25×10^6 psi

Viscose Rayon : Work was continued on carbon fibres using viscose rayon produced by M/s Century Rayon. It was possible to produce carbon fibres with a strength of 80×10^3 psi and a modulus of $7-8 \times 10^6$ psi on a 10-hour batch process.

Pitch Fibres : Efforts were primarily concentrated on drawing fibres from petroleum pitch, and carbonizing them. Softening point of about 200°C for drawing pitch fibres by melt spinning was obtained from a raw pitch of 80°C softening point, by treatment in nitrogen atmosphere around 400°C. The study of viscosity variation of pitch with temperature showed that between the temperature range 300°C to 400°C the viscosity was minimum, and meso-pitch, which is the real precursor for carbon fibres, was formed. The modulus and the strength of the carbon fibres developed were 7×10^6 psi and 100×10^3 psi respectively.

Characterization of Fibres : Extensive characterization studies were carried out on PAN-based carbon fibres. The properties of the ultimate carbon-fibres depend very much on the transformations that take place during oxidation. This was confirmed by characterization studies. During the year, special emphasis was laid on the studies on (i) the influence of the time of pre-oxidation on the tensile strength of fibres under constant load conditions, (ii) the influence of the change in the length of the carbon fibres on their tensile strength, (iii) X-ray low angle scattering of carbon fibres to study the size and surface area of the pores in carbon fibres, (iv) surface area determination, and (v) the behaviour of carbon fibres during adsorption and desorption.

4.2 ARC CARBONS

Progress

The production of cinema arc carbons by the NPL-licencees increased considerably during the year. The details of the process know-how for rotating carbons were also worked out and passed on to the licencees of arc carbons, for commercial exploitation.

4.3 MIDGET ELECTRODES

Progress

The Laboratory continued processing midget electrodes and sending them to a few battery manufacturers. A new centreless grinder for automatic grinding was also commissioned during the year. Supply of electrodes produced at the experimental pilot plant, to M/s. Koman Industries, Kaninad, who have taken the know-how for dry cell manufacture from the Central Electro-Chemical Research Institute, Karaikudi, was continued. The process know-how for midget electrodes was released to M/s. Shreyas Engineering & Chemical Industries Ltd, Bangalore. M/s. Britelite Carbons Limited, Bombay, continued production of the midget electrodes with the NPL know-how, and the samples of the firm were approved by the National Test House, Calcutta, and M/s. Jesons Electronics Ltd., New Delhi. The firm also supplied a few lakh pieces of midget electrodes to the battery manufacturers.

4.4 ELECTROGRAPHITIZED GRADES OF BRUSHES

Progress

Automobile grades of brushes were developed successfully using graphite scrap which is available in abundance. These brushes required heating upto 2000°C, and their performance was found quite satisfactory.

4.5 CARBON MIXES

Progress

During the period under report, studies were carried out to investigate the effect of pressure, particle size and binder in moulding, on the final properties of these moulded products after baking.

4.6 CARBON MICROPHONE GRANULES

Progress

Techniques were developed for processing of raw materials for making carbon granules which are vital for the telephone communication systems. With precise control of temperature and environment, which form critical parameters, cheap raw material was successfully converted into a sophisticated product having negligible porosity and optimum pyro-electric deposition on a partially graphitized interior.

The manufacturing process essentially consists of heat treatment of a selected type of anthracite coal in an inert atmosphere in the range of 1000-1200°C, giving it then an oxidation treatment at a certain temperature followed by a mechanical agitation to make it stable, and finally elutriating and sieving.

The granules developed at the Laboratory underwent vigorous testing according to stringent specifications and international standards, and were found not only to be satisfactory by the Indian Telephone Industries and the Defence authorities, but also comparable to the imported granules in all the properties.

DIVISION OF RADIO SCIENCE

The principal objectives of this Division are :

(i) To study, analyse and disseminate information on propagation of radio waves at all frequencies ;

(ii) To conduct research on the nature of the media through which radio waves are transmitted ;

(iii) To monitor solar-terrestrial environment ;

(iv) To provide space environment disturbance monitoring and predictions. (Solar-geophysical services, radio warning services) ;

(v) To explore new radio techniques for use in communication, meteorology, geodesy, environment monitoring, and time standards ;

(vi) To utilise the newly emerging techniques of space research in the study of the near space environment, and to explore new areas of applications ; and

(vii) To study and identify the extent of man-made and natural environmental hazards.

1. GROUND BASED FACILITIES FOR ENVIRONMENT MONITORING

Scope and Objectives

(i) To develop facilities and competence in environment monitoring by radio methods, comparable to those in advanced countries ;

(ii) To provide environmental data required for practical radio communication and aeronomical studies ; and

(iii) To undertake research on techniques.

The project provides basic material for planning and optimum use of radio and TV broadcasts and other communication systems on a national basis.

Progress

Routine monitoring of the radio environment with the existing equipments was continued. The equipments are :

(a) Type C-4 ionosonde ;

(b) Cosmic radio noise measurement at 28.5 MHz ;

(c) Low frequency signal strength monitoring at 164 kHz (Radio Tashkent), and at two other frequencies ;

(d) VLF amplitude and phase measurements at 22.4 kHz ; and

(e) A Dopplometer at 10 MHz at Calcutta, receiving ATA, Delhi, and JJY, Japan.

Of particular satisfaction was the re-starting of the cosmic radio noise equipment at a new site with a new aerial system.

Two new experiments were initiated during 1976. One was a phase comparator for OMEGA transmissions at 13 kHz, and the other a highly sensitive photometer for recording air glow at Hα (6563Å).

The following research work was also carried out, based primarily on the monitoring data :

(a) Electron density profiles deduced from ionograms over an extended period of time were utilised for study of loss coefficients in the ionosphere and in critical study of methods devised for such analysis. The electron density profiles were also utilized for representative ionospheric models to suit various seasonal and solar activity conditions.

(b) Studies on trans-equatorial propagation at VLF were made on phenomena like cycle slipping at sunrise, and also for deducing parameters for D-region electron density model building.

(c) Behaviour of the sporadic-E layer, particularly for the equatorial region, was studied in some detail.

The following studies were undertaken at the request of the All India Radio :

(a) Detailed computations, with the help of a computer programme written for the purpose, were made of the interference probability of sporadic-E in TV transmissions between stations operating in the same band for different hours of the day and in different seasons.

(b) Some studies were made on interference potential of high power transmitters in TV channels. This showed how the heating effect of a high power transmitter at Aligarh can cause disturbance effect in the ionosphere over Waltair, causing anomalous propagation of TV signals between Calcutta and Madras.

(c) A study was undertaken to examine the possibility of improving medium wave broadcast coverage by the All India Radio.

2. ROCKET AND SATELLITE EXPERIMENTS

Scope and Objectives

(i) To measure electron, ion and neutral number densities in the lower ionosphere ;

(ii) To measure total electron content of the ionosphere and to study scintillations and large scale irregularities ; and

(iii) To use this ionospheric study for various space applications such as refraction errors in satellite ranging and position fixing, the effects of irregularities in communication etc.

Progress

ATS-6 Experiment : Recording of the amplitude and Faraday rotation of 40 and 140 MHz transmissions from the geostationary satellite ATS-6 was continued at New Delhi (28.6°N, 77.2°E) upto the end of August 1976 until the satellite went below the horizon due to its shifting towards the western hemisphere. The amplitude and Faraday rotation of 140 MHz were also recorded at Gauhati (26.2°N, 91.8°E) for the same period. The 140 MHz Faraday rotation was recorded at Kurukshetra (29.9°N, 76.8°E) in collaboration with the Kurukshetra University, for the period April-July 1976. The Faraday rotation records were used to make comprehensive study of the TEC and its variations. The Faraday rotation of the 140 MHz transmission recorded simultaneously at New Delhi and Kurukshetra was utilized for the study of the characteristics of large and medium scale irregularities. From this analysis it was found that the irregularities have the most probable velocity component of about 400 ms^{-1} in the N-S direction(*Fig 13*).

NPL-Japan Rocket Experiment : Two Centaure rockets were flown in March 1976, from the Thumba Equatorial Rocket Launching Station (TERLS) to study the equatorial lower ionosphere, under a collaborative programme with the University of Tokyo, Japan. Electron densities were measured using a propagation experiment and a Langmuir probe. A Gerdien condenser was included in the payload to measure the positive ion densities. Neutral nitric oxide densities were also measured simultaneously. The propagation experiment and the Gerdien condenser were provided by the NPL, and the nitric oxide experiment and the Langmuir probe by the University of Tokyo.

All the experiments worked satisfactorily in both the payloads. However, the data could not be obtained during the first flight due to telemetry failure. The data obtained from the second flight were analysed. Interpretation of the data, using the simultaneously measured ion and electron densities and neutral nitric oxide densities, was initiated.

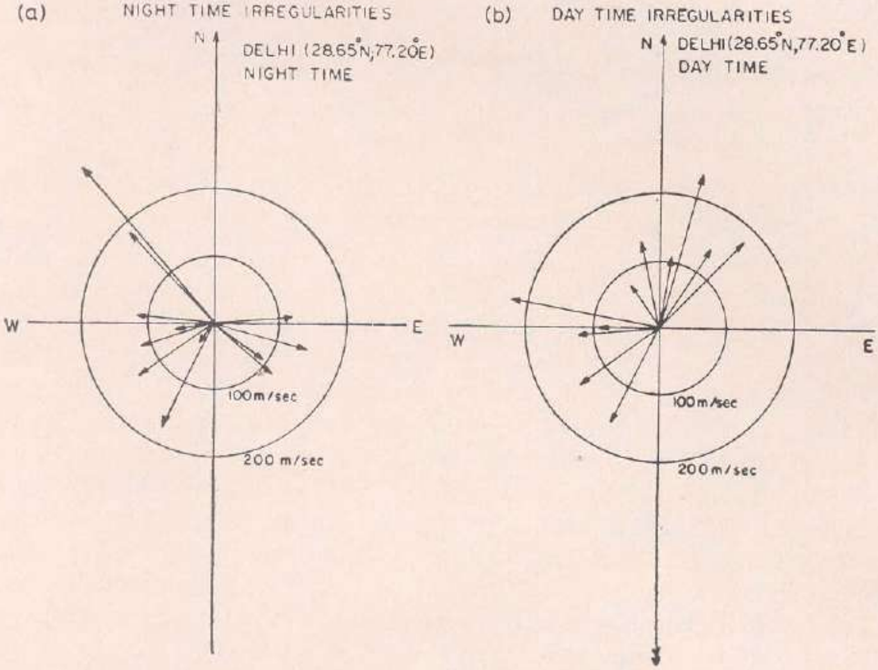


Fig 13 Velocity distribution of isolated medium-scale irregularities during (a) night-time and (b) day-time.

The total positive ion density was measured between 60—100 km, using a Gerdien condenser payload. From 80 to 100 km the positive ion densities were, within the limits of error, the same as the electron density values determined through simultaneous propagation and DC probe experiments. Below 80 km, the positive ion curve begins to diverge from the electron density curve, indicating that λ (positive ion to electron ratio) begins to be more important at these heights. At 70 km λ seems to lie within 1 and 2, and this was consistent with the earlier observations.

Reference D-Region : At Thumba, rocket measurements of the D-region electron density profiles (both propagation and probe) have covered a wider range of zenith angles than those available at any other location. The zenith angles cover a range from 6° to 98°. Based on these observations , a reference D-region was evolved using the six-ion chemistry. This reference D-region consists of distributions of the electron density, the positive ion density, positive ion composition, negative ion composition , and the effective loss coefficient over Thumba, under all conditions of solar activity and for different times of the day.

It has also been found that for the same zenith angle, the Thumba electron density profiles are, within the limits of error, identical with the profiles obtained from mid and high latitudes.

3. RADIO AND SPACE SERVICES

Scope and Objectives

(i) To predict HF radio propagation parameters in advance for the benefit of various communication organisations in India ;

(ii) To develop new techniques of propagation most suitable for the Indian conditions ;

(iii) To collect , compile and disseminate ionospheric , solar and geophysical data ; and

(iv) To broadcast in advance, geo-alerts and other disturbances that cause disruption in communication.

Progress

During 1976, the Radio Services Group continued to provide forecasts on radio propagation conditions via the ionosphere to various users in India six months in advance, and was also responsible for collection and compilation of ionospheric and solar geophysical data from various ionospheric stations in India.

ASSOCIATE REGIONAL WARNING CENTRE

(A R W C)

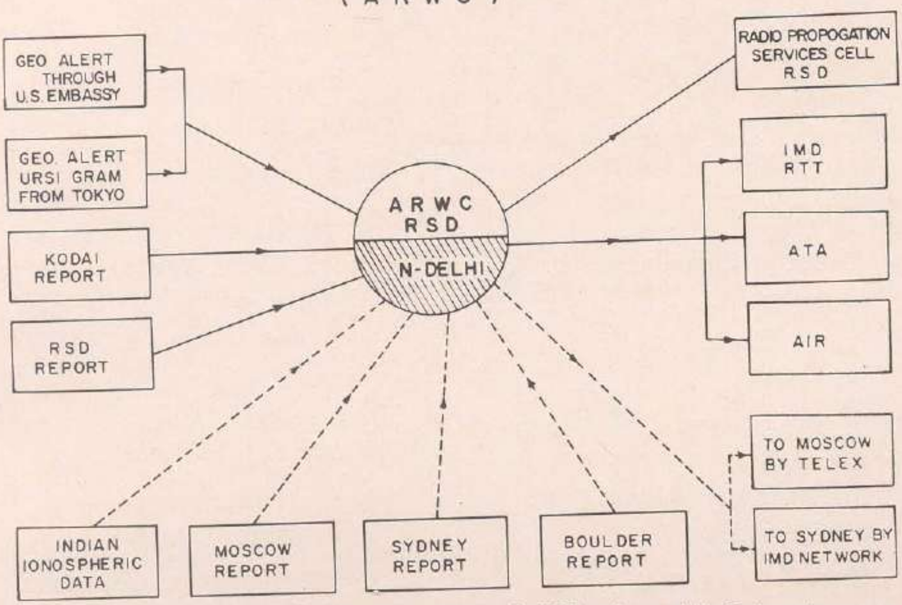


Fig 14 Associate Regional Warning Centre (ARWC) set up at the Laboratory as a part of the International Solar and Geophysical Warning Network. The data received from the national and international agencies are used to issue short-term forcasts for improving radio communication.

With the installation of a telex machine in 1975, the working of the Associate Regional Warning Centre (ARCW) (*Fig 14*) was expanded considerably. The Group, and the Hydro-meteorological Services, USSR, agreed to exchange scientific data under the ARWC programme. Under the agreement, the Group started providing monthly predictions of sunspot activity to Moscow from March 1976, and Moscow started providing information on proton events, X-ray and radio frequency flux. Single frequency measurement of solar radio flux data was received from Sydney and Culgoora through the telex system from August 1976.

Special studies were also pursued to improve the forecasting for low latitudes. The day to day variability in the height of the F_2-region at low latitudes was studied in conjunction with the day-to-day variability in f_0F2. This study was continued to ascertain whether these two were associated in any manner. Communications at low latitudes can be improved considerably if the extent of this variability can be predicted.

A representative list of services rendered during 1976 to various organizations is given below:

Organization	*Types of Services*
Defence	Antenna, Firing Angles.
Army	Optimum Frequencies.
Air Force	Power Requirements.
Navy	Noise Levels.
JCEC	Special Services.
Overseas Communication Service	Antenna, Firing Angles, Optimum Frequencies, Interference Limits, Special Services.
Police Wireless	Firing Angles, Optimum Frequencies.
Indian Space Research Organisation	Antenna, Power Requirements, Optimum Frequencies.
Post & Telegraphs	Power Requirements, Antenna, Special Services.
Directorate General of Security	Special Services.

4. AERONOMY

Scope and Objectives

(i) To study the physics and chemistry of the upper atmosphere and ionosphere ;

(ii) To measure cross-sections of processes of aeronomical interest in the laboratory ; and

(iii) To obtain basic reference information of the radio atmosphere for use in (a) communication , (b) atmospheric pollution and climatic changes , (c) satellite tracking , (d) navigation systems , and (e) systems design.

Progress

Ionospheric Scintillation Studies with the Ooty Radio Telescope : Special emphasis was placed on two important aspects of the scintillation phenomenon *viz.* (i) zenith angle effects , and (ii) irregularity drift measurement.

To visualise the zenith angle effects, sets of two-radio sources were chosen such that they correspond roughly to the same declination but differ in the right ascention by roughly 2 hrs. The Ooty radio telescope tracked one source, and a 14m dish at a line-of-sight distance of 3.5 km (in West) tracked the other. Zenith angle increase of scintillation index was not apparent , but there was an important result of scintillation rate decrease with the zenith angle (*Fig 15*). To further examine the zenith angle effect and related problems, comprehensive observations were carried out for a week, alongwith NOAA equipment receiving ATS-6 signals.

The Ooty radio telescope and the 14m dish, tracked strong sources in Virgo A and Crab Nabula to estimate irregularity drift speed in the East-West direction, and a typical value $\sim 500\ ms^{-1}$ was observed.

Polar Wind Studies using the Alouette-II Satellite Data : The electron density profiles obtained by the Alouette-II satellite were used to study the polar wind fluxes around the high latitudes. It was convincingly demonstrated that the most favourable conditions for H^+ to attain super-sonic speeds are a lower plasma temperature at a reference level of 1000 km , and a higher temperature gradient above that level. Further studies on the variation of polar wind velocities with the geomagnetic latitude in the range 50-65° yielded some very significant results. One such observation of significance was on the effect of $O^+ - H^+$ transition level on the latitudinal variation of H^+ transition level.

Models of Electron Temperature in the Ionospheric F-Region, using Electron Density Height Profiles : Models of electron temperature in the

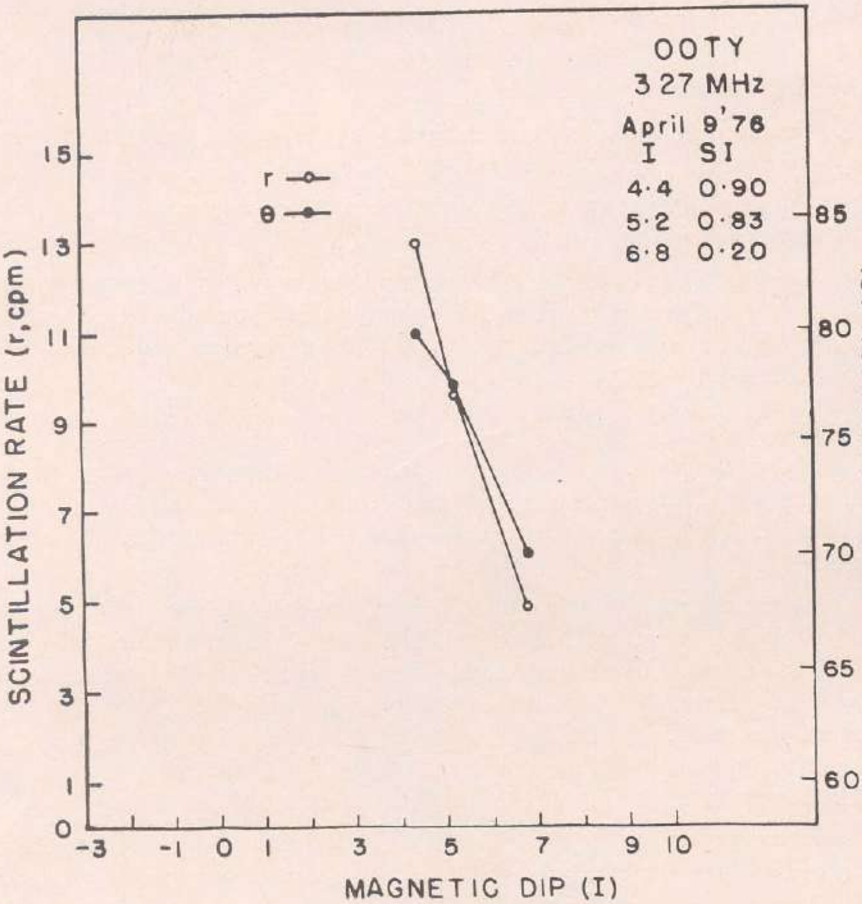


Fig 15 **Scintillation fade rate (r) and the apparent drift direction (Θ)** (*Deduced theoretically*)**, are displayed against the magnetic dip (I) for the experiment conducted with the Ooty radio telescope on 9 April 1976 to establish the slowing down of scintillations at large zenith angles.**

ionospheric F-region were prepared for the low and medium solar activity conditions. The low solar activity models were based upon the incoherent-scatter radar measurements at Arecibo during 1965-66. The medium solar activity models were based upon the incoherent scatter radar measurements at St. Santin during 1967-68. These models were constructed from the empirical relations between electron concentration and electron temperature. Comparisons of electron temperature calculated from the models , with those observed from incoherent scatter radars and Langmuir probes , showed good agreement.

Ion Composition in the Top-side Ionosphere from Satellite Measurements : The ion composition in the top-side ionosphere represents diffusive equilibrium distribution for medium solar activity as observed by the analyses of OGO-4 and Explorer-31 satellite data for Sept-Oct 1967. The transition height from O^+ to H^+ dominance during day time is around 1600 km for mid latitudes , and 1300 km for low latitudes. For night time, this transition height is 700 km for mid latitudes. An important feature of the medium solar activity is the abundance of the helium ions over the hydrogen ions, as compared to the low solar activity.

Ionospheric Electron Density Model : Electron density models were developed over a latitudinal and longitudinal range for various solar activities and seasons for the Indian subcontinent. In the present technique, the region around h_mF2 is built by assuming an α-Chapman layer extending to $1-5$ scale height above h_mF2. The f_oE and bottom-side ionosonde data were used to build the bottom-side profile. The top-side region around $(h_mF2+1.5H)$ was divided into two exponential decaying regions, the lower one corresponding to the heavy ion (O^+) as the dominant constituent, and the upper one corresponding to the lighter ions (He^+ or H^+) as the dominant constituent. The two constraints put on the development of the top side electron density profile were the electron content obtained from the satellite beacon experiment, and the electron density at 100 km obtained by the satellite probes.

Laboratory Aeronomy : The first phase of setting up of a laboratory aeronomy facility for the study of excitation due to electron impact on atmospheric gases was nearly completed. In this, the vacuum system, the collision chamber, the electron gun, and the photometer, were designed and completed. Also a facility for photon counting system was acquired.

Based on the laboratory measurement of excitation cross-sections of N_2 and O_2 bands, the CIRA 72 atmospheric models, and the penetration range of electrons in air, the ionization due to the incoming electrons in the auroral region was computed. Also the intensity of 3914Å N_2^+ first negative and OI 5577Å forbidden lines produced by different electron energy (10 keV and 1 keV) was computed, based on the latest available cross-section.

5. ENVIRONMENTAL HAZARDS

Scope and Objectives

(i) Monitoring of the atmosphere upto a height of 1 km for use in hazardous situations in communication, aviation and air pollution;

(ii) To develop the technique and instrumentation , and to calibrate the system for monitoring parameters like temperature inhomogeneities, inversions, wind velocity and turbulence intensity in the lower atmosphere ;

(iii) To study the global and regional aspects of atmospheric ozone depletion by natural and artificial means and its consequences to our environment , with special reference to the Indian sub-continent ; and

(iv) Climatic changes due to solar activity—possibility of long term forecasting.

Progress

Sodar : A monostatic sodar unit, similar to the one operating at the NPL, was set up at the Aya Nagar (Delhi) Observatory of the India Meteorological Department (IMD), for comparing the sodar observations with the meteorological data.

Trial runs of the slow rising balloon facility were made by the IMD on 8 & 9 December 1975. During this period of their trial runs, the NPL sodar unit had also been operating for part of the time. A comparison of the observations made by these two systems showed that the acoustic technique has potential as a monitor of meteorological conditions of the lower atmosphere.

An analysis of the simultaneous observations of the sodar atmospheric structures and the microwave propagation characteristics over a line-of-sight path at the NPL showed that the formation of laminated layers of 10—25m thickness during nocturnal cooling corresponds to the duct thickness of the microwave link frequency.

Tropospheric Disturbance of 17-21 December 1974 : A number of troposphere monitoring experiments were pressed into service during a large tropospheric disturbance in December 1974. The disturbance lasted for several days and the experiments that were put into intensive operational schedule included : a monostatic sodar system , a satellite radio beacon receiver at very low elevation angles, meteorological radiosondes, a 250 kW weather radar, a microwave LOS link and a micro-barograph. This multi-pronged campaign yielded voluminous data, the analyses of which were completed during the year under report. This yielded very useful results, and the correspondence between various observations was striking.

Effect of Natural and Artificial Pollutants on the Earth's Ozone Environment : Observational results on the ambient concentration of the principal minor constituents NO, NO_2, CH_4, O_3, H, OH, CH_4, and H_2O were synthesised in the context of the ozone depletion processes and the competing sources of

(i) Nitric oxide emitted by supersonic aircrafts ;

(ii) Chlorine arising from photo-dissociation of industrial chlorofluoromethanes ;

(iii) Nuclear explosions injecting nitric oxide in the stratosphere ;

(iv) Volcanic eruptions giving out chlorine ; and

(v) Solar particles, particularly after flares, producing nitric oxide through impact dissociation of atmospheric nitrogen.

DEVELOPMENTAL PROJECTS

In addition to the R & D Projects undertaken by the Division of Standards, Division of Specialized Techniques, Division of Materials, and Division of Radio Science, the Laboratory pursued work on the following four projects termed as Developmental Projects :

1. Microwaves and Display Tubes Technology ;
2. Electrophotographic Machines ;
3. Thin Film Devices ; and
4. Liquid Crystal Devices.

1. MICROWAVES AND DISPLAY TUBES TECHNOLOGY

Scope and Objectives

Under this project, activities on the following three areas are covered :

(i) Design, development and batch-production of microwave components, circuits and instruments ;

(ii) Fabrication techniques for cathode-ray tubes and TV picture-tubes ; and

(iii) Development of composite displays (3-D photography and radiography).

The objective is to develop the technology, and then to transfer the know-how to the industry for commercial exploitation.

Progress

1.1 DESIGN, DEVELOPMENT AND BATCH-PRODUCTION OF MICROWAVE COMPONENTS, CIRCUITS AND INSTRUMENTS

General Purpose Waveguide Components : The production of general purpose waveguide components by the three NPL licencees, *viz.* M/s. KLB Electronics, New Delhi, M/s. Scientific Instruments Co. Ltd., Allahabad, and M/s. Vidyut Yantra Udyog , Modinagar, reached a figure of about Rs. 5 lakhs per annum, and they started partially meeting some specific demands of Defence, TRC, ITI, HAL, Meteorological Department, IITs, Universities etc.

Several components such as coaxial to wave-guide adapter and slotted section for KU-band, matched detector mount for XN-band, multihole directional couplers for K-band, and horn antenna for KU-band were designed, and their fabrication was started.

Coaxial Line Components : Work on precision line connectors and coaxial components (50 ohm-N type), was started. Some connectors were made and evaluated for use in coaxial matched terminations and fixed attenuators etc.

Coaxial sliding matched terminations, frequency meter (1.3 to 4.0 GHz), variable attenuators, and fixed attenuators, were designed and fabricated.

Precision Microwave Components: Work relating to the development of precision waveguide components such as precision rotary vane attenuators, precision short circuits, sliding matched terminations, broad-band matched detector mounts, precision moveable short circuits, and phase shifters etc., was taken up.

Development of X-band matched detector mount and X-band sliding matched termination was completed during the year.

1.2 FABRICATION & RECONDITIONING OF TV PICTURE TUBES & SPECIAL PURPOSE CATHODE RAY TUBES

Reconditioning of CRT and TV tubes was continued as a service to the public, utilising the facility for reconditioning of one TV picture tube per day. Developmental work on another pumping unit to increase the capacity to four tubes per day was completed during the year. An automatic processing oven was installed for reconditioning of TV picture tubes upto 24" size. One of the licencees, after taking training at the NPL, started production during the year.

A special CRT for testing the deflection sensitivities of the deflection coils of scanning electron microscope was designed for the Central Electronics Engineering Research Institute, Pilani.

1.3 3-D PHOTOGRAPHIC DISPLAYS

Process know-how for making three dimensional panoramic photographic displays was released to Mr. N.M. Ramaswamy of M/s. Panographics India Pvt. Ltd., Erode, and their representatives were given initial training (*Fig 16*).

Fig 16 Release of the process know-how for making 3-D panoramic photographic dispIa to M/s Panographics India Pvt. Ltd., Erode, Tamil Nadu. Shri N.M. Ramaswamy, Managing Director of the firm. is seen at the extreme left. Others (sitting from left to right) are : Dr. A.R. Verma, Director of the Laboratory, & Dr. Kailash Chandra and Shri R.C. Dhawan—the two scientists associated with the project.

2. ELECTROPHOTOGRAPHIC MACHINES

Scope and Objectives

Electrophotographic machines are essential for document copying, and for fast and accurate dissemination of information. Manually operated machines based on the principle of electrophotography and using selenium photoreceptors, have already been developed at the NPL with complete indigenous resources, and the process know-how has been released to the industry through the National Research Development Corporation of India, New Delhi. Over a thousand machines, based on the NPL process know-how, have been sold within and outside the country.

The objective is to utilize the expertise generated, for development of other electrophotographic machines and to effect improvements in the machine already developed.

Progress

Interfacial Barrier Layers of Polymers for Selenium Plates: Work on the development of PVC coatings for use as interfacial barrier layers between the conductive aluminium substrate and the amorphous selenium coatings was initiated. PVC layers of different thicknesses, coated with layers of different thicknesses of Selenium were studied.

Some experiments were also made with the large rotary unit at the works of M/s. Advani Oerlikon, Bombay—one of the licencees of the NPL know-how for the manually operated plain paper electrtophotographic copier—and it was possible to effect a saving of about 50% of selenium by reducing the content of selenium by providing polymer barrier layers between the substrate and the layer of selenium.

Studies were also made to avoid the peeling off effect of selenium with interfacial polymer barrier layers.

Photocopying Machines using Selenium Drums: Considerable work on the study of the fabrication of selenium drums and foils was carried out during the year. Particular attention was laid on the problem of peeling off of the selenium layer.

Radio-Xerography: Some new resins were tried for the preparation of photoconductive plates, to use them in radio-xerography. Preliminary trials on taking radio-xerographs of machine parts for non-destructive testing, were made.

Electrofax Machine: A fully automatic machine of the electrofax type was developed (*Fig 17*). The sensitized paper used in this machine has a coating of photoconductive materials like zinc oxide on an electrically conducting paper which is electrostatically charged, exposed to the document to get an electrostatic image, and developed by a liquid developer. The toner image is automatically fixed and dried on the paper. The machine takes about 10 seconds to make a copy. The process know-how of the sensitized ZnO paper has already been developed and released to the industry.

Electrostatic Dust Collectors: Besides continuing work on air filters using electrets, electrostatic filters using corona discharge followed by a precipitator, were developed. These filters can remove tiny suspended particles of the size $\leqslant 1 \mu m$.

Study of Polymers: TSD current measurements, and electrical and dielectric studies of some polymers such as polypropelene, polyvinyl chloride and polyvinyl acetate were made as a function of temperature, humidity, and electric field, with a view to obtaining the best conditions of charge retentivity of these polymers. These studies revealed the

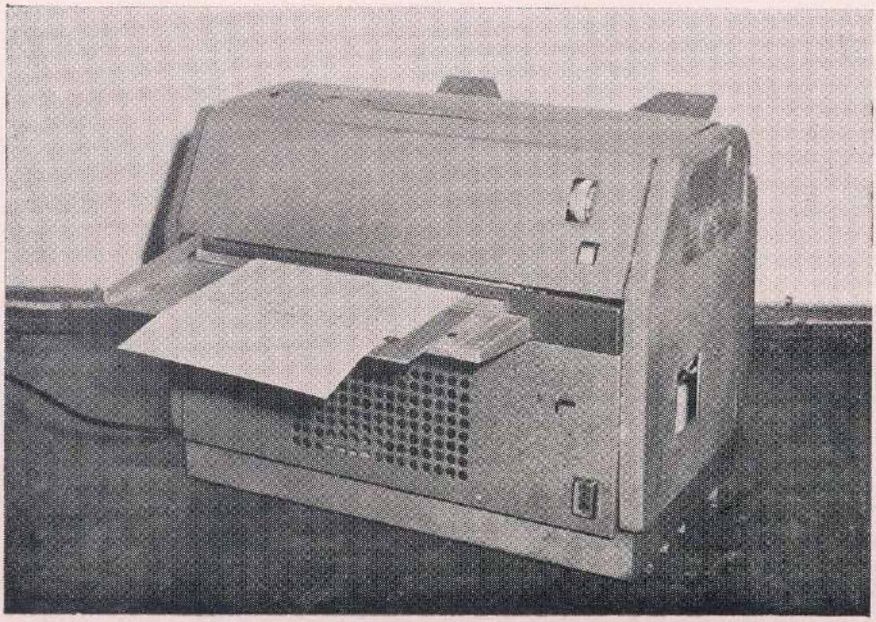


Fig 17 **Prototype of the electrofax type machine for document copying, designed, developed and fabricated at the Laboratory. The machine uses sensitized paper and liquid developer, and these have also been developed at the Laboratory. Size-to-size copy of a document (max. width ~ 22 cm) can be obtained in about 10 seconds.**

behaviour of these polymers as long life electrets, which would be useful as interfacial barrier layers in the selenium photoconductive plates, as dust collecting electrets in air filters, and also in electret microphones.

Substrates for Solar Cells : Studies were also made on suitably doped polymers to find out their electrical conductivity. The aim of this work was to reduce the resistivity from that of an insulator to one of a semiconductor. This, eventually, would be useful in making conductive substrates for solar cells, besides their use in electrophotography.

3. THIN FILM DEVICES

Scope and Objectives

(i) Development of thin film optical devices, and also, to a limited extent, putting the same into production to cater to the needs of various organisations, specially defence establishments and industries in the fields such as electronics, optics, infrared remote sensing, solar energy, electro-optics and display systems etc.; and

(ii) Investigation of the optical characteristics of thin film multi-layer systems which are useful in the development of the desired optical devices.

Progress

About 500 different types of chemicals and chemical mixtures were tried out to collect information about their evaporation characteristics and transmission characteristics in thin film form.

Interference Filters : Efforts were made to develop interference filters for use with flame photometers. Work on the development of interference filters for Na-line was taken up first. Interference filters with half-band widths upto 150 Å were successfully developed and supplied to the Central Electronics Engineering Research Institute, Pilani; DBS College, Nainital; Andhra University; Poona University; etc. However, these filters have the inherent property of showing transmission bands at other wavelengths also along with the peak transmission wavelengths. Attempts were made to suppress these side-bands.

Production of Thin-Film Devices : The versatile high vacuum plant type A 500 V imported from M/s. Leybold Hereaus, West Germany, was utilised mainly for production aspects. At a rough estimate, for 75% of the time, this plant was used for production jobs, and for the remaining 25% of the time, for R & D activity. Work on anti-reflection coatings (single and double layer type), beam splitters (metallic as well as dielectric type), laser & cold mirrors, interference filters, neutral density filters, hard chromium coatings, aluminizing etc., was carried out.

The following parties were rendered consultancy services during the year:

The Hindustan Aeronautics Ltd., Nasik.

M/s. Polypack Industries, Agra.

4. LIQUID CRYSTAL DEVICES

Scope and Objectives

(i) Development of liquid crystal thermal and electro-optical display devices ;

(ii) Development of various chemicals suitable for thermal (using cholesteric liquid crystals) and electro-optical (using either nematic or mixtures of nematic and cholesteric liquid crystals) display systems ;

(iii) Decoding, driving & multiplexing of numeric, alpha-numeric and other information displays ; and

(iv) Development of image convertor and intensifier devices.

4.1 ELECTRO-OPTICAL DISPLAY DEVICES

Research and development work on liquid crystal electro-optical digital display devices operating in the dynamic scattering mode (DSM) reached an advanced stage of completion. Success was achieved in fabricating multi-digit numeric displays operating in DSM to be used in systems such as electronic clocks, watches and test instruments.

Following is a brief of the progress made during the year :

Sealing Techniques : Work relating to the development of sealing techniques for liquid crystal cells, was continued.

During the various developmental stages three ways of putting the spacer, and of sealing the sandwich cell configuration were tried out. These were :

Using Epoxy Resins : Relatively inert organic materials such as teflon and mylar were used as the spacer material, and then the cell was sealed with epoxy resins like Araldite or Torrseal. This was the method used in the first generation of the liquid crystal displays developed at the Laboratory. On extended life testing it was found that epoxy resins swell with temperature cycling and humidity and also chemically react, in the long run, with the liquid crystalline materials. Furthermore, epoxy resins lose their grip, spacing is changed, and consequently bubbles or voids are formed.

Using Thermoplastics : In the second generation of liquid crystal display devices, thermoplastics were used for spacer as well as for sealing. A thermoplastic like mylar of suitable thickness (typically 12.5 microns) was placed between the glass plates (with desired configuration of electrodes made by photo-lithographic techniques), and heated to about 200°C for sealing the cell. This method also did not give true hermetic sealing.

Using Glass Frits : Glass frits are low melting glass compositions. They were first made in fine powder (300-350 mesh) and ultimately in paste form. They melted around 425-500°C depending on the particular composition. These frits were used as spacers as well as for sealing glass plates. True hermetic sealing along with metallization soldering of the filling hole was achieved by using this technique.

Liquid Crystal Electro-Optical Displays Operating in the Field Effect Twisted Nematic Mode : Work relating to the development of liquid crystal electro-optical displays operating in the field effect twisted nematic mode (TNM) was also carried out during the year. Various technical details for fabrication of liquid crystal electro-optical display devices, using "oblique" evaporation coatings of certain dielectric materials for surface treatment, were worked out.

4.2 LIQUID CRYSTAL LIGHT VALVES

Liquid crystal light valve is a display device in which, unlike in conventional display devices where fixed electrode system is used to display the desired digit, the desired image or pattern is obtained by juxtaposing the valve to the writing light in quasi-real time.

During the year, basic requirments of the photoconducting layer and the liquid crystal layer were identified. Two methods of depositing cadmium sulphide (CdS) films, e g. chemical spray and vacuum evaporation, were evolved. Conditions for deposition of CdS films of good stoichiometry and optical quality were established. A number of photo-electric properties of these films under various conditions of deposition and post-deposition treatment etc., were studied. In this connection, doping of various materials in CdS films during evaporation and also subsequent to it, were carried out to tailor them for aplications in light valves.

In order to establish the initial feasibility of the CdS film for light valve application the CdS film was put in uncoupled stage with a sealed liquid crystal cell operated in dynamic scattering mode, and this cell was driven above its threshold value just by illuminating the CdS layer. A study of the minimum light required for driving the liquid crystal above its threshold at different voltages was undertaken.

Based on the expertise developed in the formation of suitable CdS films, and the initial successful experiment in the uncoupled stage, the liquid crystal layer and the CdS film were put in conjunction in sandwich configuration, and sealed by epoxy. For such a sandwich device the variation of threshold voltage of the liquid crystal under various degrees of illumination to the CdS side, was studied. Also the variation of the contrast, i.e. the ratio of the incident light to the scattering light, under different writing light illumination to the CdS film and different voltages applied to the sandwich, was studied.

A prototype projection system, using He-Ne laser as the projection light and white light from a slide projector (writing light), was set-up. A pair of Fourier transform lenses was used to project the image formed in the liquid crystal plane. Projection with degrees of magnification from 5 to 50 times was achieved on a suitably placed screen.

EXPERIMENTAL PILOT PLANTS

The Laboratory has four Experimental Pilot Plants as under :

1. Pilot & Demonstration Plant in Hydrostatic Extrusion & Material Synthesis ;
2. Glass Technology Development and Production Unit ;
3. Development-cum-Production of Electronic Components Unit ; and
4. Carbon Pilot Plant.

1. PILOT & DEMONSTRATION PLANT IN HYDROSTATIC EXTRUSION & MATERIAL SYNTHESIS

Scope and Objectives

Scientific and Technical

(a) *Short term :*

(i) Development of composite materials like copper-clad aluminium and alloy aluminium clad aluminium ;

(ii) Extrusion of hard-to-extrude materials like alloy aluminium and alloy steels ; and

(iii) Extrusion of complex shapes like gear profiles and twist drills.

(b) *Long term :*

(i) To undertake development of indigenous production equipment in hydrostatic extrusion ; and

(ii) To investigate the possibility of putting up similar units in hydroforming and hydropressing.

Socio-Economic

(i) To reduce dependence on imported materials like copper, by development of composite materials ;

(ii) To make more efficient use of indigenous materials like hard aluminium alloys ; and

(iii) To cut manufacturing costs in the production of complex shapes such as gear profiles and twist drills.

Considrable work is being done the world-over in high pressure technology which holds promise of cutting down manufacturing costs, giving products with improved mechanical properties, lowering scrap. and introducing new materials which substitute expensive and scarce raw materials by cheaper ones.

Of immediate interest to the country, where this development will be of great help, is the development of (i) industrial diamonds which are presently being wholly imported at an estimated cost of Rs. 60 lakhs per year, (ii) composite materials like copper-clad-aluminium wires to effect a substantial saving in the use of copper and (iii) extruded tubes, shapes and sections in alloy steels and other hard-to-extrude materials e.g. titanium, zirconium etc.

NPL is establishing a pilot and demostration plant in hydrostatic extrusion and material synthesis to meet these objectives. This phase of the work is receiving UNDP assistance.

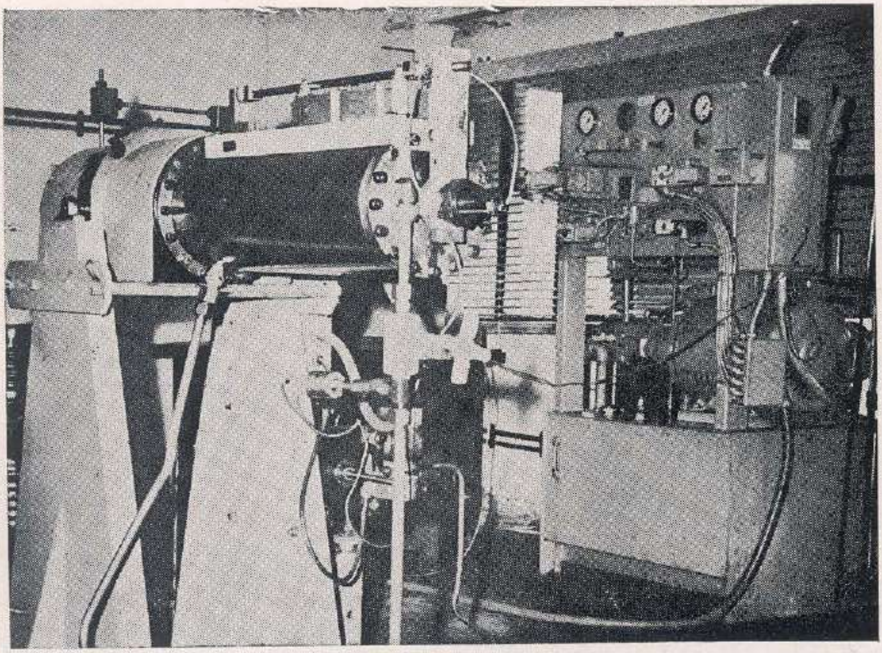


Fig 18 The laboratory hydrostatic machine installed and commissioned at the Laboratory. The machine is a completely self-contained research and development unit for studying cold extrusion on a wide range of shapes, from numerous materials including ferrous, non-ferrous and exotic high-tensile strength alloys.

Progress

Laboratory Extruder Plant : A laboratory plant for hydrostatic extrusion (Laboratory extruder model 0310) was installed and commissioned in March, 1976 with financial and technical assistance under the United Nations Development Programme (UNDP).(*Fig 18*). The facility was established for developing process parameters for cold extrusion of different materials such as copper-nickel alloys, stainless and alloy steels, titanium and zirconium, and other composite materials, in various shapes and sections required by the Indian industry.

This was the first phase of the project, which, when completed, would involve UNDP inputs in the form of sophisticated equipment including a pilot extruder, shear spinner and ring roller, and a draw bench ; experts ; consultants ; and fellowships to Indian scientists for training abroad in this sophisticated technology.

Material Synthesis : Work on the synthesis of single crystal diamonds was continued on the 200 ton cubic press installed in 1975. Different catalyst-solvent materials were tried to study their effect on the quality and quantity of the diamonds produced. Techniques for chemical separation and characterization of diamonds were also developed. The diamonds produced were subjected to X-ray examination and preliminary consumer trials. The reports indicated that the diamonds synthesised at the NPL were of acceptable quality, comparable to the imported diamonds.

GLASS TECHNOLOGY DEVELOPMENT AND PRODUCTION UNIT

This Unit undertakes fabrication and reconditioning of sophisticated scientific glass and silica equipment for use in the Laboratory as well as for outside organisations. It was started primarily to meet the Laboratory's own requirements of glass apparatus, but now it is working on semi-commercial basis.

The activities of the Unit can broadly be divided into 3 categories :

1. Fabrication and reconditioning of standard glass items ;
2. Fabrication and reconditioning of specialised glass items ; and
3. Reconditioning of mercury arc rectifier bulbs.

Under categories 1 and 2, some of the representative items fabricated during 1976 included : high vacuum stop cocks ; teflon stop cocks ; high vacuum standard ground-glass joints ; high vacuum standard ball & socket joints ; glass-to-metal seals ; discharge tubes including gas laser tubes ; gas and blood analysers ; solid, liquid and gas extractors ; mercury & oil diffusion pumps ; Mcleod gauges & manometers etc.

Regarding the reconditioning of mercury are rectifiers, NPL is the only institution in India which undertakes such jobs.

Earnings of the unit including jobs undertaken for the Laboratory during 1976-77 amounted to about Rs 4.20 lakhs.

3. DEVELOPMENT-CUM-PRODUCTION OF ELECTRONIC COMPONENTS UNIT

This unit acts as a laboratory for trying out the fruits of research and development in the area of electronic materials, undertaken by the Division of Materials on an experimental pilot plant production level, for establishing the repeatability and the commercial viability of the various processes developed by the Division. The main objective of this Unit is to pilot-produce (i) various types of piezo-electric transducers & high voltage ceramic capacitors; (ii) high frequency insulator components; (iii) professional grade Ni-Zn ferrite components, pulse transformers and mini inductors & oriented ceramic magnets using celestite ore; and (iv) silver paints, resistor paints and capacitor paints.

The plant undertook pilot production of a variety of items developed within the Laboratory, *viz.* E and C cores; cup and drum cores; TV deflection yoke cores; high frequency oscillator cores; magnetic tapes; professional ferrites; conducting silver cement; low-loss ceramic insulators; high voltage ceramic capacitors; and piezoelectric materials and devices.

The sales during the year 1976-77 were as under :

Item	*Quantity*	*Amount (in Rs.)*
Piezoelectric and dielectric materials and divices	4,542 pieces	26,708.00
Soft ferrites	1,37,236 pieces	53,921.19
Hard ferrites	4,746 pieces	3,107.14
Silver cement	24,710 kg	40,922.25
	Total	1,24,658.58

4. CARBON PILOT PLANT

The work of the Carbon Pilot Plant is intimately associated with the research and development work on carbon products undertaken by the Divisison of Materials.

During the year 1976-77, this experimental pilot plant undertook small scale production of the items detailed below for supply to the user industry for trials, and for getting feedback information for further R & D work on them, and recorded the sales as mentioned against each:

Item	*Quantity*		*Amount (in Rs.)*
Microphonic carbon granules	1 kg		1,000.00
Process carbons	600 pieces		1,260.00
Carbon graphite rings	1,660 pieces		996.00
Carbon blocks and brushes	20 Nos		140.00
		Total	3,396.00

OTHER R & D ACTIVITIES

In addition to the research and development work undertaken by the four Divisions; the four Developmental Projects, and the activities of the four Experimental Pilot Plants, the Laboratory has some other R & D activities also, which are more in the nature of consultancy/advisory services. These include :

1. Design and development of optical system ;
2. Instrumentation services ; and
3. Sensory aids for the blind.

1. DESIGN AND DEVELOPMENT OF OPTICAL SYSTEMS

Scope and Objectives

To accelerate assimilation of the results of research on optical systems by the Indian optical industry through consultation and, thereby, to ensure rationalization and standardization of the products and production processes in the field of optical instrument manufacture.

Progress

During the period under report, emphasis was laid on giving scientific and technical advice regarding the starting of a lens industry in the hills of Uttar Pradesh for industrialization of economically backward areas.

2. INSTRUMENTATION SERVICES

Scope and Objectives :

(i) Maintenance and calibration of scientific laboratory-type electrical, electronic and electro-optical instruments and apparatus. Besides rendering this service to the Laboratory, work from other institutional users in respect of imported instruments only, is also undertaken ;

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

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; and

(iv) Inspection service (for NPL scientists only) for new equipment on arrival, or for instruments being returned to the Central Stores.

Progress

Instruments Servicing : 30 instruments were serviced for the NPL scientists and another 15 instruments were serviced for outside parties.

Consultancy and Advisory Services : More than 140 requests were attended to.

3. SENSORY AIDS FOR THE BLIND

Work was undertaken to examine the feasibility of a reading aid for the blind. A working system was made wherein, a probe, on encountering a black dot on paper, generated tactile stimulation on the finger through another probe. Optical scanning was done mechanically by photo transistor, the tactile sensation was produced by piezoelectric bimorphs, and the control was electronic.

INTERNATIONAL SYMPOSIUM ON FIBRES AND COMPOSITES

An International Symposium on Fibres and Composites, jointly sponsored by the National Physical Laboratory (NPL), and Department of Science & Technology, was held at the NPL on 19-20 January 1976. Besides scientists from various R & D laboratories, and representatives of the industry and the user organisations from within the country, a number of distinguished scientists from abroad also participated in this Symposium. The Symposium, the first one of its kind to be held in India, was inaugurated by Dr. A. Ramachandran, Secretary to the Government of India, Department of Science & Technology.

Dr. A.R. Verma, Director, NPL, gave the welcome address, wherein he said that the main driving force behind this Symposium and the prime focus of its immediate attention, was the UNDP sponsored project on fibres and composites in which six Indian institutions were participating. These include (i) National Physical Laboratory, New Delhi, (ii) National Aeronautical Laboratory, Bangalore, (iii) Central Leather Research Institute, Madras, (iv) Central Glass & Ceramic Research Institute, Calcutta, (v) Indian Institute of Technology, Kanpur and (vi) Vikram Sarabhai Space Centre, Trivandrum. The work at these six institutions was being coordinated and financially supported by the Department of Science & Technology who were providing the Indian counterpart contribution for this project.

In his introductory remarks on the UNDP project on fibres and composites, Dr. V.G. Bhide, Project-Coordinator of the project from the side of India, said, 'We have amongst us almost all the research workers working in this field in various laboratories in India. We have also amongst us, representatives of industries who are manufacturing a variety of products out of glass fibre composites. It is also fortunate that present amongst us are some of the representatives of users of fibre composites and their products. It is, therefore, a happy augury that we have in this gathering experts, research workers, manufacturers, users, and the Government representatives. With this participation, I am sure that the future of composite industry in India is extremely bright.' He said that taking the clue from the glass fibres, efforts were directed to see whether polymer fibres could be made flawless so as to yield high strength and high modulus fibres, thereby bringing carbon fibres on the scene. However, it was obvious that these fibres, as they are, cannot be used as engineering materials, thus, necessitating formation of composites. This, he said, was an emerging technology even in advanced countries, but one could well imagine the impact of this technology in various industries. With the unique properties that the composites possess, they could find ever-increasing applications in several sectors of the national economy which include agriculture, fisheries, chemicals, engineering industry and aerospace industry etc. The aim of this project had, therefore, been to develop competence and to establish production of glass and carbon fibres, to make composites, and to design and fabricate composite products of utility in all these areas. He said that the project was not only inter-institutional but also interdisciplinary in character, with specific tasks assigned to each participating institution in a manner so as to take maximum advantage of my point of and competence, and added, 'What is most important from their strength view and from the point of view of the success of the project is the fact that every worker in this project is excited about it and dedicated to it. We are conscious that this novel experiment of harnessing the strong points in various laboratories to achieve a desired goal is being watched with interest by every one in the country.'

The remarks from Dr. V.G. Bhide were followed by remarks from Mr. G. Lubin, UNDP Project Co-ordinator. The inaugural function ended with a vote of thanks from Dr. G.C. Jain, Head, Division of Materials, NPL.

There were four technical sessions. Dr. R. Bacon, Parma Technical Centre, Union Carbide Corporation, USA, gave the keynote address for the first session on 'Raw Materials: Resin/Matrix', which was followed by eight other technical papers. The keynote address for the second session on 'Product and Product Processing', was delived by Dr. S. Dastin, Grumman Aerospace Corporation, USA. This session had six presented papers. The third session was devoted to 'Analysis and Design' with the keynote address by Dr. C. Chamis, Lewis Research Centre, Cleveland, Ohio, USA, followed by nine papers. The last technical session was devoted to 'Testing and Quality Control', with the keynote address by Dr. Peter J. Donohue, Materials and Process Department, Grumman Aerospace Corporation, followed by eight other technical papers. All the four keynote addresses presented the global scene in the respective areas of the four technical sessions. Out of the other thirty-one papers covered under the four technical sessions, 3 were from abroad, and 28 were from within the country. The deliberations at the Symposium were also supplemented by technical film shows.

The Symposium was followed by a three-day workshop wherein the technical problems faced by the various R &D laboratories were discussed in detail. An exhibition displaying various reinforced plastics products was also arranged at this occasion.

The proceedings of the Symposium were brought out in a mimeographed form, and they run into two volumes.

NATIONAL SEMINAR ON TIME & FREQUENCY

A National Seminar on Time and Frequency was held at the Laboratory from 18 to 20 November 1976. About 250 delegates representing the Indian Space Research Organisation, Electronics Commission, India Meteorological Department, Defence, All India Radio, Uttar Pradesh State Observatory, Indian Institutes of Technology, Ministry of Communication, Bhabha Atomic Research Centre, Tata Institute of Fundamental Research, Vikram Sarabhai Space Centre, Geodetic and Research Branch, University Grants Commission, Universities, electronics industry and other educational institutions, and the CSIR laboratories participated in the seminar.

The objectives of the seminar were: (i) to let the users know the time and frequency facilities available within the country and in return let the requirements of the users be known; (ii) to suggest means to have an immediate time coordination and time synchronization throughout India and the role which NPL can play in it; (iii) to develop, indigenously, time and frequency standards and to provide suitable facilities for it; (iv) to plan, in view of the forthcoming space programmes, time and frequency dissemination via satellite; (v) to emphasize the urgency to have LF/VLF time and frequency dissemination service in India; (vi) to point out the natural interdependence of the basic researches of precise measurements and the availability of accurate time and frequency sources; (vii) to recommend the formation of a committee to look into the above points; and (viii) to achieve the above objectives through the papers presented, mutual discussion and panel discussion.

In his inaugural address, Shri K.C. Pant, Minister for Energy, stressed the importance of accurate measurements in various fields and highlighted the need for maintenance of standared time and frequency to high accuracies commensurate with the requirements of research, industry and technology. He commended the role of NPL in this field and urged that scientists and technologists should single-mindedly orient their work towards the areas of relevance to the country in this important field.

More than sixty papers including seventeen invited talks from scientists of repute were presented at the various sessions of the seminar, and these covered almost all the aspects of time and frequency such as: general review; ATA standard time and frequency transmission; uses and applications—particularly in space technology, oscillators and synchronous systems; time and frequancy standards; techniques and measurements; and instrumentation. A separate panel discussion was also held under the chairmanship of Dr. A.R. Verma, Director of NPL, in which five other scientists, *viz*. Dr. Y.P. Rao, Director General, India Meteorological Department; Dr. S.P. Kosta, Deputy Director, Indian Space Research Organisation; Prof. B. Ramachandra Rao, Vice Chairman, University grants Commission; Brig. B.S. Paintal, Director, Telecommunication, Ministry of Defence; and Dr. Helmut Hellwig, Chief, Time and Frequency Section, National Bureau of Standards, USA, took part. Dr. Verma proposed the formation of different groups of active scientists who should review progress and formulate the future plan of work in this field periodically. Dr. Helmut Hellwig shared the problem faced by NPL in the dissemination of standard signals and said that as TV synchronization is an accurate and inexpensive means of time dissemination, the potentiality of TV network for time synchronization would be worth exploring. He also emphasized the need for procurement of a large number of portable clocks and cesium clocks to solve the problem of dissemination to some extent.

In response to the deliberations by panelists, the house contended that NPL should take the initiative for VLF transmission of time and frequency signals. It was proposed that crystal oscillators upto the acccuracy of 10^{-9} should be available at moderate prices to cater to the needs of a majority of standard time and frequency users. A few R & D laboratories and industries should take initiative for their production. The seminar suggested that the potentiality of surface wave oscillators to serve the purpose of secondary standards might also be explored. Another important suggestion was to arrange for the calculation of mean solar time (UT_1 and UT_2) in India, completely independent of foreign agencies. The seminar unanimously called for closer interaction between NPL, the custodian of standards in India, and the users of time and frequency.

An exhibition of electronic instruments related to the subject of the seminar was also arranged on this occasion. A number of firms took part in the exhibition.

CENTRAL WORKSHOP

The Workshop executed about 3,100 work orders. A few major jobs done for R & D projects were:

(i) Photometer.

(ii) Turn table for X-ray topography work.

(iii) Sputtering unit.

(iv) Reduction gear box.

(v) Recorder assembly for Sodar.

The Drawing & Design Section executed about 400 drawing & design jobs. A few important ones were:

(i) Gear box (1 rev/day).

(ii) Solar absorption apparatus.

(iii) Photometer.

(iv) Bath for reversing thermometer.

(v) Solar water heater with single bonduct.

(vi) Winding and unwinding mechanism for continuous fabrication of carbon fibres.

(vii) Flexible strength unit (Beam with four point loading).

(viii) Facsimile recorder.

(ix) Crucible holding arrangement for pulling of single crystals by Czochralski technique.

(x) Rotating arrange ment for antenna.

LIBRARY

The Library continued to provide library, documentation and reprographic services to the scientists of the Laboratory—the Library service through its additions in the Library of books, journals and other literature of interest to the staff; Documentation service through its Selective Dissemination of Information (SDI); and Reprographic service through Major-121 photocopier.

Library data on books, journals, photocopies and translations etc. during 1976 are given below:

Publications holdings as on 31 Dec 1976 (including books, journals & standards)	82048
Publications added during the year (including standards)	2797
Standard Specifications added	1240
Journals subscribed	234
Photocopies and translations accessioned	100
Publications issued (including inter-library-loan)	12800
References provided in SDI (Manual service)	2150 (approx)
Bibliographies prepared on demand	5
Xerox copies supplied	6680 (approx)

The Library is recognised as a patent inspection centre, and it continued to receive Indian patents.

KRISHNAN MEMORIAL LECTURE—1976

Prof. A Guinier from the University of Paris, delivered the Krishnan Memorial Lecture—1976, on 10 December 1976 (*Fig 19*). The topic of his lecture was '*The Role of Crystallography in Solid State Physics*'.

Prof. Guinier started his lecture by paying tributes to Sir K.S. Krishnan—the Founder Director of the Laboratory—and said that the contributions made by him are well known to solid state physicists all over the world. He gave an interesting account of the developments that had taken place in the field of crystallography, starting from the work of W.H. Bragg, and W.L. Bragg, and then proceeded to show the potentialities of crystallography in solving problems of solid state physics. He highlighted his talk

Fig 19 Prof Guinier delivering the Twelfth Krishnan Memorial Lecture

with specific examples which are characteristic of this interaction between the two fields, with particular reference to domains which are likely to have important developments in the years to come.

Developing the subject, Prof. Guinier mentioned about the Lang method which helps one to study the dislocations in a crystal and also their plastic properties. He then mentioned how the experiments of Lang in the field of X-rays, and of Hirsch and Whelan in the field of electron microscopy, led to the development of microplasticity. He also talked about diffuse scattering—also called 'Monochromatic Laue method'—and its potentialities. He said that X-rays coupled with neutron diffraction experiments constitute another important tool for studying the dynamics of crystals.

Prof. Guinier also talked about structures which cannot be considered either as a crystal or as a typical amorphous body. These intermediate structures have very interesting applications. He mentioned about β-alumina which behaves like a two dimensional liquid, and the KCP which may be considered as a one dimensional conductor. As another example of a one-dimensional conductor he mentioned the famous organic compound TTF-TCNQ which is a good conductor at 50 K. He also talked about liquid crystals in the nematic phase, and said that, 'It is obvious that the properties of these substances depend on the state of local disorder and hence the interest in development of these structural studies inspite of difficulties.'

Prof. Guinier, in conclusion, said, 'Crystallographers have now solved the problem of the structure of perfect crystals. The consequences of their work have been immense—mainly in chemistry, biochemistry etc. But it is a fact that matter in our world is, in a very large proportion, not completely ordered, nor completely disordered. The progress of crystallography allows us to begin to characterize a state of partial disorder. Our knowledge, at the present time is, however, limited not only because of the uncertainties of interpretation of experimental data but also because the number of samples which have been studied is still low. There is an immense field of research which is now open to a new and extended crystallography, and it is certain that any advance in this domain will be very fruitful'.

After the lecture, Prof. Guinier gave away the NPL Merit Awards-1976.

NPL MERIT AWARDS—1976

Design Development and Fabrication of Infrared Spectrophotometer and Detectors

A team of scientists under the leadership of Dr. S.P. Varma, and assisted by Dr. B.B. Lal, designed and fabricated a far infrared spectrophotometer for the spectral region 15 to 300 μm and a high resolution, high-sensitivity 1-3 μm spectrometer (*See Page 29*). With the commissioning of these instruments, the Laboratory got equipped to undertake infrared studies in the range 1-300 μm for characterization of materials and study of lattice vibrations etc.

The 1-3 μm spectrometer uses the pyroelectric TGS infrared detector developed by Dr. M.M. Pradhan and Shri Rakesh Kumar Garg. They set up facilities not only for growing of single crystals of TGS (*See Page 30*), but also for studying pyroelectric properties as well as for fabrication of infrared detectors for remote sensing devices.

In recognition of this significant work, the group was awarded the NPL Merit Award—1976, and a cash prize of Rs. 1000.

Satellite Radio Beacon Technique

The team of scientists under the leadership of Dr. Y.V. Somayajulu, assisted by Dr. Tuhi Ram Tyagi and Shri A.B. Ghosh, and consisting of Sarvashri P.N. Vijaya Kumar, Lakha Singh, J.K. Gupta and S.R. Bakshi, was given the NPL Merit Award—1976, and a cash prize of Rs. 1000 for their successful and unambiguous identification of tropospheric effects on VHF radiowave propagation, using the satellite radio beacon technique.

This group had pioneered in India, as early as 1962, satellite radio beacon measurements for ionospheric study using the Russian satellite COSMOS V, and had since then being continuing these measurements which had made significant contributions to space science, and had helped in evaluating and correcting eorrors due to tropospheric and ionospheric refraction in satellite and radar tracking.

That the troposphere could also be monitored by radio beacons had been suggested in the past, but no clear evidence was available. This team of scientists was the first to unambiguously identify this effect during the tropospheric event of December 1974 (*See Page 68*) and subsequently, using the radio beacon transmission of the satellite INTASAT.

Devolpment of Carbon Granules for Telephone Communication Systems

A team of scientists consisting of Dr. P.T. John and Shri K.K. Datta, under the guidance of Dr. G.C. Jain, developed a process for the processing of carbon granules which are vital for telephone communication systems. The team had developed techniques for processing of raw materials for making these granules.

With precise critical parameteres, these scientists had been successful in converting the cheap raw material into a sophisticated product having negligible porosity, and optimum pyroelectric deposition on a partially graphitized interior (*See Page 58*). The carbon granules produced by this team were sensitive to the slightest change of sound pressure, and conformed to international specifications having extremely close tolerances.

For its innovative skill, persistent efforts, and basic understanding of the physics and technology of carbon, this team had thus been able to develop this sophisticated technology in the country, and in recognition of this, it was presented the NPL Merit Award—1976, and a cash prize of Rs. 1000.

OTHER HONOURS AND AWARDS

1. Dr. G.C. Jain was elected fellow of the Indian National Science Academy.
2. Dr. B.M. Reddy was selected for Shri Hari Om Ashram Prerit Dr. Vikram Sarabhai Research Award (1975). The award was in recognition of Dr. Reddy's achievements in the field of planetary and space sciences, and carried a cash prize of Rs. 4000/- and a gold medal. The award was presented at an investiture ceremony held in Ahmedabad on 12 August 1976.

PAPERS PUBLISHED

1. Aggarwal(S), Lakshmi(DR) & Reddy(BM): Some problems of hf communication at low latitudes & possible solutions. *Indian J Radio Space Phys*. Vol 5; 1976; 302-306.

2. Agrawal(VK), Miyazaki(Y) & Akao(Y): Analysis of hybrid modes in an optical waveguide bounded at one side by a gyromagnetic medium. *Opt Comm*. Vol 16; 1976; 104-109.

3. Agrawal(VK), Miyazaki(Y) & Akao(Y): Waveguide type optical modulator using Kerr magneto-optic effects in Ni-Fe thin films: Theoretical study. *Japan J Appl Phys*. Vol 15; 1976; 2155-71.

4. Arora(VK), Prem Kumar & Ram Parshad: A new saw-tooth sweep circuit. *IEEE Trans Ind Electron Control Instrum*. Vol IECI-23; 1976; 330.

5. Bahl(OP) & Manocha(LM): Methods of determining optimum preoxidation time of PAN fibres. *Fibre Sci Tech*. Vol 9; 1976; 77-80.

6. Banerjee(P): Phase-locked loop acquisition for a noisy FM signal. *IEEE Trans Aerospace Electron Sys*. Vol AES-12; 1976; 545.

7. Banerjee(P), Bhattacharya(AK) & Biswas(BN): Capture capability of a phase locked loop for an angle modulated signal. *Indian J Pure Appl Phys*. Vol 14; 1976; 288-93.

8. Bansal(MC) & Ram Parshad: Speeding up of recovery process of monostable multivibrators. *IEEE Trans Ind Electron Control Instrum*. Vol IECI-23; 1976; 110-13.

9. Bansal(MC), Suri(SP) & Ram Parshad: A monostable multivibrator for long time delays. *IEEE Trans Ind Electron Control Instrum*. Vol IECI-23; 1976; 339-40.

10. Bhagyalakshmi(K): On electropolishing of waveguides by using double waveguide technique. *Students' J Inst Electron Telecom Engnrs*. Vol 17; 1976; 100-102.

11. Bhargav(Bharat) & Shah(VV): A new procedure for alignment and calibration of an ellipsometer. *Indian J Pure Appl Phys*. Vol 14; 1976; 324-26.

12. Bhatia(G): Characteristics of extruded carbon mixes at high pressures of extrusion. *Carbon.* Vol 14; 1976; 131-32.

13. Bhatia(G): Bulk density characteristics of binary mixtures of carbon powders. *Carbon.* Vol 14; 1976; 311-13.

14. Bhatia(G): Rheological properties of carbon mixes at very low shear rates using a capillary rheometer. Part III. *Carbon.* Vol 14; 1976; 315-17.

15. Bhatia(G): Rheological properties of carbon mixes using a capillary rheometer. Part IV. *Carbon.* Vol 14; 1976; 319-21.

16. Bhatia(G): Physical characteristics of extruded carbon mixes. *J Mat Sci* Vol 11; 1976; 1375-77.

17. Bhatnagar(KN) & Jain(PC): Machine for durability test on spring balances. *Res & Ind.* Vol 21; 1976; 7-8.

18. Bhide(VG), Chandra(S), Jain(SC) & Medhekar(RK): Structure and properties of bubble domains in cholesteric nematic mixtures. *J Appl Phys.* Vol 47; 1976; 120-26.

19. Bhuchar(VM): A novel mode of evaluating color changes of indicators and rapid method of assessment of synthesis and purification of chemicals. *Technical News Service (Sarabhai M Chemicals, Baroda)* Vol 8; 1976; 40 pages.

20. Bindal(VN): Ultrasonic transducer for automation, sensing and remote control applications. *Res & Ind.* Vol 21; 1976; 80-85.

21. Bindal(VN), Gogia(VK) & Kohli(GK): Angle probe heads for ultrasonic inspection. *Res & Ind.* Vol 21; 1976; 85-89.

22. Bindal(VN) & Kohli(GK): Ultrasonic testing of aluminium pipes, plates and their welds. *NDT News.* Vol 11; 1976; 1-7.

23. Bindal(VN) & Mukesh Chandra: A piezoelectric-micrometer for precision movement. *J Opt.* Vol 5; 1976; 51-55.

24. Bindal(VN) & Singhal(SK): A piezoelectric miniaturized tuning fork. *Indian J Pure Appl Phys.* Vol 14; 1976; 378-81.

25. Bipin Kumar & Ram Parshad: The effect of pressure on current-voltage characteristics of metal-semiconductor like contacts. (Hindi) *Vijnana Parishad Anusandhan Patrika.* Vol 19; 1976; 325-29.

26. Biswas(BN) & Banerjee(P): Phase locked demodulator threshold—a new criterion. *IEEE Trans Aerospace Electron Sys.* Vol AES-12; 1976, 537-44.

27. Biswas(BN), Banerjee(P), Ray(SK), Bhattacharya(AK), Majumdar(T) & Pramanik(K): Injection synchronized digital phase locked loop. *Indian J Pure Appl Phys*. Vol 14; 1976; 922-26.

28. Bohra(JN): Characterisation of precursory fibre for the development of carbon fibre using kerosene and mercury displacement densities. *Fibre Sci Tech*. Vol 9; 1976; 315-17.

29. Chetty(VK) & Naidu(PR): Specific surface area of arsenic sulphide. *Indian J Chem*. Vol 14A; 1976; 271-72.

30. Das(BK), Stern(EA) & Lieberman(DS): Displacive transformations in near equiatomic Nb-Ru alloys-II: Energetics and mechanism. *Acta Met*. Vol 24; 1976; 37-44.

31. Dutta(HN), Lal(JB) & Somayajulu(YV): Some aspects of ionospheric irregularities. *Indian J Radio Space Phys*. Vol 5; 1976; 123-30.

32. Fuhrmann(WD) & Tyagi(Tuhi Ram): 140 MHz ATS-6 radio receiving system. *Indian J Radio Space Phys*. Vol 5; 1976; 55-57.

33. Gautam(CBL): A quality transformerless audio amplifier. *Students' J Inst Electron Telecom Engnrs*. Vol 17; 1976; 143-48.

34. Ghosh(PK), Shanker(Virendra) & Reddy(TRS): Anomalous EPR Spectra of Mn^{2+} ions in polycrystalline calcium sulphide. *Indian J Phys*. Vol 50; 1976; 438-40.

35. Ghosh(SN) & Kundu(Namita): Latitudinal variation of the intensity of 5577 Å line of night airglow. *Indian J Phys*. Vol 50; 1976; 668-77.

36. Goel(MK), Rao(BCN), Chandra(S) & Maier(EJ): Satellite measurements of ion composition and temperatures in the topside ionosphere during medium solar activity. *J Atmos Terr Phys*. Vol 38; 1976; 389-94.

37. Goswami(MB): Role of secondary zinc in zinc industry. *Chem Engng World*. Vol 11; 1976; 69-73.

38. Gupta(PK) & Trehan(JC): Thermogravimetric behaviour of polyacrylonitrile & study of the reaction mechanism for making carbon fibres from it. *Indian J Tech*. Vol 14; 1976; 133-37.

39. Harish Bahadur & Ram Parshad: Effect of magnetic field on oscillating properties of quartz crystals vibrating in the fundamental & overtone modes. *Indian J Pure Appl Phys*. Vol 14; 1976; 855-56.

40. Harish Bahadur & Ram Parshad: Measurement of time. *Students' J Inst Electron Telecom Engnrs*. Vol 17; 1976; 103-107.

41. Harish Bahadur & Ram Parshad: A new circuit for generating radio-frequency oscillations. *J Inst Instrum Scientists & Technologists (India)*. Vol 5; 1976; 13-20.

42. Harish Bahadur & Ram Parshad: Optical pumping for alkali gas cell frequency standard. *J Opt.* Vol 5; 1976; 59-67.

43. Harish Bahadur & Ram Parshad: Radiation effects on oscillating characteristics of quartz crystals. *J Mysore Univ Sec B : Science.* Vol 26; 1976; 425-32.

44. Jain(GC), Das(BK) & Avtar(R): Calcination study of spray-dried Mn-Zn ferrite powder. *Indian J Pure Appl Phys.* Vol 14; 1976; 796-99.

45. Jain(GC), Das(BK) & Goel(NC): Grain growth during sintering of Mn-Zn-Fe ferrites. *Indian J Pure Appl Phys.* Vol 14; 1976; 87-92.

46. Jain(GC), Das(BK), Khanduja(RS) & Gupta(SC): Effect of intra-granular porosity at initial permeability and coercive force in a manganese zinc ferrite. *J Mat Sci.* Vol 11; 1976; 1335-38.

47. Jain(GC), Sadana(DK) & Das(BK): Electrical properties of phosphorus diffused GaAs. *J Mat Sci.* Vol 11; 1976; 741-48.

48. Jain(GC), Sadana(DK) & Das(BK): Phosphorus diffusion in gallium arsenide. *Solid St Electron.* Vol 19; 1976; 731-36.

49. Jain(PC): The essentials of engineering metrology. *Instrum India.* Jan-Mar 1976; 5-12.

50. Jain(PC) : Line standards of length. *Instrum India.* July-Sept 1976; 7-13.

51. Jain(PC), Bhatnagar(KN) & Wasan(VP) : A simple device for thermal conductivity determination. *ISI Bull.* Vol 28; 1976; 367-69.

52. Jain(PC), Bhatnagar(KN) & Wasan(VP): A probe for thermal conductivity determination. *Indian J Tech.* Vol 14; 1976; 583-84.

53. Jain(SL) & Rai(RK) : Nocturnal variation of total absorption & night-time E-region. *Indian J Radio Space Phys.* Vol 5; 1976; 263-64.

54. Jain(SL) & Rai(RK): Peak amplitude recording system for ionospheric absorption measurement. *J Inst Engnrs (India).* Vol 57 Part ET1; 1976; 22-26.

55. John(PT) & Aggarwal(RK): Determination of surface area of porous adsorbents from free surface energy & mean pore size. *Indian J Tech.* Vol 14; 1976; 130-32.

56. John(PT) & Aggarwal(RK): Separators—Their properties & functions in storage batteries. *Chem Age India*. Vol 27; 1976; 438-40.

57. John(PT) & Datta(KK): Microphonic carbon granules for telephone transmitters. *Res & Ind.* Vol 21; 1976; 78-80.

58. John(PT), Datta(KK) & Mohan Das(CV) : Apparatus for measurement of resistance of carbon products. *ISI Bull.* Vol 28; 1976; 174-75.

59. Kundra(KD) & Ali(SZ) : X-ray study of thermal expansion and phase transformation in β-In_2S_3. *Phys St Sol* (*a*). Vol 36; 1976; 517-25.

60. Lal(Krishan) : National conference on crystallography. *J Sci Ind Res.* Vol 35; 1976; 502-503.

61. Lal(Krishan) : X-ray diffraction topography. *J Phys Edu.* Vol 4; 1976: 1-5.

62. Lal(Krishan) & Mader(S) : Characterization of dislocations in gadolinium gallium garnet single crystals by transmission X-ray topography. *J Crystal Growth.* Vol 32; 1976; 257-62.

63. Mahajan(KK) & Saxena(OP) : Continuous measurements of nighttime electron concentration profiles and estimation of neutral wind velocities at Arecibo. *J Geophys Res.* Vol 81; 1976; 3165-70.

64. Majumdar(SC): Prediction of transmission loss over trans-horizon tropospheric propagation paths in the Indian sub-continent. *Indian J Radio Space Phys.* Vol 5; 1976; 152-57.

65. Majumdar(SC) & Sarkar(SK) : Tropospheric trans-horizon propagation characteristics at 2 GHz in northern India. *Radio Electron Engnrs.* Vol 46; 1976; 29-33.

66. Majumdar(SC), Sarkar(SK) & Karfa(M): Radio refractivity gradient in lower troposphere & its influence on trans-horizon radiowave propagation. *Indian J Radio Space Phys.* Vol 5; 1976; 281-84.

67. Mehendru(PC), Jain(K) & Mehendru(Praveen): Space charge induced relaxation in polymer thin films. *Nucl Phys Soild St Phys.* Vol 19C; 1976; 97-99.

68. Mehendru(PC); Jain(K) & Mehendru(Praveen): TSD current studies of iodine-doped polyviny-acetate thin films. *J Phys D: Appl Phys.* Vol 9; 1976; 83-88.

69. Mehendru(PC) & Narendra Kumar : Optical absorption studies of KCl:Ru and NaCl:Ru crystals. *Phys St Sol* (*b*). Vol 77; 1976; K 133- K 134.

70. Mehendru(PC), Pathak(NL) & Satbir Singh: Electrical conductivity in pure and iodine-doped polyvinyl acetate thin films. *Nucl Phys & Solid St Phys.* Vol 19C; 1976; 31-34.

71. Mehendru(PC), Pathak(NL), Satbir Singh & Mehendru(Praveen): Electrical conduction in polypropylene thin films. *Phys St Sol* (*a*). Vol 38; 1976; 355-60.

72. Mehendru(PC), Satbir Singh & Jain(K): Electrostatic dust collector. *Science Reporter.* Vol 13; 1976; 60-62.

73. Mitra(Desh) & Ali(SZ): Crystal data on apophyllite. *J Appl Cryst.* Vol 9; 1976; 54-56.

74. Mohan Lal & Ram Parshad : A single trigger source using binary flip-flop. *J Inst Electron Telecom Engnrs.* Vol 22; 1976; 191-92.

75. Mohan Lal & Ram Parshad : Double pulse generator for determination of recovery times for binary and other counters. *IEEE Trans Ind Electron Control Instrum.* Vol IECI-23; 1976; 466.

76. Nagpal(KC) & Ali(SZ) : X-ray data on thermal expansion of InSe. *Indian J Pure Appl Phys.* Vol 14; 1976; 348-51.

77. Nagpal(KC) & Ali(SZ) : X-ray crystallographic study of Indium monoselenide. *Indian J Pure Appl Phys.* Vol 14; 1976; 434-40.

78. Nair(VPS), Aziz(RA), Jain(PC) & Saxena(SC) : Intermolecular potentials and transport properties for neon, argon and krypton. *J Chem Phys.* Vol 65; 1976; 3242-49.

79. Narlikar(AV): National seminar on cryogenics & its applications. *J Sci Ind Res.* Vol 35; 1976; 277.

80. Pasricha(PK), Lakshmi(DR) & Reddy(BM) : Studies on polar wind and its dependence on plasma temperature using Alouette-II data. *Indian J Radio Space Phys.* Vol 5; 1976; 16-19.

81. Pasricha(PK), Reddy(BM), Mitra(AP) & Sharma(NVG) : A comparative study of equatorial radio source scintillations & the scintillations expected for ATS-6 emissions over India. *Indian J Radio Space Phys.* Vol 5; 1976; 31-34.

82. Pawar(SH) & Narlikar(AV) : Mechanism of luminescence in CaS:Bi phosphor. *Mat Res Bull.* Vol 11; 1976; 821-26.

83. Pradhan(MM) & Garg(RK) : Five and six-grid interference filters for far infrared. *Infrared Phys.* Vol 16; 1976; 449-52.

84. Prem Kumar, Arora(VK) & Ram Parshad : Synchronous up/down decade counter. *IEEE Trans Ind Electron Control Instrum.* Vol IECI-23; 1976; 342-43.

85. Ram(RS) : Emission spectrum of AlBr. *Spectroscopy Lett.* Vol 9; 1976; 435-49.

86. Ram(RS) : Rotational structure in the ultraviolet bands of SnF. *Spectroscopy Lett.* Vol 9; 1976; 523-43.

87. Ram Prasad : A strategy for the development of optical and ophthalmic industries in India. *All India Optical Federation Souvenir*, 1976.

88. Rao(MNM), Kutiev(IS), Gogoshev(M), Serafimov(KB), Rao(BCN) & Karadimov (MD) : Production of secondary electrons by precipitating proton flux. *Comptes Rendus.* Vol 29; 1976; 49-52.

89. Rao(MNM), Rao(BCN), Gogoshev(M), Kutiev(IS), Serafimov(KB) & Karadimov(MD) : Electron production by energetic particle precipitations in the equatorial ionosphere. *Comptes Rendus.* Vol 29; 1976; 1439-42.

90. Risal Singh & Rao(BCN) : Estimation of electron heating rates in the topside ionosphere during medium solar activity. *Indian J Radio Space Phys.* Vol 5; 1976; 269-71.

91. Saksena(RC) : A possible effect of small and large wind shears on temperate latitude sporadic-E. *Indian J Radio Space Phys.* Vol 5; 1976; 235-39.

92. Saksena(TK) & Pancholy(M) : A transistorized swept frequency generator for the ultrasonic range. *J Inst Electron Telecom Engnrs.* Vol 22; 1976; 119-20.

93. Sarma(KS) : Is your home well lit? Science Today. April 1976.

94. Sastri(VDP) : Locus of daylight characteristics in relation to atmospheric conditions. *J Phys D: Appl Phys.* Vol 9; 1976; L1-L3.

95. Shanker(Virendra). Ghosh(PK) & Reddy (TRS): EPR of point-defects in polycrystalline calcium sulphide. *Indian J Pure Appl Phys.* Vol 14; 1976; 193-200.

96. Sharma(JKN) & Pradeep Mohan: A sensitive oil manometer. *J Phys E: Sci Instrum.* Vol 9; 1976; 618-19.

97. Sharma(JKN) & Sharma(DR) : Pumping speed measurement of positive-displacement vacuum pumps. *Vac News.* Vol 7; 1976; 5-12.

98. Sharma(VD) : Pracheen Bharat mein pradushan (Hindi). *Prasarika.* Vol 5; 1976; 15-18.

99. Sharwan Kumar, Sita Ram and Govil(AK) : Accurate radio frequency voltage measurement. *J Sci Ind Res.* Vol 25; 1976; 19-28.

100. Singal(SP) : Acoustic imaging and holography. *J Acoust Soc India.* Vol 4; 1976; 93-99.

101. Singal(SP) : Acoustic radar—Application to communication. *J Inst Electron Telecom Engnrs.* Vol 22; 1976; 48-52.

102. Singal(SP) : Sodar in communication aviation. *Sainik Samachar Annual.* 1976; 84-86.

103. Singal(SP) : Nichale Vayumandal ke anveshan hetu—Sodar (Hindi). *Vigyan Pragati.* Vol 25; July 1976; 186-91.

104. Singal(SP) : Sodar—The remote acoustic sensor for the study of lower atmosphere. *Invent Intell.* Vol 11; Jan 1976; 19-30.

105. Singh(VR) : A strain gauge jaw force transducer. *Biotelemetry III.* Ed. T.B. Frayer, H.A. Miller & H. Sandler, Academic Press, New York, USA. 1976; 263-66.

106. Sootha(GD) & Gupta(SK) : Electron spin resonance study of manganese (II) & free radical in pulses. *Indian J Biochem Biophys.* Vol 13; 1976; 304-305.

107. Sootha(GD), Padam(GK) & Gupta(SK) : Electron spin resonance study of copper (II) oxalate complexes. *Acta Physica Polonica.* Vol A50; 1976; 641-46.

108. Sundaram(R) : One-dimensional superconductivity : Finite temperature singularity from the renormalization group theory. *J Low Temp Phys.* Vol 24; 1976; 491-96.

109. Suri(SK) : Correctional calibration of instruments. *Electronics Today.* Aug 1976.

110. Suri(SK) : Maintenance of scientific & medical instruments. *Electronics For You (Annual Number) 1976.*

111. Trigunayat(GC) & Verma(AR) : Polytypism and stacking faults in crystals with layer structure. *Physics and Chemistry of Materials with Layered Structures. Vol 2 : Crystallography and Crystal Chemistry of Materials with Layered Structures.* Ed. F. Levy, Reidel Publishing Co., Holland, USA. 1976; 269-340.

112. Tyagi(Tuhi Ram) : Latitudinal variation of electron content & f_oF2 in subauroral zone. *Indian J Radio Space Phys.* Vol 5; 1976; 105-109.

113. Varma(SP), Lal(BB) & Srivastava(NK) : Infrared studies on pre-oxidized polyacrylonitrile fibres. *Carbon.* Vol 14; 1976; 207-209.

114. Vij(DR), Mathur(VK), Shanker(Virendra) & Ghosh(PK): Cathodoluminescence of CaS:Ce phosphor. *J Phys D: Appl Phys.* Vol 9; 1976; 1509-13.

115. Vishan(Vijay) & Narlikar(AV) : Structure and superconductivity of splat quenched Pb-Bi solid solutions. *Mat Res Bull.* Vol 11; 1976; 1257-64.

116. Williams(FE), Varma(SP) & Hillenius(S) : Liquid water as a lone pair amorphous semiconductor. *J Chem Phys.* Vol 64; 1976; 1549-54.

117. Windawi(H), Varma(SP), Cooper(CB) & Williams(FE) : Analysis of lead azide thin films by Rutherford back scattering. *J Appl Phys.* Vol 47; 1976; 3418-20.

PAPERS PRESENTED AT SYMPOSIA, SEMINARS & CONFERENCES

1. Aggarwal(S), Lakshmi(DR) & Reddy(BM): ome problems of hf communication at low latitudes and possible solutions. Symposium on Solar Planetary Physics, PRL, Ahmedabad, Jan 20-24, 1976.

2. Bahl(OP), Manocha(LM), Bhatia(G) & Puri(DPS): Some R & D aspects of carbon fibres development at National Physical Laboratory. International Symposium on Newer Fibres and Composites, NPL, New Delhi, Jan 19-20, 1976.

3. Banerjee(P) : Recent developments of ATA time signal processing & monitoring. National Seminar on Time & Frequency, NPL, New Delhi, Nov 18-20, 1976.

4. Bansal(MC) & Ram Parshad: Improvements of functional operation of monostable multivibrators by reduction of their recovery times. National Seminar on Time & Frequency, NPL, New Delhi, Nov 18-20, 1976.

5. Bansal(MC) & Ram Parshad : Increased stability of pulse-time durations of monostable multivibrators for applications in space electronics. Conference on Electronics in Space, Jadavpur University, Jadavpur, Dec 26-27, 1976.

6. Bhide(VG), Kandpal(MC) & Subhas Chandra : Mossbauer Effect in non-crystalline materials. National Meeting on Mossbauer Effect, IIT, Kanpur, Apr, 1976.

7. Bhide(VG), Kandpal(MC) & Subhas Chandra: Mossbauer studies of lattice properties of a supercooled monotropic smectic-B liquid crystalline glass. National Meeting on Mossbauer Effect, IIT, Kanpur, Apr, 1976.

8. Bindal(VN) & Ashok Kumar: Performance and characteristics of the newly developed ceramic capacitors for high voltage and power applications. Convention on Radio and TV Broadcasting in India, New Delhi, Dec 24-26, 1976.

9. Bindal(VN) & Mukesh Chandra: A piezoelectric micrometer for precision movement. Fourth All India Symposium of the Optical Society of India on Optical Techniques and Instruments used in Scientific and Industrial Measurements, CSIO, Chandigarh, Jan 21-25, 1976.

10. Chandra(K) : A review of echelon I standards of electrical and electronic parameters. National Seminar on Time & Freqency, NPL, New Delhi, Nov 18-20, 1976.

11. Chandra(K) : Role of primary standards for electrical and electronic measurements in calibration, testing, and evaluation of electronic products. All India Seminar on Reliability in Electronics, EIL, Bangalore, Sept 17-19, 1976.

12. Dandawate(VD), Kulkarni(VG), Puntambekar(PN) & Sen(Debabrata): Frequency-stabilized lasers.—Their use in measurement of length and velocity of light. National Seminar on Time & Frequency, NPL, New Delhi, Nov 18-20, 1976.

13. Das(SR) : Photometry and radiometry—Comparative evaluation of accuracies. Fifth Annual Symposium of the Optical Society of India. Chandigarh, Feb 21-24, 1976.

14. Das(SR) : Reflectance of fluoresent materials by a single monochromator. NTH Symposium, Dec 8-10, 1976.

15. Dutta(HN), Chaturvedi(Rakesh), Bhardwaj(RK) & Lal(JB): Characteristics of scintillations of 40 MHz satellite signals observed at Kurukshetra. Symposium on Solar Planetary Physics, PRL, Ahmedabad, Jan 20-24, 1976.

16. Ekbote(SN), Narlikar(AV), Mathur(BS), Yadav(VS), & Yadav(RS): Development of superconducting cavity systems for frequency stabilization. National Seminar on Time & Frequency, NPL, New Delhi, Nov 18-20, 1976.

17. Ekbote(SN), Suri(SP) & Narlikar(AV) : Design and fabrication of a superconducting magnet energiser. Second National Symposium on Cryogenics, IIT, Madras, Dec 8-10, 1976.

18. Ekbote(SN), Yadav(VS), Mathur(BS), Narlikar(AV) & Chandra(K): Some preliminary studies relating to the development of superconducting cavity stabilized oscillator. Second National Symposium on Cryogenics, IIT, Madras, Dec 8-10, 1976.

19. Ghosh(AB) & Somayajulu(YV) : Ionospheric refraction errors in satellite tracking and navigation in low latitudes. Symposium on Solar Planetary Physics, PRL, Ahmedabad, Jan 20-24, 1976.

20. Ghosh(BB) & Saksena(RC) : Prediction of atmospheric radio noise field strengths for the Indian subcontinent. Symposium on Ionosphere & Magnetosphere, Andhra University, Waltair, Jan 7-9, 1976.

21. Goel(MK) & Rao(BCN) : Ion composition on changes observed in the topside ionosphere during the geomagnetic storm of 13 September 1967. Symposium on Ionosphere and Magnetosphere, Andhra University, Waltair, Jan 7-9, 1976.

22. Goel(MK) & Rao(BCN): Satellite measurements of helium ion abundance in the topside ionosphere during medium solar activity. Symposium on Solar Planetary Physics, PRL, Ahmedabad, Jan 20-24, 1976.

23. Gupta(AC) & Sharma(JKN) : A low cost VCO. National Seminar on Time & Frequency, NPL, New Delhi, Nov 18-20, 1976.

24. Harish Bahadur & Ram Parshad : Optical pumping for alkali gas cell frequency standards. Fourth All India Symposium of the Optical Society of India on Optical Techniques and Instruments used in Scientific and Industrial Measurements, CSIO, Chandigarh, Jan 21-25, 1976.

25. Harish Bahadur & Ram Parshad : Radiation effects on oscillating characteristics of quartz crystals. National Symposium on Radiation Physics, Mysore University, Mysore, June 10-12, 1976.

26. Harish Bahadur & Ram Parshad : A new method for determination of frequency spectrum of a quartz crystal. National Seminar on Time & Frequency, NPL, New Delhi, Nov 18-20, 1976.

27. Harish Bahadur & Ram Parshad : New methods for excitation of quartz crystals in overtones for frequency standardization. National Seminar on Time & Frequency, NPL, New Delhi, Nov 18-20, 1976.

28. Harish Bahadur & Ram Parshad : New techniques for obtaining standard frequencies from quartz crystals for application in space electronics. Conference on Electronics in Space, Jadavpur University, Jadavpur, Dec 26-27, 1976.

29. Jain(GC), Das(BK) & Goel(NC) : Iufluence of Ca, Nb, Ni and Mo additives on grain growth kinetics of high permeability Mn-Zn ferrites. Second International Conference on Ferrites, Bellevue, France, Sept 1976.

30. Jain(GC), Das(BK), Khurana(BS), Sharma(SK) & Dhawan(U) : Preparation of manganese zinc ferrite powder by hydrothermal oxidation. Seminar on Electronic and Special Ceramics, DMRL, Hyderabad, Nov 1976.

31. Jain(GC), Das(BK) & Santosh Kumari : Effect of silica on microstructure and core losses in a manganese zinc ferrite. Seminar on Electronic and Special Ceramics, DMRL, Hyderabad, Nov 1976.

32. Jain(GC), Das(BK), Tripathi(RB) & Sharda(SK) : Effect of ferrous ions on temperature factor of nickel-zinc ferrites. Nuclear Physics & Solid State Physics Symposium, Gujarat University, Ahmedabad, Dec 27-31, 1976.

33. Jain(SL) & Rai(RK) : Nocturnal variation of total absorption and night-time E-region. Symposium on Ionosphere & Magnetosphere, Andhra University, Waltair, Jan 7-9, 1976.

34. Jain(SL) & Subrahmanyam(CV) : Recording system for phase and amplitude transmission on 22.3 kHz (VLF). National Seminar on Time & Frequency, NPL, New Delhi, Nov 18-20, 1976.

35. Kapoor(SK) : Training of science writers. Seminar on Science Publishing in India : Problems & Prospects, PID, New Delhi, Nov 18-19, 1976.

36. Laksmi(DR), Pasricha(PK) & Reddy(BM) : The consequences of supersonic polar wind on the magnetosphere and the plasma sheet. Symposium on Solar Planetary Physics, PRL, Ahmedabad, Jan 20-24, 1976.

37. Lal(BB), Pradhan(MM), Srivastava(NK), Garg(RK) & Varma(SP) : One to three micron high resolution infrared spectrophotometer. Symposium on Infrared Materials and Devices, SSPL, New Delhi, Mar 11-12, 1976.

38 Lal(Krishan) : Structural studies utilising X-ray topography. (*Invited Talk*). Nuclear Physics & Solid State Physics Symposium, Gujarat University, Ahmedabad, Dec 27-31, 1976.

39. Luthra(SC), Sood(PC) & Mathur(BS): Time and frequency broadcast from National Physical Laboratory. National Seminar on Time & Frequency, NPL, New Delhi, Nov 18-20, 1976.

40. Mahajan(KK) : Electron density profiles in the E and F regions during sunrise and sunset. Symposium on Ionosphere & Magnetosphere, Andhra University, Waltair, Jan 7-9, 1976.

41. Mahajan(KK) : Semiannual effect in the neutral composition. Symposium on Solar Planetary Physics, PRL, Ahmedabad, Jan 20-24, 1976.

42. Mahajan(KK) & Pandey(VK) : Solar activity changes in the electron temperature from the langmuir probe measurements on Explorer-22 and ISIS-I satellites. Symposium on Ionosphere & Magnetosphere, Andhra University, Waltair, Jan 7-9, 1976.

43. Majumdar(SC) & Sarkar(SK) : Effect of tropospheric phenomena on line-of-sight propagation of 7 GHz. Symposium on Solar Planetary Physics, PRL, Ahmedabad, Jan 20-24, 1976.

44. Majumdar(SC), Sarkar(SK) & Karfa(M) : Microwave propagation characteristics of 7 GHz and their relationship with meteorological conditions. Symposium on Ionosphere & Magnetosphere, Andhra University, Waltair, Jan 7-9, 1976.

45. Mathur(BS) : Time and frequency activities at NPL. National Seminar on Time & Frequency, NPL, New Delhi, Nov 18-20, 1976.

46. Mitra(AP) : Recent advances in the D-region-observations and chemistry. (*Review Talk*). Symposium on Solar Planetary Physics, PRL, Ahmedabad, Jan 20-24, 1976.

47. Mitra(AP) : Reference ionosphere for solar flare conditions. Symposium on Solar Planetary Physics, PRL, Ahmedabad, Jan 20-24, 1976.

48. Mitra(AP) : Simplified schemes for D-region ion chemistry—A unified picture. Symposium on Solar Planetary Physics, PRL, Ahmedabad, Jan 20-24, 1976.

49. Mitra(AP) : Ionospheric errors in time transmission and their predictions. National Seminar on Time & Frequency, NPL, New Delhi, Nov 18-20, 1976.

50. Mohan Lal, Prem Kumar & Ram Parshad : A circuit for measurement of charge density of either polarity in the atmosphere. Conference on Electronics in Space, Jadavpur University, Jadavpur, Dec 26-27, 1976.

51. Narlikar(AV) : Hard superconductors. CSIR Conference on Materials, Bangalore, Oct 15-16, 1976.

52. Narlikar(AV) : Structural and microstructural effect in hard superconductors. Second National Symposium on Cryogenics, IIT Madras, Dec 8-10, 1976.

53. Pandey(VK) & Mahajan(KK) : Solar geomagnetic seasonal variation of H^+ flow velocity from Alouette-II topside sounder. Symposium on Solar Planetary Physics, PRL, Ahmedabad, Jan 20-24, 1976.

54. Pradhan(MM) & Garg(RK) : Study of pyroelectric IR detectors. Symposium on Infrared Materials and Devices, SSPL, New Delhi, Mar 11-12, 1976.

55. Ramanamurty(YV) : A study of ionospheric absorpation on 164 kHz at oblique incidence. Symposium on Ionosphere and Magnetosphere, Andhra University, Waltair, Jan 7-9, 1976.

56. Ramanamurty(YV) : Type of solar flare effect on 164 kHz in relation to stratospheric circulation. Symposium on Solar Planetary Physics, PRL, Ahmedabad, Jan 20-24, 1976.

57. Ramanamurty(YV) & Nakra(DR) : Class I Omega monitoring at NPL. National Seminar on Time & Frequency, NPL, New Delhi, Nov 18-20, 1976.

58. Rao(MNM) & Malhotra(PL) : Neutral gas temperature at the F_1-F_2 transition region over Delhi during the low solar activity. Symposium on Ionosphere & Magnetosphere, Andhra University, Waltair, Jan 7-9, 1976.

59. Rao(MNM) & Tandel(CB) : Results of positive ion density measurements by a rocket-borne Gerdien condenser in the height range of 39.5 to 23 km. Symposium on Solar Planetary Physics, PRL, Ahmedabad, Jan 20-24, 1976.

60. Reddy(BM) : Ionosphere-magnetosphere interactions—A review. Symposium on Ionosphere & Magnetosphere, Andhra University, Waltair, Jan 7-9, 1976.

61. Reddy(BM) : Power and Antenna requirements for adequate coverage of time & frequency transmissions over India and neighbourhood. National Seminar on Time & Frequency, NPL, New Delhi, Nov 18-20, 1976.

62. Reddi(BV), Narlikar(AV) & Raghavan(V) : Effect of Tin concentration in bronze on the properties of superconducting Nb_3Sn. Second National Symposium on Cryogenics, IIT, Madras, Dec 8-10, 1976.

63. Reddi(BV), Narlikar(AV) & Raghavan(V) : Critical parameters affecting superconducting transition temperature of Nb_3Sn made by bronze route. Sixth International Conference on Cryogenics Engineering, Grenoble, France, May 1976.

64. Reddi(BV), Raghavan(V) & Narlikar(AV): Fabrication of superconducting Nb_3Sn. Sixth International Conference on Cryogenics Engineering, Grenoble, France, May 1976.

65. Risal Singh & Rao(BCN): Estimates of electron heating rates in the topside ionosphere from satellite measurements. Symposium on Solar Planetary Physics, PRL, Ahmedabad, Jan 20-24, 1976.

66. Saha(AK): Limits of error in height and electron density information obtainable from ionograms. Symposium on Ionosphere & Magnetosphere, Andhra University, Waltair, Jan 7-9, 1976.

67. Saha(AK): Phase and frequency variations in radiowave propation. National Seminar on Time & Frequency, NPL, New Delhi, Nov 18-20, 1976.

68. Saksena(RC) & Owen-Jones(ES): Short and long term movement of sporadic-E auroral zone. Symposium on Solar Planetary Physics, PRL, Ahmedabad, Jan 20-24, 1976.

69. Sarkar(SK) & Majumdar(SC): Rain attenuation at 7 GHz over the line-of-sight paths in northern and eastern regions of India. Convention on Radio & TV Broadcasting in India, New Delhi, Dec 24-26, 1976.

70. Saxena(GM): A study of frequency stability using Allan variable. National Seminar on Time & Frequency, NPL, New Delhi, Nov 18-20, 1976.

71. Saxena(GM) & Mathur(BS): Development of rubidium optical assembly at NPL, New Delhi. National Seminar on Time & Frequency, NPL, New Delhi, Nov 18-20, 1976.

72. Sharma(MC) & Sarma(SBSS): Behaviour of total electron content during magnetic storms at Hawaii. Symposium on Ionosphere & Magnetosphere, Andhra University, Waltair, Jan 7-9, 1976.

73. Sharma(MC) & Sarma(SBSS): A new method of deriving F-region contribution from the riometer cosmic noise absorption. Symposium on Ionosphere & Magnetosphere, Andhra University, Waltair, Jan 7-9, 1976.

74. Sharma(RG), Hari Kishan & Tripathi(TC): An apparatus for measuring thermal conductivity of insulating materials at low temperatures. Second National Symposium on Cryogenics. IIT, Madras, Dec 8-10, 1976.

75. Sharma(RG), Hari Kishan & Tripathi(TC): A single cold plate guarded apparatus for measuring the thermal conductivity of cryogenic insulating materials between 77 and 300 K. Second National Symposium on Cryogenics, IIT, Madras, Dec 8-10, 1976.

76. Sharma(VD): Editorial responsibilites & problems. Seminar on Science Publishing in India.—Problems and prospects. PID, New Delhi, Nov 18-19, 1976.

77. Singal(SP): Sodar application in aviation. Symposium on Operational Problems, NAL, Bangalore, Oct 5, 1976.

78. Singal(SP), Aggarwal(SK) & Gera(BS): Sodar studies of the thermal structure of the lower troposphere at Delhi. Symposium on Solar Planetary Physics, PRL, Ahmedabad, Jan 20-24, 1976.

79. Singal(SP), Aggarwal(SK) & Gera(BS): Studies of the thermal structure of the lower atmosphere at Delhi during Dec 1974 using acoustic sounding (SODAR). Symposium on Ionosphere & Magnetosphere, Andhra University, Waltair, Jan 7-9, 1976.

80. Singal(SP), Dutta(HN), Gera(BS) & Aggarwal(SK): Analytical studies of sodar observations at Delhi. Ninety-Second Meeting of the Acoustical Society of America, San Diego, California, USA, Nov 16-19, 1976.

81. Singal(SP), Saxena (Mithilesh), Aggarwal(SK) & Gera(BS): The development of an indigenous portable monostatic sodar. Symposium on Ionosphere & Magnetosphere, Andhra University, Waltair, Jan 7-9, 1976.

82. Singh(VR): A strain gauge jaw force transducer. Third International Conference on Biotelemetry, Palo Alto, California, USA, May 17-20, 1976.

83. Singh(VR): A strain gauge blood flow transducer. Eleventh International Conference on Medical & Biological Engineering, Ottawa, Canada, Aug 2-6, 1976.

84. Somayajulu(YV): Night time plasma influx into midlatitude topside ionosphere derived from electron content changes. Symposium on Ionosphere & Magnetosphere, Andhra University, Waltair, Jan 7-9, 1976.

85. Somayajulu(YV): Time and frequency dissemination via satellites. National Seminar on Time & Frequency, NPL, New Delhi, Nov 18-20, 1976.

86. Somayajulu(YV) & Ghosh(AB): Ionospheric refraction errors in satellite tracking and navigation in low latitudes. Symposium on Geophysical Use of Satellite Beacon Observations, Boston, USA, 1976.

87. Somayajulu(YV) & Ghosh(AB): Ionosphere refraction error in low latitude. Symposium on Solar Planetary Physics, PRL, Ahmedabad, Jan 20-24, 1976.

88. Somayajulu(YV), Tyagi(Tuhi Ram), Garg(SC) & Vijaya Kumar(PN): Early results from ATS-6 radio beacon experiment at New Delhi. Symposium on Solar Planetary Physics, PRL, Ahmedabad, Jan 20-24, 1976.

89. Somayajulu(YV), Tyagi(Tuhi Ram), Ghosh(AB): Satellite radio beacon monitoring of the troposphere. Symposium on Solar Planetary Physics, PRL, Ahmedabad, Jan 20-24, 1976.

90. Somayajulu(YV), Tyagi(Tuhi Ram) & Ghosh(AB): Monitoring of the troposphere using low elevation satellite radio beacons. Symposium on Geophysical Use of Satellite Beacon Observations, Boston, USA, 1976.

91. Subrahmanyam(CV): Some aeronomic results on neutral nitric oxide densities in the lower ionosphere inferred from election density profiles. Symposium on Ionosphere & Magnetosphere, Andhra University, Waltair, Jan 7-9, 1976.

92. Subrahmanyam(CV) & Saha(AK): Frequency deviation observed on the standard time & frequency transmissions at 10 MHz. National Seminar on Time & Frequency, NPL, New Delhi, Nov 18-20, 1976.

93. Sundaram(R): One-dimensional superconductivity—Influence of interchain coupling. Nuclear Physics and Solid State Physics Symposium, Gujarat University, Ahmedabad, Dec 27-31, 1976.

94. Sundaram(R): One-dimensional superconductivity—Response functions from the renormalization group theory. Second National Symposium on Cryogenics, IIT, Madras, Dec 8-10, 1976.

95. Suri(SP), Prabhakar(AC) & Bahl(Madhu): Digital display systems. National Seminar on Time & Frequency, NPL, New Delhi, Nov 18-20, 1976.

96. Tyagi(Tuhi Ram), Lakha Singh, Barbara(AK) & Minakshi Devi: Some preliminary results of total electron content measurements at Gauhati. Symposium on Solar Planetary Physics, PRL, Ahmedabad Jan 20-24, 1976.

97. Uppal(GS) & Raina(MK): Radiometer development for rain attenuation and water vapour studies at X and K bands. Convention on Radio and TV Broadcasting in India, Dec 24-26, 1976.

98. Varma(SP): A grating spectrophotometer for 600-30 cm^{-1} spectral region. Seminar on Infrared Materials and Devices, SSPL, New Delhi, March 11-12, 1976.

99. Venkatachari(R) & Saha(AK): On collision frequency measurements in the ionospheric E-region. Symposium on Ionosphere & Magnetosphere, Andhra University, Waltair, Jan 7-9, 1976.

100. Verma(AR): Standards at the NPL. National Seminar on Time & Frequency. NPL, New Delhi, Nov 18-20, 1976.

101. Vishan(Vijay) & Narlikar(AV): Superconductivity in splat quenched systems. Second National Symposium on Cryogenics, IIT, Madras, Dec 8-10, 1976.

102. Zalpuri(KS), Rao(SUM) & Sethi(JK): Reliability study of an electronic system. All India Seminar on Reliability in Electronics, EIL, Bangalore, Sept 17-19, 1976.

INDIAN PATENTS FILED

(during 1976)

Sr. No.	*Application Number*	*Date of Filing*	*Title of the Patent at Filing*	*Inventors*
(1)	(2)	(3)	(4)	(5)
1.	383/Cal/76	4.3.1976	A crystallizer for growing crystals from solutions.	M.M. Pradhan & Rakesh Kumar Garg
2.	1303/Cal/76	21.7.1976	A heat treatment process for substantial increase in the mechanical properties particularly strength of carbon products for all applications moulded or extruded using pitch or tar or any other carbonaceous binder.	P.T. John & K.K. Datta
3.	46/Del/76	3.12.1976	Improvements in or relating to a process of making a photo-sensitive paper for electrographic machines.	P.C. Mehendru, D.C. Parashar & Narendra Kumar

INDIAN PATENTS ACCEPTED
(during 1976)

Sr. No.	*Complete Specification Number*	*Application Number*	*Date of Filing*	*Date of Acceptance*	*Title of the Patent at Acceptance*	*Inventor (s)*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	138310	1713/Cal/73	21.7.1973	17.1.1976	Angle beam probe for ultrasonic non-destructive testing.	V.N. Bindal & Vinod Gogia
2.	138886	2254/72	28.12.1972	10.4.1976	Improvements in or relating to photo-chemical etching process on plastics for the manufacture of precision protectors, panels for electronics and electrical instruments and slide rules.	O.P. Bhola
3.	139041	1064/Cal/73	7.5.1973	1.5.1976	A gas lighter.	O.P. Bhola
4.	139724	1447/Cal/73	21.6.1973 21.9.1974*	24.7.1976	A process for manufacture of silver cadmium oxide composite materials.	Daneswar Sen
5.	140100	2462/Cal/73	9.11.1973	11.9.1976	A linear drive transducer for precision movement.	V.N. Bindal

*Refers to the date of filing of the complete specification with the Patent Office.

(*Contd.*)

Indian Patents Accepted (during 1976)

Sr. No.	Complete Specification Number	Application Number	Date of Filing	Date of Acceptance	Title of the Patent at Acceptance	Inventor (s)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
6.	140214	1480/Cal/73	26.6.1973 26.9.1974*	2.10.1976	A process for manufacture of copper, copper alloys—graphite composite materials.	Daneswar Sen
7.	140284	1775/Cal/73	31.7.1973	9.10.1976	Improvements in or relating to the manufacture of ceramic capacitors.	V.N. Bindal, C. V. Ganapathy, T.R.K. Menon & N. Narayana Swami
8.	140346	1571/Cal/73	6.7.1973	23.10.1976	A process for the manufacture of trilaminates suitable for use as sensing elements for cartridges in record players or microphone.	V.N. Bindal, C.V. Ganapathy, T.R.K. Menon & N. Narayana Swami
9.	140432	2768/Cal/73	19.12.1973	6.11.1976	A process for preparing an etching composition suitable for etching on glass to give permanent and opaque markings.	Mohinder Nath
10.	140602	2822/Cal/73	28.12.1973	11.12.1976	A linearized resistance bridge to read temperatures directly.	K.D. Beveja, R.K. Luthra & P.P. Bahl
11.	140635	768/Cal/75	3.4.1975	11.12.1976	A process for microencapsulating cholesteric material for use as a liquid crystal thermal device.	V.G. Bhide, Subhas Chandra & Sukhmal Chand Jain
12.	140791	2540/Cal/73	20.11.1973	25.12.1976	A device for varying and/or measuring the width of an X-ray beam.	Krishan Lal D.R. Pawha Vijay Kumar Keshav Agarwal

*Refers to the date of filing of the complete specification with the Patent Office.

PROCESSES RELEASED FOR COMMERCIALIZATION
(during 1976)

Sr. No.	*Process Title*	*Party*	*Terms of Release*		
			Premium	*Rayalty*	*Nature of Licence*
(1)	(2)	(3)	(4)	(5)	(6)
1.	Ultrasonic probes for non-destructive testing—angle beam probes and surface wave probes.	M/s. Technotronics Industries, New Delhi.	Rs 5,000	5%	Non-Exclusive for 7 years.
2.	3-Dimensional panoramic photographic display unit.	Mr. N.M. Ramaswamy, Erode. (M/s. Panographics India Pvt. Ltd., Erode, Tamil Nadu).	Rs 10,000	3%	Non-Exclusive for 10 years.
3.	Silver impregnated graphite contacts.	M/s. Sahni Industries, New Delhi.	Rs 1,500	1%	Non-Exclusive for 10 years.
4.	Monocrystalline silicon from polycrystalline silicon.	M/s. Semiconductors Ltd., Bombay.	Rs 5,000	2% on conversion charges.	Non-Exclusive for 5 years.
5.	Gas lighter.	(i) M/s. Ganesh Traders, Baroda.	Rs 1,000	5%	Non-Exclusive.
		(ii) M/s. Ranjan Enterprises, New Delhi.	Rs 1,000	5%	Non-Exclusive.

(*Contd.*)

Processes Released for Commercialization (during 1976)

Sr. No.	Process Title	Party	Terms af release		
			Premium	*Royalty*	*Nature of Licence*
(1)	(2)	(3)	(4)	(5)	(6)
6.	Liquid crystal thermal devices.	(i) Electronics Research & Development Centre, Trivandrum.	Rs 3,000	5%	Non-Exclusive.
		(ii) M/s. Dimpal International, New Delhi.	Rs 5,000	5%	Non-Exclusive for 10 years.
7.	Solid carbondioxide machine. (Carbondioxide solidifier).	M/s. Indo-Burma Petroleum, Co. Ltd., Bombay.	Rs 5,000	3%	Non-Exclusive for 10 years.
8.	Electronic digital clock. (*Technical Aid*).	M/s. KLB Electronics, New Delhi.	Rs 14,000	per year for	five years.
9.	Holography kit using He-Ne laser. (*Sponsored*).	M/s. Thermometer & Thermometric Appliances, New Delhi.	Rs 2,000	5%	
10.	Liquid air/nitrogen dewars.	M/s. Refrigeration & Cryogenics, New Delhi.	Rs 2,000	3%	Non-Exclusive.
11.	Ceramic capacitors. (Indian Patent Nos. 53482, 53817, 53372, 53528 54263).	M/s. Southern Electronics (India), Cochin.	Rs 5000	2.5%	Non-Exclusive for 14 years.
12.	High voltage ceramic capacitors.	(i) M/s. Dielectro Magnetics Ltd., Palghat. (ii) M/s. Oblum Electrical Industries (P) Ltd., Hyderabad.			

PROCESSES WHICH HAVE GONE INTO PRODUCTION
(during 1976)

Sr. No.	*Process Title*	*Party*	*Year of Release*	*Premium*	*Terms of Release*	
					Royalty	*Nature of Licence*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	Cadmium sulphide photo cells.	M/s. KLB Electronics, New Delhi.	1971	Rs 2,000	5%	Non-Exclusive
2.	Extrusion viscometer.	M/s. Associated Instruments Manufacturers (India) Pvt. Ltd., New Delhi.	1971	Rs 2,500	2.5%	Non-Exclusive
3.	Hard ferrites. (Indian patent No. 93725).	M/s. Ferrites and Electronic Components Pvt. Ltd., Lucknow.		Nil	2.5%	Non-Exclusive
4.	Distillation apparatus.	M/s. Scientronics Instruments, New Delhi.		Rs 10,000	2.5%	Non-Exclusive
5.	Electrostatic photocopying machine.	M/s. Systronics Ltd., Ahmedabad.	1971	Rs 1,00,000	7%	Non-Exclusive

REPRESENTATION ON ISI COMMITTEES

No. & Name of the Committee			*Members*
AFDC		*AGRICULTURAL & FOOD PRODUCTS DIVISION COUNCIL*	
AFDC	34	*Dairy products and laboratory apparatus*	Dr. S.V. Gupta (P) Mr. Mohindar Nath (A)
AFDC	34:1	Milk products	Dr. P.K. Gupta (P) Mr. J.C. Trehan (A)
AFDC	34:2	Methods of test and laboratory apparatus	Dr. S.V. Gupta (P) Mr. Mohinder Nath (A)
BDC		*CIVIL ENGINEERING DIVISION COUNCIL*	
BDC	5:P 1	Panel for application of acoustical plastic finish	Dr. M. Pancholy (P)
BDC	12:3	Day light standards	Dr. S.R. Das (P) Dr. V.D.P. Sastri (A)
BDC	12:5	Architectural acoustics and sound insulation	Dr. M. Pancholy (P)
BDC	12:8	Forced ventilation (Industrial)	Mr. Shiv Nath (P)
BDC	19	*Sieves, Sieving and other sizing methods*	Dr. M. Pancholy (P) Dr. P.T. John (A)
BDC	19:1	Sieves	Dr. M. Pancholy (P) (upto 26.8.1976) Dr. P.C. Jain (P) (Con) (from 26.8.1976) Dr. P.T. John (A)
BDC	19:2	Sizing by methods other than sieving	Dr. P.T. John (P)
BDC	22:5/A-1	Helmets	Mr. M.K. Das Gupta (P)

No. & Name of the Committee			*Members*
BDC	31	*Building materials and components sampling*	Dr. M. Pancholy (P) Dr. P.T. John (A)
BDC	60	*Hydraulic structures instrumentation*	Dr. B.K. Agarwala (P)
BDC	64:P 12	Panel on lighting & ventilation	Mr. K.S. Sarma (P)
BDC	64:P 15	Panel on acoustics & sound insulation	Dr. M. Pancholy (P)
CDC		*CHEMICAL DIVISION COUNCIL*	
CDC	1	*Chemical standards*	Mr. V.M. Bhuchar (P)
CDC	1:P 2	Panel for sampling procedures for general chemical products	Mr. V.M. Bhuchar (P) (Con)
CDC	17:14	Polyester fibre reinforced plastics	Dr. S.S. Chari (P)
CDC	26	*Water*	Mr. V.M. Bhuchar (P) Mr. Jitendra Rai (A)
CDC	26:P 1	Panel for methods of test for water and effluents	Mr. V.M. Bhuchar (P)
CDC	27:2	Caramic whiteware	Dr. V.N. Bindal (P) Mr. A.K. Mehrotra (A)
CDC	27:3	Whiteware & technical ceramics	Mr. A.K. Mehrotra (P)
CDC	33	*Laboratory glassware and related apparatus*	Mr. Mohinder Nath (P) Mr. B.G. Mathur (A)
CDC	33:1	Volumetric glassware	Mr. Mohinder Nath (P)
CDC	33:2	Thermometers	Mr. K.D. Baveja (P) Mr. V.P. Wasan (A)
CDC	33:3	Hygrometers	Mr. Mohinder Nath (Con)
CDC	37	*Thermal insulation materials*	Mr. V.P. Wasan (P) Mr. K.N. Bhatnagar (A)
CDC	37/P 6	Panel for thermal insulation meterials for cryogenic temperatures	Dr. J.S. Dhillon (P) Dr. R.G. Sharma (A)

No. & Name of the Committee			Members
ISAC/S-2		Safety equipment	Dr. M. Pancholy
CPDC		*CONSUMER PRODUCTS & MEDICAL INSTRUMENTS DIVISION COUNCIL*	
CPDC	12	*Medical glass instruments & appliances*	Dr. K.C. Joshi (P) Dr. S.V. Gupta (A) (upto 21.2.1976) Mr. P.C. Jain (A) (from 21.2.1976)
EDC		*MECHANICAL ENGINEERING DIVISION COUNCIL*	Dr. B.K. Agarwala (P) (*Statutory representation to NPL*)
EDC	1	*Engineering standards*	Dr. B.K. Agarwala (P)
EDC	1:1	Atmospheric conditions for testing	Dr. B.K. Agarwala (P)
EDC	36	*Optical and mathematical instruments*	Mr. P.C. Jain (P) Mr. Ram Prasad (A)
EDC	36:1	Drawing instruments	Mr. P.C. Jain (P)
EDC	36:2	Optical instruments	Dr. S.R. Das (P) Mr. Ram Prasad (A)
EDC	36:3	Surveying instruments	Mr. P.C. Jain (P)
EDC	36:5	Materials & components for instruments	Mr. Ram Prasad (P)
EDC	41	*Commercial weights & measures*	Dr. A.R. Verma (C)
EDC	41:1	Commercial weights, lengths and capacity measures	Mr. P.C. Jain (P)
EDC	41:3	Taximeters	Mr. P.C. Jain (P)
EDC	43	*Engineering metrology*	Mr. P.C. Jain (P)
EDC	43:2	Precision measuring equipment	Mr. P.C. Jain (P)
EDC	43:3	Gauges	Mr. Mohinder Nath (P)
EDC	43:4	Surface roughness	Mr. P.C. Jain (P)
EDC	57	*Chemical engineering*	Dr. J.K.N. Sharma (P)
EDC	57/P 2	Panel for standardization of vacuum equipment	Dr. J.K.N. Sharma (P)
EDC	62	*Compressors*	Mr. Naunihal Singh (P)

No. & Name of the Committee			Members
EDC	66	*Refrigeration and air-conditioning*	Mr. Naunihal Singh (P)
EDC	66:1	Air-conditioning and refrigeration appliances and commercial refrigerators	Mr. Naunihal Singh (P) Mr. R.S. Khandekar (A)
EDC	70	*Screw threads*	Dr. B.K. Agarwala (P)
CWCE		*Standing Working Committee, Mechanical Engineering*	Dr. B.K. Agarwala (P)
ETDC		*ELECTROTECHNICAL DIVISION COUNCIL*	Dr. G.C. Jain (P)
ETDC	1	*Electrotechnical standards*	Mr. V.K. Batra (P)
ETDC	1:3	General nomenclature and symbols	Mr. V.K. Batra (P)
ETDC	5	*Electric fans*	Dr. R.N. Dhar (P)
ETDC	10	*Primary cells and batteries*	Dr. G.C. Jain (P) Mr. S.K. Kapur (A)
ETDC	10/P 3	Panel for export cells	Dr. G.C. Jain (Con)
ETDC	10/P 8	Panel for multipurpose dry batteries	Dr. G.C. Jain (Con)
ETDC	15:3	Carbon brushes	Dr. G.C. Jain (P) Mr. K.K. Datta (A)
ETDC	18	*Electrical insulation*	Dr. R.N. Dhar (P)
ETDC	23	*Electric lamps and accessories*	Mr. K. S. Sarma (P)
ETDC	23:1	Lamps for aircraft and aerodrome lighting	Mr. K.S. Sarma (P)
ETDC	23:2	Auto-lamps	Mr. K.S. Sarma (Con)
ETDC	23/P 2	Panel for IEC work	Mr. K.S. Sarma (P)
ETDC	23/P 4	Panel for tubular fluorescent lamps	Mr. K.S. Sarma (P)
ETDC	23/P 5	Panel for miniature bulbs	Mr. K.S. Sarma (P)
ETDC	23/P 6	Panel for life test requirements in different Indian standards	Mr. K.S. Sarma (P)
ETDC	23/P 7	Panel for construction of materials & import substitution	Mr. K.S. Sarma (P)

No. & Name of the Committee		*Members*
ETDC 23/P 8	Panel for tungsten filament general service electric lambs	Mr. K.S. Sarma (P)
ETDC 28	*Safety electronics and telecommunications*	Dr. M. Pancholy (P)
ETDC 34	*Instrument transformers*	Mr. V.K. Batra (P) Mr. V.N. Sharma (A)
ETDC 35	*Relays*	Dr. A.F. Chhapgar (P) Mr. P. Suryanarayan (A)
ETDC 43	*Electrical appliances*	Dr. R.N. Dhar (P)
ETDC 43/P 6	Panel for safety requirements for household & similar electrical appliances	Dr. R.N. Dhar (P)
ETDC 43/P 7	Panel for refrigerators & food freezers	Mr. R.S. Khandekar (Invited to attend the the second meeting held on 19.4. 1976).
ETDC 45	*Illuminating engineering*	Mr. K.S. Sarma (P)
ETDC 45/P 2	Panel for code of practice for industrial lighting	Mr. K.S. Sarma (P)
ETDC 45/P 3	Panel for aviation lighting fittings	Mr. K.S. Sarma (P)
ETDC 45/P 4	Panel for lighting fittings for hospitals.	Mr. K.S. Sarma (P)
ETDC 45/P 6	Panel for evaluation of glare	Mr. K.S. Sarma (Con)
ETDC 45/P 7	Panel for road traffic signals	Mr. K.S. Sarma (P)
ETDC 45/P 8	Panel for examining IEC documents	Mr. K.S. Sarma (P)
ETDC 47	*Cinematographic equipment*	Dr. A.F. Chhapgar (P) Mr. Ram Prasad (A)
ETDC 47/P 2	Panel for cinema arc carbons	Dr. G.C. Jain (P) Dr. V.D.P. Sastri (A)
ETDC 48	*Electrical instruments*	Mr. V.K. Batra (P)
ETDC ASCI/1	Standardisation of industrial process measurement and control	Mr. S.P. Suri (P) Dr. A.F. Chhapgar (A)
ETDC ASCI/P 1	Panel for instruments coordination	Mr. S.K. Suri (P)

No. & Name of the Committee		Members
SWCET	*Standing Working Committee, Electrotechnical*	Dr. G.C. Jain (P)
LTDC	*ELECTRONICS & TELECOMMUNICATIONS DIVISION COUNCIL*	Dr. Kailash Chandra (P) Dr. A.F. Chhapgar (A)
LTDC 1	*Basic standards on electronics & telecommunication*	Dr. Kailash Chandra (P)
LTDC 2	*Environmental testing procedures*	Dr. Y.V. Somayajulu (P) Mr. P. Suryanarayan (A)
LTDC 2/P 6	Panel for eqipment for environmental tests	Mr. P. Suryanarayan (P)
LTDC 2/P 7	Panel for climatic tests	Mr. P. Suryanarayan (P)
LTDC 2/P 8	Panel for mechanical tests	Mr. P. Suryanarayan (P)
LTDC 3	*Reliability of electonics and electrial components and equipment*	Mr. P. Suryanarayan (P)
LTDC 3:1	Study of statistical problems of reliability of electronic and electri cal items	Dr. Y.V. Somayajulu (P) Mr. V.N. Sharma (A)
LTDC 4:1	Radio receivers	Dr. Ram Parshad (P) Mr. Suresh Chandra Mathur (A)
LTDC 4:1:4	Panel for television receivers	Dr. Ram Parshad (P) Mr. Suresh Chandra Mathur (A)
LTDC 4:2	Electronic measuring equipment	Dr. Ram Parshad (P) Mr. T.N. Ghosh (A)
LTDC 4:3	Safety for electronic equipment	Dr. M. Pancholy (C)
LTDC 5	*Acoustics*	Dr. M. Pancholy (C)
LTDC 5/P 3	Panel for acoustical terminology	Dr. M. Pancholy (Con)
LTDC 5/P 4	Panel for hearing aids and audiometers	Dr. M. Pancholy (Con)
LTDC 5/P 5	Panel for tapes & tape recorders	Dr. M. Pancholy (Con)
LTDC 5/P 6	Panel for sound systems	Dr. M. Pancholy (P)
LTDC 6	*Capacitors & resistors*	Dr. V.N. Bindal (P) Mr. T.R.K. Menon (A(

No. & Name of the Committee		Members
LTDC 8	*Transformers & inductors for electronic equipment*	Mr. P. Suryanarayan (P)
LTDC 10	*Semiconductor devices & integrated circuits*	Dr. G.C. Jain (P) Dr. Y.R. Anantha Prasad (A)
LTDC 10/P 5	Panel for terminology of semiconductor devices	Dr. G.C. Jain (P) Dr.Y.R. Anantha Prasad (A)
LTDC 10/P 7	Panel for methods of measurements on transistors	Dr. G.C. Jain (P) (Con) Dr. Y.R. Anantha Prasad (A)
LTDC 11	*Cables, wires & wave guides for Telecommunication equipment*	Dr. Kailash Chandra (P)
LTDC 12	*Piezoelectric devices for frequency control & selection*	Dr. V.N. Bindal (P)
LTDC 13	*Magnetic components & ferrite materials*	Dr. G.C. Jain (P) Dr. B.K. Das (A)
LTDC 13/P 3	Panel for magnetic data storage devices	Mr. C.V. Ganapathy (P)
LTDC 13/P 4	Panel for aerial rods and slabs	Dr. B.K. Das (P)
LTDC 14	*Resistors*	Mr. P. Suryanarayan (P)
LTDC 15	*Capacitors*	Mr. J.K. Sethi (P)
LTDC 16	*Connectors for electronic equipment*	Mr. Ram Swarup (P) Dr. Omkar Nath Khanna (A)
LTDC 18	*Wires & cables for electronic equipment*	Mr. V.N. Sharma (P) Dr. Omkar Nath Khanna (A)
LTDC 19	*Microwave components & accessories*	Dr. Kailash Chandra (P) Dr. V.K. Agrawal (A)
LTDC 20	*Radio communication*	Dr. A.F. Chhapgar (P) Mr. Suresh Chandra Mathur (A)
LTDC 20/P 2	Panel for radio receivers	Dr. A.F. Chhapgar (P) Mr. Suresh Chandra Mathur (A)
LTDC 20/P 3	Panel for TV receivers	Dr. A.F. Chhapgar (P) Mr. Suresh Chandra Mathur (A)

No. & Name of the Committee		*Members*
LTDC 20/P 5	Panel for safety requirement for entertainment electronic equipment	Dr. A.F. Chhapgar (P) Mr. Suresh Chandra Mathur (A)
LTDC 21	Electronic measuring equipment	Dr. Kailash Chandra (P) Dr. Sharwan Kumar (A)
LTDC 21/P 4	Electronics weighing instruments & systems	Mr. S.P. Suri (P)
LTDC 21/P 5	Microwave instrumentation	Dr. Kailash Chandra (P) Dr. V.K. Agrawal (A)
LTDC 22	*Electromagnetic interference suppression*	Dr. A.F. Chhapgar (P) Mr. Suresh Chandra Mathur (A)
SWCLT	*Standing Working Committee, Electronics & Telecommunication*	Dr. Kailash Chandra (P)
PCDC	*PETROLEUM, COAL AND RELATED PRODUCTS DIVISION COUNCIL*	
PCDC 1:11	Petroleum testing apparatus	Mr. P.C. Jain (P) Mr. B.G. Mathur (A)
SMDC	*STRUCTURAL & METALS DIVISION COUNCIL*	
SMDC 2	*Methods of chemical analysis*	Mr. V.M. Bhuchar (P)
SMDC 2:4	Non ferrous metals analysis	Mr. V.M. Bhuchar (P)
SMDC 3	*Methods of Physical tests*	Mr. M.K. Das Gupta (P)
SMDC 25	*Non-destructive testing*	Dr. A.F. Chhapgar (P) Mr. M.K. Das Gupta (A)
SMDC 25/P 3	Panel for reference blocks for ultrasonic testing	Dr. V.N. Bindal (P)

(C) : Chairman
(Con) : Convenor
(P) : Principal Member
(A) : Alternate Member

EXECUTIVE COMMITTEE
(As on 31st December, 1976)

Chairman
Dr. A.R. Verma
Director
National Physical Laboratory
New Delhi

Members

Dr. A.S. Bhaduri,
Director,
National Test House,
Calcutta.

Dr. A.K. Kamal,
Head,
Department of Electronics
& Communication Engineering,
University of Roorkee,
Roorkee.
(U.P.)

Mr. U. Venkateswarlu,
Managing Director,
Central Electronics Ltd.,
NPL Campus,
New Delhi.

Dr. V.G. Bhide,
Scientist (Director's Grade),
National Physical Laboratory,
New Delhi.
(*Member-Secretary*)

Dr. S.R. Das,
Scientist 'El',
National Physical Laboratory,
New Delhi.

Dr. K.K. Mahajan,
Scientist 'C',
National Physical Laboratory,
New Delhi.

Mr. H.L. Khurana,
Accounts Officer,
National Physical Laboratory,
New Delhi.

Mr. Kharati Lal,
Administrative Officer,
National Physical Laboratory,
New Delhi.

Permanent Invitees

Director-General, SIR
(or his nominee)

Chairman, Coordination
Council for Physical and
Earth Sciences Group of
CSIR Laboratories.

Receipts on Account of Fabrication, Supply and Servicing of Instruments etc. during 1976-77

Sr. No	*Item*	*Rs.*
1.	Instruments servicing	5,970.00
2.	Supply of thin film coatings etc.	17,221.00
3.	Supply of photometric integrators	15,500.00
4.	Supply of slicon wafers	2,927.98
5.	Supply of single crystals	3,500.00
6.	Supply of liquid crystal materials	718.00
7.	Supply of platinum resistance thermometers	362.00
8.	Supply of Moire gratings	4,400.00
9.	Polishing & lapping of optical flats	2,172.00
10.	Conditioning of TV picture tubes	2,180.00
11.	Repair and supply of ultrasonic probes and transducers	7,140.00
12.	Repair and supply of metal detectors	6,750.00
13.	Repair of liquid air containers	200.00
14.	Workshop jobs	3,420.00
15.	Packing and forwarding charges	482.00
16.	TA/DA charges	224.70
	Total	73,167.68

STAFF STRENGTH
(As on 1st June 1976)

Category of Staff	*NPL*	*DPEC*	*CPP*	*GTU*	*HEMS*	*TECC*	*Total*
(A) *Gazetted/Officers Ranks*							
A.1.Scientific Officers	127	5	—	—	2	2	136
A.2.Technical Officers	42	4	—	4	—	—	50
A.3.Non-Technical Officers	6	—	—	—	—	—	6
A.4.Part-Time Officers	1	—	—	—	—	—	1
Sub-Total (A)	**176**	**9**	—	**4**	**2**	**2**	**193**
(B) *Non-Gazetted/Establishment*							
B.1.Scientific Establishment (SSA & JSA)	39	4	1	—	—	—	44
B.2.Technical Establishment	322	93	3	48	7	21	494
B.3.Non-Technical Establishment	110	10	—	2	1	3	126
Sub-Total (B)	**471**	**107**	**4**	**50**	**8**	**24**	**664**
(C) *Class IV Staff*	**202**	**2**	—	**6**	**1**	**6**	**217**
TOTAL (A) + (B) + (C)	**849**	**118**	**4**	**60**	**11**	**32**	**1074**

Note 1: 'Technical' covers 'Auxiliary Technical' staff also.

Note 2: The information has been drawn from the Conventional Budget Document of the Laboratory. Scheme posts are excluded.

Abbreviations Used:

NPL : National Physical Laboratory (Main Laboratory)

DPEC : Development-cum-Production of Electronic Components Unit

CPP : Carbon Pilot Plant

GTU : Glass Technology Development-cum-Production Unit.

HEMS : Pilot & Demonstration Plant in Hydrostatic Extrusion & Material Synthesis.

TECC : Test, Evaluation & Calibration Centre.

EXPENDITURE (1976-77)

(Rs. in lakhs)

Activity	*Recurring*	*Capital*	*Total*
(A) Main Laboratory (NPL)	124.134	40.161	164.295
(B) Test, Evaluation & Calibration Centre (TECC)	5.011	—	5.011
*(C) Pilot Plants			
(i) Development-cum-Production of Electronic Components Unit (DPEC)	16.007	3.775	19.782
(ii) Glass Technology Development-cum-Production Unit (GTU)	7.558	0.620	8.178
(iii) Carbon Pilot Plant (CPP)	1.322	0.671	1.993
(iv) Pilot & Demonstration Plant in Hydrostatic Extrusion & Material Synthesis (HEMS)	3.389	23.015	26.404
Sub-Total (C)	28.276	28.081	56.357
TOTAL (A)+(B)+(C)	157.421	68.242	225.663

*The Break-up of the Expenditure into 'Recurring' & 'Capital' in respect of the Pilot Plants, is on the analogy of the expenditure incurred under these categories in respect of the Main Laboratory.

ERRATA

Table-II on Page 38—Last Two Columns

For		**Read as**	
Buffer medium	*$PHmcc—PH\frac{1}{2}trf$*	*Beffer medium*	*$PHmcc—PH\frac{1}{2}trf$*
(KCl + HCl buffer bet. PH 0.75—2.5)	+.07	(KCl+HCl buffer bet. PH 0.75—2.5	+.07
(KH_2PO_4 as buffer bet. PH 7.8—8.9)		(KH_2PO_4 as buffer bet. PH 7.8—8.9)	
(Glycine as buffer bet. PH 8.1—9.0)	+.19	(Glycine as buffer bet. PH 8.1—9.0)	+0.19
(KCl+HCl buffer bet. PH 1.0—2.4)	—.01	(KCl+HCl buffer bet. PH 1.0—2.4)	—.01
(KH_2PO_4 as buffer bet. PH 7.6—8.9)	—0.2	(KH_2PO_4 as buffer bet. PH 7.6—8.9)	—0.2