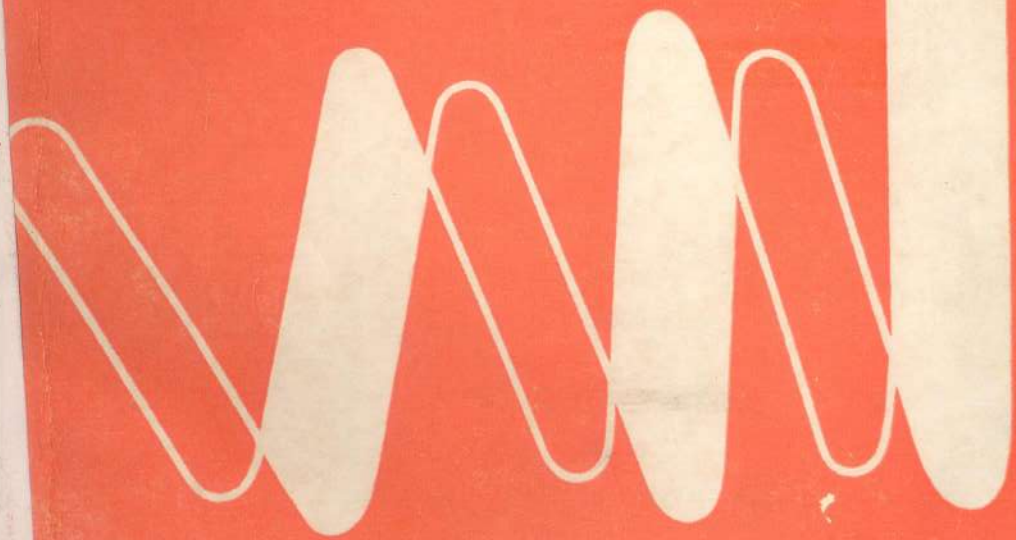
ANNUAL REPORTS

1971-72 & 1972-73



ATIONAL PHYSICAL LABORATORY - NEW DELHI

NATIONAL PHYSICAL LABORATORY
HILLSIDE ROAD, NEW DELHI - 110012

Printed at Crescent Printing Works (P) Ltd., 14/90, Connaught Circus, New Delhi-1

CONTENTS

INTRODUCTION

I am happy to bring out combined issues of the Annual Reports for the years 1971-72 and 1972-73 with a view to provide more uptodate information and reduce the gap between its publication and the period for which report has been brought out. The major research and development activities pursued during the period have been described briefly below :—

One of the main objectives of the NPL is custody, research, development and maintenance of the national standards of measurement at internationally accepted accuracy, and research on standards and on new techniques of measurement. Maintenance of and research on standards was continued. The following items deserve mention. To improve the accuracy of mass standard, development of 1 kg interchangeable pan balance has been taken up. Work on design of an interferometric comparator is being continued to establish length standard in terms of wavelength of Kr 86. Fixed points on the temperature (K) scale were realised according to International Practical Temperature Scale (IPTS)-68. Zinc, Tin and Oxygen points were realised to the desired accuracy. International comparison of weston-cadmium cells was done which form the national standard of current.

Work was carried out to improve the accuracy of standards for derived units e.g., microwave power, acoustic pressure, force (newton), radiometric and spectro-radiometric standards and vacuum.

Periodic calibration of standards of measuring instruments and equipment used by various Govt. and other testing authorities, industries, Defence against national standards was carried out and standards were supplied to some organisations. Demand for calibration of instruments and testing of industrial products and appliances for performance, life and for effect of environmental conditions is on the increase as is revealed by the 3240 and 4405 test certificates issued in 1971-72 and 1972-73 respectively compared to 2724 certificates issued during 1970-71

As industry becomes increasingly more sophisticated and science based, there is an increasing need to characterize materials for purity and perfection. National Physical Laboratory perceived this need of the industry and is gearing itself up to undetake the testing of materials for purity and perfection by using very sophisticated techniques such as X-ray fluorescence, X-ray diffraction, electron paramagnetic resonance spectroscopy, Mossbauer spectroscopy, electron microscopy etc. Lang camera is one such sophisticated technique recently developed to study perfection of materials. It can be used for (1) detection of

grain boundaries and determination of angle of misorientation between adjoining grains, (ii) detection of low angle boundaries in crystals and to determine the amount and direction of misorientation (iii) to study impurity aggregates in nearly perfect crystals (iv) observation of individual dislocations and their classification into edge and screw dislocations. In view of the importance of this technique in characterizing particularly semiconducting materials, the laboratory had undertaken a programme on the design and fabrication of Lang camera. The Lang's camera has not only been fabricated but has been successfully used to study the X-ray topography of NaCl, LiF, kcl, ADP and $\alpha - Al_2O_3$ crystals. The topographs show very clearly individual dislocations and bring out the internal imperfections on atomic scale.

Mossbauer spectroscopy has continued to be utilized for characterization of materials. During the years, methods were developed to determine not only the transition temperatures in ferrites but also the Fe^{2+} and Fe^{3+} concentration in a given ferrite, deviation from stoichiometry and the nature of magnetic interaction between magnetic ions.

In the field of materials, the activities have been confined on Carbon Technology, Semiconductor Technology, Ferrites, Pyro-electric and Piezo-electric ceramics and Alumina ceramics. In the area of Carbon Technology, the process devoloped for projector and process carbons was licensed to eight entrepreneurs. Further experimentations were carried out to improve the light output and consumption rate. To meet the interim demand, the projector and process carbons were pilot-produced in the NPL-pilot-plant and products worth Rs. 3.09 lakhs were supplied to consumers for further consumer acceptability data. Three grades of electrographite brushes were developed and sent for field trials. Experimentations with anthracite coal yielded favourable results in the development of carbon granules. Arrival of imported anthracite coal is awaited for batch production of the granules. Carbon Technology unit successfully completed the work on the project sponsored by NIDC to find the suitability of indigenous raw materials for the processing of solderberg anode paste. At the request of Research, Designs and Standard Organisation (Ministry of Railways) Lucknow a project on silver impregnated graphite relay contacts was undertaken and contacts using imported graphite have been developed. The D.C.M. sponsored a project for processing graphite scrap to make anodes for electrolytic cells. Anodes processed from the scrap were sent for field trials to M/s. D.C.M.

Indigenous ferro-silicon was purified by the trichlorosilane process and silicon of resistivity 1-10 ohm centimeter N type was obtained. Single crystals of silicon were grown in the laboratory and know-how for growing single crystals was passed on to N.R.D.C. for commercial exploitation. Work on the project of high current silicon rectifiers sponsored by M/s. Usha Rectifiers made substantial progress. Technology for silver tungsten tablets and solders used in the rectifiers was developed. It was possible to standardise diodes of PIV 500 volts. The coloured phosphors for TV tubes were prepared on experimental scale.

Professional ferrites with initial permeability in the range of 1000-5000 were developed in the torroidal shapes using imported raw materials. Efforts to purify indigenous raw materials were successful. Samples of pot cores of type 3B7 were sent to ITI for testing and found satisfactory. T.V. deflection yokes using cheap indigenous raw materials were developed and approved by CEERI, Pilani after testing. The pilot-plant activities in ferrites were continued for those items which were not taken by the licencees. 100 tons of ferrites valued at Rs. 30 lakhs have so far been processed in the pilot-plant.

Products using 85 per cent alumina were developed and pilot-produced. Development of Fosterite is nearing completion.

N.P.L. has developed niobates of alkaline oxides with certain additives which are good as pyroelectric materials.

PZT materials of various grades were developed and pilot-produced. High voltage ceramic capacitors with capacitance in the range of 100-300 p.f. and voltage range upto 5 KV were developed. Piezoelectric ceramics and high voltage ceramic capacitors worth approximately Rs. 32,000 were supplied to consumers for their acceptability.

Various ultrasonic devices using piezoelectric elements were developed in the laboratory. These devices include probes for non-destructive testing, an apparatus to study Bragg diffraction with ultrasonic waves, ultrasonic interferometer for velocity measurement, linear displacement transducer, transducers for automatic sensing and remote control.

The laboratory has been undertaking research and development programmes in selected technologies to acquire the know-how of a product or a process. In thin film technology, know-how has been acquired to make variety of thin film optical devices such as high reflection coatings, both mettalic and all dielectric type, anti-reflection coatings, interference filters, beam splitters etc. The work in this field has reached a stage where full scale production of these devices is envisaged in coming years.

After release of the know-how for electrostatic photocopying machine, work was continued to improve the quality of various components. Carriers and toners used for developing the electrostatic latent image were further modified. Improvements were made in the photoconductive plates and other accessories with a view to reduce the operation time and cost of production. Work was carried out on the development of electrophotographic machines using sensitized paper.

Know-how for the indigenous manufacture of Penning-Pirani vacuum gauges and vacuum leak detector was released. A large variety of highly sensitive strain gauge transducers of industrial, bio-medical and research applications have been developed.

Apart from developing microwave components for 10 cm, 6 cm, 3 cm, 2 cm and 1.5 cm microwave bands, new activity on microwave instrumentation was initiated and technical know-how for three instruments viz. V.S.W.R. meter, universal klystron power supply and modulation unit for klystrons was released to a private industry.

Full facilities and techniques for fabrication and re-conditioning of general purpose cathode ray tubes, T.V. picture tubes and radar display tubes have been established and one party has already signed an agreement with N.P.L. to undertake the re-conditioning of these tubes on commercial scale.

In the field of radio physics, the ionospheric environment was continuously monitored with a wide variety of radio techniques to provide the basic data required for practical radio communications and for aeronomical studies. A number of transient events such as solar flares (one of the most outstanding ones occurred in Aug. 1972 on which a compendium of Indian data was published) and nuclear explosions were detected. A rather unusual observation made during this period was the significant effect produced by celestial X-ray sources on the ionosphere. Yet another ground-based system, SODAR, was successfully initiated to monitor the lower troposphere. This system has high potentialities to study the tropo-medium to aid radio communication and in identifying turbulent zones hazardous to aircrafts.

The services rendered by the Laboratory in improving radio communications in the country have been very impressive during 1971-73. For example, a large number of requests for point-to point communication from OCS, including one for direct Delhi-Dacca radio link on an emergency basis in December 1971, were attended to successfully. The division catered to a large number of organisations seeking help in H.F. radio communcations. During this period, the division initiated a programme to intercharge vital geophysical data with U.S.S.R. and Australia. With the aid of the data collected in India as well as the data obtained rapidly from other countries, it has been possible to start the short-term forecasting service (beamed by A.I.R., RTT of IMD and the Time and Frequency Service of NPL) to help experimental aeronomers and communication people. It was also shown conclusively how the equatorial sporadic-E can be exploited for main land to island (Andamans) communications. A tropo-link in the GHz range has been made operational and a new method of calculating tropospheric transmission loss (which is an improvement over the best existing in the world) was developed.

In the field of space research and applications, it has been possible, by using orbiting satellites, to estimate the errors introduced by troposhere and ionosphere in space communications, radar tracking and navigation systems over the Indian subcontinent. Results of several rocket launchings made from Thumba have shown that solar Lyman-α is the dominant source of production in the altitude range of 70-80 km.

Aeronomical studies of the ionosphere were pursued intensely during 1971-73. A remarkable discovery was the discovery of a drastic decrease of the loss coefficient in the D-region during flares that was traced to progressive destruction of water cluster ions. This led to the introduction of an internationally acclaimed comprehensive six-ion chemical scheme and a unified picture of D-region chemistry for quiet periods, moderate and strong flares, day and night PCAs and solar eclipses. Definitive evidence has been provided during this period to show that photo-electrons from the sun-lot conjugate hemisphere play an important role in determining the structure of the ionosphere. A number of investigagations on magnetic storms, ionosphere magnetosphere interactions and neutral winds have yielded rewarding results that have profoundly influenced the international thinking in aeronomy.

Basic investigations in various physical phenomena provide a deeper insight and the applied research and developmental research programmes derive their strength from such an understanding. In pursuance of this philosophy the laboratory undertakes basic investigations in fields related to the applied research programs. During the period under review, the influence of pair breaking mechanism on Josephson tunnelling was theoretically investigated. Tunnel currents between two A.C. superconductors i.e. superconductors containing magnetic impurities was evaluated using the time dependence Ginzburg Landau equation for the order parameter. Depairing causes a reduction in the current amplitude in the d.c. Josephson effect. In the A.C. Josephson effect, this causes increased broading of the Josephson line.

Transport properties in dilute magnetic alloys has continued to attract our attention. These investigations have shown that the logarithmic divergence in the exchange scattering of the conduction electrons by the impurity spins leads to a realization that strong spin correlations must exist between the conduction electrons in the neighbourhood of the magnetic impurity, below a certain temperatures called the Kondo temperature T_K.

Mossbauer effect studies of ferroelectric lattices have elucidated the nature of the chemical bond through isomer shift, the spontaneous polarization and its temperature dependence through quadruplate interaction, behaviour of the soft mode through the Lamb Mossbauer factor. Although number of attempts have been made in the past to understand the nature of the ferroelectric transition, hardly any effort has been made to understand the lower phase transition at which direction of spontaneous polarization changes. Mossbauer studies in $BaTiO_3$ and other ferroelectrics have shown that the lower transitions are also due to the temperature dependent soft modes.

DR. A. R. VERMA,
Director

STANDARDS

It is a statutory obligation of the NPL to maintain National Standards of base and derived units of physical measurement. Closely linked to this activity is the research work on standards to uptodate them in accordance with the internationally accepted accuracy laid down by the General Conference on Weights & Measures. Work was carried out on the standards of base units i.e. mass, length, time, temperature, current & illumination to attain the internationally accepted accuracies.

Base Units

Mass : The laboratory maintains prototype of Kilogram received from BIPM as the base standard of mass and facilities exist to calibrate one kilogram weights to an accuracy of 1 in 10^7. Programme was taken up to improve the accuracy. The design of a 1 kg inter-changeable-pan balance was taken up and its fabrication is in progress.

Simultaneously, an existing balance has been modified to attain higher accuracy. It may be possible to attain an accuracy of few parts in 10^8 by further sophistication of the balance.

Length : The existing standard of length at the N.P.L. is the metre bar made of Pt-Rh alloy as the base standard of length. Facilities exist to make linear measurements to an accuracy of 1 in 10^7. Work was initiated to establish the length standard in terms of the wavelength of Krypton 86 and the stabilised He-Ne gas laser to keep pace with the international practice. Design, fabrication and installation of an interferometric comparator for length standardisation in terms of wavelength of Kr 86 was undertaken. The basic design of the metre interference comparator was completed. This comparator will be used to attain accuracy of $\pm 0.01/\mu$ 4m for the standardisation of line gauges. Design of a 60 cm interference comparator was taken up to attain accuracy of $\pm 0.2/\mu$ 4m. This comparator will find use for the calibration of moire grids and other transparent scales. Some of the optical components for 60 cm comparator, Twyman Green interferometer and Fizeau interferometer were fabricated. Work was continued on frequency stabilisation of He-Ne laser which is finally to be used for the length standardisation.

Temperature : Fixed points on the temperature (K) scale were realised according to International Practical Temperature Scale (IPTS)—68. The accuracy of the NPL set up was intercompared with those of standard laboratories in various parts of the world. Zinc, Tin and Oxygen points were realised to the desired accuracy. The present

accuracies to which the fixed points are maintained for calibration are :—

Temperature range °C	Accuracy mK
—182.962+0.01	5
231.9681	0.1
419.58	0.1
961.93	100
1064.43	100 (Thermocouple)
	500 (Opt. Pyr.)
1800	2000
2500	5000

Illumination : The Laboratory maintains 'candela' Unit of illumination to an accuracy of 2%. The incandescent lamps calibrated at BIPM, Paris are maintained for measurement of luminous intensity, luminous flux and colour-Temperature.

Current : Accuracy of the national standard of electric current 'ampere' depends upon the accuracy by which the national standards of electromotive force (e.m.f.) and electrical resistance (ohm) are maintained. Readings of the electromotive force and electrical resistance at a controlled temperature of 20°C were regularly intercompared to ensure the accuracy of these standards. To make an international comparison of the values of the national standard, six new cadmium cells (for e.m.f. comparison) were sent for test at the BIPM Sevres, France, and twelve standard resistances were sent to the NPL Teddington. After calibration with the international stadards, these standards will be used for assigning new values to the existing standards of e.m.f. and resistance at the laboratory. Work is being done to increase the range of the resistance scale from the one ohm level at present to have a continuous scale of resistance.

Efforts are being made to set up the derived standard of Power i.e. Watt. Facilities would also be created for the determination of the temperature co-efficient and the power co-efficient.

Time and frequency : Broadcasting and monitoring of Time/Frequency signals is a continuous activity of the laboratory. To improve the accuracy of the standards for the time and frequency, a Caesium Clock will be set up. With the installation of this clock, the laboratory would be able to render the standard time and frequency services to the highest achievable accuracy.

Derived Units

Efforts were made to improve the accuracy of standards for the derived units.

Microwave Standards : Working standard for measurement of microwave power was established upto 10 GHz with an accuracy of ± 2%. A method was developed for measurement of impedance using directional couplers, tuners and standards moveable short circuit. It will cover the frequency range of 8.2 to 12 4 GHz. Attenuation measurement facilities are available to an accuracy of .05 db. A 30 megacycle/s attenuator incorporated in a microwave receiver is used. Microwave frequency measurements are done using the Heterodyne frequency meter calibrated in terms of the reference crystal oscillator maintained for Time/Frequency standard whose stability is 1 part in 10^8.

Acoustic Standards : At present standard of acoustic pressure (dB) is being maintained in terms of reciprocity calibration of standard microphone to an accuracy of 0.2 dB in cavity. Audiological standard is being maintained in terms of calibrated WE 705 earphone and A.F. attenuation is being maintained in terms of-attenuator with 0.1 dB steps verified periodically through DC measurements.

Force Standard : 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 the testing machines of the industries and other organisations.

Radiometric & Spectro-radiometric Standards : Work on fabricating an absolute radiometer to serve as a standard of irradiance was carried out.

Spectral sensitivity is one of the most essential characteristics of photoreceptors. To specify spectral sensitivity of the photo-receptors, their calibration against a standard for spectral radiance is essential. Work is in progress to evolve the standard based on the absolute irradiance measurement.

Vacuum Srandard : A set up has been fabricated to create vacuum of the order of 10^{-9} torr for the calibration of vacuum instruments.

TESTING AND CALIBRATION

Calibration of instruments and testing of industrial products and appliances for performance, life and for effect of environmental conditions is one of the main objectives of the National Physical Laboratory. The calibration of various instruments like voltmeters, ammeters, wattmeters, insulation testers, resistance bridges, klystron power supply, attenuators and frequency meters, precision weights, slip gauges, universal machines etc. is a continuing activity of the laboratory. Testing of products like fuse units, ballasts, air break switches, voltage stabilizers, motors, cables, ceiling fans, plastic materials, conduit pipes, helmets, power cables and microwave components is also undertaken by the laboratory.

The volume of work undertaken by the laboratory for performance testing of a wide variety of industrial products, measuring instruments and prototypes is on the increase. During the year 1971-72, the laboratory issued 3240, test certificates compared to 2724 in 1970-71. The number of test certificates issued to various organisations for their products has increased to a figure of 4405 in 1972-73. The test fee realised for testing and calibration work has also increased from Rs. 2,00,750.15 in 1970-71 to Rs. 2,36,441.36 during 1972-73.

It has been observed that performance of many electronic equipment and instruments is effected because of extreme variations in climatic conditions. A Test and Evaluation Centre to undertake environmental and life tests of electronic and electrical components and systems has been set up on the recommendations of the Electronics Commission (the then Electronics Committee). Specialised equipment for the purpose is being installed. In the next phase it is proposed to set up field stations in the various climatic zones of the country to correlate field data with those obtained in the laboratory under simulated conditions. Many foreign countries have shown their interest to collaborate in field testing to their electronic goods.

Ultra-High Vacuum facilities are being established to meet the growing needs of the industry. An ultra-high vacuum system has been fabricated and vacuum of the order of 10^{-9} torr has been achieved A number of runs were made to confirm the repeatability of the system. Work is in hand to achieve vacuum of the order of 10^{-11} torr. Facilities have been set up for the calibration of vacuum gauges upto 10^{-6} torr. Equipment is being fabricated to create additional facilities to test vapour diffusion and rotary pumps according to ISO & ISI specifications.

The laboratory undertakes design and development of test equipment to test specific products according to ISI and other relevant

specifications. During the period, test set up for testing helmets according to ISI specifications was completed. The test set ups have also been supplied to other testing laboratories, namely, Defence Research Laboratory, Kanpur, CMRS Dhanbad, the Police Departments, ISI, National Test House.

The purity and perfection of materials is most essential for the quality of any components and devices made therefrom. The knowledge about suitability of materials without processing them into the finished goods saves wasteful trials with unsuitable materials. At the National Physical Laboratory various sophisticated techniques are deployed which facilitate these investigations, such as, X-ray diffractography and spectroscopy, electron microscopy, Mossbauer spectroscopy, Electron Paramagnetic Resonance Spectroscopy, infrared spectroscopy, etc. The Laboratory also renders service to the industry and research organisations in assisting them to develop new materials.

The laboratory is fully equipped to undertake analysis work employing these specialised techniques. One of the examples is the analysis of three samples of diamond grit sent by the Customs Deptt., Bombay. These were confirmed to be the synthetic diamond. Very interesting satellite lines of the diamond pattern were observed. Further studies are being carried out to interpret the nature of the phases co-existing with the diamond crystals with the help of X-ray fluorescence analysis.

The scientists of the laboratory have also provided consultancy to various organisations in many related fields of research being pursued by the laboratory. This laboratory has also assisted the ISI in drawing specifications for various products and in laying down the methods of tests for ascertaining these specifications. The recommendations made to the ISI by the laboratory are based on the experimental work done by the scientists at the laboratory. A large number of scientists serve on various ISI Committees (see Appendix).

STATEMENT SHOWING THE TEST FEE EARNED AND NUMBER OF TEST REPORTS ISSUED DURING THE YEAR 1971-72.

Name of the Division	*Number of Test Reports issued*	*Test Fee earned Rs. P.*
Weights & Measures	1505	49,313.32
Mechanics	450	36,383.00
Microwaves	471	22,745.00
Optics	124	20,956.20
Chemistry	194	18,047.00
Electricity	181	14,235.00
Acoustics	65	5,402.00
Refrigeration Testing	3	5,400.00
X-Ray	4	3,500.00
Heat	161	3,574.00

Electronics	17	3,468.00
T. E. C.	44	2,733.34
Electron Microscopy	8	1,200.00
Carbon plant	5	428.50
High Vacuum	8	360.00
Total	3240	1,87,745.36

STATEMENT SHOWING THE MISCELLANEOUS REALISATIONS ON ACCOUNT OF FABRICATION JOBS DONE & SALE OF CARBON PRODUCTS DURING 1971-72

1.	Electrostatic Photocopying Machine & Photo Conductive Plates	86,600.00
2.	Moire grids/gratings	5,504.30
3.	Fabrication of Ice Point Equipment	527.00
4.	Fabrication of Microwave Components	1,134.00
5.	Platinum resistance thermometer	550.00
6.	Instrumentation & Servicing	2,725.00
7.	Mossbauer Linear Drive	10,025.00
8.	Chemicals for colour transmission & Vacuum Coating	3,556.00
9.	Photometric integrator	5,200.00
10.	Supply of Silicon & Alkali Halide Crystal Photocell, Photometal, Lab. Equipment	2,852.85
11.	Supply & Repair of Metal Detector	1,805.80
12.	Ultrasonic Generator	1,250.00
13.	Jobs done by Workshop	7,704.45
14.	Fabrication of liquid air/nitrogen container	919.50
15.	Supply of Liquid Nitrogen	3,026.70
16.	Supply of Liquid Air	5,717.40
17.	Supply of Process & Projector Carbons	1,76,034.19
18.	Supply of Microwave Components	24,917.50
19.	He-Ne Laser	1,602.75
20.	Shock absorption testing equipment for helmets	33,700.00
21.	Oscilloscope Kit	2,400.00
22.	Repair of Traffic Signal Unit	2,270.00
	Total	3,80,022.44

STATEMENT SHOWING THE TEST FEE EARNED AND THE NUMBER OF TEST REPORTS ISSUED DURING 1972-73

S. No.	*Division*	*No. of Test Report*	*Test Fee*
1.	Mechanics	501	43,599.67
2.	Length Metrology	782	27,704.89
3.	Mass	1652	27,381.86
4.	Electricity	310	26,634.68
5.	Optics	100	25,861.25
6	Microwaves	590	25,815.00
7.	Chemistry	153	17,614.00
8.	Refrigeration Testing	4	13,400.00
9.	Heat Standards	145	8,416.00
10.	Electronics	22	5,695.00
11.	Acoustics	60	5,355.67
12.	T.E.C.	50	5,263.34
13.	Electron Microscopy	3	1,200.00
14.	Low Temperature	1	720.00
15.	High Vacuum	22	705.00
16.	Carbon Plant	8	675.00
17.	X-ray	1	300.00
18.	Material Testing	1	100.00
		4405	Total 2,36,411.36

STATEMENT SHOWING REALISATIONS ON ACCOUNT OF FABRICATION JOBS DONE AND SALE OF CARBON PRODUCTS DURING 1972-73

		Rs. P.
1.	Moire grating	3,032.00
2.	Photo Conductive Plates	16470.00
3.	Low Temp. Dewar Flask/Liq Air Container	503.00
4.	Coating of Mirrors/Laser	9,520.00
5.	Ice Shaving Machine/Pt. res. Thermometer/Ice Pt. Equipment	18,735.00
6.	Workshop charges	1,995.10
7.	Repair and Servicing of Instruments	3,825 00
8.	Calibration of Weights	22.05
9.	Metal Detector	3,575.80
10.	Coating of prism/glass	585.00
11.	Repair and Supply of Traffic Control Unit	27,060.50
12.	Photo Integrator	5,500.00
13.	Repair and Supply of Ultrasonic Probes	200.00
14.	Repair of Hydraulic Press	575.00
15.	Sample Holder Unit	2,000.00
16.	Photocells	48.00
17.	Microwave Components	31,006.50
18.	Distilled Water	160.80
19.	Liquid Nitrogen	312.24
20.	Liquid Air	2,944.78
21.	*Carbon :*	
	(a) Process Carbon Rs. 1,05,345.57 (b) Projector Carbon Rs. 16,560.52 (c) Carbon points Rs. 1,649.27	1,23,555.36
22.	Packing, Postage, Duplicate copies of Test Report, etc.	1,099.05
	Total	2,52,725.18

APPLIED RESEARCH AND DEVELOPMENTAL PROJECTS

In perference to short term projects, care is taken to select such areas wherein a sustained effort can be maintained on a continuing basis aimed at developing a technology which should be skill oriented, requiring a high degree of scientific competence and which would suit Indian conditions utilizing as far as possible indigenous raw materials, and would have relevance to our needs and priorities.

Metrological & Diffraction Gratings

Moire Technique is one of the latest and most precise techniques with diverse applications such as in determination of strains, metrology, automatic machine tool control systems, study of crystal dislocations, etc. As a first step in developing Moire Techniques, the laboratory has set up facilities for making large size linear gratings for which a linear ruling engine was designed and fabricated. These moire gratings have been supplied to a number of teaching and research organisations for strain analysis work. A circular ruling machine for making circular gratings has also been designed and fabricated. A collimated light beam of wide aperture has been designed, and installed for use with circular ruling engine. A crossing jig has been designed and it is being fabricated to draw triangular and orthogonal gratings.

Techniques for copying the large size moire gratings and their reproduction on metallic as well as non-metallic specimen have been perfected. Efforts are being made to devise methods for using these gratings for strain analysis in elastic and plastic regions of the specimen. The KPR techniques of reproducing gratings for metallic specimen has shown satisfactory results. A 10-ton hydraulic loading machine has been designed and fabricated for strain analysis work. Design of a 30 ton loading frame and a device to fix oversize discs without deformation is in progress.

Lang Camera for X-ray Topography

Lang Camera is an extremely useful tool for organisations carrying out research and development work in the field of semiconductor technology. The Lang Camera is used for :-

(i) the detection of grain boundaries and determination of angle of misorientation between adjoining grains;

(ii) the detection of low angle boundaries in crystals and to determine the amount and direction of misorientation;

(iii) the study of impurity aggregates in nearly perfect crystals;

(v) the observation of individual dislocations and their classification into edge and screw dislocations.

Various parts of the Lang Camera such as collimating slit system, turntable, scintillation counter for the detection of X-rays, the plate holder to suit size of X-ray dental film and nuclear emulsion plates, the traversing mechanism to move the crystal and the photographic film/plate across the X-ray beam have been made at the laboratory. A vertical circle goniometer to provide rotation around the horizontal axis in the plane of wafer under investigation has also been developed. This goniometer can be used to align the crystal for different planes of the same zone.

With the Lang Camera developed at the laboratory projection topographs of NaCI, LiF, KCI, ADP and α-Al_2O_3 crystals were successfully recorded. Systematic investigation of dislocation structure in CVD grown α-Al_2O_3 wafers was undertaken with a view to understanding the mechanism of crystal growth. The quality of the topographs of α-Al_2O_3 wafer so obtained very clearly showed the individual dislocations. Further analysis of dislocation structure in CVD grown α-Al_2O_3 wafers would be continued.

With a view to understanding the mechanism of crystal growth investigations about the defect structure in whisker crystals of ZnS, NaCl, KCI and Cu etc. would be carried out. Topographs with diffraction vector along the length of the whisker would also be recorded.

Thin Films

Work on the preparation of various optical coatings such as thin film interference filters, beam splitters, anti-reflecting coatings, neutral density filters etc. was started in 1966. As a result of the continuous efforts made considerable success has been achieved in developing the necessary technology for the fabrication of thin film optical devices.

The technical know-how for the following devices has already been developed :

1. High reflection coatings, both metallic and all dielectric type.
2. Deposition of difficult materials like metal oxides, fluorides and alloys.
3. Single layer and double layer anti-reflection coatings.
4. Transparent conducting coatings.
5. Film thickness monitor and controller
6. Metal-dielectric-metal interference filters
7. Induced transmission filters
8. All dielectric filters
9. Beam Splitters

10. Electronically controlled anodizing apparatus for aluminium and tantalum films.

11. Colour coating of sunglasses.

Techniques developed at the laboratory for deposition of anti-reflection coatings on glass surfaces have resulted in the reduction of total reflection from 8 per cent for uncoated surface to 3—4 percent for the coated surface. The coatings deposited are quite durable and hard. Work was mainly directed to fulfil the needs of a public sector undertaking who required urgently such coatings on glass panels in various sizes for their instruments.

The electronically controlled anodizing apparatus developed at the laboratory has given satisfactory results for anodization of aluminium films.

Work on the deposition of transparent conducting tin-oxide coating on glass has been completed and now the coating can be prepared to desired conductance.

A sample of glass toroid (part of Betatron, under fabrication with AMD, BARC) was received from Atomic Minerals Division of Bhabha Atomic Research Centre. The inner surface of the toroid was to be coated with tin oxide transparent conducting film. The work was completed to their satisfaction.

Processes have been released for the deposition of Colour Coatings on Sun Glasses and also for the manufacture of Film Thickness Monitor and Controller.

Design of a versatile 51 cm diameter coating unit has been completed. Work is in progress on the preparation of absorption colour coatings having transmission bands in specific region, which could be used finally for the suppression of side bands appearing in the thin film interference filters.

Phosphors—Luminescent Materials & Devices

The technical know-how for the preparation of zinc sulphide and cadmium sulphide phosphors for use in T.V. and CR tubes from the indigenous raw materials has been perfected. The feasibility report for a pilot plant scale production of these phosphors has been submitted to M/s. Bharat Electronics Ltd. Testing of the phosphors prepared by the laboratory was carried out by M/s. Bharat Electronics Ltd. The performance was found to be as good as that of the imported phosphors.

Facilities for the testing of all type of phosphors for particle size, spectral energy distribution, total light out-put and decay time under high energy electron excitation have been established. Decay time of

upto 1 μs and spectral energy distribution between 4000Å—6500Å can now be measured in the laboratory.

The coloured phosphors (blue, green and red) for the television tubes have been prepared successfully on an experimental scale. For the preparation of a more efficient red phosphor materials such as Ytrium (Y), Vanadium (V) and Gadolinium, etc. would be developed.

Development work on devices such as electroluminescent display panels and X-ray image intensifiers has been initiated. The electroluminescent phosphors and cadmium sulphide powders used in these devices have been developed. Work is also in progress to prepare thin electroluminescent films by vacuum evaporation. The thin films so prepared would be suitable for applications where low voltage is applied for switching digital panels. Electroluminescent panels on conducting glass have been prepared by various phosphor coating methods.

Fabrication/Re-conditioning of Cathode Ray Tubes and T. V. Picture Tubes

Cathode-ray tube is the vital part of a cathode-ray oscilloscope, which is an important electronic instrument used for the visual display of information. Television picture tube is a special type of cathode ray tube. These tubes consist of an electron gun mounted inside a glass envelope. The front surface of the glass envelope is coated with a suitable phosphor, which gives out light when electrons hit the screen.

The laboratory has been making efforts to develop the technology of fabricating various types of cathode ray tubes and television picture tubes since 1968. Significant achievements have since been made.

Techniques involved in the fabrication of cathode ray tubes and television picture tubes such as electron gun assembly, aquadag coating, phosphor deposition, sealing, processing, etc., have been perfected by the laboratory. Cathode ray tubes of 5UPI and 5AQP31 type with acceleration voltage of 1500 and 3000 respectively have been batch-produced. Electronic circuitry for a general purpose oscilloscope kit using 5UPI tubes has also been evolved. Television tubes of various sizes have also been fabricated.

Cathode-ray tubes and television picture tubes often require reconditioning because of poor vacuum, burnt heater, low cathode emission, or bad screens. The laboratory has successfully developed the techniques for reconditioning and fabrication of such tubes. To widen the scope of already established facilities for reconditioning and fabrication, work on reconditioning of radar-display tubes has also been completed.

To accelerate the pace of the work a vertical sealing machine was purchased for sealing of the large television tubes. The sealing machine has been modified and it can now be used for the cathode ray tubes of all sizes and the televison tubes of 30cm to 58cm screen sizes.

Table

CHARACTERISTICS OF SOME COMMERCIAL PHOSPHORS DEVELOPED BY N.P.L.

No.	International Equivalent	Composition	Peak Wavelength	I.C.I. Coordinates	I.C.I. Coordinate of international equivalents	Persistence	Uses
1.	P-31	ZnS-Cu (Green)	5300A See graph above	0.23, 0.54	0.193, 0.420	10^{-3} sec(medium)	CR tubes
2.	P-22a	ZnS-Ag (Blue)	4500A See graph above	0.145, 0.0475	0.146, 0.052	10^{-4} sec(med. short)	Counters
3.	P-4	ZnS-Ag (Blue) ZnS/CdS-Ag (Yellow)	4500A & 5600A See graph above	0.26, 0.26	0.27, 0.30	10^{-4} sec(med. short)	TV
4.	P-20	ZnS/CdS-Ag (Green)	5500A			10^{-4} sec(med. short)	Image Converter tubes
5.	P-1	Zn_2Si04-Mn (Green)	5300A			10^{-2} sec(medium)	Low Voltage CR Tubes
6.	P-7	ZnS/CdS-Cu (Yellow Green)	5500A			1 sec (long)	Radar tubes
7.		(ZnS-high Cu (Green)	5300A			short	Electroluminescent devices e.g. LEF's* and X-ray image intensifiers.
		ZnZ-Mn (Orange)	5800A			short	

* *LEF—Light Emitting Films used in the form of information display panels e.g. alphanumeric, graphic and video display panels.*

Several 58cm size television picture tubes were reconditioned on payment basis on behalf of outside agencies. Radar display tubes were also reconditioned for D.T.D. & P. (Air).

The technical know-how for the fabrication and reconditioning of cathode ray tubes and the television tubes is being released to industry for commercial exploitation. M/s. Videotronics New Delhi have already signed the agreement through the NRDC. Training was imparted to the persons deputed by M/s. Videotronics.

Work on the development of transistorised television picture tube is in progress. Development of a test-console for the television tubes is also in progress.

Development of Microwave Components and Instruments

Microwaves in the frequency range of 1,000 to 300,000 MHz (wavelength range of 30 centimeters to fraction of a mm), are being extensively used in microwave systems like radar, microwave communication links, satellite communication, navigation, scientific research and education.

Microwave instruments and components required in these applications are very sophisticated in their design and demand a high degree of precision in fabrication techniques. Their mechanical dimensions permit only extremely close tolerances. With a view to meeting this requirement and developing the technical know-how for the fabrication of microwave components and instruments, work was initiated at the laboratory few years ago.

(i) *Waveguides* : Waveguides used to transmit microwave energy from one point to another in a system or subsystem, are hollow metallic pipes of suitable dimensions having good inside surface finish. A machine has been developed by the laboratory at a modest cost of about Rs. 10,000 only. With this machine waveguides made of copper, brass or aluminium in any size for different microwave frequency bands can be drawn. Waveguides suitable for X-band (3 centimeter wavelength), XN-band (5 cm wavelength), K-band (1 cm wavelength) and S-band (10 cm wavelength) have been successfully drawn.

(ii) *Microwave Components* : Apart from straight waveguides, a variety of microwave components are required for the assembly of microwave systems. Techniques for the fabrication of 25 different types of microwave components such as slotted sections, probes, bends, twists, T-joints, attenuators, directional couplers, horns, etc. for the 10 cm, 6 cm, 3 cm, 2 cm, and 1.5 cm microwave bands have already been perfected. Complex shapes like transisions etc. are being fabricated by electroforming.

To meet the demand for microwave components in the country, batch-production of the components for X-band, C/XN band, S-band, K & KU band was undertaken. The laboratory is batch-producing

microwave components on orders from outside organisations. Thirty complete microwave test benches useful for research purposes and testing sub-systems of the full microwave systems were made at the laboratory and were supplied to various organisations. Total cost of batch produced components is Rs. 3,50,000. As a result of these indigenously made microwave test benches, foreign exchange amounting to Rs. 8,00,000 has been saved. Two firms have already started production with the technical know-how developed at the laboratory. The annual turn-over of these firms is estimated at Rs. 5,00,000. This will further help to save the valuable foreign exchange.

(iii) Technical know-how for fabrication of K-band, S-band and KU-band components is also ready for commercial exploitation.

Microwave Instruments : Work on the Voltage Standing Wave Ratio meter sponsored by M/s. K.L.B. Electronics, New Delhi was completed and prototype of the V.S.W.R. meter was handed over to them. The V.S.W.R. meters are now being manufactured on a commercial scale by the firm.

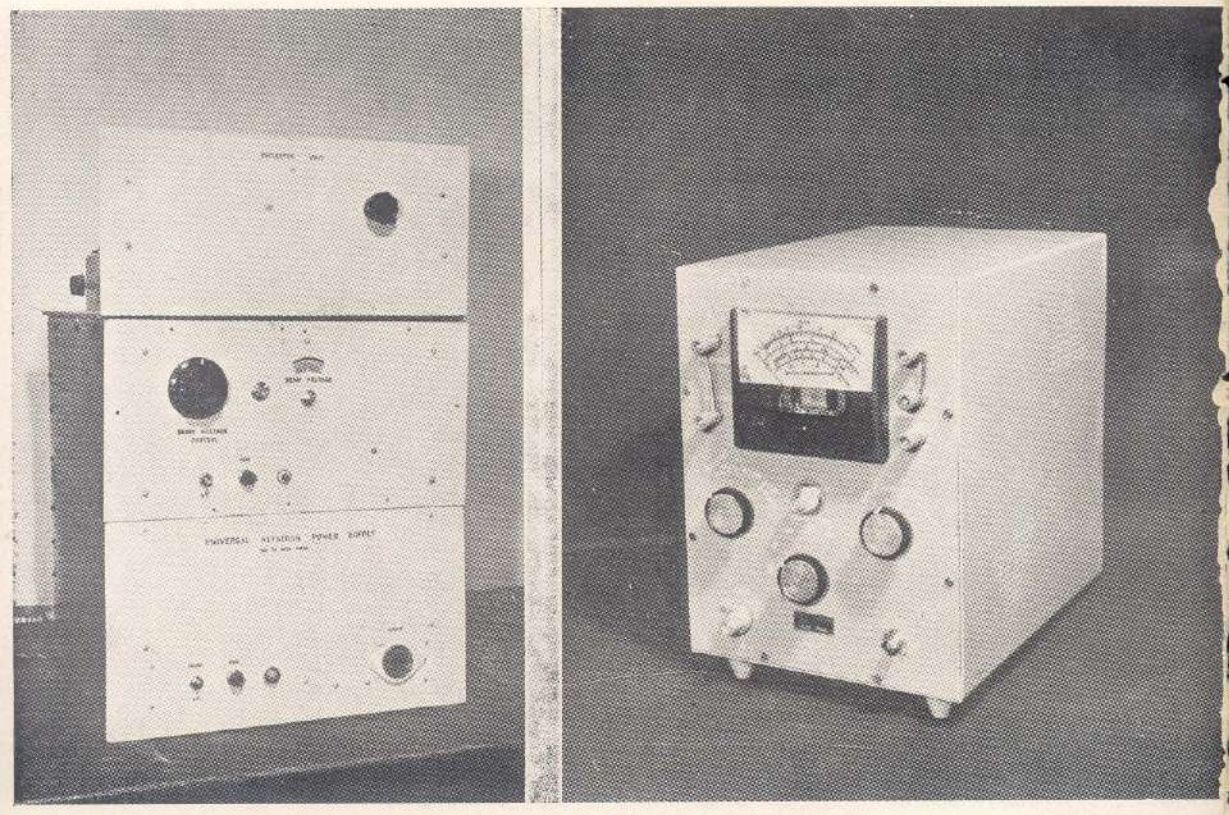
Prototype of the Universal Klystron Power Supply (cavity voltage 200—2000 volts and repeller voltage 0—600 volts) was developed. Waveform generator for klystron modulation with facilities for sine wave, square wave, saw tooth and pulse output has also been perfected. The process for the manufacture of the universal klystron power supply and modulation unit has been released to M/s. K.L.B. Electronics through the N.R.D.C.

Reflex Klystron type 2K28 : Reflex klystrons are used as source of microwave power in radar receivers and mircowave links. They are also used as a signal source in the microwave test-benches. Prototypes of external cavity reflex klystron of 2K28 type for 10 cm wavelength have been successfully fabricated at the laboratory. Typical output power for these klystrons is of the order of 90—100 milliwatts at 10 cm wavelength. The reflex klystrons are now being batch produced at the laboratory. Harmonic generators to be used with the reflex klystrons 2K28, have also been developed to serve as microwave sources in XN-band and X-band.

Penning & Pirani Vacuum Gauges

Vacuum gauges of Pirani-Penning type have been developed at the N.P.L. The project was undertaken on behalf of a firm who sponsored the project. The Pirani-Penning Vacuum gauge is the most common type of gauge used to measure vacuum upto an order of 10^{-6} torr.

The gauge consists of two distinctive parts, viz., Pirani gauge and Penning gauge, used in two separate parts, from 10^{-2} torr to 10^{-6} torr. The gauges developed at the N.P.L. have transistorized stabilised voltage supply which eliminates the need for a 'set voltage' adjustment,



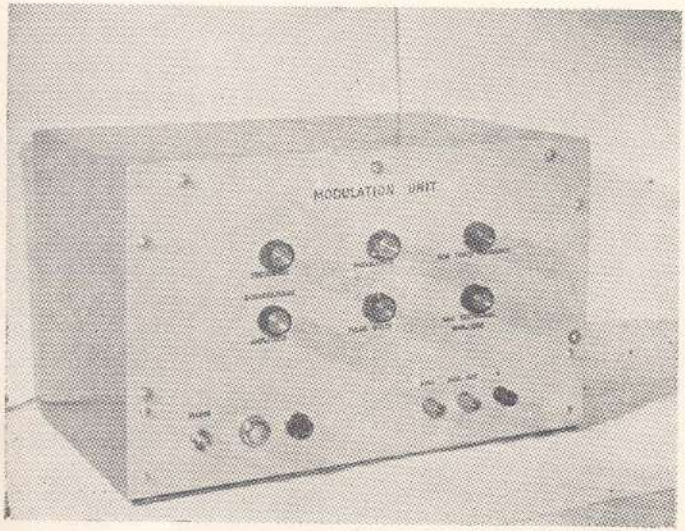


Fig. 1 Univeral Klystron Poswer Supply, VSWR Meter and Modulation Unit developed at the NPL are being produced by a firm.

a process which has to be done before each reading taken either with Pirani or with Penning gauge. The Pirani head has a compensating element sealed at 10^{-2} torr. The Penning gauge head is an all metal construction which is completely demountable. The construction is quite rugged and the geometry is such that it initiates discharge even at low pressures of the order of 10^{-5} or 10^{-6} torr. This gauge uses almost 100% indigenous components and its performance is comparable with imported gauges.

Vacuum Leak Detector

After the successful development of the Penning and Pirani type of gauges, the developmental work on the Thermal Conductivity type vacuum leak detector was taken up.

The first prototype of the leak detector has been made. The process would be released for commercial exploitation.

Design and Development of Optical Systems

Nearly 100 designs of various optical systems required by the industry have been evolved by the laboratory. These include :

(i) eye pieces and objectives for microscopes, telescopes, binoculars, levels and theodolites, etc.

(ii) objectives for cameras, projectors and enlargers.

(iii) Condensers for microscopes, projectors and enlargers.

Because of availability of these optical systems, devices such as miniprojectors, advertisement slide projectors and overhead projectors have been made by the industry.

A novel approach to the designing of lens systems, based on the presumption that all positive lens systems are derivable by a method of synthesis from the single lens was developed. A new concept of demerit values of lens systems was evolved for inter-comparison of different systems intended for the same requirement.

Field—Ion Microscope

In collaboration with the metallurgy department of the Banaras Hindu University work on the development of a field-ion microscope has been initiated recently. The design of the microscope has been made keeping in view the indigenous availability of various components. Fabrication of the field-ion microscope is in progress.

3-Dimensional Photography & Radiography

A camera and the techniques for taking 3-dimensional photographs in black and white as well as in colour using a lenticular grid have

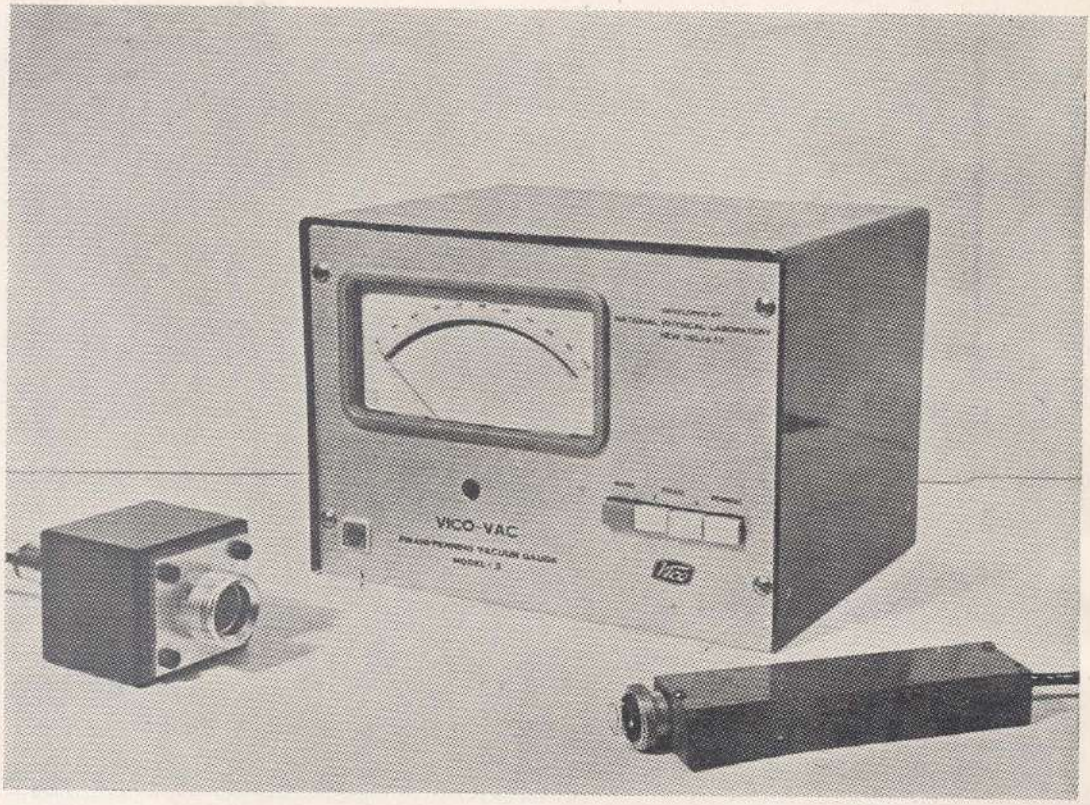
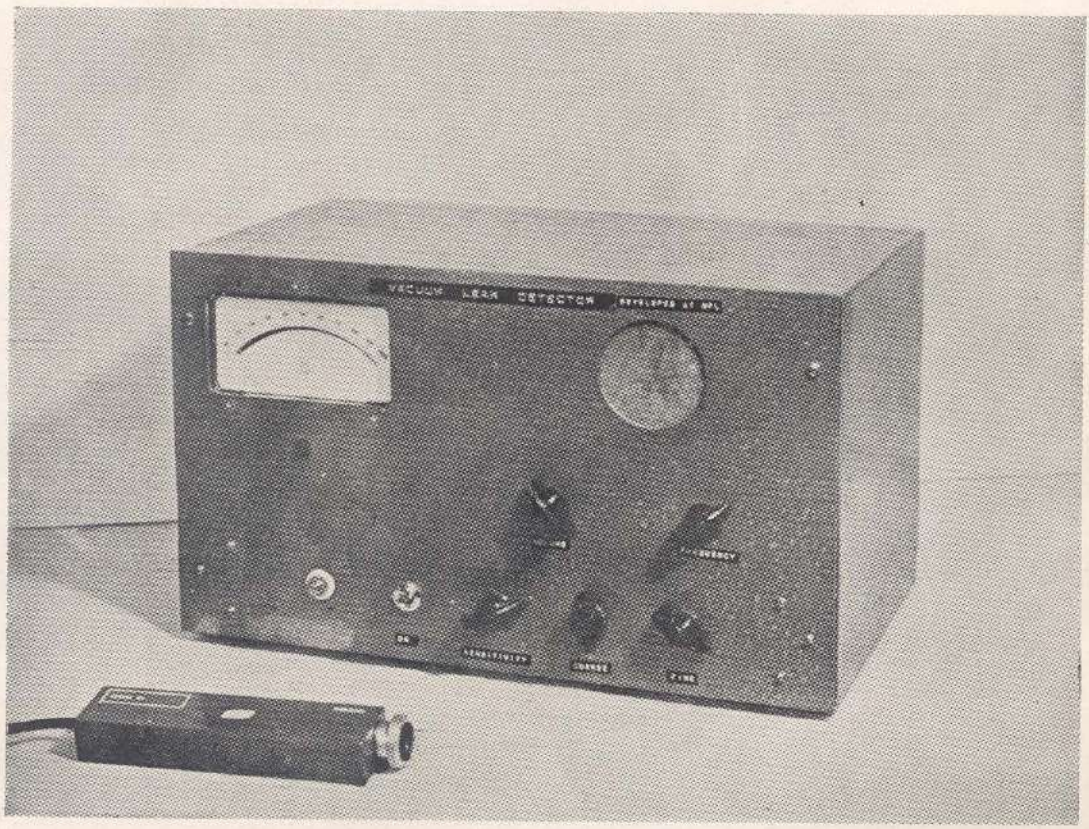


Fig. 2 Pirani—Penning Vacuum Gauge (above), vaccum leak Detector (below) developed with NPL know-how are now available in Market.



been perfected. Methods for developing colour films have also been established.

X-rays pictures taken on the grids developed from aluminium and paper strips were found satisfactory. Work on the development of a grid to accommodate full size x-ray plates is in progress. The grids, specially made for this purpose, would be very useful for medical and radiographic work.

Ultrasonic Aid for the Blind

In view of the heavy incidence of blindness in the country, work on the development of an ultrasonic aid for the blind was initiated. Several methods deploying electromagnetic or sound waves can be used to help the blind. A working model of the sonic aid in the form of a torch was made using a solid dielectric transducer specially developed for this purpose.

In order to further reduce the torch model in size and ensure more reliable operation, printed circuitry was employed. The transducers of the improved model have been so shaped that they can be used as spectacles while the circuitry of the device in small size case can be put into the pocket.

Five such units of the blind aid were assembled employing printed circuitry. Field trials on the blind people to evaluate the performance of this model will be carried out.

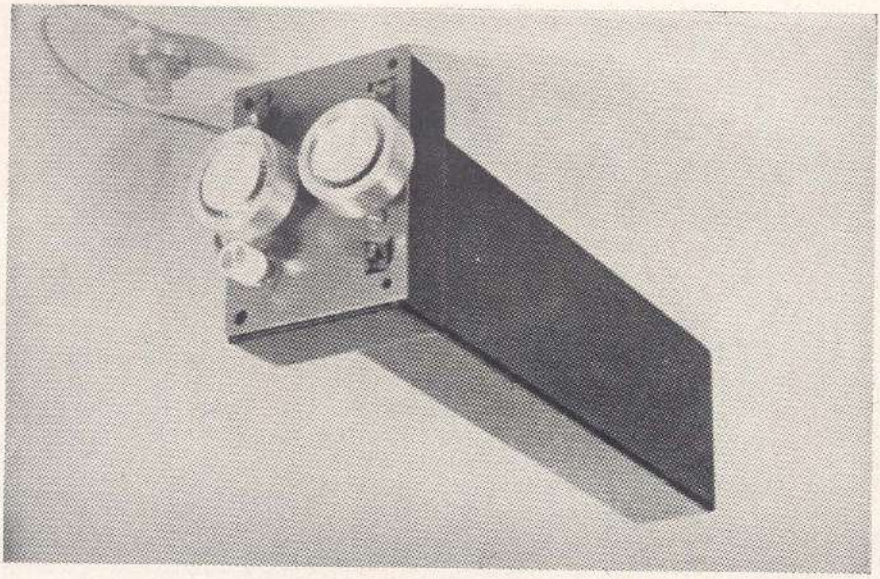


Fig. 3 Ultrasonic aid for the blind.

In the next phase of the programme the development of blind aids using integrated circuits and the electret transducers would be taken up. It is felt these improvements would make the blind aid more efficient and more compact.

Gas Lasers

Gas lasers, especially the He-Ne lasers, have been instrumental in the improvement of the precision by at least one order of magnitude in many scientific and engineering measurements. In metrological laboratories the He-Ne lasers are now widely used for many applications i.e. standardization and calibration of length, measurement of vibration, measurement of velocity of light, optical testing, alignment and stress analysis. The National Physical Laboratory has been working on the development of reliable and stable He-Ne lasers for such applications since 1968.

Initially, the development of multilayer dielectric coated laser mirrors was started, thereafter, the development of the He-Ne laser was taken up. In the beginning, the lasers of Brewster window type were made. Work on this type of lasers was discontinued because of criteria of ruggedness and the development of internal mirror type lasers was initiated. Several designs of internal mirror He-Ne lasers were attempted and a co-axial design having required properties was developed. It is about 50 cm. in length and gives 0.5 to 1 milliwatt beam power at the wavelength 633 nm. The technical know-how of the process for making such lasers has been released to two private firms through the NRDC.

At the time of release of the process the operating life of the laser was about 300 hours. The cause of their insufficient life was investigated and it was found to be due to loss of neon because of the absorption of the neon ions by the electrodes. Intensive work has been done to improve the operational life of the lasers during these years. As a result of the continued efforts the operational life of these lasers now exceed 1000 hrs. Up till now eight such lasers have been supplied to the research and educational institutes.

After the successful development of the low power He-Ne lasers, development of higher power gas lasers was undertaken for holographic and spectroscopic applications. Several pulsed argon-ion lasers, one 10 mw CW argon-ion laser and a one-watt CO_2 laser were fabricated. However, the main effort remained directed to the development, of higher power He-Ne lasers and such lasers of upto 10 mw beam power have been developed. These lasers are also internal mirror type and have over 1000 hours operational life but are not as rugged as the smaller He-Ne lasers. Work is being continued on the improvement of the design and efficiency of these lasers.

To use the He-Ne laser for length standardisation and measurement work, single frequency He-Ne lasers have been developed. Work is being carried out on stabilizing the emission wavelength of these

lasers. A scanning Fabry-Perot interferometer has been set up for measurement and improvement of the design and efficiency of these lasers.

Applications

(a) *Holography* : Holograms of good quality have been obtained by using the He-Ne lasers made in the NPL. A holographic system has been set up for both live-fringe and frozen-fringe holographic interferometric measurements. It is proposed to take up work on metrological applications of holography.

(b) *Interferometry* : Compressive shear laser interferometers have been developed for optical testing. Variable compression, linear or radial, can be introduced in these interferometers. The radial compression is used for measuring aberration of camera and similar objectives. The linear compression is utilised for measurement of the resolution of photographic emulsions. An unequal path inverting interferometer has also been developed for precision alignment with the laser beam.

Cryogenic Equipment—Fabrication of low Pressure air Liquefier

Cryogenics has assumed enormous importance during the past two decades. It is being extensively used for many applications such as in the steel and fertilizer production, petrochemical complexes, metal working industry, food and fish preservation, space programme and the Defence. In addition, the cryogenic facility has become an essential part of any research establishment these days.

Realising the importance of cryogenics in such diverse fields, work on the development of cryogenic equipment was started at the laboratory.

The main items of equipment required for establishing cryogenic facilities are gas liquefiers and containers for storage of liquefied gases. At present there are very few organisations in the country which have low temperature facility of their own because of the non-availability of the required equipment indigenously.

In order to enable the country produce the equipment indigenously, the development of air liquefier and metallic containers for liquid air/nitrogen was undertaken in the NPL.

A high pressure air liquefier of 'Linde type' was developed initially using two high pressure compressors imported from abroad.

However, high pressure compressors are not available indigenously. Accordingly, the development of Claude Type low pressure air liquefier, working at 250 psi was undertaken. The important critical components of this liquefier other than compressors are expansion engine, heat exchanger and Joule Thompson assembly.

Trial runs of the expansion engine in conjunction with the Hampson Type exchanger have given a drop in temperature of 55°C across the engine. The lowest temperature of —124°C for the exhaust stream has been successfully attained. Still lower temperatures for liquefaction would be obtained by incorporating more efficient heat exchangers in the circuit.

Metallic dewars, the double walled evacuated vessels, of spun copper have been designed and fabricated, of these some 5 litre capacity containers have been supplied to the universities. The production of these containers would be streamlined. Development of the large size containers of 15, 25, 100 and even 200 litre capacity is proposed to be taken up. The use of aluminium in place of copper would be made.

Electrostatic Photocopying Machine

Electrostatic Photocopying Machine has become indispensable for the modern libraries, commercial concerns, big offices and various other organisations because of the need for rapid, accurate, economical duplication and dissemination of scientific, technical, commercial and educational information. The high cost (over a lakh of rupees) of the imported machines had so far prevented universities, business corporations and other institutions to have this facility which is a regular fixture in the libraries of advanced countries. With the technical know-how developed by the laboratory the electrostatic photocopying machine can be produced at a cost of about Rs. 12,000—20000 depending upon the various models produced by the licensees.

The electrostatic photocopying machine developed in the N.P.L. consists of a re-usable photoconductive plate; an electrostatic charging system for exposing the sensitized photoconductive plate to the object/document to be copied; a developing system for the development of the latent image on the plate and a heat or vapour fusion fixing system for fixing the toner image on the paper.

The electrostatic photocopying machine uses a completely dry process for copying the documents. No chemical reactions are involved. It is a direct positive to positive operation for copying documents, diagrams and half-tone pictures. The process is economical and versatile; prints may be obtained on almost any type of paper or material having a reasonably smooth surface.

Copies of the documents can be made very rapidly with this machine. Six prints can be made from one image formed on the photoconductive plate. The same photoconductive plate can be used about 2000 times, thus making it possible to take about 12000 prints from one plate. The cost per print works out to about 15 to 20 paise. Enlarged, reduced or size to size copies of the document can be obtained. Paper/metal off-set masters can also be made with the machine for obtaining thousand of copies.

The process has been released for commercial exploitation through the National Research Development Corporation of India to M/s. Advani Oerlikon Pvt. Ltd., Bombay; M/s. Macneill & Barry Ltd., New Delhi; and M/s. Systronics, Admedabad. Prototype of the machine fabricated at the laboratory was supplied to each of the three licencees alongwith the know-how. Open kits of the machine were also supplied. Research and production engineers deputed by the licencees were trained in various fields relating to the production of the machine. Some of the scientists, who developed this machine visited the premises of entrepreneurs to help them in overcoming their teething problems.

Since the development of the basic know-how is involved in the process, efforts were continued to improve the quality of various components and accessories. Carriers and toners, used for developing the electrostatic latent image have been further modified. Improvements in the photoconductive plates and other accessories were also made, particularly with a view to reducing the operation time and the cost of production, besides achievement of better performance.

Work was also initiated to develop the technical know-how for the electrophotographic machine using sensitized paper. ZnO coatings have been tried with various proportions of resinous materials and sensitizers on paper and metallic substrates. Encouraging results have been obtained with these coatings. Steps are being taken to improve the quality of these coated surfaces. The corona system for charging the sensitized paper has already been designed and is under fabrication.

Work on the design and fabrication of an automatic version of the selenium photoreceptor machine is in progress. The development of electrofax type paper machine is proposed to be taken up.

Carbon Technology

Pilot Plant : The production of Projector and Process Carbons was continued further to improve the technical know-how already developed. The laboratory supplied the projector and process carbons to consumers worth Rs. 2,99,589.55. As many as eight firms have been licenced by NRDC to manufacture the carbons on the NPL know-how.

Besides, the production of cinema arc carbons and process carbons batch production of midget electrodes was carried out.

Development of Electrographite Grade Brushes : Electrographitic grades of brushes, dense and porous, have a very high consumption in the country. These grades are being imported at present worth over Rs. 50 lakhs annually and the demand is steadily increasing. With a view to make substitute of this import, the development of these grades was taken up. Intensive study of raw-materials, compositions and processing techniques has been made and is being continued. A few of the grades have been developed and supplied for field trials.

Development of Microphonic Carbon Granules : Granular carbon is most widely used as a media for conversion of sound into electrical energy fluctuations in telephones and certain other types of microphones.

The quantity of carbon granules needed for microphones is small but there are stringent requirements in terms of response to sound pressure, a good measure of fidelity and high sensitivity.

The carbon granule is an imported item. Its import was 500 kg. during the year 1970 and has gone up very fast due to increased demand as a result of rapid expansion in business and industrial activities. The NPL is the only institution which has taken the development and contributed towards the development of this item.

Midget Electrodes : Midget carbon electrodes are used in very large quantities in dry cell batteries. The sole manufacturer of these electrodes is a foreign company utilizing foreign know-how. This company is manufacturing these electrodes entirely for consumption in their dry cell plant. All other battery manufacturers in the country are importing electrodes resulting in a drain of foreign exchange.

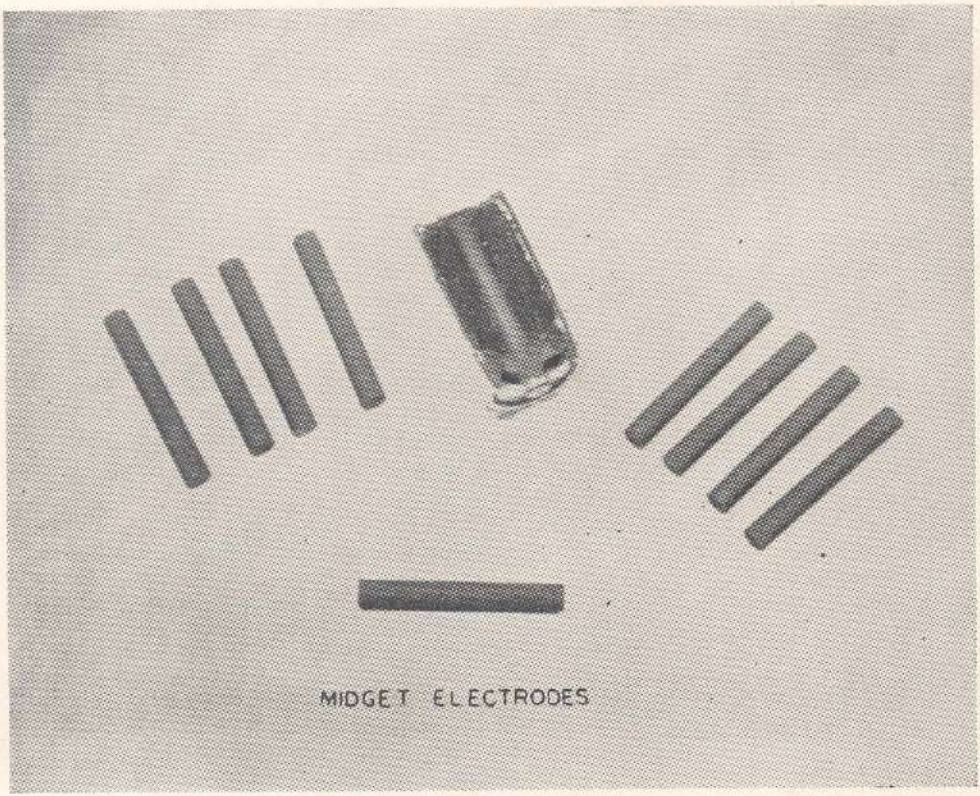


Fig. 4. Midget Electrodes for Dry cells

In order to have indigenous technology, the development of know-how of midget electrodes was taken up in the NPL in the year 1971. The experience gained in the field of carbon technology earlier has been utilized fruitfully during the development. The R & D was completed in a year and electrodes were sent to battery manufacturers for trails and feed back. These electrodes are now being produced in the experimental plant at the NPL which meet the standard specifications. Satisfactory test reports have been received.

The various raw materials used are available indigenously. The main equipment required for processing of these electrodes comprise size reduction units, mixing units, extruder, furnace and dimensioning machines, etc. The equipment is available and can be fabricated indigenously.

The total capacity approved by the licensing committee for the batteries is 1400 million numbers which will be 2000 million numbers by the end of Fifth Plan. The demand is likely to increase further with the commencement of production of dry cells by four new units by the end of 1973. The techno-economics of the project will be studied and further development work will be undertaken regarding scaling up, project engineering and transfer of technology to industry. The process will then be released for commercial exploitation through the NRDC, New Delhi.

Solderberg Anode Paste : Solderberg anode paste is used in preference to the prebaked anodes in the Aluminium industry. Low initial cost and simple process of making the anode paste and in situ baking are some of the advantages of using the solderberg anode paste.

The National Industrial Development Corporation Ltd., New Delhi sponsored the work on the preparation of solderberg anode paste of given specifications using the indigneous raw-materials. The laboratory earned Rs. 10,000 for undertaking this work.

Suitability of the indigenously calcined petroleum coke and coal tar pitch for making anode paste of required specifications has been established. A process for making the anode paste using indigenous raw materials has been perfected. A technical report on the development of the anode paste was prepared and submitted to the NIDC.

Silver impregnated graphite relay contacts : Graphite relay contacts are widely used by the Indian Railways, but at present these are being imported. At the request of the Research Design and Standards Organisation, Ministry of Railways, work on the development of silver impregnated graphite relay contacts was taken up at NPL. These contacts are required for manufacture of Railway's Signalling Safety Relays. The need for such contacts is increasing with the introduction of more modern signalling techniques.

The stringent specifications laid down by RDSO envisage extensive testing of contacts for properties like hardness, mechanical strength,

resistivity, ash content, number of cycles run etc. Raw materials required for production of contacts to their stringent specifications have to be imported.

At present these contacts have been successfully developed using the imported raw materials by the vacuum impregnation techniques. The vacuum impregnation equipment has been fabricated in the laboratory. Contacts with indigenous raw materials for use in other applications have also been developed.

Graphite Anodes for Caustic Soda Cells : M/s. D.C.M. Chemical Works, Delhi sponsored the project for processing their graphite scrap into anodes for electrolytic cells. Anodes of size $5 \times 5 \times 90$ cm ($2 \times 2 \times 36$ inches) have been made successfully and supplied to the firm. The 200 tonne Extrusion Press was used and a new furnace was designed for baking the long anodes. The performance of the electrodes was found comparable to the new imported electrodes. The process would save substantial amount of foreign exchange. The process has been fully developed and the know-how has been passed on to the firm.

Semi-Conductor Grade Silicon

Silicon is, at present one of the most important semi-conductor material used in the electronic industry. The requirement of silicon in India by 1975 is estimated to be of the order of about 1000 kg./year which is sufficient for fabricating 100 million solid state electronic devices like transistors, diodes, integrated circuits etc. At NPL polycrystalline silicon is prepared by Trichlorosilane process and single Crystals of silicon are grown by Czocharlski method. The single crystal is then cut into thin wafers of thickness about 350 microns which are lapped, polished and processed for fabrication of devices. Details of the process are given as under :

Ferrosilicon having a silicon content greater than 95 per cent is reacted with HCI gas at 200° - 300° to give Trichlorosilane ($SiHCl_3$). $SiHCl_3$ (liquid) is then purified by distillation and decomposed pyroelectrically at about 1000°C in the presence of hydrogen gas, according to the reaction :

$$SiHCl_3 + H_2 \rightleftharpoons Si + 3HCl$$

Polycrystalline silicon is deposited either on tantalum wire or on thin silicon rod. The impurity concentration in polycrystalline silicon is about 10 ppb, and the material is n-type of about 10ohmcm resistivity.

Polycrystalline silicon prepared by the above process has the dislocation density in the crystals of about $10^3/cm^2$ and the radial resistivity variation $\pm$ 10% and the minority carrier life time is $\sim$ 50 microseconds.

The process has been released to NRDC for commercial exploitation.

Silicon Rectifier (Diodes)

Know-how for high power silicon rectifiers has been developed using silicon developed at the NPL. All other components have also been indigenously fabricated. The support material for the mounting of silicon chips is silver-tungsten. Technology has been developed for making silver-tungsten tablets which can meet the requirements of the semi-conductor industry. The solders for the diodes have also been developed in the laboratory.

Specifications :

Rating	...	50-60 amps
Forward drop	...	0.05 V
P. I. V.	...	500 volts

Know-how has been transferred to the firm who had sponsored the project.

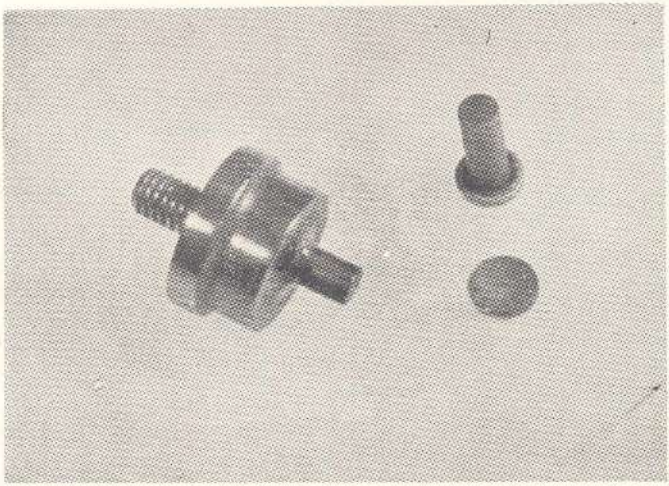


Fig. 5 Silicon Diodes developed in the laboratory with all indigenous components.

Development of Electronic Components

The National Physical Laboratory has been the pioneer in the country to lay the foundation of a self-reliant electronics industry. The laboratory has singled out itself in its achievements in diverse fields like development of basic materials of strategic significance for the electronics industry, making of components for various sophisticated electronics equipment from these indigenously developed materials,

and the development of many complicated electronic instruments and systems.

The contribution made by the NPL in the field of electronics has been recognised by the Govt. It has decided to set up an electronics components unit as public sector undertaking under the Department of Science and Technology. The Unit has been conceived to fully utilize the indigenous research and development effort on manufacture of electronic components based on sophisticated ceramic technology that the NPL has developed over the past many years.

Some of the important projects pursued during the period of report are given below :

High Permeability "Professional Grade" Soft Ferrites : High permeability soft ferrites are used almost exclusively in telecommunication equipment for low loss filters, coils and transformers. They are also used in pulse circuits, wide band transformers, deflection yokes and EHT transformers for TV Sets. They generally operate in the low frequency range upto 200 kc/s beyond which they exhibit high losses.

Highly sophisticated technology is required to produce high permeability ferrites. Raw materials used have also to be very pure, better than the analytical grade. The testing of the end product also requires sophisticated equipment and several testing techniques such as X-ray analysis, optical microscopy, spectro-chemical analysis, Mossbauer spectroscopy, EPR spectroscopy etc.

Ferrites with permeabilities in the range of 1000 to 5000 have been developed by sintering manganese-zinc ferrites under controlled atmospheric conditions. Since the starting materials of the desired grade are not available commercially from the indigenous sources, the preparation of pure material has also been successfully undertaken at NPL. Only through a well planned and coordinated inter-disciplinary approach could all this be achieved.

Work on development of professional grade ferrites was started with the Laboratory's commitment to the P & T Department to develop material equivalent to Philips 3B7. The samples produced by NPL have been tested by the Telecommunication Research Centre and the Indian Telephone Industries, and have been found satisfactory.

The accompanying table shows the electrical characteristics of the high permeability ferrites developed at the NPL.

Ferrite components produced at pilot Plant scale : Various types of ferrite components for use in entertainment and professional electronic equipment have been developed and produced at the pilot plant scale.

To meet the requirements of the Television Industry, a ferrite core

together with its centering and line correction magnets for T.V. Deflection Yoke has been developed and batch-produced. The requirement of Deflection Yokes by the end of the Fifth Five Year Plan is estimated to be 100 tonnes annually, valued at about Rs. 100 lakhs.

Complete sets of ferrite components for T.V. Deflection Assembly were supplied to CEERI, Pilani and a number of parties for winding and testing. Their test reports show that the performance of the cores is satisfactory as compared to those manufactured by foreign manufacturers. Thus the repeatability of the process of manufacturing these ferrite cores has been achieved. The know-how developed is entirely indigenous.

The other ferrite components for T.V., developed at the Laboratory are the E-cores and U-cores for EHT Transformers, Plastic Moulded Hard Ferrites, and High Frequency I.F. and Balun cores. The demand for EHT cores is estimated to be about 50 tonnes, valued at Rs. 60 lakhs by 1978-79.

Some of the other ferrite components developed and produced by NPL on a pilot-plant scale, for use in entertainment and professional electronics are :

Ferrite Antenna Rods and Strips,
Ferrite R.F. and I.F. cores,
Low Frequency Toroids,
Switching Cores,
Memory Cores,
Pot Cores,
Microwave Ferrite Strips,
Isotropic Moulded Hard Ferrites,
Ferrite Beads.

So far NPL has produced about 100 tonnes of ferrites (valued at about Rs. 30 lakhs) in the Pilot Plant set up at the Laboratory.

Alumina ceramics with high alumina content (85% onwards) are characterized by controlled composition and microstructures monitored to yield products of fine structure, uniform crystal size, and minimal micro-porosity. This makes it possible to take full advantage of the inherent properties of aluminium oxide e.g its ability to withstand high operating temperatures, chemical inertness, thermal shock resistance, excellent mechanical strength, extreme hardness, high resistivity even at elevated temperatures, high dielectric strength, high thermal conductivity, vacuum tightness and low dielectric loss.

With controlled fluxing agents and crystal growth inhibitors, success has already been achieved in developing ceramics upto 96% alumina content, having the desired microstructure, and density near to the theoretical value. For this it was imperative that the processed raw materials, alumina and its additives be generated on a highly reactive form through special treatments so as to give the final density

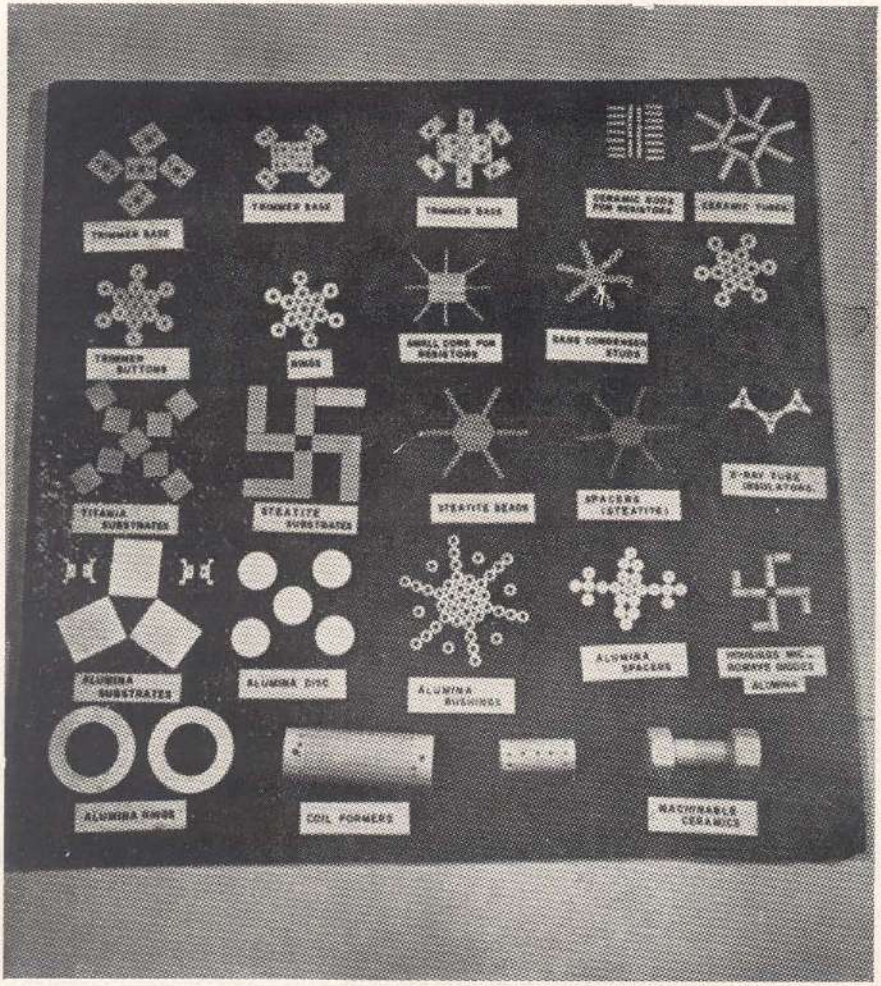


Fig. 6 A range of technical ceramics developed by the NPL.

at lower temperatures. Special developmental procedure adopted by the Laboratory has made it possible to attain the desired density of the product at much lower sintering temperatures than otherwise possible.

Alumina ceramics have a wide range of applications starting from Radomes for rockets and armour plating, to thin substrate chips required for integrated-circuit base. Development of alumina substrates for thick-film integrated circuits has also been undertaken.

Fosterite, like alumina, has the desired vacuum tightness and is more frequency-stable than steatite upto 20,000 MHz. Development of this is also nearing completion.

ELECTRICAL CHARACTERISTICS OF 'PROFESSIONAL-GRADE' SOFT FERRITES DEVELOPED AT THE NATIONAL PHYSICAL LABORATORY (HIGH PERMEABILITY FERRITES)

Ferrite Type		HP-1	HP-2	HP-3A	HP-3B	HP-4	HP-5
Initial Permeability (μi)		1000±20%	1500±20%	2300±20%	2300±20%	3000±20%	5000±20%
Loss factor	4 kc/s	⩽1.5	⩽1.5	⩽1.0	⩽1.0	⩽2.5	⩽2.5
$\left(\frac{\tan\delta}{\mu i}\times 10^{-6}\right)$	100 kc/s	⩽5.5	⩽5.5	⩽5.0	⩽5.0	⩽15.0	⩽15.0
Disaccommodation factor (10—100 min) $\times 10^{-6}$		⩽4.0	⩽4.0	⩽4.0	⩽4.0	⩽4.0	⩽4.0
Hysterisis factor (q2-24-100)		⩽1.8	⩽1.8	⩽1.8	⩽1.8	⩽4.0	⩽4.0
Temperature factor (30—70°C)		0.5 to 2.0	0.5 to 2.0	0.5 to 1.5	—0.6 to 0.6		
Curie temperature (°C)		⩾130	⩾130	⩾170	⩾170	⩾125	⩾125
Resistivity (ohm-cm)		⩾250	⩾250	⩾100	⩾100	⩾30	—
Nearest Corresponding Philips Material Type		3B3/3C2	3B5	3H1	3B7	3E1	3E4/3E2

Ferroelectric-Pyroelectric Ceramics. Some ferro-electric materials, when subjected to a change in temperature, which may be as small as 10^{-5} °C, are capable of generating a voltage. Such materials are known as pyroelectric materials.

The NPL has developed pyro-electric materials like niobates of alkaline oxides with certain additive systems, titania-zirconia of lead oxide with other additives, and titanate of barium with suitable additives, which are sensitive to infrared and have broad spectral response. Making of prototype of remote control temperature indicator by using these indigenously developed pyroelectric transducers has shown the possibility of making other devices like remote controlled heat sensing devices, explosion sensing devices etc. In addition, the initial work done on these pyro-electrics has shown the feasibility of using them to advantage for thermal imaging devices which, like temperature indicator etc. have many applications.

STATEMENT OF SALE OF FERRITE PRODUCTS BY DIFFERENT SECTIONS DURING THE YEARS 1971-72 AND 1972-73

Description	*Sale During the Year* 1971-72	1972-73
Soft Ferrites	2,76,725.65	1,78,877.66
Hard Ferrites	11,996.00	4,280.92
Professional Ferrites	10,736.15	7,531.77
Piezoelectric Ceramics	8,496.63	23,183.85
Technical Ceramics	1,325.00	1,056.20
Silver Cement	4,704.50	5,889.10
Total	3,13,984.53	2,20,819.50

Ultrasonic Instrumentation and Piezoelectric Devices

Various ultrasonic instruments and piezoelectric devices have been developed by the laboratory, using the indigenous raw materials available in the country. The devices so far developed include the following :-

(1) Ultrasonic interferometer for velocity measurement with variation of temperature and with variation of frequency.

(2) Ultrasonic transducers for automatic sensing and remote control applications.

(3) An apparatus to study Bragg diffraction with ultrasonic waves.

(4) Calibration block, a reference standard for ultrasonic flaw detection.

(5) Mini Tuning Fork.

(6) Linear displacement transducer.

(7) Angle beam probes for various angles, normal probes and the surface wave probes.

(8) Pressure transducers

(9) Biomorph elements for gramophone pick-ups.

Probes for ultrasonic non-destructive-testing applications

Ultrasonic methods of Non-Destructive-Testing of materials are becoming more and more important because of their efficiency in locating and sizing of flaws, cavities, shrink holes and such other defects which are not readily detectable by other means. Since in Ultrasonic-Non-Destructive-Testing only one surface of the job under test need be accessible it has an added advantage over other modes of testing.

The heart of the ultrasonic flaw detector is the ultrasonic probe which usually gets damaged or worn out in use. There is a large number of Indian as well as imported flaw detectors in use in the country. The Indian manufacturers of flaw detectors are importing the probes from other countries and supplying them with their equipment. It was found that most of these flaw detectors were lying unutilised or under-utilised for want of probes. Know-how has been developed at the NPL for the indigenous production of the probes.

The following three different types of probes have been developed using the piezoelectric (NPLZT-5) material also developed at the NPL :

(a) Normal Probes,

(b) Angle Beam Probes, and

(c) Surface Wave Probes.

(a) *Normal Probes* : These probes send ultrasonic energy in the job under test, at right angles to the surface and are used for detecting blow holes in castings, cracks caused by metal fatigue and other flaws in metallic and non-metallic materials. They are also employed in assessing the physical and metallurgical characterists of the material through measurements of velocity and attenuation properties of the material. These probes are available in various different frequencies and diameters, at present, from the NPL.

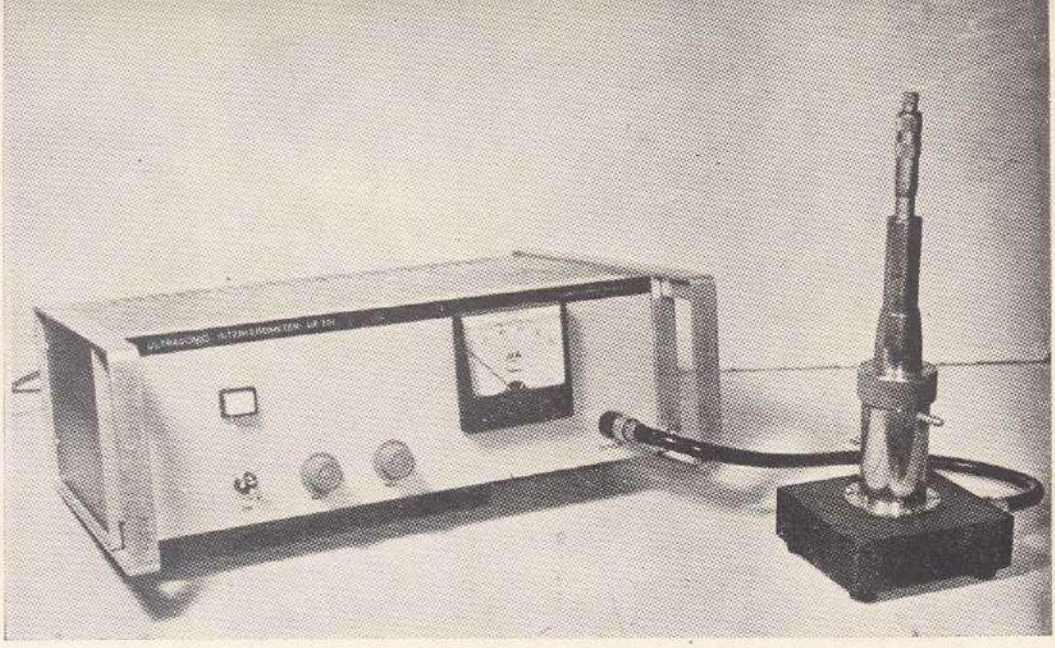


Fig 7 (above) Ultrasonic interferometer for velocity measurement.

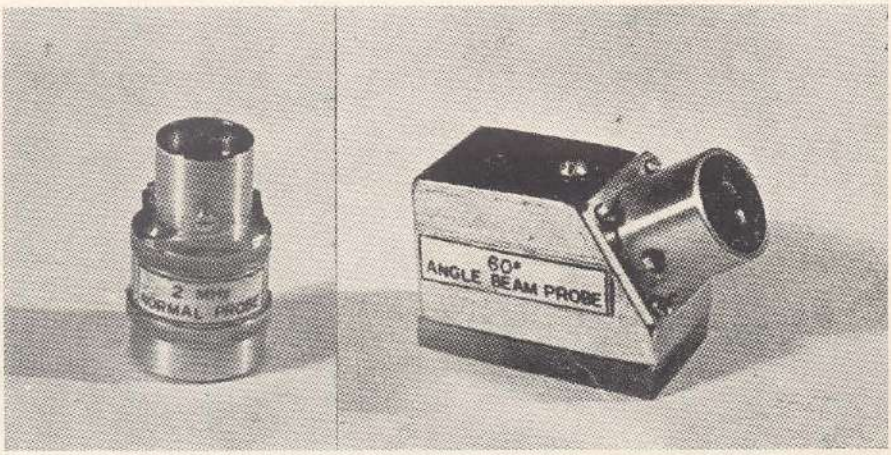


Fig. 7 (middle) Normal and Angle Probes for ultrasonic flaw detectors developed at the Laboratory.

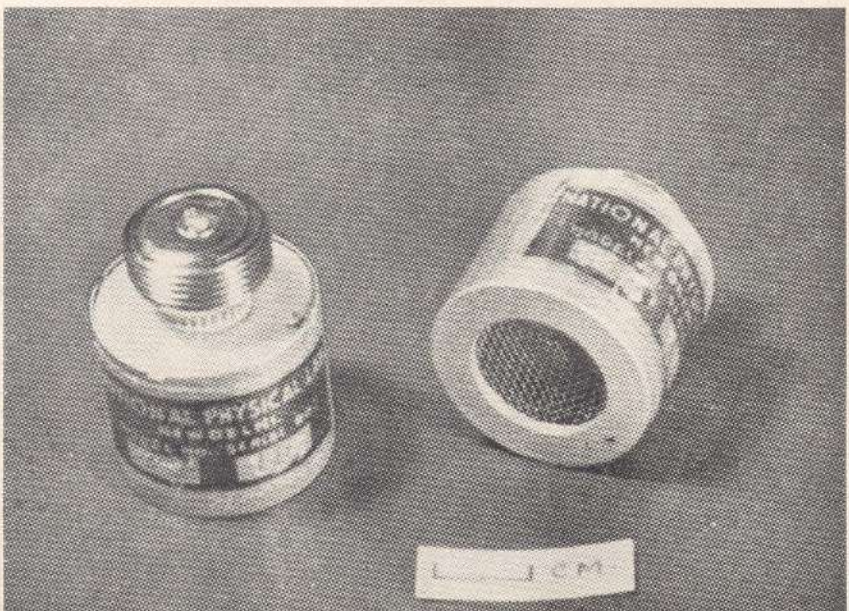


Fig. 7 (below) Ultrasonic transducers for automatic sensing and remote control applications.

(2) Ultrasonic transducers for automatic sensing and remote control applications.

(3) An apparatus to study Bragg diffraction with ultrasonic waves.

(4) Calibration block, a reference standard for ultrasonic flaw detection.

(5) Mini Tuning Fork.

(6) Linear displacement transducer.

(7) Angle beam probes for various angles, normal probes and the surface wave probes.

(8) Pressure transducers

(9) Biomorph elements for gramophone pick-ups.

Probes for ultrasonic non-destructive-testing applications

Ultrasonic methods of Non-Destructive-Testing of materials are becoming more and more important because of their efficiency in locating and sizing of flaws, cavities, shrink holes and such other defects which are not readily detectable by other means. Since in Ultrasonic-Non-Destructive-Testing only one surface of the job under test need be accessible it has an added advantage over other modes of testing.

The heart of the ultrasonic flaw detector is the ultrasonic probe which usually gets damaged or worn out in use. There is a large number of Indian as well as imported flaw detectors in use in the country. The Indian manufacturers of flaw detectors are importing the probes from other countries and supplying them with their equipment. It was found that most of these flaw detectors were lying unutilised or under-utilised for want of probes. Know-how has been developed at the NPL for the indigenous production of the probes.

The following three different types of probes have been developed using the piezoelectric (NPLZT-5) material also developed at the NPL :

(a) Normal Probes,

(b) Angle Beam Probes, and

(c) Surface Wave Probes.

(a) *Normal Probes* : These probes send ultrasonic energy in the job under test, at right angles to the surface and are used for detecting blow holes in castings, cracks caused by metal fatigue and other flaws in metallic and non-metallic materials. They are also employed in assessing the physical and metallurgical characterists of the material through measurements of velocity and attenuation properties of the material. These probes are available in various different frequencies and diameters, at present, from the NPL.

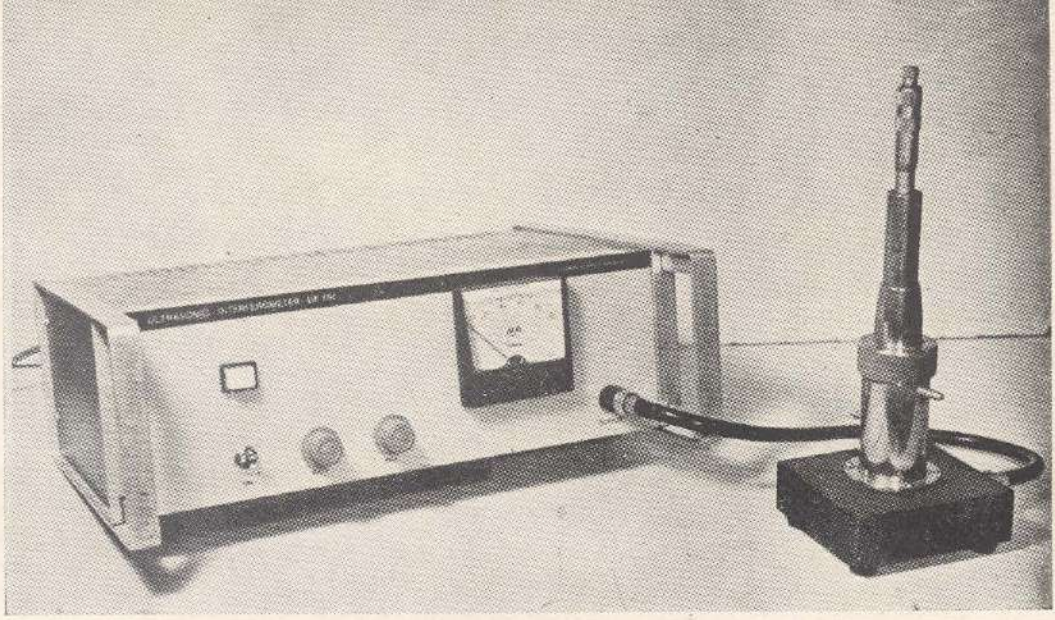


Fig 7 (above) Ultrasonic interferometer for velocity measurement.

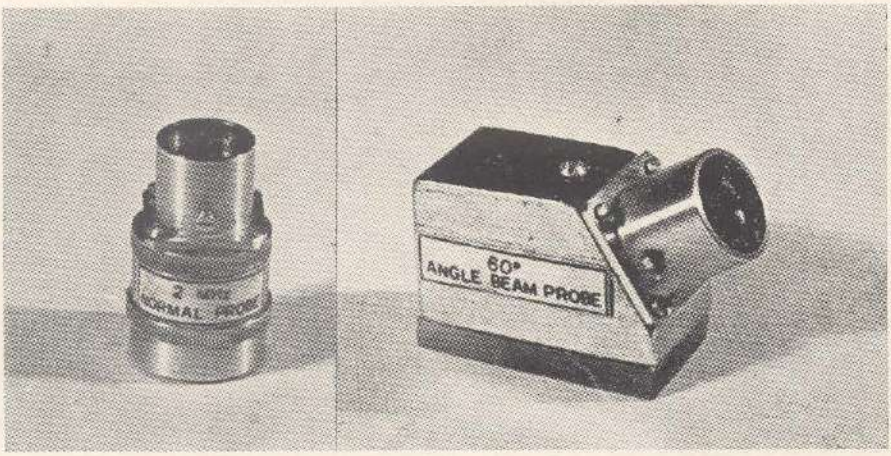


Fig. 7 (middle) Normal and Angle Probes for ultrasonic flaw detectors developed at the Laboratory.

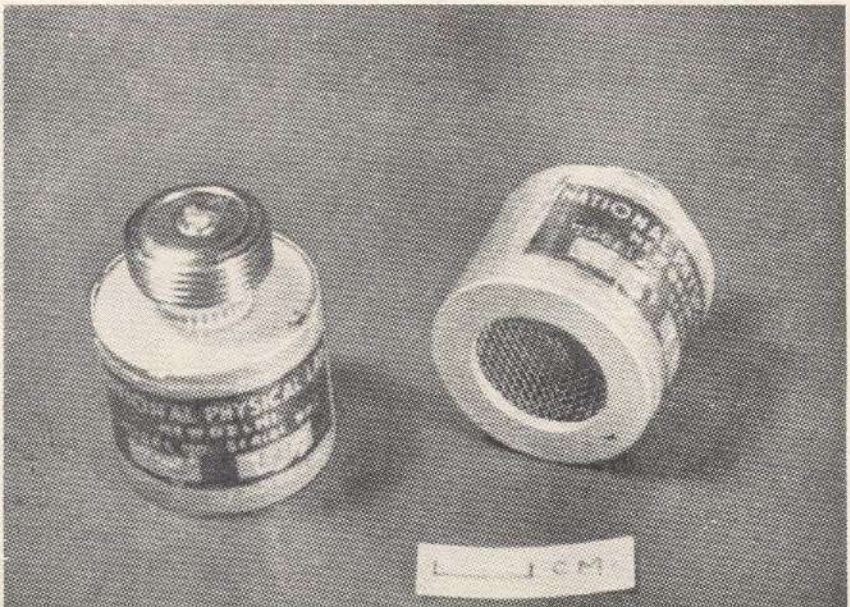


Fig. 7 (below) Ultrasonic transducers for automatic sensing and remote control applications.

(b) *Angle Beam Probes* : These probes are used for detecting the flaws and cracks in plates and for testing of welded joints. These are available for angles 35,° 45,° 60,° 70,° 80° in steel and have the operating frequency of 2 Mc/s.

(c) *Surface Wave Probes* : These probes send ultransonic waves at grazing angle along with surface of the job under test and are used for testing of flaws which occur just near the surface e.g., fatigue cracks in turbine blades etc.

The know-how regarding the manufacture of the above probes is ready for commercial exploitation and is being referred to the N.R.D.C., New Delhi for its transfer to industry. The probes are also available from the NPL, till these are commercially available.

The laboratory is also now undertaking the repair of the damaged ceramic disc probes of the imported flaw detectors.

Ultrasonic transducers for automation, sensing and remote control applications

The ultrasonic transducers developed at the laboratory were designed for sending and receiving ultrasonic waves in air. These transducers can be used in a variety of applications in remote control devices, alarm systems and automation and are capable of sensing liquids, or solids, ferrous or non-ferrous metals, opaque transparent materials, at a wide range of distances. They are thus useful for presence, detection, alarm systems, liquid level control, automatic door opener, size control, automatic length control, positioning, package routing, motor vehicles detection etc. These transducers are specially useful where ordinary photo cells, operated by a beam of light, cannot be used.

These are resonant type of transducers and can be designed to have any desired fixed frequency, in the 25 kc/s to 50 kc/s frequency range. The ambient conditions such as humidity water vapour, fog, smoke or dust laden atmosphere, high or low intensities of light or total darkness do not effect the functioning of the system.

Ultrasonic Interferometer

In many applications, ultrasonic velocity in a medium is required to be accurately measured since many physical constants are known to have a direct relationship with the velocity. For example, the sound velocity measurements in liquids enable the determination of adiabatic compressibility and thereby other thermodynamic properties which are otherwise difficult to be obtained. In solutions, since the compressibility depends on the concentration, the sound velocity measurements are used for concentration determination. In the case of mixtures because of the same reasons the mixture ratio can be determined by means of sound-velocity.

An ultrasonic interferometer for the ultrasonic velocity determination in various media has been successfully designed in the laboratory.

Strain-gauge Transducers

The sensitive strain gauge techniques developed by the laboratory pertain to measuring pressure and small displacements. The capability achieved to measure even the minute compressions and displacements have resulted in the development of the pressure transducers and load cells which can be used in various applications in the industrial, medical, engineering and research fields.

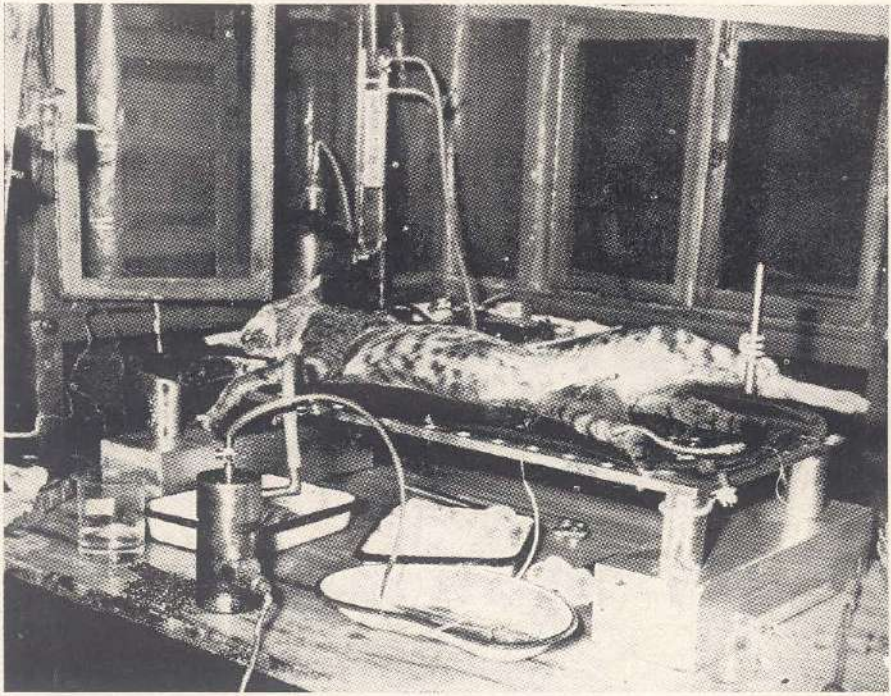


Fig. 8 Semi-Conductor strain gauge transducer for measuring intra-arterial blood pressure being tried on a Cat.

Pressure transducers developed at the laboratory can be deployed to determine column heights, immersion depths, flow-rates, high pressures, vacuum, and level in opaque pipes. Pressure transducers for use in hospitals to determine the blood pressure, the breathing rate, and the pulse rate have also been developed.

Different forms of load cells made can be used for sounding burglar alarm, vehicle actuated traffic control, detection of presence of trains on a platform, and the measurements of large weights (one kilogram and above) as well as small weights (milligrams). With the developmant of load cells for sounding the burglar alarm the beam of light from a photocell is no longer essential.

The techniques developed for the measurement of weights using load cells can be used to detect small changes of weights even in the "weight-loaded-conditions".

Suitability of the raw quartz crystals for making oscillators and transducers therefrom can be established with the techniques developed by the laboratory without actually processing the raw crystals into finished products. This can save considerable time and money by not working on the raw crystals which have not been found good and proper for the transducer work. Employing the techniques of measurement of very small displacements from about 2 microns upward studies were carried out regarding the effect of magnetic field on piezo-resistant behaviour of semiconductors, the effect of magnetic field on changes of dimensions of materials (ferrielectric and ferroelectric), and the effect of electric field on change of dimensions of solid state materials.

A physiological observation that all parts of the body except the skull move from 1/20th to 1/100th distance of movement of chest inwards and outwards, under respiration, was made with the help of devices developed based on the techniques used in strain-gauge transducers.

Sulfam—Phthalein Indicators

The work was initiated in 1972 with the objective of introducing new products and improved methods of chemical analysis.

The evaluation of color changes of existing acid-base phthalein and sulfone-phthalein indicators had been carried out at the laboratory earlier also and the indicators of trade were found to be impure. A new series of indicators were conceived so that comparative values of the three series : phthalein, sulfone-phthalein and sulfam-phthalein indicators could be made. Therefore, work was initiated with a view of academic pursuit, viz.

(i) Evaluation of color changes of indicators,

(ii) Synthesis and introduction of a new series of indicators to the analytical chemist, and

(iii) their utility in chemical analysis.

However, this work is expected to lead to fulfil an economic need of the country by substitution of the import of indicators.

Small lots of the individual members of this series viz. phenol-, cresol-, resorcinol-, orcinol-, sulfamphthaleins etc. have been synthesised. Some of these have been purified and their nitrogen and sulphur content have been determined. The yield is quite encouraging.

GLASS TECHNOLOGY UNIT

The Glass Technology Unit was started at NPL primarily to meet its own requirements of glass apparatus needed for its various research activities. It has now grown to an almost self-sustaining stage. The laboratory provides specialist service to industry, research organisations and medical institutes in the fabrication and re-conditioning of glass apparatus of intricate designs.

Sophisticated glass apparatus such as distillation and fractionating columns, industrial and chemical equipment like reaction kettles and various testing apparatus, equipment for high vacuum systems and for low temperature systems have been successfully made by the laboratory. The apparatus for determining molecular weights and complicated medical and biomedical instruments like Vanslyke blood analysis apparatus and cryostellate for performing cataract operations have also been successfully made. The National Physical Laboratory has also developed the teflonglass stop-cocks for the first time in the country.

The unit is rendering much needed service in re-conditioning of mercury arc rectifiers which used to be sent abroad earlier. During the last seven years the laboratory has re-conditioned about 350 bulbs. On an average, therefore, about 50 rectifier bulbs are being reconditioned every year. The cost of one rectifier bulb is about Rs. 10-15 thousand.

Considerable success has also been achieved in the fabrication of small capacity mercury arc glass rectifiers. During the period of report the sale proceeds of Glass Technology Unit were Rs. 10.444 lakhs in addition Catering to the needs of various sections of the NPL.

	Rs. lacs
1971-72	4.736
1972-73	5.708

Theoretical Study—Dilute Magnetic Alloys

It is well known that Abrikosov's diagrammatic treatment of the Kondo problem explains well the behaviour of the scattering amplitude of the conduction electrons by magnetic impurities only in the regions above the Kondo temperature. In order to understand the behaviour of the scattering amplitude below the Kondo temperature, this diagramatic treatment, otherwise known as the parquet theory was extended by considering many particle intermediate states. This extension involved correction to the pseudofermion Green function through the self-energy term while the conduction electron Green function remained the same as in the elementary parquet theory. Essentially what was achieved was a self-consistent renormalisation of the vertex and the self-energy. A vertex function integral equation similar in structure to the integral equation in the elementary parquet theory was obtained. Renormalised coupling constant was the main feature of the new equation. The integral equation was recast as a Riccati-type nonlinear differential equation and it was shown that Kondo singularity occurs at a branch point clearly revealing the difference between ferromagnetic and antiferromagnetic couplings. A fundamental relation for the function responsible for Kondo type divergences was derived. The power law behaviour of the scattering amplitude was proved from this basic relation.

Josephson Effect

The influence of a pair-breaking mechanism on Josephson tunneling was theoretically investigated. Tunnel current between two AG super-conductors, i.e. superconductors containing magnetic impurities was evaluated using the time dependent Ginsburg Landau equation for the order parameter. Depairing mechanism causes a reduction in the current amplitude in d.c. Josephson Effect. In the a.c. Josephson effect, an expression for the increased broadening of the Josephson line was obtained. This clearly brings out the enhancement to the fluctuations of the order parameter below transition temperature, caused by the pair-breaking mechanism.

The next step taken was to study the fluctuations of the order parameter and the problem of fluctuation conductivity or paraconductivity. The time-dependent Ginzburg-Landau equation was treated like a langevin equation by the addition of stochastic terms. A time-dependent vector potential was used. The expression obtained for current from this treatment was compared with those of other workers.

It appears, a generalised treatment covering Azlamasov-Larkin effect and correction by Maki is possible.

Transport Properties in solids at low Temperatures

(i) *Dilute Magnetic Alloys* : In some dilute alloys, in which a small amount of transitional metal dissolved in a noble metal base carries a localised magnetic moment, the electrical resistivity ρ presents a minimum around liquid hydrogen temperatures. From the effects of the Pauli exclusion principle on the intermediate states of the higher order scattering for s-d exchange, Kondo showed that the spin flip scattering of the conduction-electrons by the localised solute spins (uncorrelated with their neighbours) in such alloys, leads to a term in resistivity involving cJ In T, where c is solute concentration in atoms percent. For a negative exchange integral J, this would increase with fall in T and in combination with the usual T^5-dependent intrinsic resistivity, would give rise to the minimum.

The work at NPL has shown that the variation with c of the (Kondo) slopes of the ρ/c versus In T curves of some dilute magnetic alloys resembles the variation of the function f ($=\cos^6 \delta \cos^2$) with the phase shift δ for ordinary scattering. Also the variation of the extremum value S_m of the thermo-electric power in these alloys with c is akin to the variation of the function f' ($=\cos^6 \delta \sin^2 \delta$) with δ. It is as if each impurity ion on increasing with c, effectively offers an increasing attractive potential to the conduction electrons. In such a case, introduction of more and more lattice defects into dilute magnetic alloys containing a given solute content should approximate the alloy more and more to the model of the isolated impurity scattering, implicit in theoretical discussion.

The logarithmic divergence in the exchange scattering of the conduction electrons by the impurity spins led to a realisation that strong spin correlations must exist between the conduction electrons in the neighbourhood of the magnetic impurity, below a certain temperature, called the Kondo temperature T_k. As T tends to zero, these electrons, polarised around the impurity should then partially (if not wholly) compensate its magnetic moment.

Cobalt and Vanadium dissolved in gold (or copper) are known to be border-line cases for the Blandin-Friedel-Anderson criterion to be realised, namely $UN \simeq 1$ (where N is the density of states in the unsplit virtual bound state for one spin direction, and U the self-energy of two electrons of opposite spin in the virtual state). They have high spin fluctuation temperatures T_{sf} (analogous to T_k). In dilute magnetic alloys, an inerease of cobalt content and a consequent increase in the mutual interactions between the cobalt atoms is found to depress T_{sf}, considerably, whereas an increase of vanadium content is found to rise. Studies at NPL have explained this behaviour.

(ii) *Investigations-on-InSb* : The Hall effect, the electrical resistivity in a zero field and the transverse magneto-resistivity (TMR) of a

zone-refined single crystal of n-InSb are measured from 2K to room temperature. The resistivity below 50K has a logarithmic rise with the fall of temperature. The TMR at helium temperatures is negative in small magnetic fields with a quadratic field dependence below 60 Oersteds. These are interpreted on the basis of the theory of Toyozawa visualising a small fraction of the random array of impurity sites to carry localised spins.

In the extrinsic region below 100K, the behaviour of the Hall mobility has been accounted for by a combination of ionised impurity and accoustic lattice scattering. The number of scattering centres N_I in specimens studied at NPL were estimated between 20 and 100K, using Mansfield's formula. At 100K, N_I is found comparable to the extrinsic carrier concentration. The variation of the Hall coefficient between 100 and 4K gave no evidence of an impurity ionisation energy.

Mossbauer Studies of Alkali Halides

Progress in experimental techniques has played a notable role in reviving an active interest in problems in the physics and chemistry of ionic crystals. New applications of ionic crystals in science and technology have stimulated in recent years an increased interest to the study of this class of solids. In recent years, the experimental techniques have progressed to a state where it is possible to observe details in the motion of atoms in solids. Indeed, the magnitude of the quadropole splitting of the Mossbauer spectra and its temperature dependence can reveal internal imperfections in crystals.

Valuable information of the behaviour of impurity atoms in the crystal lattice can be obtained by applying Mossbauer method to such systems. Very little work has been done relating to the nature of tin impurity centers in alkali halides. The detailed structure of these centers remained unknown up to the appearance of Mossbauer studies. This can be attributed, in particular to the impossibility of applying radio-isotropic methods to the systems of the types NaCl Sn^{2+} and NaCL Sn^{4+}, because the tin atoms are diamagnetic. The study of the impurity ions of cobalt, iron and tin in ionic crystals by the Mossbauer method has so far proceeded along two lines. Some authors doped crystals with stable Mossbauer isotopes iron-57 and tin-119, and used such crystals as absorber. The principal disadvantage of this method was the use of a fairly high concentration of the impurity, making possible its precipitation in the form of an additional phase. At the same time attempts to use low concentrations, decrease the sensitivity of the method and involve considerable experimental difficulties. To overcome such difficulty, use has been made of emission Mossbauer spectroscopy which is capable of studying low concentrations of the impurity atoms.

The emission Mossbauer spectroscopy was used to study the system $NaCl^{119}$ Sn. It has been found that the emission spectrum of the system $NaCl^{119}$ Sn has a line associated with Sn^{4+} (with the chemical shift and line width close to the corresponding characteristics of the spectrum of

SnO_2) with respect to $BaSnO_3$ absorber. Furthermore, the Isomer-shift characteristics with respect to $BaSnO_3$, show clearly that Mossbauer impurity, tin is in Sn^{4+} state and further the ionic character, in the light of Isomer shift characteristics as in SnO_2, implies the bond ionicity of nearly 48 per cent.

The emission spectra for this system were taken from liquid nitrogen temperature to 450°K (78°K to 450°K) with an interval of 20°. The curve of area under the resonance versus temperature was fitted with the calculated values of f vs. Temp. for different θeff's, f was calculated with the formula.

$$f = \exp\left\{\frac{-6R}{k\theta'_{eff}}\left[\frac{1}{4}+\frac{T}{\theta'_{eff}}\left(\int_0^{\theta'_{eff}}\frac{xdx}{\exp(x)-1}\right)\right]\right\}$$

where $\theta'_{eff}=\left(\frac{M}{M'}\times\frac{q'}{q}\right)^{\frac{1}{2}}\theta_D$ host

where M and M′ are the masses of the host and the impurity atoms respectively and q′ and q are the coupling constants of the impurity atom, and the host atom with the neighbouring atoms. The best fit was for θ'eff=300°K. A measurement of the Mossbauer factors for the NaCl Sn^{4+} type systems permitted study of local vibrations of the impurity atoms. According to—Kagan—the density of probability of the impurity atom vibrations should shift to lower frequencies the more, the larger the ratio (MSn/MMe). In the study under report it was observed that MSn/MMe is large enough but θeff is nearly the same as θD for NaCl, which shows that the q′/q ratio for Sn impurities in NaCl is very large.

After the temperature study of NaCl : ^{119}Sn system by Mossbauer spectroscopy, it was proposed to see effects of X-ray irradiation and additive coloration on the system. NaCl : ^{119}Sn sample was irradiated by X-rays for different intervals of time. It was found qualitatively that the Debye-Waller factor decreases owing to a decrease in the Debye temperature. It is also seen that this decrease is dependent of the time for which sample is irradiated. NaCl : ^{119}Sn was also additively coloured. The colour of the crystal became pale yellow. The coloured crystals were etched with dilute HCl. Spectra of these were taken at 80°K and 300°K. It was found experimentally that our Mossbauer line (Sn^4 state) completely resisted. It seems that there is a change in the charge state of Sn in NaCl after additive coloration

X-ray K-absorption edge studies of molybdnum

Studies using our 400 mm bent-crystal spectrograph show the X-ray K-absorption edge of molybdnum, in its chalcogenides, to lie on the higher energy side with respect to that in the pure metal. The shift in the higher Selenide ($MoSe_2$) and Telluride ($MoTe_2$) being smaller than that in the lower Selenide (Mo_3Se_4) and Telluride (Mo_3Te_4)

respeetively. On the other hand, the selenium K-absorption edge changes from low energy side in Mo_3Se_4 to the higher energy side in $MoSe_2$ with respect to that in selenium metal. This has been explained on the basis of the molecular orbital theory.

Mossbauer Studies of Ferroelectric Materials

Mossbauer effect can provide information on a variety of aspects of ferroelectrics, such as (1) the nature of chemical bond, through the isomer shift (2) spontaneous polarization through quadrupole interaction (3) existence of soft optic mode and its temperature dependance, through the Lamb-Mossbauer factor.

For the better knowledge of phenomenon of ferroelectricity Barium Titanate is the most suitable ferroelectric material because of its simpler structure. In addition to the ferroelectric transition at 120°C (cubic to tetragonal), $BaTiO_3$ undergoes two more phase transitions; one at 5°C (tetragonal to orthorhombic) and the other at-90°C (orthorhombic to rhombohedral), at which the direction and magnitude of spontaneous polarization and the dielectric constant change abruptly.

Although number of attempts have been made to understand the origin of ferroelectric transition (120°C), hardly any effort has been made either theoretically or experimentally to investigate the nature of the lower transitions. Only Cochran attempted to provide an explanation for the lower transitions on the basis of lattice dynamics. In view of the efficacy of the unique tool of Mossbauer Effect, an investigation of the two lower transitions in $BaTiO_3$ using Sn^{119} as the Mossbauer probe was undertaken $BaTiO_3 : Sn^{119}$ sources were prepared by thermally diffusing Sn^{119} activity at 950°C for four hours. The Mossbauer spectra were taken over the temperature range 78°K to 450°K at the interval of 10°K. A plot of the area under resonance Vs the temperature clearly shows minima near the two lower transition temperatures. These results clearly show that the two lower transitions in $BaTiO_3$ are caused by lattice dynamical instability, as suggested by Cochran.

In extension of the above work to the other pervoskites, Potassium Niobate was chosen. The Curie point of $KNbO_3$ lies at 435°C and the crystal exhibits, on coolling the same sequence of phase transitions as is found in $BaTiO_3$. The symmetry of polar phase below 435°C is tetragonal; it becomes orthorhombic at 225°C and finally rhombohedral at-10°C. All these transitions are of first order and connected with detectable thermal hysteresis. $KNbO_3$ was undertaken for study, employing Mossbauer effect so as to get an insight of the ferroelectric phenomena and to find the evidence for the validity of Cochran's theory. The source $KNbO_3 : Sn^{119}$ was prepared by placing the required quantity of Sn^{119} activity in Chloride form on the well pressed $KNbO_3$ ceramics, and evaporating under an infrared lamp. The thermal diffusion of the activity was accomplished by firing the sample in air in a platinum boat at 900°C for about an hour. Mossbauer spectra has been

taken for the complete range of temperature i.e. from room temperature to 500°C at an interval of 20°C. The strength of resonance absorption was obtained from the area under the resonance curves at various temperatures. The area A of the resonance dip is related to the recoilless fraction of f_s of the source through $KxA\ (T) = f_s\ (T)$ where K is a constant As expected, the area under resonance against the temperature curve showed anomalous behaviour near 440°C and 240°C, suggesting the decrease in zero phonon probability near the transition temperatures and hence the presence of the soft optic mode as predicted by Cochran.

The earlier studies of 120°C phase transition in $BaTiO_3$ (Bhide and Multani, 1965 and 1966) using Co^{57} as the Mossbauer probe have shown that the charge compensating oxygen vacancies play an important role. To investigate the role of these vacancies at lower transitions $BaTiO_3 : Co^{57}$ sources were prepared by taking good single crystals of $BaTiO_3$. The crystals were etched with phosphoric acid vapours, cleaned by double distilled water and annealed at 900°C for an hour in an H_2 atmosphere, prior to diffusion of Co^{57} activity. Then the required quantity of Co^{57} activity in the chloride form was dried on these crystals under the infrared lamp. Then these crystals were fired in the furnace at 950°C in H_2 atmosphere for about 3 hours, and then quenched to room temperature. Quenching time being approximately a minute. Mossbauer spectra were taken over the complete range of temperature from 78° to 450°K at 10°K intervals. The work is in progress.

Mossbauer Studies of Rare Earth Cobaltates

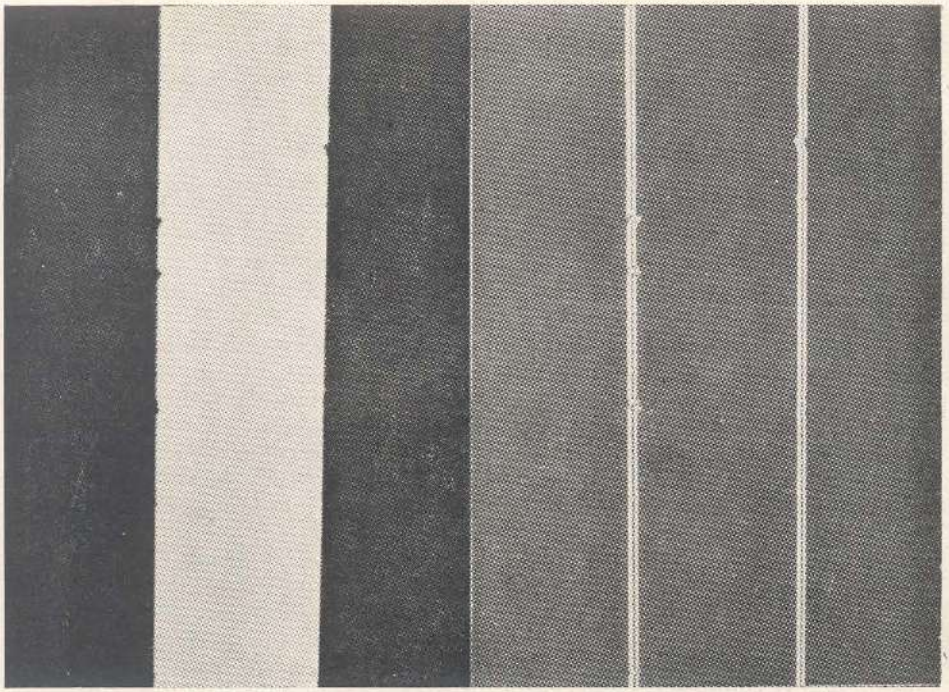
Recent studies in transition metal oxides with pervoskite structures have suggested that the transition metal ion exists in the high spin or low spin state depending on the strength of crystal field splitting $\triangle cf$; when $\triangle cf < \triangle ex$ (exchange energy) the transition metal ion exists in the high spin state and the electrons are called Localized electrons. On the other hand when $\triangle cf \geq \triangle ex$ the metal ion exists in the low spin state; in this case band theory well describes the electron and the electrons are called collective electrons. In the covalent crystal field approach the governing factor is the magnitude of the overlap integrals $\triangle_{cac.}^{\sigma,\pi}$, $LaCoO_3$ is one of the few material oxides, where $\triangle cf \sim \triangle ex$, which exhibits interesting electrical and magnetic properties. Inverse magnetic susceptibility in $LaCoO_3$ shows three regions (1) a low temperature region where 1/xg is almost linear with temperature giving a lower effective magnetic moment; (2) intermediate temperature region in which 1/xg is almost independent of temperature and (3) in high temperature region 1/xg is again almost linear and gives higher effective magnetic moment. These studies led Goodenough to suggest the coexistence of low spin state CoIII and high spin state Co^{3+}; with the latter state lies just abovc the former at an energy difference $E_0 \leq .08$ eV. He has also reported the first order transition in $LaCoO_3$ at 937°C as a localised$\rightleftharpoons$collective electron transition.

In the fortunate circumstances that Co^{57} is a Mossbauer isotope, detailed studies of this lattice were undertaken investigating through Mossbauer effect and Magnetic susceptibility measurements. The magnetic susceptibility data agree well with that reported earlier. Mossbauer spectrum of $LaCoO_3$. Co^{57} matched with $K_4Fe(CN)6$. $3H_20$ shows two resonances one near $0.0 \pm .04$mm/sec and the other at $.40 \pm .04$ mm/sec. These resonances after having ruled out the possibility of a quadruple splitting of a single valence state, which is true in $LaCoO_3$, can be attributed to arise due to FeIII and Fe^3 states arising out of an electron capture decay of original CoIII and Co^{3+} states of the host lattice. Thus Mossbauer studies, which unambigously showed the coexistence of two spin states, agree well with the magnetic susceptibility data in the low temperature region upto 200K and it has been possible to calculate the energy difference Co_{3+}—CoIII$\approx$·02 eV in this temperature region. In higher temperature region, the mossbauer studies which show that above 200K the relative intensity of higher energy resonance (Fe^{3+}) and lower energy resonance decreases progressively to disappear completely at the first order transition at 937°C, are in contradiction with the magnetic susceptibility data (which show increase in magnetic moment). However, Goodenough has also suggested an electron transfer of eg electron from Co^{3+} to Co^{III} at higher temperatures to create Co^{2+} and Co^{IV} polar states. An electron transfer of eg electron also creates Co^{II} and Co^{4+}, Co^{IV} (tetravalent intermediate spin), Co^{IV} (tetravalent low spin cobalt). Since magnetic susceptibility data show an increase in magnetic moment the only possibility out of the above is that electron transfer of eg electron creates Co^{II} and Co^4 states. These states on electron capture, in Mossbauer spectrum, would give Fe^{II} and Fe^{4+} states. These states have isomer shift very near to 0.0 mm/sec and thus overlap the resonance due to Fe^{III}. The Lamb Mossbauer factor variation with temperature agrees excellently with that Debye Waller temperature factor variation with temperature determined through X-ray diffraction studies of Raccah and Goodenough. Further Lamb Mossbauer studies coupled with isomer shift studies suggest that Se_1 (change of entropy of outer electrons) is the real cause for the observed localised$\rightleftharpoons$collective electron transition at 937°C in $LaCoO_3$.

Similar were extended studies in $GdCoO_3$ and $NdCoO_3$. The magnetic susceptibility studies are similar to that of $LaCoO_3$, however, the flat intermediate region in $1/\chi g - T$ variation differs both in extension and location from one cobaltate to other. The first order transition at 950K and 1000K have also been investigated through Mossbauer studies for $NdCo_3$ and $GdCoO_3$ respectively.

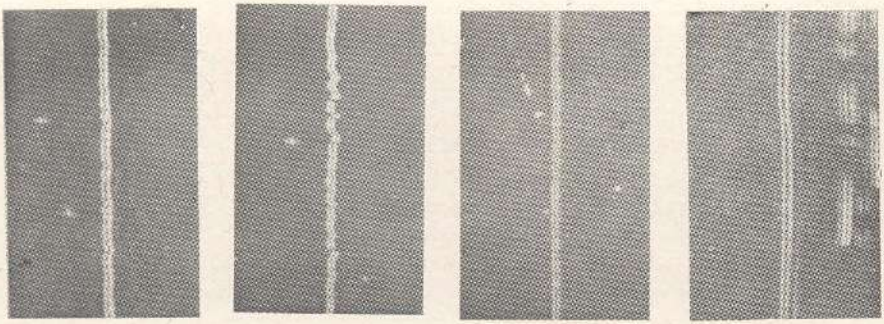
STUDY OF IMAGE FORMATION UNDER PARTIALLY COHERENT ILLUMINATION BY USING SPATIAL FREQUENCY FILTERS.

Intensity distributions in the diffrimoscopic images of (1) half plane (straight edge) (2) slit and opaque strip (3) periodic objects and (4) phase objects (half planes) have been theoretically derived both for coherent and partially coherent illumination.



a b

FIGURE 9



3λ/8 λ/4 λ/7 λ/16

C

When an object is illuminated with a collimated beam of light and a suitable amplitude filter is placed at the back focal plane of the imaging lens, then a dark fringe outlines the image of the objects. Such an image is called diffrimoscopic image. The amplitude filter removes zero and lower spatial frequencies. Figure 9 (a) & (b) shows respectively the normal image and the diffrimoscopic image of a slit. The fineness of the dark fringe and the symmetrical intensity distribution about it, enhances the readability of the diffrimoscopic images of each edge and increase the precision of locating the microscope wire by a factor of 10. Therefore, this method of imaging is potentially useful for the dimensional measurements of edge objects and also for the critical inspection of the quality of the edges.

Half plane (straight edge). It has been shown theoretically that the dark fringe represents exactly the position of the geometric image of the edge both under coherent and partially coherent illumination and that the intensity distribution is perfectly symmetrical about this dark fringe.

Slit and opaque strips, While considering the two edges situated close by i.e. the cases of an opaque strip or a slit, it has been seen that for very small inter-edge separations, the dark fringes do not coincide with the geometric image of the edges, causing a relative error in the measurement of the inter-edge separation. To make the method directly useable for dimensional metrology, the methods and situiations in which, the relative error in the inter-edge separation, is mintmised or made zero have been studied. The tables of corrections for he inter-edge separations for various parameters have also been prepared. It has been shown that the image intensity distributions of an opaque strip and a slit of same dimensions are indentically equal.

Periodic objects. It has been shown that under coherent illumination the centres of the dark fringes have zero intensity and coincide with the geometric images of the edges separating dark and light portionsof a grating. The intensity distributions are symmetrical about the dark fringe only in case of gratings having equal widths of dark and light strips and asymmetrical otherwise. The asymmetry in the distribution is reversed if one more order spectrum, in addition to the previously removed spectra is obstructed. For objects under partially coherent illumination, the intensity distributions are symmetrical even for gratings having unequal widths of dark and light strips, if the ratio of the numerical aperture of the collimator to that of the imaging lens is an integral of the spatial frequency.

Phase objects. Diffrimoscopic images due to phase objects (in the forms of half planes of different step heights) have been studied and it has been established that the case of phase objects also the fine dark fringe exactly represents the profile of the edge. The image contrast is independent of the actual phase change (step height) at the edge thereby increasing the capability of detecting the small phase changes. This has been experimentally verified. Figure 9c. shows the diffrimoscopic images of phase steps of different heights.

Resolution of a diffrimoscopic system. The resolution of the two trans-illuminated lines in an opaque screen with the present system has also been analysed. It has been shown that the resolution with the present system is always better in comparison to that with the normal imaging system. Also the relationship between the resolution limit and the degree of coherence has been established.

Diffrimoscopic microscope. A diffrimoscopic microscope for profile measurement has been designed and is under fabrication. This microscope will be used for checking the knife edges of high precision balances.

RADIO SCIENCE

The Radio-Science Division, as in the past several years continues to be engaged in the exploration and uses of Radio waves in communication, in space science and technology, in meteorology, in the monitoring of the solar-terrestrial environment, and to disseminate the information to the various users in the country and outside. The activities thus involved are essentially as under :

1. Radio and Space Services
2. Ground Based facility for Environment Monitoring
3. Rocket and Satellite experiments
4. Aeronomy, ionospheric physics and solar terrestrial relationships.
5. Inter-disciplinary project on atmospheric turbulence and radiation hazard.

1. RADIO AND SPACE SERVICES

1.1 Ionospheric radio propagation predictions

The Radio-Science Division provides forecasts on Radio propagation conditions via the ionosphere to users in India and neighbouring areas, six months in advance. Such forecasts have proved helpful to various communication organisations to plan proper frequencies well in advance. Special forecasts have been made available on request to O.C.S., Defence, P & T, Civil Aviation, for regions of their interest.

The forecasts also include prediction of sunspot activity every month, six months in advance and this forms the basis for long term forecasts of propagation conditions.

Ionospheric predictions have for the time been prepared for East zone only. A different prediction technique has been tried. Twenty-five stations have been used in predictions and for all these stations foF2 vs IF2 plots for all the 12 months of the year have been prepared. A sample prediction for the east zone foF2 values for September 1970 has been prepared to compare with the already existing predictions for foF2. Comparison for all the Indian Stations have shown that for low latitude, there is an improvement in the night-time predicted values when IF2 is used as the basic index.

To facilitate, short-term forecasts, efforts have been made to study the effect of large solar flares and magnetic storms on the propagation parameters at local latitudes.

Values of FOT's and angles of reception for a press cast from Hong Kong to New Delhi were supplied to OCS for the year 1973. Army signals have been supplied with contours of h'F over the Indian subcontinent for summer and winter of a low solar activity period. Army signals, OCS, Police wireless have been the major users of the additional information supplied on request.

Since the demand for prediction parameters to aid point to point communication over the Indian subcontinent is increasing, an effort has been made to computarise the input data into very narrow latitude and longitude bands so as to be able to forecast accurate predictions in future without much delay. It is also contemplated to prepare an atlas of height variations over the Indian subcontinent to enable quick calculations of angles of arrival and departure for operation people.

1.2 Ionospheric and Solar Geophysical Data

Over the year Division has been engaged in the collection and dissemination of Ionospheric and Geophysical data collected from the network of Indian Stations and these have been printed and made available to interested research organisations in the country as well as to organisations abroad on exchange basis. Some of the major users of this service in India are (i) Universities and other research Organisations (ii) All India Radio, (iii) Overseas Communication Service. (iv) Defence and (v) Wireless Planning & Coordination.

As some kind of a short-term warning system, data on solar and ionospheric disturbances are disseminated daily through broadcasts by the AIR and through the NPL operated transmitter for standard time and frequency transmission. Some selected solar and ionospheric data are sent to Australia and USSR. Similar data from Australia and USSR are being received by CSIR Telex system on essentially a real time basis and are added to Indian data.

1.3 Special Radio Propagation Studies

Study of special problems of research nature are also undertaken at the instance of Radio Service Organisations. In one such case, a survey has been made on occurrence probability of Es in the Indian region and the likely effect of Es on TV systems. With a view to developing expertise. research work on propagation problems is also undertaken. A suitable ray tracing programme (computerised) is being developed for high frequency propagation.

A continuous round the clock soundings of the ionosphere at 15 minutes interval (at 5 min. interval on world days) has been in operation. Weekly summary data are sent to interested people on request in India and abroad.

Selected records have been specially scaled and reduced to true heights with an electronic computer programme and supplied to research workers in this laboratory and other laboratories on request. Hourly data of ionospheric parameters have been published every-month in ionospheric data bulletin issued for RTRC by this division. A computer programme has been set up for tabulation of monthly data and getting the monthly median values.

1.4 Ionosonde—C4 recorder

The study has been extended to the high frequency range where the nature and behaviour of ionospheric disturbances have been deduced from the measurements made with ionosondes and riometers. The effects of ionospheric disturbance on radio signals of oblique incidence have been studied in relationship to other geophysical and solar phenomena. Total electron content and absorption studies during eclipses have been undertaken to get the information on the recombination and redistribution at various ionospheric heights. Research work on tackling of anomalies in the procedure of reduction of ionograms to electron density height profiles have been in progress.

2. GROUND BASED FACILITIES FOR ENVIRONMENT MONITORING

2.1 Riometer

Routine measurement of ionospheric absorption by cosmic radio noise monitoring has been continued at 22.4 MHz and 30 MHz. The riometers have also been used for patrolling of radio effects of Solar flares.

In trying to establish the validity of this riometer technique as a routine monitoring device of absorption, comparison of this riometer absorption data has been made with the data derived from the investigation of long wave propagation, an established technique of monitoring the lower ionospheric absorption. It has been observed that both the data compared very well resulting in a linear relationship. From this analysis it has been possible to separate out the F-region contributions from the riometer absorption data.

The effects of magnetic storm on riometer absorption has also been studied during the various phases of the sudden commencement of storms which in a way gives information on the effect of magnetic activity on H.F. communication via F2 layer.

In addition, solar background x-ray control on the riometer absorption during quiet and disturbed conditions has been in progress and intensively pursued for various x-ray flare events by studying the decay characteristics of x-ray bursts at these high frequencies. Focussing effects due to large scale irregularities on cosmic noise records at this latitude has also been studied.

2.2 Dopplometer

A dopplometer, recording frequency deviation of 10 MHz standard frequency-time signals, installed by this Division, has been operating at Haringhata Field Station of Calcutta University. It records an NPL operated ATA transmission from Delhi between 1100-1500 IST and rest of the time on JJY, Japan. In addition to obtaining data on solar flare frequency deviation effects (SFD), the data are being utilised for studying ionospheric irregularities through study of short period fluctuations in the frequency of signals received.

2.3 LF and VLF propagation

Signal amplitudes of a few low frequency broadcast stations, including Radio Tashkent at 164 KHz, are recorded on a routine basis. The records have been used for solar flare effect studies. They have also been found useful in establishing the effect on the D-region of the ionosphere of x-ray emissions from certain stars.

A VLF phase and amplitude recording set up has been made operational from August 1972 and 19.8 KHz NWC and 16.0 KHz GBR have been recorded.

2.4 Radio Patrol of solar flares

A routine patrol of ionospheric effect of solar flares is maintained through use of all the ground-based environment monitoring equipments mentioned above. Solar flares data recorded are supplied regularly to the Radio and Space Services group in the Division, where they are disseminated through prompt messages sent through URSIGRAM messages via India Meteorological Dept. to interested national and international organisations, for use in short term predictions of radio propagation conditions. The data are also published in the Solar and Geophysical Data monthly bulletins issued by the Division.

Research work has been carried out on the physical processes causing the ionospheric effects of solar flares.

2.5 Radio Detection of Atmospheric Nuclear Tests

The equipments on routine operation for solar flare patrol have also been useful in monitoring possible ionospheric effects of Chinese nuclear tests. A particularly large effect was observed for one of the tests in late 1970, indicating that conditions were different in this particular test from those in any other test carried out by China so far.

3.1 Satellite Radio Beacon Studies of the Ionosphere

Radio Beacon Studies have been in progress to measure the electron content and its variation using orbiting satellites BE-B and BE-C.

The variation of electron content with solar and magnetic activities and seasons etc. have been studied. An attempt has been made to apply the electron content data to compute the range and elevation angle errors in navigation system using satellites over the Indian sub-continent.

3.1(a) ATS-F Geostationary Satellite Instrumentation

The ATS-F Satellite is scheduled to be launched by the middle of 1974. This is a Geostationary Satellite and is intended for international participation for studying Ionospheric and Magnetospheric Physics and various other applications. A start has been made to developing the instrumentation of the receiving system.

3.2(b) NNSS Satellite Receiving System

A prototype of a rotating antenna has been constructed and tested for its mechanical performance. A converter for the receiving system has been designed and its construction using mostly indigenous components has been started. This would also form part of the instrumentation for observing other geostationary satellites such as Intelstat-2F2, 2F3, if and when it comes into the field of view.

3.3(c) 3-Dimensional Ray Tracing

A 3-dimensional ray tracing technique for computing the group path, phase path and elevation angle errors for position fixing and satellite navigation is under progress. The effects of magnetic storms on the spatial distributions of electron content is also in progress.

3.4 Rocket studies of the lower ionosphere

Work has been in progress to achieve competence and expertise in selecting important and fruitful areas for rocket sounding studies, design, develop and fab.icate rocket payloads for understanding physical and chemical processes in the lower ionosphere. In this connection, two instrumented rockets from Thumba and six from Wallops Island (U.S.A.) (in a programme carried out at GSFC) were successfully launched.

A new technique, rocket borne riometer, proposed by NPL Scientists to determine the D region electron densities has been tried out successfully. Two riometer payloads were flown. As a back-up in the same payloads a conventional propagation experiment, DC probe and Lyman-α experiments were included. A feasibility study and system design of the new experiment was made. The instrumentation and fabrication of all the experiment was done. The data obtained from these experiments have been analysed and results are published.

Two series of rockets were launched to obtain the flare time electron densities and to study the role of X-rays in the D-region ionization during

the flares. In another programme three rockets were launched on the same day in a collaborative programme with NASA to study the daytime variation of the D-region at the equator. Electron density profiles are derived from the absorption data obtained from the propagation experiments included in these payloads and neutral atmospheric density profiles from the Lyman-α experiment. These results have been published.

All the measured electron density profiles are used to study the behaviour of the equatorial D-region and describe the diurnal variation of electron densities in the D-region. A diurnal asymmetry has been observed. Based on the observed variation of electron density with solar zenith angle, the lowest altitude upto which solar Lyman-alpha radiation controls, is identified.

The equatorial electron density profiles are then compared with the profiles obtained at midlatitudes for similar conditions of solar activity. The comparison reveals that the electron density profiles in the altitude range 70-80 km for mid and equatorial latitudes agree well both in magnitude as well as in the general features. This is the altitude range where Lyman-alpha acts as dominant production source and no significant latitudinal dependence is expected to be observed in this altitude range. Thus the results are consistent and support the concept of solar Lyman-alpha as being the dominant production source in the altitude range of 70-80 km. Significant differences are, however, observed below 70 km. In this altitude range equatorial electron densities are found to be larger than the mid-latitude values. This cannot be explained on a simple basis of production mechanisms. These differences are attributed to the complex negative ion chemistry controlling that region.

Production rates are estimated using the simultaneous measurement of x-ray flux together with NO ionization rates based on the recent measurements of Meira (1970) and O_2 ($^1\triangle_g$) ionization rates by Huffman et al (1971). It is shown that charged particle distribution observed can be explained using this production rate and an effective recombination coefficient compatible with the recent laboratory measurements of the dissociative recombination coefficient for electrons with hydrated cluster ions.

A CW transmitter has been fabricated. Subsequently this transmitter has been used for the propagation experiment conducted in connection with the NPL-Japan collaboration flight.

The NPL-Japan collaborative experiments have utilised the Gerdian condenser pay loads to make a comprehensive study of the lower ionosphere. It has been observed that the gerdian condensers suffer from an important defect called fringe field effect. This causes field configuration changes with altitude of the rocket thereby changing the effective collecting data. This defect is proposed to be eliminated by covering both the entry and exit of the condenser with grounded wire mesh. Experiments have to be carried out to test this.

4. AERONOMY, IONOSPHERE PHYSICS AND SOLAR TERRESTRIAL RELATIONSHIPS

The Scientific interest of the Radio Science Division has essentially been to study the ionized regions of the atmosphere which starts with the so called D-region around 50 kms and extends to very great altitudes. This naturally involved a study of the neutral atmosphere which is the parent body of the ionosphere, a study of the ionosphere itself, and a study of number of other solar terrestrial relationships. The programmes that have been carried out to make a study of the ionospheric phenomena are :

4.1 Ionospheric studies with Incoherent-Scatter radar measurements

Incoherent-Scatter measurements of the ion temperature at Arecibo have been used to develop neutral temperature models for the upper atmosphere. It has been found that the COSPAR international reference atmosphere of 1965 overestimates the neutral temperature, when compared with our model. Our model is based on direct temperatural measurements, while the COSPAR model is based upon atmospheric density measurements.

An attempt has also been made to resolve the conflict of the large different in the values of atomic oxygen in the lower thermosphere, as measured with rocket-borne neutral mass spectrometers by various groups. For this purpose, the incoherent scatter measured values at 400 km have been extrapolated down into the lower thermosphere by using the measured temperature profiles. These measurements have also provided input to revise the COSPAR international reference atmosphere of 1965.

From the energy balance consideration in the ionosphere, it has been shown that F-region absorption should be a function of the difference between electron and ion temperature alone. This result has been used to advantage in obtaining F-region electron temperature from Riometer measurements.

Continuous measurements of night time electron concentration with the Arecibo radar have been examined and transport velocities calculated. These velocities can be explained only, if contributions from neutral winds, electric fields and diffusion under gravity are included.

Neutral temperature measurements on the Ogo-6 satellite have been used to calculate the neutral wind velocities for magnetically quiet and storm time conditions. Significant changes in wind velocity are found to occur during magnetic storms. These changes, however, do not explain the ionospheric behaviour during magnetic storms.

4.2 Magnetosphere-Ionosphere Relationships and Interactions

Magnetosphere has a lot of influence on the terrestrial ionosphere and in particular on the high latitude ionosphere, at all times. During

magnetic storm, the influence can be felt at the mid and low latitudes also. The magnetosphere-ionosphere interactions have thus been used to interpret the global behaviour of ionosphere during quiet and disturbed conditions. The latitude variations of the electron concentrations on quit and disturbed days in the topside ionosphere have also been examined and the position of the Plasma pause and the mid latitude through has been studied in the light of ion composition measurements. Aloutte-2 topside sounder data have been used to calculate the H^+ flow velocity, which depletes the lighter ions at the high latitudes. This velocity is found to be supersonic and agrees with that expected from the Polar wind theory.

4.3 Average Storm time behaviour of electron content

The electron content data for Hawaii located in the transition zone from low-to-mid latitudes is studied for the effects of magentic storms. Twenty-four severe and moderately severe storms occurred during the year 1967 have been used in this study for the period of moderate solar activity. The percentage deviations of the electron content compared to the quiet time median values, have been computed for each hour starting from the time of sudden commencement for the next 72 hours. These are used to obtain a general features of the storm-time variations. Generally, the electron content shows an increase following the sudden commencement and the main phase effect is a depression. The time of the enhancements during the main phase seems to have a local time control.

4.4 Topside ionosphere studies with satellite data

The satellite studies have been undertaken to explore the region between 300 km and 3000 km to use the most recent data on topside ionosphere from several space experiments and to study the problems on diffusion, plasma interchange between magnetosphere phenomena of common origin.

The programme during the year 1971 included analysis of TIRO-7 satellites data for obtaining the plasma concentration at 600 km around the globe and the analysis of data from Aloutte-2 satellite for obtaining profiles of electron concentration and scale heights from F_2 peak to an altitude of about 3000 km.

TIRO7-7 data was also used to explore the characteristic trough in the mid latitude topside ionsphere. This data was compared with the whistler data about plasma pause position. To this study, data from Aloutte-II satellite was supplemented and a new result, namely that the through location is exactly identical with the plasmapause position during high magnetic activity was obtained. Further study of the ionospheric magnetospheric interaction was undertaken using data from Aloutte-II satellite over the Japanese region. By using the electron temperature measurement from Explorer-22 satellite in the same period the ion mass variation in the trough region was obtained. It was possible to arrive at the magnitude of O^+ and H^+ fluxes in the

trough region and at higher latitudes from a detailed study of the scale height profiles. It is intended to investigate the weak correspondence between the "Knee" and the trough behaviour during quiet conditions with the aid of recent ideas regarding connective process in the high latitude magnetosphere.

4.5 ev Range Electrons and Ionospheric Phenomena

The rocket measurements of photo-electrons in the range of 2-30 ev made during the solar eclipse on March 7, 1970 over wallops island have shown definite evidence for the existence of photo-clectrons coming from the conjugate sunlight at hemisphere. Photo electrons have been found in the altitude range of 120 km to 260 km. These measurements show that conjugate photoelectrons play an important role in determining the electron density and temperatue in the F-region during eclipse. In this connection to study the effects of normal F-region data on photo-electrons obtained with the retarding potential analyser on explorer-31 have been analysed and the pitch angle and spectral energy distribution obtained for mid-day conditions both at equatorial and mid latitudes. The pitch angle distribution showed an increase of flux by about 50% along the magnetic field. The flux was found to decrease over the equator compared to mid-latitudes in the altitude range of 600-800 km. Further studies have been initiated to measure the photos electrons in the energy range of 1 60 ev over the magnetic equator from the Thumba Rocket range.

Theoretical studies have also been conducted on the Thermal structure of the topside ionosphere for the low solar activity. It has been found that the experimental observations of Te and Tc over the equatorial station Jocamarca are consistent with the existing theory. The electron and ion temperature in the topside equatorial ionosphere were theoretically estimated for the medium solar activity also with a view to see the differences observed. The heat input variations were calculated with the help of observed photo electron fluxes. The ion composition was compiled through satellite data. The theoretical results could reproduce the observed changes viz. larger width of isothermal region, lower Te around 700 km and higher Te at 400 and 1000 km during moderate activity compared to low solar activity. Observations of ev range electrons in the night-time showed the existence of night-time heat source in the equatorial region.

Studies on the H^+ fluxes into the magnetosphere during daytime and its effects on the H^+ density in the topside ionosphere in low and mid latitudes are being studied. The effects of ring current protons on the thermal structure of higher mid latitude ionosphere, are also in progress.

5. INTERDISCIPLINARY PROJECT ON ATMOSPHERIC TURBULENCE AND RADIATION HAZARDS

A study has recently been initiated for developing sophisticated physical techniques for monitoring and control of physical parameters

in the atmosphere like turbulence, acoustic noise level and electromagnetic noise from heavy electrical machines or high power transmitters. This work is of applied nature and involved the study of atmospheric turbulence and radiation hazards—monitoring and control. The three specific areas in which work is to be initiated involves, Acoustic sounding of the troposphere. Acoustic noise measurement and control and electromagnetic radiation hazards and control.

The Acoustic sounding technique will provide a means for monitoring of the atmosphere upto a height of about 2 km and this would facilitate (a) monitoring of air turbulence over airport and its vicinity thereby providing added safety in aviation, (b) monitoring of immersion boundary layers etc. and the information obtained thereby would be useful to tropospheric radio communication and (c) monitoring of air pollution in industrial area.

The growth of acoustic noise in urban and industrial areas and airports cause health hazards, medical as well as pscychological and this would therefore need noise surveys, preventive and other remedial measures. It is proposed to handle such problems also.

Electromagnetic radiation from heavy electrical machines and high power transmitters may be a health hazard. It is therefore intended to monitor such radiations and suggest remedial measures with ever increasing industrialisation. Preliminary work has already been started and an acoustic sounder with limited capability has been set up and test observations taken. Noise survey in selected urban areas have been made.

Steps have been initiated for (i) The development of transmitter/ Receiver Transducer, development of recording system, Setting up of a suitable parabolic dish, study of tropospheric turbulence with the recorder ;

(ii) Construction of a mobile system, field study with mobile sounder in various locations.

(iii) Procurement and assembly of noise monitoring equipment.

(iv) Setting up of mobile units for noise monitoring.

(v) Design and construction of radiation measuring equipment.

(vi) Measurements and survey at various locations.

PLANNING & LIAISON DIVISION

The main objectives of this division are (i) to establish effective liaison between scientists and the industry, Govt. Deptts., & others; (ii) to assist the Director in research planning, coordination and evaluation (iii) dissemination of information on the achievements and current activities of the laboratory, carry out survey and Data collection. During the period under report considerable efforts were made in this direction and as a result encouraging response was received from the industries and others.

Sponsored Projects : In the existing methodology the research projects identified by laboratory scientists or national committee are initiated keeping in view the futuristic requirements of the country. Also the projects sponsored by the industry and others falling within the purview of the NPL and with expertise and resources available are initiated with a view to develop the indigenous technology for utilisation by the sponsorer and others as well. The industry showed increasing confidence in the competence build in at this laboratory and came forward to sponsor a number of projects viz. development of process for colour coating of sunglasses, 25 tonne universal testing machine, two function desk calculator, VSWR meter for the calibration of microwave components, Penning-Pirani gauges, silicon diodes, process for utilising scrap graphite into anodes, investigations on soderberg anode pastes were successfully completed and the knowhow was transferred to the industries. Sponsored projects on the development of carbon tracks for patentiometers is nearing completion.

Transfer of Technology through NRDC

There has been a rising trend in the release of processes. Following new processes were released in addition to the release of processes developed in the previous years to other licencees.

Microwave Components C-Band & X-Band

1. M/s. K.L.B. Electronics, New Delhi.

Piezoelectric Materials

1. M/s. Murphy India Ltd., Thana
2. M/s. Vijay Electronic Component Industries, Delhi.

Extrusion Viscometer and Constant Stress Viscometer

1. M/s. Associated Instrument Manufacturers (I) Pvt. Ltd., New Delhi.

Sequential Switching Devices

1. M/s. Beacon Electronics, Delhi.
2. M/s. Electronic Control Devices Ltd., Bulandshahar.

Linear Mechanical Drive for a Mossbauer Spectrometer

M/s. Toshniwal Instruments & Engg. Co., Delhi.

Cinema Arc Carbons

1. Dr. C. N. S. Prasad Verma, Andhra Pradesh.
2. M/s. Allied Carbons (P) Ltd., Hyderabad.
3. M/s. Bajaj Carbons Ltd., New Delhi.
4. M/s. Advani Oerlikon Pvt. Ltd., Bombay.
5. M/s. Bharat Carbons Pvt. Ltd., New Delhi.
6. M/s. Britelite Carbons, Gujarat.

Broad Band Ferrite Resonance Isolators for Microwave Applications

M/s. K. L. B. Electronics, New Delhi.

Metal Graphite Brush Blocks

M/s. Moba Carbon Pvt. Ltd., Bombay.

He—Ne Gas Laser

M/s. K. L. B. Electronics Ltd., New Delhi.
M/s. Thermometer & Thermometric Appliances, New Delhi.

Cadmium Sulphide Photo-Conductive Cell

M/s. K. L. B. Electronics Ltd., New Delhi.

Ultrasonic Transducers for automation, sensing and remote control

M/s. Vibronics, Bombay.

Universal Klystron Power Supply & Modulation Unit

M/s. K. L. B. Electronics Ltd., New Delhi.

Electrostatic Photocopying Machine

M/s. Advani—Oerlikon Ltd., Bombay.

M/s. McNeil—Bary Ltd., New Delhi.
M/s. Systronics Ltd., Ahmedabad.

Fabrication and Reconditioning of cathode-ray Tubes and T.V. Picture Tubes

M/s. Videotronics, New Delhi.

Ceramic Capacitors

1. M/s. Vijay Ceramic Industries, Delhi.
2. M/s. Asian Electronics Ltd., Bombay.
3. M/s. Oblum Electrical Industries Pvt. Ltd., Hyderabad.
4. M/s. Calculator & Computer Components, Bombay.

Soft Ferrites

1. M/s. Oblum Electrical Industries Pvt. Ltd., Hyderabad.
2. M/s. Calculator & Computer Components, Bombay.

Hard Ferrites

1. M/s. G. Narayana, Hyderabad.
2. M/s. Oblum Electrical Industries Pvt. Ltd., Hyderabad.
3. M/s. Ferrite & Electronic Components Pvt. Ltd., Bangalore.

Technical Ceramics

1. M/s. Vijay Ceramic Industries, Delhi.
2. M/s. Micro Ceramics Industries, Delhi.

Patents : There has been increase in the number of patents filed, sealed and taken. Upto March 1971 the laboratory had taken about 110 patents while during these two years 26 patents have been taken.

Publicity : Publicity plays a significant role in creating the image of any organisation. The need of publicity is more to apprise the industry and the public for whom R & D is being pursued.

Efforts were made to publicise the achievements of the laboratory and its present activities in a number of ways.

Write-ups on achievements of the laboratory were brought out in newspapers, technical journals, souvineers for wide circulation. The growing interest shown by the industry and the public is revealed by the marked increase in the technical enquiries received and personal visits to the laboratory.

The laboratory actively participated in the exhibitions and the industrial fairs held in the country. The visitors to the NPL stalls showed keen interest in the NPL activities. Consequently, a large number of enquiries were received which is a direct result of impact made

on the public. During the period the laboratory participated in the following exhibitions :

(i) Third Asian International Trade Fair	Held at New Delhi November-December 1972.
(ii) National Science Exhibitions :	Held in Nov. 1971 in the NPL Campus. Held in 11—19-11-1972 at Teen Murti House.
(iii) Annual Exhibitions organised by the Institute of Telecommunication Engineers.	Held at I.I.T., Delhi on 11-2-72.

Open days were organised on 16-18th August 1972 on the occasion of Silver Jubilee Celebrations of the Independence of India. The laboratory was kept open for three days for the public to see themselves the achievements and the activities of the laboratory.

More than 5,000 scientists, industrialists, engineers, students and other citizens visited the various sections of the Laboratory. An exhibition was also organised to highlight achievements of the

Fig. 10. Some students visiting the Laboratory on the open days.

laboratory. NPL products like photocopying Machine, Microwave Components, Ferrites and Ceramics, Lasers, Vacuum Gauges, Ultrasonic Devices, Overhead Projector attracted large crowds.

Non-technical notes were prepared on the processes/products developed by the laboratory and sent to various industries, individuals interested in the commercial exploitaion of the processes. Two folders 'Step to Self-Reliance' and 'Technical Information' were brought out for wide circulation. Script for CSIR Annual Reports was prepared and provided to PID.

Training : Practical training forms a part of curriculum for every higher engineering or science degree to make it more job-oriented. The training facilities were extended to students from universities. IITs, Engg. Colleges from all over the country in areas like Solid State Physics, Electronics, X-rays, Applied Mechanics, Microwaves, Workshop Technology, Optics, etc. Courres were also organised to meet the specific requirement. Two science orientation courses were arranged for the officers of the Border Security Force. The courses have been well received to the extent that it has become an annual feature.

Since the National physical Laboratory is custodian of National Standards of Measurement and Calibration of Reference standards for Government Deptt., research organisation, Defence etc. Training courses are also organised for the industries, research organisations and Enforcement Deptts. Accordingly, the laboratory continued to organise training courses for the officers of the Weights & Measures Directorates of the various States in the country.

Research Planning and Coordination : The group assisted the Director in planning activities of the laboratory. Vigorous efforts were made to maintain effective coordination of R & D activities. Periodic progress reports were prepared for consideration of reviewing bodies, like Projects Committee, Scientific Sub-Committee, Executive Council. Project cards are maintained for every project in progress at the laboratory and the progress is periodically endorsed on the cards. Research programme of the laboratory was prepared and circulated among CSIR laboratories, Defence labs., universities, Chambers of Commerce and Industry, Associations etc. Encouraging interest has been shown by many of them in the activities of the laboratory. Five Year Plan of the laboratory was prepared for submitting to CSIR/ Planning Commission. Advice was rendered to the CSIR on the applications of the industries seeking foreign collaboration. During the period a large number of reports on the projects were prepared to meet the specific needs of CSIR and other Government agencies.

Lectures and Symposia : As in the past, Krishnan Memorial Lecture was delivered by Dr. Alfred Castler on 24.3.1972 among the citizens of Delhi.

SYMPOSIA ORGANISED

Following symposia were organised in the laboratory during the period :

Symposium on Solid State Materials

Solid state materials are finding extensive use in the modern technological world. A need is being felt for newer and better materials for the rapid developments in the field of semi-conductor technology. Vigorous efforts are being made world over to find new materials, understand their nature and properties and tailor their properties to suit the specific requirements of the industry. A Symposium was organised by the National Physical Laboratory in collaboration with the Solid State Physics Laboratory, Lucknow Road, Delhi-110007 during Feb. 6-10, 1973.

More than 100 delegates including some from foreign countries attended the symposium. About 95 papers were presented in the symposium in the diverse fields such as Semiconductors, Characterisation of Materials, Magnetic Materials, Optical Materials. Thin Film Technology & Physics of Solids.

The raw materials required for the semiconductor industry in India for the next five years were discussed. The need of indigenously manufacturing major items such as single crystals of silicon and germanium, epitaxial silicon slices, gallium arsenide/phosphide crystals, high purity chemicals, photo-resisting and packaging materials were emphasized. Specific areas were identified where new research and development programmes should be initiated so as to meet their demand by 1978-79.

SYMPOSIUM ON AERONOMY AND RADIO WAVE PROPAGATION

A symposium on "Aeronomy and Radio wave propagation" was held at National Physical Laboratory during February 19-23, 1973. The symposium was organized to bring together the concerned scientists to a common platform to facilitate exchange of ideas, results etc. for furthering fruitful research in the different branches of ionospheric and space physics. The symposium dealt with the following main topics :

1. Description of the neutral and ionized atmosphere
2. Monitoring of environment
3. Space disturbances—origin, propagation and their effects

4. Electromagnetic wave propagation

5. Prediction of environment

The response to the symposium had been very encouraging and in fact a total number of 215 papers were presented. The symposium was well attended by both young as well as prominent scientists from within the country and abroad. A proceedings volume of the symposium incorporating papers presented is intended to be brought out in collaboration with the Indian Journal of Radio and Space Physics.

SYMPOSIUM ON SATELLITE BEACON EXPERIMENTS

A one day seminar on Satellite Beacon Experiments was held at the NPL on 23rd Feb. 1973. The purpose of this seminar was to bring together all the Indian groups interested in the satellite beacon experiments for scientific studies as well as for application and to provide necessary background information on the opportunities currently available and it would be available in future, the scope of the beacon experiments, instrumentation and the data processing problems and to evolve a programme of coordinated experiments utilizing Satellite beacons. The seminar was very successful and it was suggested that a little later another seminar devoted to an indepth study of technicalproblems such as instrumentation would be heighly useful for the Indian workers in this field.

SYMPOSIUM ON 'VACUUM MEASUREMENTS & LEAK DETECTION'

A symposium on 'Vacuum Measurements & Leak Detection' was held at National Physical Laboratory on March 6-7, 1973, organized by National Physical Laboratory and Indian Vacuum Society. It was inaugurated by Prof. B. D. Nagchaudhuri, Scientific Adviser to the Defence Minister. The participants were drawn from all parts of the country, from National Laboratories, Bhabha Atomic Research Centre, ISRO, Defence Laboratories, Institute of Sciences, Bangalore, all Indian Institutes of Technology and various universities and industries.

Dr. A. R. Verma, Director, National Physical Laboratory while welcoming the delegates, said that the nature abhors vacuum and scientist loves it. He emphasized the need for organising the symposium and the role which National Physical Laboratory as the custodian of National Standards can play in accurate measurement of vacuum.

Prof. B. D. Nagchaudhuri in his inaugural address said that vacuum science which during his student days, late thirties, was regarded as an art, has become an important technology today with its demand in space technology, high energy accelerator and environments in fundamental research.

The key-note address was delivered by Shri C. Ambasankaran, Director, Electronics and Instrumentation Group, Bhabha Atomic Research Centre, Bombay. He pointed out how the ingenious idea of

Nottingham, Bayard and Alpert who, by simply changing the order in a triode ionisation gauge made it possible to measure pressure as low as 10^{-12} torr and with little modification to measure pressure in lunar space of better than 10^{-15} torr. He said that just a decade back people were satisfied with 10-15% accuracy in their measurements. He emphasised the need and the role which National Physical Laboratory could play in the calibration of gauges to the accuracy required by the present day scientists. Four technical sessions were held and about 20 contributed papers were presented.

First session was on Vacuum Measurements. Prof. V. G Bhide, Scientific Adviser to the Cabinet was in Chair. It started with review talk on Vacuum Standards by Dr. J. K. N. Sharma of National Physical Laboratory. He gave a comprehensive review of various standards being adopted internationally from atmospheric pressure down to 10^{-8} torr. Calibration and testing facilities developed at National Physical Laboratory for vacuum instruments were also mentioned. Notable among the contributed papers were strain gauges developed at National Physical Laboratory and on the sensitivity of indigenous BA gauge and residual gas Mass Analyser developed at Bhabha Atomic Research Centre.

The second session held was on 'Leak Detection in Vacuum' with Dr. Harshwardhan, Director, CSIO, Chandigarh in Chair. Discussions started with a nice review talk on the various leak detection techniques by B. S. Prahallada Rao of Bhabha Atomic Research Centre. Papers on the indigenous thermal conductivity leak detector developed at National Physical Laboratory, the use of ultrasonics in leak detection by Mr. P. Vijendran of Bhabha Atomic Research Centre, the experience in leak detection on Graf 35 Mass Spectrometer, the role of Mass Spectrometer in leak detection etc. were highly appreciated.

The third session which was of general nature was presided by Dr. B. K. Banerjee, Director, Defence Science Laboratory, New Delhi. Papers on some design aspects of vacuum system at ISRO and some studies on the performance of rotary vane, vacuum pumps (I. I. Sc. Bangalore) were quite interesting.

In the fourth session, Mr. S. S. Ramamurthy of Bhabha Atomic Research Centre, Bombay gave an excellent talk on 'Present State of Vacuum Instrumentation in India'. The session was presided by Dr. A. P. Mitra of NPL.

The most important phase of the symposium 'A Panel Discussion on the present state of Vacuum Instrumentation in India' proved to be the most interesting and was made very lively by the Chairman, Dr. K. L. Chopra, Head of the Department of Physics, Indian Institute of Technology, New Delhi and other members of the panel body drawn from the vacuum industry and users as follows :

1. Dr. R. P. Wadhwa, Deputy General Manager of BEL, Vacuum Tubes, Bangalore.

2. Mr. P. Vijendran, BARC, Bombay.
3. Mr. B. K. Dutta of BASYNTH, Calcutta.
4. Mr. Rama Brahma of TOVAC Equipments, Madras.

The participants from industry, research institutions and universities discussed their difficulties of varied aspects and diverse nature.

The participants felt highly satisfied by the role of BARC and NPL in the development of vacuum technology in the country. The general opinion was that more stress be laid in these institutions on developing the know-how for vacuum components and apparatus. The panel body was of the opinion that the users should insist on quality products and the manufacturers must satisfy the requirement as per ISI specifications which are in the process and the finalisation. It was stressed by various speakers that the calibration and testing facilities developed at NPL should be utilised by the manufacturers.

In the end, Dr. A. R. Verma, Director, National Physical Laboratory thanked all the delegates and participants. He said that NPL gladly shoulders the responsibility to create and to maintain standards and will try to calibrate secondary standards of manufacturing companies that is to say calibrate the calibrator. NPL for the time being, he said, is prepared to calibrate all vacuum equipments for which facilities exist, till manufacturers acquire their own test set-ups.

It was quite useful symposium and has contributed considerably to the knowledge of vacuum measurement and leak detection and brought out the importance of vacuum technology in the development of science in the country.

SYMPOSIUM ON NOISE CONTROL

An all-India inter-disciplinary symposium on Noise Control was held under the auspices of Acoustics Division, NPL, to highlight the problems involved, to suggest possible remedial measures and to coordinate action required to implement the recommendations.

Nearly a hundred delegates representing various fields such as physicists, acousticians, educationists, lawyers, Government officials, engineers, public health authorities, transport authorities, police, doctors, architects, journalists, etc., from different parts of the country took part in the deliberations.

The symposium started with a closed session discussion among group of selected experts from various fields, under the Chairmanship of the late Shri Pitambar Pant, Chairman, Human Environments Committee of the Planning Commission. The Chairman asked the scientists to find out (i) if there was a noise problem in India, (ii) to what extent the problem was serious at present or was likely to be in future, and (iii) what steps could be taken to mitigate it. He also stated that the problem should be considered keeping in view the availability of financial resources in relation to other development activities.

Discussions were held on the evaluation of the problem in the home, in factories, on the road, near airports, etc., on the extent of noise pullution, on the need for preventive measures and on specific remedies against the nuisance. It was agreed that, although the problem was not so acute as in other developed countries, a problem did exist in large towns and in factories and that it would be advantageous to tackle the same before it got out of hand. Some of the specific problems cited were those of (i) hearing loss in industrial workers exposed to high noise levels in such operations as rivetting, chipping, boiler-making, textile weaving, etc., (ii) traffic noise in high traffic density areas, (iii) noise from loudspeakers in season and out and from hooting of motor car horns, (iv) noise from adjacent apartments in multi-storeyed buildings, etc.

The question of cost of anti-noise measures was discussed in terms of the priorities to be accorded to basic amenities like provision of drinking water, basic medical facilities, education, etc. Among the specific remedies suggested were (i) proper town planning to reduce traffic density in residential localities, (ii) preference for efficient mass public transport as against individual motorised transport, (iii) stricter enforcement of existing noise regulatory measures against loudspeakers and horns, (iv) provision of adequate noise insulating walls and better design in houses, (v) ear-protection to labour in noisy trades, (vi) laying down maximum permissible limits of noise under various conditions, (vii) making hearing loss in industry compensable, etc.

In the next two sessions devoted to formal reading of papers, over 25 papers were read. The topics included (i) noise in industry, (ii) noise in buildings, (iii) legal aspects of noise legislation, (iv) vehicular and traffic noise, (v) aesthetic offence and noise pollution, (vi) hearing conservation, (vii) ear defenders, (viii) aircraft noise, (ix) standards relating to noise, (x) noise control, (xi) noise measurement, etc.

The last session was devoted to giving specific suggestions for noise control. The following were the main suggestions :—

1. *Instrumentation*

There is an urgent need for developing indigenous sound level meters and other noise measuring instruments. A time-bound programme should be formulated for producing the equipment indigenously.

2. *Standards & Criteria*

There is a need for data for laying down simple standards and criteria for acceptable and objectionable noise under different conditions.

As a starting point, therefore, permissible limits as laid down by International bodies or national bodies or other countries may be adopted. These can be modified suitably in due course, if necessary.

In this connection, the code to be presented by ICA at the forthcoming UNESCO meeting on environment in Sweden may also be taken into account.

3. *Town Planning*

There is an urgent need for adoption of correct and effective methods in respect of noise in town planning. It is, therefore, necessary to (a) constitute an expert advisory body to advise town planning authorities on noise, (b) adopt measures such as zoning according to use as residential, industrial, commercial, etc.; segregation of arterial traffic from residential areas; reduction of traffic density in residential areas; ensuring smooth, uninterrupted flow of traffic.

4. *Transport & Traffic*

There is need for—

(a) Formulating overall transport and traffic policy such as private vs. mass transport, zoning, segregation etc.

(b) Effective implementation of laws where existing.

(c) Improving other legal provisions to make them enforceable such as 'unduly noisy' vehicle or 'provision of silencers'.

(d) Fresh regulations or legislation such as misuse of horns, for purpose other than warning and use of musical horns etc.

(e) Ban on heavy vehicles at night in certain localities.

(f) Data on effectiveness and acceptable noise limits of silencers.

Therefore suitable action may be taken on these points.

5. *Aircraft Noise*

It was pointed out that although the problem of aircraft noise was not acute yet but it is bound to grow particularly with supersonic flights. Necessary action on the following lines is suggested :

(a) Flight Paths and Flight patterns (including approach and take off angle) may be regulated.

(b) This factor may be taken into account in town planning and buildings near the airport.

(c) Usual device of double windows are not considered feasible in local climate. Other methods may be evolved.

It was also pointed out that noise of the aircraft machine could be lowered in design provided the cost is spread over bulk produced quantities. This may not be practicable in this country at present where planes are purchased from abroad.

6. *Buildings*

There is a need for taking appropriate measures for noise reduction in building construction. It is suggested that :

(a) Measurement and compilation of data on sound insulating properties of indigenous materials may be undertaken for the guidance of engineers, architects and builders.

(b) Technical data on sound transmission properties may be classified into simple standardised and meaningful gradation.

(c) Results of research and investigations followed up and implemented in building practice.

7. *Domestic Appliances*

(a) Criteria may be prescribed for maximum noise of domestic appliances such as sanitary fittings, plumbing, room coolers, fans, kitchen gadgets.

(b) Measures may be taken on reduction of noise of the above devices.

(c) Education and information on the effect of noise of these devices may be encouraged.

8. *Hearing & Industrial Noise*

It was felt that there is a need for protecting industrial workers from effects of excessive noise during work. It is, therefore, suggested that :

(a) Pre-employment audiometry examination may be made compulsory.

(b) Hearing loss may be made a compensable disability.

(c) Use of noise control measures in industry and use of ear defenders where excessive noise is unavoidable may be enforced.

9. *Speech Interference*

For places involving conversation, direct or telephonic, criteria for maximum permissible noise levels may be implemented to facilitate relaxed communication.

10. *Health*

With a view to evaluating the physical and physiological effects of noise on health other than on hearing, information may be collected and analysed.

11. *Education*

There is a need for educating the public in respect of effects of noise. This can be done through :

(a) Usual publicity means such as Press, radio, T.V., documentaries, booklets, popular write-ups and other audio visual aids. Also it may be included in school hygiene books.

(b) Education of industrial employers and workers on noise risks and methods of prevention including maximum duration, rest and recovery etc.

(c) Training in noise reduction for engineers, architects, town planners and similar concerned personnel.

12. *Research and Higher Education*

(a) Universities and Technical Institutions may introduce specialised courses in noise.

(b) Special institute for investigation on specific problems of noise and vibration may be created.

(c) Coordination and correlation of research and investigations carried out by different individuals and institutions all over the country in areas such as Physical, Engineering, Medical, Transport, Industry, Building Science, Architecture, Legislative, etc., may be effected.

13. *Legal*

(a) Legal measures may be taken to prescribe noise limits in respect of industrial noise, noise in building, traffic noise, etc., as described under the various heads.

(b) Uncontrolled output of noise from any source such as radio, T.V., amplified speech and music may be curbed.

(c) Hearing loss may be made a compensable disability in industry. A committee to go into the various legal aspects of the problem may be formed.

14. *General*

(a) Advisory Committee may be formed to advise on problems of noise in various areas.

(b) All noise problems may be listed.

(c) Responsibilities for implementation of the various recommendations may be defined.

(d) Formation of noise abatement societies to make the public aware of noise and to campaign for reducing noise.

LIBRARY

The library continued to provide library and documentation services to the scientists of the laboratory; Documentation services through its fortnightly bulletin entitled "Current Titles" and through the additions of books, journals and other literature of relevant interest. Scientists have evinced good interest in "Current Titles" and felt its increasing importance and usefulness in the context of their research work.

A new section for Reports (Scientific, Technical and Annual Reports) and Trade Literature has been organised. Reports are being received from several Indian and foreign institutions/organisations, engaged in the field of physical sciences. Attempts are being made to establish exchange arrangements with more foreign organisations.

Library added Majox 121-Electrostatic Photocopier in the beginning of 1973 to provide reprographic services to the scientific and technical staff of the laboratory.

Library data inter alia on purchase of books, journals, photocopies, translations etc. during 1971-73 are given below :—

		1971-72	1972-73	Total 1971—73	Total as on 31-3-73
1.	Publications accessioned	3501	1445	4946	75,165
2.	(a) Journals Subscribed	382	327		
	(b) ,, Dropped	—	55		
3.	Photocopies, Translations Accessioned	79	74	153	4,631
4.	Indian Patents added				90,000
5.	Standard Specifications added	1229	897	2126	12,000
	IS	712	895	1607	
	BS	508	1	509	
	DIN	6	—	6	
	IEC	2	1	3	
	ISO	1	–	1	
6.	Publications loaned (including inter-library loan)			24312	

INSTRUMENTATION SERVICING

The laboratory has facilities for servicing of sophisticated instruments to outside organisations in addition to serving of its own instruments. The laboratory also provides advisory service on the instrumentation problems such as their availability and suitability to meet particular needs and suggest modifications in the existing apparatus to suit to a particular requirement.

The ever increasing number of inquiries about the servicing of equipment from far and near organisations in the country reveal that such facilities do not exist anywhere else in the country. Medical institutions continued to be the major users of the laboratory's expertise besides universities, research institutes, U.N. Organisations, and various other public and private industrial organisations. Sixty-six scientific instruments were serviced during 1971-72 and in 1972-73, the number increased to 72.

The instruments serviced include : Oscilloscopes, Flaw Detectors, Microvolters, Amplifiers, Cautery. Diathermy, E.C.G., E.E.G., Audiometers, Oxymeters, Flame Photometers, Microscopes, Colorimeters, Photostat Machines, Respirators, Nuclear Apparatus, Jet Inoculators, Auto Technicon, pH meters, Spectrophotometers.

Instruments which are returned after use to the Central Stores of the Laboratory by the scientists are also tested by this department. Those instruments which are found defective are serviced.

STAFF : 31-3-1973

Total Staff Strength ... 1017

NPL			
Gazetted			
Scientific	...	...	102
Aux. Tech.	...	...	36
Non-Tech.	...	...	5
			143
Non-Gazetted			
Scientific	...	...	46
Aux. Tech.	...	...	314
Non-Tech.	..	...	97
Class IV Tech.	...	...	118
Class IV Non-Tech.	...	...	94
			669
DPECU			
Gazetted...Scientific/Tech.	...	...	7
Non-Gazetted Supporting	...	...	59
			66
G.T.U.			
Gazetted...Scientific/Tech.	...	...	3
Non-Gazetted Supporting	...	...	59
			62
ECPU			
Gazetted...Scientific/Tech.	...	...	4
Supporting Staff	...	...	48
			52
CARBON ELECTRODES			
Technical Staff	...	...	3
TEC			
Gazetted...Scientific	...	...	3
Supporting Staff	...	...	19
			22

NPL REPRESENTATION ON ISI COMMITTEES

No. & Name of the Committee		*Member*
BDC 20:2	Helmets	Dr. Ram Parshad (P)
BDC 19	Sieves, Sieving and other sizing methods Sectional Committee	Dr. M. Pancholy (C) Dr. P.T. John (P)
BDC 19:1	Use of Sieves	Dr. M. Pancholy (P) Dr. P.T. John (A)
BDC 19:2	Sizing by Methods other than sieving	Dr. M. Pancholy (P) Dr. P.T. John (A)
BDC 60	Instrumentation Sectional Committee	Dr. B.K. Agarwal (P)
BDC 12:3	Day Light Standards	Dr. S. Das (P) Dr. V.D.P. Sastry (A)
BDC 12:5	Architectural Accoustics and Sound Insultation.	Dr. M. Pancholy (P)
ARDC 34	Dairy Products and Laboratory Apparatus Sectional Committee	Sh. S.V. Gupta (P) Sh. Mohinder Nath (A)
ARDC 34:2	Methods of Test and Laboratory Apparatus Sub Committee	Sh. S.V. Gupta (P) Sh. Mohinder Nath (A)
SMDC 3	Methods of Chemical Analysis Sectional Committee	Dr. V.M. Bhucher (P)
SMDC 3	Methods of Physical Tests Sectional Committee	Sh. M.K. Das Gupta (P)
SMDC 25	Non-destructive Testing Sectional Committee	Sh. M.K. Das Gupta(P) Dr. V.N. Bindal (A)
SMDC 25/P-8	Panel to revise IS : 4904	Dr. V.N. Bindal (P) Dissolved vide ISI letter dated 2.5.73
ETDC	Electrotechnical Division Council	Dr. G.C. Jain (P)

No. & Name of the Committee		*Member*
ETDC 1	Electrotechnical Standards Sectional Committee	Sh. V.K. Batra (P)
ETDC 1:2	General Nomenclature and Symbols Sub-Committee	Sh. V.K. Batra (P)
ETDC 5	Electric Fans Sectional Committee	Dr. R.N. Dhar (P)
ETDC 10	Primary Cells and Batteries Sectional Committee	Dr. G.C. Jain (P)
ETDC 10/P1	Panel for Flash light Torches	Dr. G.C. Jain (P)
ETDC 10/P8	Panel for Export	Dr. G.C. Jain (Con.)
ETDC 14	Automobile Electrical Equipment Sectional Committee	Dr. R.N. Dhar
ETDC 15:3	Carbon Brushes Sub-Committee	Dr. G.C. Jain (P) Sh. K.K. Datta (A)
ETDC 18	Insulating Materials Sectional Committee	Dr. R.N. Dhar
ETDC 23	Electric Lamps and Accessories Sectional Committee	Sh. K.S. Sarma (P)
ETDC 23:1	Lamps for Aircraft and Aerodrome Lighting Sub-committee	Sh. K.S. Sarma (P)
ETDC 23:2	Auto-Lamps Sub-committee	Sh. K.S. Sarma (P)
ETDC 23/P2	Panel for IEC Work	Sh. K.S. Sarma (P)
ETDC 23/P4	Panel for Tubular Flourescent Lamps	Sh. K.S. Sarma (P)
ETDC 24	Electronic Equipment Sectional Committee	Dr. Ram Parshad (P)
ETDC 24:1	Radio Receivers Sub-Committee	Dr. Ram Parshad (P) Sh. S.C. Mathur (A)
ETDC 24:1:4	Panel for Television Receivers	Dr. Ram Parshad (P) Sh. S. Chandra (A)
ETDC 24:2	Electronic Measuring Equipment Sub-Committee	Dr. Ram Parshad(Con) Sh. T.N. Ghosh (A)

No. & Name of the Committee		*Member*
ETDC 24:3	Safety for Electronic Equipment Sub-Committee	Dr. M. Pancholy (C)
ETDC 26	Environmental Testing Procedures Sectional Committee	Dr. Y. Somayajulu (P) Sh. P. Saryanarayana(A)
ETDC 27	Acoustics Sectional Committee	Dr. M. Pancholy (C)
ETDC 27/P3	Panel for Acoustical Terminology	Dr. M. Pancholy (Con)
ETDC 27/P4	Panel for Hearing Aids & Audiometers	Dr. M. Pancholy (Con)
ETDC 27/P5	Panel for Tapes & Tape Recorders	Dr. M. Pancholy (Con)
ETDC 27/P6	Panel for Sound System	Dr. M. Pancholy (P)
ETDC 28	Advisory Committee on Safety Electronics and Telecommunications Sectional Committee	Dr. M. Pancholy (P)
ETDC 34	Instrument Transformers Sectional Committee	Sh. R.K. Tandon (P)
ETDC 36	Capacitors & Resistors	Dr. V.N. Bindal Sh. T.R.K. Menon
ETDC 38	Transformers and coils for Electronic Equipment Sectional Committee	Sh. P. Suryanarayan (P)
ETDC 40	Semiconductor Devices and Integrated Circuits Sectional Committee	Dr. G.C. Jain (P) Dr. Y.R. Ananth Prasad (A)
ETDC 40/P5	Panel for Terminology	Dr. G.C. Jain Dr. Y.R.A. Prasad (A)
ETDC 40/P7	Panel for Methods of Measurements on Transistors	Dr. G.C. Jain (Con) Dr. Y.R.A. Prasad
ETDC 42	Cables, Wires & Waveguides for Tele-Communication Equipment Sectional Committee	Dr. K. Chandra (P)
ETDC 43	Electrical Appliances Sectional Committee	Sh. R.K. Tandon (C) Dr. R.N. Dhar (A)

No. & Name of the Committee		*Member*
ETDC 45	Illuminating Engg. Sectional Committee	Sh. K.S. Sarma (P)
ETDC 45/P2	Panel for Code of Practice for Industrial Lighting	Sh. K.S. Sarma (P)
ETDC 45/P3	Panel for Aviation Lighting Fittings	Sh. K.S. Sarma (P)
ETDC 45/P4	Panel for Lighting Fittings for Hospitals	Sh. K.S. Sarma (P)
ETDC 45/P6	Panel for Evaluation of Glare	Sh. K.S. Sarma (Con)
ETDC 47	Cinematographic Equipment Sectional Committee	Dr. A.F. Chhapgar (P) Sh. Ram Parshad (P)
ETDC 47/P1	Panel for Still Projector	Sh. Ram Prasad (P)
ETDC 47/P2	Panel for Cinema Arc Carbons	Dr. G.C. Jain (P) Dr. S.S Chari (A)
ETDC 48	Electrical Instruments Sectional Committee	Sh. V.K. Batra
SHDC 52	Magnetic Component & Ferrites	Dr. G.C. Jain (P) Sh. R.S. Khanduja (A)
SHDC 52/P3	Magnetic Component & Ferrites	Sh. C.V. Ganapathy
CDC 1	Chemical Standards Sectional Committee	Sh. V.M. Bhuchar (P)
CDC 10:7	Signal Glasses Sub-Committee	Dr. S.R. Das (A)
CDC 10:13	Protective Glass Sub-Committee	Dr. S R. Das (P) Dr. D. Sen (A)
EDC 10:13:1	Panel for Glass Lenses for Automobile	Dr. S.R. Das (P) Sh. K.S. Sharma (A) Dissolved vide ISI letter dt. 16-3-74
CDC 26	Water meters Sectional Committee	Sh. V.M. Bhuchar (P) Sh. Jitendra Rai (A)
CDC 33	Laboratory Glassware and Related Apparatus Sectional Committee	Sh. Mohinder Nath (P)

No. & Name of the Committee		*Member*
CDC 33:1	Volumetric Glassware Sub-Committee	Sh. Mohinder Nath (P)
CDC 33:2	Thermometers Sub-Committee	Sh. T.D. Bansal (Con) Sh. V.P. Wasan (A)
CDC 33:3	Hygrometers Sub-Committee	Sh. Mohinder Nath (Con)
CDC 37	Thermal Insulation Materials Sectional Committee	Sh. T.D. Bansal (C)
CDC 37:P1	Panel for Terminology & Methods of Test for Thermal Insulation Materials	Sh. T.D. Bansal (Con)
CDC 37:P6	Panel for Thermal Insulation at Cryogenic Temperatures	Dr. M.S.R. Chari (P) Dr. J.S. Dhillon (A)
TDC	Mechanical Engg. Divn. Council	Dr. B.K. Agarwal
CWCE	Standing Working Committee Mech. Engg.	Dr. B.K. Agarwal
EDC 1	Engineering Standards Sectional Committee	Dr. B.K. Agarwal
EDC 1:1	Atmospheric Conditions for—Testing Sub-Committee	Dr. B.K. Agarwal
EDC 36	Optical and Mathematical Instruments Sectional Committee	Sh. P.C. Jain (P) Mr. Ram Prasad (A)
EDC 36:1	Drawing Instruments Sub-committee	Sh. P.C. Jain (P)
EDC 36:2	Optical Instruments Sub-committee	Dr. S.R. Das (P) Sh. Ram Prasad (A)
EDC 36:3	Surveying Instruments Sub-committee	Sh. P.C. Jain (P)
EDC 36:5	Materials and Components for Instruments Sub-Committee	Sh. Ram Prasad (P)
EDC 41	Commercial Weights & Measures Sectional Committee	Dr. A.R. Verma (C)

No. & Name of the Committee		*Member*
EDC 41:1	Commercial Weights, Lengths and Capacity Measures Sub-committee	Sh. P.C. Jain (P)
EDC 41:3	Taximeter Sub-committee	Sh. P.C. Jain (P)
EDC 41:7	Beam Scales and Counter Scales Sub-committee	Sh. Prem Prakash
EDC 43	Engineering Metrology Sectional Committee	Sh. P.C. Jain (P)
EDC 43:2	Precision Measuring Equipment Sub-committee	Sh. P.C. Jain (P)
EDC 43:3	Gauges Sub-committee	Sh. Mohinder Nath (P)
EDC 43.4	Surface Roughness Sub-committee	Sh. P.C. Jain (P)
EDC 57/P2	Panel for Standardization of Vacuum Equipment	Dr. J.K.N. Sharma (C)
EDC 62	Compressors Sectional Committee	Sh. Naunihal Singh (P)
EDC 66	Refrigeration and Air-conditioning Sectional Committee	Sh. Naunihal Singh (P)
EDC 66:1	Air Conditioning and Refrigeration Appliances and Commercial Refrigerators Sub-Committee	Sh. Naunihal Singh (P) Sh. R.S. Khandekar (A)
ETDC 51	Piezo-electric Crystals for Frequency Control and Selection Sectional Committee	Dr. V.N. Bindal (P)
EDC-70	Screw Threads Sectional Committee	Dr. B.K. Agarwala
	General Council and Executive Committee ISI	Dr. M. Pancholy
ETDC 35	Relays Sectional Committee	Dr. Y.V. Somayojulu (P) Sh. K.S. Sastry (A)
SHDC-25/P3	Panel for Reference Blocks for Ultrasonic Testing	Dr. V.N. Bindal

No. & Name of the Committee		*Member*
ETDC 54	Reliability of Electronic Components and equipment Sectional Committee	Dr. Y.V. Somayajulu (P) Sh. P. Suryanarayan (A)
BDC 31	Building Materials and Components Sampling Sectional Committee	Dr. M. Pancholy (P) Dr. P.T. John (A)
CPDC 12	Medical Glass Instruments Sectional Committee	Dr. K.C. Joshi (P) Dr. S.V. Gupta (A)
BDC 12:8	Forced Ventilation Industrial Sub-Committee	Sh. Naunihal Singh (P) Sh. Shiv Nath (A)
SWCET	Standing Working Committee	Dr. G.C. Jain (P)
EDC-57	Electro-technical Chemical Engineering Sectional Committee	Dr. J.K.N. Sharma (P)

P = Principal
C = Chairman
A = Alternate
Con = Convener

FINANCIAL BENEFITS FOR 1971-72 & 1972-73

Rupees in Lakhs

	1971-72	1972-73
Sale proceeds of Glass Technology Unit	4,73,632.00	5,70,815.00
Sale proceeds of Development-cum-Production of Electronic Components	3,42,739.26	2,10,831.43
Sale proceeds of Carbon Products	1,76,034.19	1,23,555.36
Sale proceeds of Microwave Components	26,051.50	31,006.50
Sale proceeds of Miscellaneous items	8,744.10	4,516.87
Servicing of Equipment	2,725.00	3,825.00
Fabrication of Equipment	1,66,467.65	89,821.45
Testing & Calibration Fees	1,87,745.36	2,36,441.36
Royalties	68,266.12	2,05,972.99
Premia	2,05,000.00	5,000.00
	16,57,405.18	14,81,785.96

BUDGET 1971-72 & 1972-73

In Lakhs

	1971-72	1972-73
Pay and Allowances	48.061	50.054
Contingencies	9.687	12.171
Maintenance	1.073	1.285
Chemical Apparatus & Equipment	7.756	8.478
Capital	27.896	29.783
T. E. C.	1.339	1.754
Pilot Plants : 1. Carbon	0.843	1.729
2. G. T. U.	6.457	8.338
3. D. E. P. C.	18.060	12.653 (including Prod.)
4. E. P. U.	—	14.058
Total	121.172	133.303

GUEST WORKERS

S.No.	*Institution*	*Nos.*	*Field of Training*
	1971-72		
1.	I.I.T., Madras	3	Electronics
2.	I.I.T., Kanpur	1	Electronics
3.	Banaras Hindu University, Varanasi	8	Electronics
4.	Delhi College of Engg., Delhi	17	W/Shop & Electronics
5.	I.I.T., Delhi	11	DPEC, Microwave, Materials
6.	M.I.T., Madras	3	Electronics
7.	Regional Engg. College, Tiruchirapali	1	W/shop
8.	Central Polytechnic, Chandigarh	1	Electronics
9.	NCERT, New Delhi	6	Basic Physics, Solid State Physics, Low Temperature
10.	Birla Institute of Technology & Science, Pilani	3	Electronics
11.	M.L. Engg. College, Allahabad	1	W/shop
12.	Board of Apprenticeship Trg., Kanpur	15	Different Sections of NPL
13.	Roorkee University	1	Materials
14.	A.M.U., Aligarh	1	Optics
15.	Saugar University, Sagar	1	Optics
16.	Raisina Bengali Hr. Sec. School, Delhi	1	Phosphors
17.	505 Army Workshop, Agra	1	Electronics
18.	Hans Raj College, Delhi	1	Electronics
19.	Punjab University, Chandigarh	1	Lang Camera
20.	M.A.C.T., Bhopal	1	Optics
21.	B.I.T. Ranchi	1	Electronics

1972-73

1.	R.E.C., Kurukshetra	9	Electronics
2.	Thapar Inst. of Engg., Patiala	2	W/shop
3.	B.I.T.S., Pilani	4	Electronics
4.	S.D. College, Ambala	1	Material
5.	M.I.T. Madras	2	R.P.U.
6.	Board of Apprenticeship Trg., Kanpur	15	Different Sections of NPL
7.	Banaras Hindu University, Varanasi	4	Electronics
8.	I.I.T., Kharagpur	1	High Vacuum
9.	Reg. Engg. College, Kurukshetra	1	Electronics & W/shop
10.	Delhi College of Engg., Delhi	4	Electronics
11.	I.I.T., Delhi	1	Electronics
12.	T.T.T.I., Chandigarh	1	Electronics
13.	Punjab Engg. College, Chandigarh	3	Weights & Measures
14.	Govt. Quality Marketing Centre, Sonepat	1	Standards Group
15.	CMRS, Dhanbad	1	Electronics
16.	Roorkee University, Roorkee	2	Microwaves
17.	J.K. Inst. of Applied Physics, Allahabad	2	Electronics
18.	Pusa Polytechnic, New Delhi	6	W/shop, Electronics, Electricity

PATENTS

Accepted

1971-72

A process for uniform electrostatic charging of photoconductive plates for Electrophotographic Machine	120641	P.C. Mehendru D.C. Parashar G.D. Sootha Devinder Singh Narinder Kumar	21.7.71
A process for making a print of a document with an electrophotographic machine	126506	-do-	5.8.71
A process for making photoconductive plates for electrophotographic machines	123640	-do-	21.3.71
A process for making multiple prints of a document with an Electrophotographic Machine	127748	P.C. Mehendru D.C. Parashar G.D. Sootha Devinder Singh Narinder Kumar	5.8.71

1972-73

A Strain Gauge Flow Transducer	133676	V.R. Singh Ram Parshad	18.11.72

Filed

1971-72

Electrostatic charging of photoconductive plates for machines	131907	P.C. Mehendru D C. Parashar G.D. Sootha Narinder Kumar Devinder Singh	29.7.71
Process for making multiple prints of a document with an Electrophotographic Machine	131774	-do-	18.6.71 19.7.71 (Australia)
A process for uniform charging of photoconductive plates for Electrophotographic machines	123641	-do-	20.7.71 (Japan)
A bath for making silver powder by electrolysis	134077	D. Sen	20.12.71
-do-	134019	D. Sen	20.12.71

A draw of tap for fluids	133893	B.K. Agarwal A.K. Agarwal	9.12.71
A strain gauge load cell	134265	V.R. Singh Ram Parshad	12.1.72
A strain gauge transducer	134169	-do-	3.1.72
A strain gauge pressure transducer		-do-	3.1.72
A photoemulsion for printed circuits or surfaces such as plastic glass sheets and instrument panels	134716	Surinder Singh	23.2.72

1972-73

A strain gauge blood pressure transducer	134978	V.R. Singh Ram Parshad	18.3.72
A strain gauge breathing transducer	134919	-do-	13.3.72
A method for preparing a photoemulsion suitable for printed circuits	134963	Surinder Singh	13.3.72
A strain gauge obstruction flow transducer	135066	V.R. Singh Ram Parshad	27.3.72
Improvements in or relating to printing dots	135145	J. Singh W.S. Khokle	4.4.72
A process for making photoconductive cells	135211	Balbir Singh Indradev	10.4.72
Improvements in or relating to a process for making photoconductive plates for electrophotographic machines	131907	P.C. Mehendru D.C. Parashar G.D. Sootha Narinder Kumar Davinder Singh	18.5.72
A new method of encapsulating photo-conductive cells	135211	Balbir Singh Indradev	27.3.72
Super sensitive opto electronic solid state switch		S.P. Suri Madhu Khullar	20.6.72
An ultrasonic interferometer	603172	V. N. Bindal	20.6.72
Light intensity analogue to digital convertor	397172	S.P. Suri Madhu Khullar	2.6.72
A large rate flow transducer		V.R. Singh Ram Parshad	9.6.72
A strain gauge level transducer		—do—	13.6.72
An infrared detector	483172	S.P. Suri Madhu Khullar	9.6.72
A modified distillation flask	123527	F. Kiss	5.7.72
Electronic High Voltage Detector		V.N. Sharma	22.10.72

Sealed

1971-72

Ultrasonic transducers for automation, sensing & remote control applications	116564	V.N. Bindal	28.7.70
Improvements in or relating to carbon composition resistances & composition thereof	115127	T.V. Ramamurti N.R. Nair M.I. Alam	17.7.70
Improved thin film thickness monitor	120706	S.P. Suri V.V. Shah	17.2.71
Improvements in or relating to hard ferrites	123878	T.V. Ramamurti S.C. Gupta N.R. Nair B.S. Khurana	17.9.71
Improvements in or relating to nozzles for extrusion press in the manufacture of plastic products by extrusion method	124994	G.D. Joglekar C.L. Verma	25.6.71
A distillation apparatus	122568	F. Kiss	23.7.71
Improvements in or relating to electro & magnetic ceramics	123139	G. Govindaswamy C.V. Ganapathy S.M. Khullar S.S. Hanspal K. Narayanan	13.8.71

1972-73

A process for uniform electrostatic charging of photoconductive plates for electrophotographic machines	123641	P.C. Mehendru D.C. Parashar G.D. Sootha Davinder Singh Narinder Kumar	24.1.72
A process for making photoconductive plates for electrophotographic machines	123640	—do—	24.1.72
A process for making multiple prints with electrophotographic machine	127748	—do—	15.4.72
An apparatus for studying Bragg Diffraction	122862	Dr. V.N. Bindal	23.7.72
An apparatus for cracking SiI4	122692	F. Kiss P.K. Gupta V.K. Amar	25.6.71

PAPERS PUBLISHED

Indian Journals

1. "Ultrasonic detection of residual stress", M. Pancholy, Sarvan Kumar, I.J. Tech., pp 465-66, Vol. 8, No. 12, 1971.

2. "A simple method for determining monolayer capacity (surface area) of finely divided and porous materials", K.K. Datta & P.T. John, I.J. Tech., pp 195, Vol. 9, No. 5, 1971.

3. "Derivation of adsorption isotherms for different pressure ranges from a single isotherm", P.T. John & K.K. Datta, I.J. Tech., pp 199-203, Vol. 9, No. 5, 1971.

4. "Some applications of Mossbauer effect in solid state physics", V.G. Bhide, J.S.I.R., April 1971.

5. "Stress-distribution round a hetrogenous inclusion in an infinite elastic plate under simple tension", B.K. Agarwal & Rakesh Kumar, I.J. Tech., pp 403-6, 1971.

6. "Primary aberrations of tools and systems of acromatised doublet type", Ram Prashad, I.J. Pure & App. Phys., Vol. 9, pp 715-18, 1971.

7. Estimation of surface area for non-linear Harkins and Jaura isotherm", J.N. Bohra & P.T. John, I.J. Tech., 1972.

8. "Slip gauges and their calibration", P.C. Jain & K.N. Bhatnagar, J. Inst. of Engrs., Vol. 52, No. 7, pp. 272-77, 1972.

9. "Direct complexometric determination of calcium & Magnesium using Glyoxallics Hydroxyl acid as indicator", V.K. Amar & V.M. Bhucher, I.J. Chem., pp 557-58, May 1972.

10. "Effect of dissolved salts and reducing agents on sonoluminescence intensity", M. Pancholy & M. Siddiqui, I.J. Phys., Vol. 4, No. 11, 1971.

11. "Broad band Matching of Magic Tees", N.K. Bansal, V.K. Agrawal & K. Chandra, Electrotechnology, Nov. - Dec., 1971.

12. "Research Consultancy Service for Small Scale Industries", Ram Prasad, Indian Manufacturer, Decade Number 1960-71, p-45, 1971.

13. "Primary Aberrations of Two-lens Systems of Reversed Ramsden and Reversed Hugyenian Type", Ram Prasad, Indian J. Pure & Appl. Phys , 10, 187, 1972.

14. "Study of Demerit Values of Andeyev's Eyepiece", Ram Prasad, Indian J. Technol , Vol. 10, p. 99, 1972.

15. "Why not the Single Lens?", Ram Prasad, Sci. & Cul., 38, 170, 1972.

16. "Need for Job-orientation in Scientific Activities" Ram Prasad, Seminar "The Best Use of Scientific Talent in India" organized by the Society for Parliamentary Studies, New Delhi on June 3, 1972, BASWI, 3, 12, 1973.

17. "LENS Udyog Ka Vikas", Ram Prasad, (Hindi) Vigyan Pragati, 22, 162, 1973.

18. "Lenses in India", Ram Prasad, Souvenir of All India Seminar on Optical and Ophthalmic Industry (Small Industries Service Institute, New Delhi 110020) held in New Delhi on May 19-20, 1973, p-17.

19. "Need for Inter-disciplinary Approach to Science Planning" Ram Prasad, Symposium on Science Planning organised by CSIR Scientific Workers' Association at CDRI, Lucknow on April 14, 1973.

20. "Improved method for the determination of fluorine in fluorspar", M.R. Verma & K.K. Munjal, Research & Industry, 16, 215-6, 1971.

21. "Evaluation of Purity of Saffron", M.R. Verma, K.K. Munjal & J. Rai, Research & Industry, 16, 294-8,1971.

22. "Thermal analysis, Methodology & Standardisation", M R. Verma & K.K. Munjal, I.S.I. Bulletin, 23, 530-1, 1971.

23. "Ammoniacal Nitrogen in Fertilizers—Rapid assay method", M.R. Verma, J. Rai and K.K. Munjal, I.S.I. Bulletin, 25, 201-2, 1973.

24. "Investigation into the evaluation of agricultural materials", M.R. Verma, J. Rai and K.K. Munjal, I.S.I. Jubilee Session Delhi Seminar, S/4, 1972.

25. "Iron Through the Ages", M.R. Verma, Engineering World Oct. 1972.

26. "Consumer and the Scientist", M.R, Verma, Science & Culture, 39, 33, 1973.

27. "Thermal methods of analysis—a review of methods & applications", M.R. Verma, Instruments (India), 14-21. July 1971.

28. "Evolution System of Measurements" M.R. Verma, 15th I.S.I. Convention Coimbatore, Dec. 1973.

29. "Electron transport properties at low temperatures", M.S.R. Chari, Invited talk for Symposium on 'Thermal and Transport Properties at low temperatures—Indian Science Congress, Feb. 1972, Calcutta.

30. "Theory of the Kondo Anomaly in dilute magnetic alloys", R. Sundaram, Proc. of the Symp. on Thermal and Transport Properties of Metals and Alloys at Low Temperatures—Indian Science Congress, 1972, Calcutta.

31. "Pair Breaking Mechanism in Josephson Effect", R. Sundaram, Abstracts of the Solid State Symposium, organised by B.A.R.C., Bombay, 1972.

32. "Spin compensation in dilute Cu-Fe alloys at helium temperatures", R.G. Sharma and M.S.R. Chari, Solid State and Nuclear Physics Symp., Chandigarh, Dec. 1972—Jan. 1973.

33. "Scattering mechanisms in n-InSb at low Temperatures", Hari Kishan, Lakha Singh, M.S.R. Chari and R.B. Saxena, Solid State and Nuclear Physics Symp. Chandigarh, Dec. 1972—Jan. 1973.

34. "Use of He-Ne lasers for alignment", D. Sen, Proc. Ind. Nat. Acad, Sci., A37, p 257, 1971.

35. "Estimation of Calcium in Zinc-Manganese Ferrites by the X-ray Fluorescence Method" R.H. Bhawalkar, K.C. Nagpal & S.Z. Ali. Indian Journal of Technology. Vol. 10, pp 388-390, Oct. 1972.

36. "A method to determine the monolayer capacity (surface area) of microporous materials", P.T. John & V.K. Goyal, I.J. Tech., 11, No. 2, pp 90-1, 1973.

37. "Equation of State for adsorbed vapour", P.T. John & K.K. Datta, I.J. Tech., Vol. 10, No. 9, pp 358-360, 1972.

38. "Industrial application of particle size, pore size and surface area measurements", P.T. John & K.K. Datta, Chem. Age of India, Vol. 23, No. 2, pp 125-128, 1972.

39. "Rapid methods of chemical analysis of quality evaluation & maintenance—Pt II", V.M. Bhuchar & A.K. Agrawal, I.S.I. Bull., 25 Dec., 1973.

40. Rapid determination of copper, silver & gold in the mixture", V.M. Bhuchar & A.K. Sarkar, Ind. J. Tech., 11 Aug., 1973.

41. "Spectrophotometric determination of nitrites with L-thiol acetic acid", V.M. Bhuchar & V.K. Amar, Ind. J. Tech. 11 433, 1972.

42. "Rapid methods of chemical analysis of quality evaluation and maintenance—Pt I", V.M. Bhuchar, V.K. Amar J.C. Trehan, V.P. Kukreja, A.K. Sarkar, S.M. Khullar, I.S.I. Bull., 24, 399, 1972.

43. "Rapid methods of chemical control of products of trade", V.M. Bhuchar, Rasayan Vyapar, p 36, Jan. 1972.

44. "Rapid methods of chemical analysis", V.M. Bhuchar, World Science News, 8, 18, 1971.

45. "Noise and Noiseness", M. Pancholy, Proceedings of Symposium on Noise and Hearing, New Delhi, 1971.

46. "Traffic Noise in Indian Cities" S.P. Singal, Proceedings of Symposium on Noise and Hearing, New Delhi, 1971.

47. "Instrumentation for Noise Measurements", A.F. Chhapgar, Swasth Hind, 16-6, 170, June 1972.

48. "Acoustic Sounder for Probing the Lower Atmosphere" S.P. Singal & M. Pancholy, Proceedings of Science Congress, Calcutta, Feb. 1972.

49. "A Transistorised Swept Frequency Generator for the Ultrasonic Range", Dr. T.K. Saksena & Dr. M. Pancholy, sent for publication in J. Inst. Telecom. Engrs., India.

50. "Remote Sensing of the Troposphere using Sodar Technique", S.P. Singal, J. Acoust. Soc. India, 160, 1973.

51. "Contribution of NPL to Pollution Studies", S.P. Singal, Proc. Symposium on Environmental Pollution, Nagpur, Jan. 1973.

52. "Acoustic Sounder for Probing of the Lower Atmosphere", M. Pancholy and S.P. Singal, Indian J. Radio & Space Physics, 1, 202, 1972.

53. "Effect of Dissolved Salts and Reducing Agents on Sonoluminescence Intensity", M. Pancholy and M.A. Siddiqui, Ind. J. Physics, 54, 513, 1971.

54. "Remote Sensing of the Troposphere using Lidar and Sodar Techniques", S.P. Singal, Proceedings of Symposium and Advanced Course on Troposphere Propagation and Antenna Measurements, NPL, New Delhi, 1972.

55. "Strain Gauge Transducers for Measuring Blood Pressures", Ved Ram Singh & R. Parshad, Res. & Ind., Vol. 18, No. 2. pp 48-50, June, 1973.

56. "Use of Silicon Strain Gauge for Measuring Fluid Pressures", Ved Ram Singh & R. Parshad, Instruments India, May 1972.

57. "Semiconductor Strain Gauge Transducers and Their Applications", Ved Ram Singh and R. Parshad, Proc. Symp. on Electronics Electron Devices) Hyderabad, Vol. II, pp. 205-214, Feb.7-9, 1972.

58. "A Review of Strain Measuring Gauges Applied to Medical and other Industrial Problems", Ved Ram Singh, Instruments India, Vol. 6, pp 23-24, Aug. 1971.

59. "A Review of Tranducers for Physiological Applications", Ved Ram Singh, J. Instr. of Engrs. (India), Vol. 54 (Part IDGE-I) pp 17-24, Sept. 1973.

60. "An Application of Silicon Strain Gauge for Investigating Periodic Motion of Parts of Body with Breathing", Ved Ram Singh and R. Parshad, J. of Institution of Engineers (India), Vol. 54 (Part IDGE-I) pp 15-16, Sept. 1973.

61. "Detection of Rhythmic Movement of External Body Parts with Respiration Using Strain Gauge Instrumentation", Ved Ram Singh and R. Parshad, Proc. 3rd All India Symp. on Biomedical Engineering, Madras Nov. 27-29, 1972, pp 17-18.

62. "An integrating phase comparator for frequencies, standardisation and other applications", P.N. Taneja, T.N. Ghosh and Ram Parshad, J. Inst. Telecom. Engrs. Vol. 17, No. 9, pp 331-33, Sept. 1971.

63. "On the V-I Characteristics of Ge & Silicon Using Broad Pressure Contacts and a New Method of Determining the n or p type nature of silicon", S C. Mehta & R. Parshad, I.J. Pure & App. Phys. Vol. 9, No. 7, pp 490, 1971.

64. "The Use of Precision Slotted Line in Dielectric Measurements at Higher Frequency Ranges", K. Bhagyalakhshmi and B.K. Kataria, Part I, Vol. 17, No. 4, pp 131-34, J. Inst. Telecom. Engrs. 1971.

65. "Standardisation Improves Performance of Transistorised Radio Receivers", P.P. Jha, & Suresh Chandra & R Parshad, I.S.I. Bulletin, Vol. 23, No. 12, 1971.

66. "A Formula for Correlating Dielectric Constant of Powder and Bulk", D.C. Dube, R.S. Yadav & Ram Parshad, I.J. Pure & App. Phys., Vol. 9, pp 719-21, 1971.

67. "An Experimental Set-up Using Strain Gauge for Measuring Fluid Pressures in Medical and other Applications", Ram Parshad & Ved Ram Singh, Resear. & Ind., pp 116-118, June 1971.

68. "Recent Developments in the Use of Strain Gauge in Medical Field", Ved Ram Singh, Resear. & Ind., pp 13-17, March 1972.

69. "Engineering Applications of Semiconductor Strain Gauge", Ved Ram Singh, Resear. & Ind., pp 18-20, March 1972.

70. "What are Atomic Clocks", Harish Bahadur & R. Parshad, Science Reporter, 10, No. 9, 425-431, Sept. 1973.

71. "Basic Reference Standards", A.R. Verma, S.V. Gupta & P.C, Jain, Chapter 9 in the book entitled "Metric Change in India" Ed. L.C. Verman & J.N. Kaul, published by Indian Standards Institution, 1970.

72. "The influence of magnetosphere heat flux on the plasma temperature and composition in the topside ionosphere" B.C. Narasinga Rao, I.J. Pure & App. Phys., **9**, 501-03, 1971.

73. "Neutral atmospheric temperature from charged particle meansurements in the top side ionosphere", K.K. Mahajan and O.P. Sexena, INj. Pure & App. Phys. **9**, 516-18, 1971.

74. "Effect of magetic activity on cosmic noise absorption at 28.6 MHz", Sarma S.B.S.S. J. Pure & App. Phsy., **9**, 533-55, 1971.

75. "Recent progress in the study of ionospheric storms", Y. V. Somayajulu, J. Sci. Indus. Res., **30**, 394-407, 1971.

76. "Solar cycle variation of electron content over Delhi", Tuhi Ram Tyagi and Kamlesh Kumari Mittal, I. J. Pure & Appl. Phys., **9**, 504-08, 1971.

77. "Geomagnetic influence on long wave propagation", Y.V. Ramanamurty and V. R. K. S. Prakasa Rao, I. J. Pure and App. Phys., **9**, 546-47, 1971.

78. "Charges in electron content during the 25-26 May 1967 magnetic storm event", Y. V. Somayajulu, A. K. Sehgal, T.R. Tyagi and N.K. Negi, I. J. Pure and App. Phys , **9**, 548-52, 1971.

79. "Particle precipitation and random movements of ionization irregularities in E-region of the ionosphere", N. D Kaushika and M. C. Sharma, I. J. Pure and App. Phys., **9**, 656-58, 1971.

80. "Rocket measurements of D-region electron densities at the equator", Y. V. Somayajulu & M. B. Avadhanula, Ind. J. Radio and Space Phys., **1**, 81-83, 1972.

81. "Ionospheric electron content in subtropical region", Y. V. Somayajulu, Tuhi Ram Tyagi and N. K. Negi, I. J. Radio and Space Phys., **1**, 62-71, 1972.

82. "Techniques of reduction of ionogram to true-height electron density profiles", A. K. Saha and V. C. Jain, I. J. Radio and Space Phys., **1**, 52-56, 1972.

83. "Anomalous behaviour of F2 region during solar eclipse of September 22", R. Venkatachari, L. H. Sharma and D. K. Chakravarthy, I. J. Radio and Space Phys., **1**, 246-48, 1972.

84. "Sudden ionospheric disturbances", A. P. Mitra and C. B. Subrahmanyam, I. J. Radio and Space Phys., **1**, 93-171, 1972.

85. "Atmospheric radio noise intensities in the Northern and Eastern regions of India", I. J. Radio and Space Phys., **1**, 236-47, 1972.

86. "Electron cooling in the F2 region at low and midlatitudes", K. K. Mahajan and Sudesh Kumari, I. J. Radio and Space Phys,, **1**, 211-13, 1972.

87. "Cosmic radio noise absorption in the ionosphere; A review of results for the first two decades of riometry at low latitudes", S. B. S. S. Sarma and A. P. Mitra, I. J. Radio and Space Phys., **1**, 84-92, 1972.

88. "Electron temperature measurements from cosmic noise studies", S. B. S. S. Sarma and M. C. Sharma, I. J. Radio and Space Phys., **1**, 175 77, 1972.

89. "Thermal structure of the equatorial topside ionosphere", B. C. Narasinga Rao and Risal Singh, I. J. Radio and Space Phys., **1**, 151-153, 1972.

90. "Photoelectron escape fluxes over the equatorial and mid-latitude regions", B C. Narasinga Rao, Risal Singh and E. J. Maier, I. J. Radio and Space Phys., **1**, 198-201, 1972.

91. "Variation of F2-region electron temperature with solar activity as deduced from collision frequency measurement", B. M. Reddy, D. R. Lakshmi and R. Ramnadham, I.J. Radio and Space Rhys., **1**, 138-40, 1972.

92. "Study of the behaviour of the topside during sunrise from Alouette-1 and Alouette-II satellite data," D.R. Lakshmi and B.M. Reddy, I. J. Radio and Space Phys., **1**, 154-57, 1972.

93. "Electron density trough in the topside ionosphere and its relationship with the plasma pause position", B. M. Reddy and D. R. Lakshmi, I.J. Radio and Space Phys., **1**, 221-23, 1972.

94. "Escape altitude of ionospheric photoelectrons in the low altitude region", R.C. Bhatia and Y, V. Somayajulu, I. J. Radio and Space Phys., **1**, 148-50, 1972.

95. "Characteristics of large scale ionospheric irregularities over Delhi", S.K. Chopra, T. R. Tyagi and Y.V. Somayajulu, I. J. Radio and Space Phys., **1**, 224-26, 1972.

96. "The earth's near space environment", A. P. Mitra, J. Sci. & Indus, Res., **31**, 492-98, 1972.

97. "E-region electron temperature measurements—A Review", I.J. Radio and Space Phys.. **2**, 1973.

98. "Electron content measurements during magnetic storms at Kurukshetra", B.M. Reddy, D.R. Lakshmi Sant Prakash and J. B. Lal, I.J. Radio and Space Phys.. **2**, 26-29, 1973.

99. "Movement of Sporadic-E auroral zone between IGY and IQSY", I.J. Radio and Space Phys., **2**, 30, 1973.

Foreign Journals

1. "X-ray K absorption studies of Niobium, selenides and Tellurides", V.G. Bhide, and M.K. Bahl, J.P.C.S., 32/5, pp 1001-6.

2. "A sample holder for dielectric and electrical conduction studies in insulators", Krishan Lal & D.R. Pahwa, Rev. of Scientific Instruments, Vol. 42, No. 4, pp 534-35, April 71.

3. "A new method for reducing the sensitivity of an interferometer", D. Sen & C.P. Grover, Optica Acta, Vol. 18, No. 4, pp 305, 1971.

4. "Common path interferometer with compressive shear", D. Sen & C.P. Grover, App. Optics, Vol. 10, pp 182, May 71.

5. "Unit cell Data and expansion coefficients of Bismuth and Sellinotelluride", K.D. Kundra & S.Z. Ali, J. Phys. D. App. Phys., pp 685-89, May 71.

6. "Spectral distribution & colour of north sky at Bombay", V.D.P. Shastri & S.B. Manmohan, J. Phys. D. App. Phys. Vol. 4, 1971.

7. "Disffrimoscopic image formation under partially coherrent illumination (Straight edge)", S.V. Gupta, D. Sen, Optica Acta, Vol. 18, No. 7, pp 507-21, 1971.

8. "X-ray spectroscopic investigation of the Bismuth Selenide Telluride and their alloys", V.G. Bhide, B.A. Patki & A.S. Nigvekar, J.P.C.S., Vol. 32/7, pp 1565-71, 1971.

9. "Evaluation of colour changes of indicators", S.R. Das, V.M. Bhuchar and V.P. Kukreja, Jl. Amm. Chemical Soc., Vol. 43, Vo. 13. pp 1847-53, Nov. 1971.

10. "X-ray K emission spectra of niobium in niobium metal and some of its compounds", V.G. Bhide & M.K. Bahl, J.P.C.S., Vol. 33, 285-92, 72.

11. "Diffrimoscopic image formation under partially coherrent illumination (slits & opaque strips)", S.V. Gupta & D. Sen, Optica Acta, Vol. 18, No. 100, pp 779-92, 1971.

12. "Sn119 Mossbauer studies of lower transitions in Barium Titanate", V.G. Bhide and V.V. Durge, S.S.C., Vol. 10/5, pp 401-3, 1971.

13. "Crystallization in vacuum operated films", S.K. Sharma & O.P. Behl, J. Material Science, 6, pp 1326, 1971.

14. "Determination of vacuum jump frequencies from dielectric loss measurements on Ni -doped NaCl crystals", Krishan Lal D.R. Pahwa, Physical Review B, Vol. 4. No. 8, Oct. 1971.

15. "Cosmic noise absorption studies at Delhi over a solar cycle", S.B.S.S. Sharma & M.C. Sharma, Planet Space Science, Vol. 20, pp 253-59, 1972.

16. "A simple inverting interferometer", D. Sen & P.N. Puntambekar, Optica Acta, Vol. 18, No. 10, pp 719-28, 1971.

17. "Dark field images of slits & opaque strips under coherrent illumination", S.V. Gupta & D. Sen, Optik (Sonderaduk), 34, pp 519-27, 1972.

18. "Dark field diffrimoscopic images of periodic objects—partially coherrent illumination", S.V. Gupta & D. Sen, Optica Acta, Vol. 19, No. 2, 137-54, 1972.

19. "Dark field diffrimoscopic images of periodic objects—coherrent illumination", S.V. Gupta & D. Sen, Optica Acta, 19, pp 125-36, 1972.

20. "Structure & Electrical resistivity of thin amorphous Germanium films", S.K. Sharma, S.C, Jain, S.S. Aggarwal & V.G. Bhide, J. Non-crystalline Solids, 285-294, Vol. 7, No. 3, April '72.

21. "Mossbauer studies of high spin-low spin equilibria & the localised collective electron transition in $LaCo0_3$", V.G. Bhide, D.S. Rajoria and G. Rama Rao and C.N.R. Rao, Physical Review B, pp 1021, Aug. 72.

22. "The fine structure. In the K. Absorption Spectrum of Niolium", V.G. Bhide and M.K. Bahl, J.P.C.S., Vol. 33/9, pp 1669-74, 1972.

23. "Mossbauer effect for Fe^{57} in ferroelectric lead titanate", V.G. Bhide & M.S. Hegde, Physical Review B, pp 3488, Vol. 5, No. 9, 1972.

24. "Luminance Distribution of Tropical Sky", V.D.P. Sastri and S.B. Manamohanam, presented at the International Commission on Illumination held in Barselona in Sept. 1971.

25. "Thermogravimetric Studies of Thermal Insulation Composition Part-I, Basic Magnesium Carbonate—magnesia asbestos", M.R. Verma and J.C. Trehan, Zement, Kalk & Gips, 23, 39, 1971.

26. Nucleation and Growth of Silver Films on pure and doped substrates", S.K. Sharma and O.P. Bahl, J.J. Appl. Physics, 10, 375, 1971.

27. "Analysis of the Parquet theory for Kondo Problem", R. Sundaram, Journal of Low Temp. Physics, Vol. 12, No.1/2, 1973.

28. "Effect of Brownian Motion on the Mossbauer Line Shape", V.G. Bhide, R. Sundaram, H.C. Bhasin and T. Bonchev, Physical Review B. Vol. 3, No. 3, 673, 1971.

29. "Lorenz number of dilute Cu-Cr alloys at liquid helium temperatures", R.G. Sharma, M.S.R. Chari and N.S. Natarajan, Indo-Soviet Conference on Solid State Materials, Bangalore, December, 1972.

30. "Electrical resistivity and magneto-resistivity of n—InSb at Low Temperature", Hari Kishan, Lakha Singh, M.S.R. Chari, N.S. Natarajan and R.G. Sharma, Indo-Soviet Conf. on Solid State Materials, Bangalore, Dec. 1972.

31. "Effect of finite solute concentrations on electron transport anomalies of dilute magnetic alloys", M.S.R. Chari, N.S. Natarajan and R.G. Sharma, Indo-Soviet Conference on Solid State Materials, Bangalore, Dec. 1972.

32. "Variation of Kondo temperature with the nature and concentration of solute metal", M.S.R. Chari, N.S. Natarajan & R.G. Sharma, J. Low Temp. Phys. (U.S.A.), 10, 309, 1973.

33. "Effect of Annealing on the anomalous Electrical Resistivity of Dilute Copper-Iron Alloys at Low Temperatures" R.G. Sharma and M.S.R. Chari, J. of Low Temp. Phys., 13, Nos. 5/6, pp 555-571, 1973.

34. "Electronic Lorenz Number of Transition Metals at High Temperatures", M.S.R. Chari, (Miss) B.K. Reddy and Lakha Singh. The XIII International Conference on Thermal Conductivity, University of Missouri, Rolla, USA, November, 1973.

35 "Thermal Conductivity of Dilute Copper-Iron Alloys at Helium Temperatures", R.G. Sharma, M.S.R. Chari and Hari Kishan, The XIII International Conference on Thermal Conductivity, University of Missouri, Rolla, USA, November, 1973.

36. "The Dielectric response of the homogenous electron liquid in generalised random phase approximation : An analysis", J.S. Vaishya & A.K. Gupta, Phys. Rev. B 7, 4300, 1973.

37. "Two-point resolution for dark-field (diffrimoscopic) imaging system under partially coherent illumination", S.V. Gupta & D. Sen; J. Optica (India), 1, pp 16-21, 1972.

38 "Optical and Electron Spin Resonance Absorption Spectra of Manganate Ions in Alkali Halide", S. C. Jain, S. K. Agarwal & O. D. Sootha. J. Phys. Chem. Solids, Vol. 32, 897, 1971.

39. "Colloidal Metallic Particles in Non-Mettalic Crystals", S. C. Jain & G. D. Sootha, Enc. Dict. Physics, Suppl. 4, 1971.

40. "Transition Metal Impurities in Alkali Halides II ESR Absorption of 3rd Transition Metal Impurities", G. D. Sootha and S. K. Agarwal, Phys. Stat. Sol. (a)5, 293, 1971.

41. "Optical and ESR Absorption Spectra of Ytterbium in KGI and NaCl crystals" G. D. Sootha, T. C. Tripathi and S. K. Agarwal, Phys. Stat. Sol. (b)44, K61, 1971.

42. "ESR Absorption Spectra of Palladium in KI", G. D. Sootha, T.C. Tripathi and D.C. Parashar; Phys. Stat, Sol. (b) 48, K 45, 1973.

43. "Thermal cxpansion and phase transformation in B-In_2S_3" by K.D. Kundra and S Z. Ali, Abstracts of the International Conf. on Crystallography, Japan, August, 1973.

44. "Rapid Spectrophotometric determination of chromium & manganese in steels", V.M. Bhuchar & V.P. Kukreja ; Metallurgia & Metal Forming, 40, 91, 1973.

45. "Simultaneous Extrusion Process of Projector Carbon", S.S. Chari and J.N. Bohra, Carbon, Vol. 10, pp 747-750, 1972.

46. "Electrical Resistivity of the Core Mixes used in Projector Carbons", J.N. Bohra, Carbon, Vol. 10, pp 751-752, 1972.

47. "Acoustic Sounding of the Lower Atmosphere", Dr. S.P. Singal, Proceedings of Workshop on Atmospheric Acoustics, NOAA Environmental Research Lab., Bounder (Eolo), U.S.A., 1972.

48. "On the Utilisation of Bottcher' Formula for Correct Correlation of Dielectric Constant of Powder and Bulk", A.S. Yadav and R. Parshad, J. of Phys. D (App. Phys.), 4, 822-824, 1971.

49. "A Formula for Dielectric Correlation between Powder and Bulk over Wide Ranges of Permittivities and Packing", A.S. Yadav and R. Parshad, J. Phys. D., App. Phys. 5, 1469, 1972.

50. "Permittivity of Haterogenous Mixtures", K. Lal and R. Parshad, I. of Phys. D (App. Phys.), 6, 1363, 1973.

51. Use of Silicon Strain Gauge Transducer for Measuring Milligram Weights", Ved Ram Singh & R. Parshad, Instrument Practice (London) Vol. 1, No. 6, Sept. 1972.

52. "Observations on the Mechanical Strain in Quartz Crystals under Electric Field Using Strain Gauge Instrumentation and their Application for Determining the Goodness of Raw Quartz Crystals", R. Parshad and V.R. Singh ; The Twenty-sixth annual Frequency Controi Symposium on 6th, 7th and 8th June 1972 at Atlantic City, Proc. p, 104-105.

53. "An Experimental Method Using Strain Gauge for Detecting Small Movements of Structures Under Weight-Loaded Conditions", Ved Ram Singh and R. Parshad, paper presented for panel discussion at 6th Congress of the Intn'l Measurement Confederation" Dresden (G.D.R.) June 17-23, 1973.

54. "An Immersion Type Silicon Strain Gauge Transducer for Measurement of Column Heights and Pressures in Liquids", Ved Ram Singh and R. Parshad, Control and Instrumentation (London), July 1973.

55. "Use of Strain Gauge for Measuring Voltage", Proceed. of Ins. of Electronics & Electrical Engrs. Vol. 60, No. 6, June 1972.

56. "Effect of Magnetic Field on Sensitivity of Silicon Strain Gauges", V.R. Singh and Ram Parshad, J. App. Phys. pp 4827-28, No. 1972.

57. "Abnormal latitudinal distribution of the F2 layer critical frequency" M.N. Fatkulin, P.L. Malhotra and S. Aggarwal, Nature, Physical Sciences, **230**, No. 16, 171-72, 1971.

58. "Electron temperature dependence of F-region absorption", Sudesh Kumari and K.K. Mahajan, J. Atmosph. Terrest. Phys. (England), **33**, 1277-79, 1971.

59. "Ionospheric estimates of atomic oxygen concentration from charged particle measurements", K.K. Mahajan, J. Geophys. Res. (U.S.A.) **76**, 4621-29, 1971.

60. "Latitude variation of cosmic noise absorption", S.B.S.S. Sarma and M.C. Sharma, Planet. Space Sci., **19**, 1579, 1971.

61. "Electrons and positive ions density distribution with altitude in the equatorial D-region", A.C. Aikin, R.A. Goldberg, Y.V. Somayajulu and M.B. Avadhanulu, J. Atmosph. Terrest. Phys., **34**, 1483-94, 1972.

62. "Solar activity variation of $NO^+/02^+$ and NO^+/O^+ in the E and F regions", A.P. Mitra and P. Banerjee, Space Res., **12**, 1315-20, 1972.

63. "Cosmic radio noise absorption studies at Delhi over a solar cycle", S.B.S S. Sarma and M.C. Sharma, Planet. Space Sci., **20**, 253-59, 1972.

64. "Rocket measurements of conjugate photoelectrons during the total solar eclipse of 7 March 1970 over Wallops Island", E.J. Maier and B.C. Narasinga Rao, J. Atmosph. Terr. Phys. **34**. 689, 1972.

65. "Ionospheric effects of solar flares-I, the statistical relationship between X-ray flares and SID's", S.D. Deshpande C.V. Subrahmanyam and A.P. Mitra, J. Atmosph. Terr. Phys., **34**, 211, 1972.

66. "Ionospheric effects of solar flares-II, the flare spectrum below 10A deduced from satellite observations", S.D. Deshpande, and A.P. Mitra, J. Atmosph. Terr. Phys., **34**, 229, 1972.

67. "Ionospheric effects of solar flares-III, the quantitative relationship of flare X-rays to SID's", S.D. Deshpande and A.P. Mitra, J. Atmosph. Terr. Phys., **34**, 243, 1972.

68. "Ionospheric effects of solar flares-IV, electron density profiles deduced from measurements of SCNA's and VLF phase and amplitude", S.D. Deshpande and A.P. Mitra, J. Atmosph. Terr. Phys., **34**, 255, 1972.

69. "Ionospheric effects of solar flares-V, the flare event of January 30, 1968 and its implications", S.D. Deshpande and A.P. Mitra, S. Ganguly and V.C. Jain, J. Atmosph. Terr. Phys., **34**, 267, 1972.

70. "Tropospheric and ionospheric refraction errors in satellite over the Indian sub-continent", T.R. Tyagi, A.B. Ghosh, A.P. Mitra and Y.V. Somayajulu, Space Res., **12**, 1195-1203, 1972.

71. "D-region electron density by cosmic X-rays", A.P. Mitra and Y.V. Ramanamurthy, Radio Science, **7**, 67, 1972.

72. "Changes in ion chemistry in the D-region during solar flares", A.P. Mitra and J.N. Rowe, J. Atmosph. Terr. Phys., **34**, 795, 1972.

73. "Effect of modified thermal conductivity on the temperature distribution in the protonosphere", H.G. Mayr, E.G. Fontheim and K.K. Mahajan, Report X-621-72-107, Goddard Space Flight Center, Greenbelt, Maryland, U.S.A., pp. 1-10, April, 1972.

74. "Rocket measurements of conjugate photoelectrons during the total solar eclipse of March 7, 1970 over Wallops Island, B.C. Narasinga Rao and E.J. Meir, J. Atmosph. Terr. Phys., **34**, 689, 1972.

75. "A study of the equatorial D-region", Y.V. Somayajulu, M.B. Avadhanulu and K.S. Zalpuri, Space Res., **13**, 1973.

76. "Seasonal variation of atmospheric composition in the F-region as a function of solar activity deduced from electron content measurements", T.R. Tyagi, K.K. Mittal, A.P. Mitra and S. Prakash, Space Res., **13**, 1973.

77. "Estimate of thermospheric neutral constituents from ion composition measurements", A.P. Mitra and P. Chakrabarty, Space Research, **13**, 1973.

78. "Neutral composition and its variations in the lower thermosphere", K.K. Mahajan and Sudesh Kumari, Space Research, **13**, 299-306, 1973.

HONOURS AND AWARDS

1. Dr. V.N. Bindal received Invention Promotion Award for the development of Ultrasonic Transducers for automation, sensing and remote control applications.

2. Dr. V.N. Bindal received Award from Invention Promotion Board for the development of Ultrasonic Interferometer for velocity measurement in liquids.

3. Drs. P.C. Mehendru, D.C. Parashar, G.D. Sootha, S/Sh. Narendra Kumar and Devendra Singh received Award from Invention Promotion Board for the development of Electrostatic Photocopying Machine.

4. Drs. P.C. Mehendru, D.C. Parasher, G.D. Sootha, S/Sh. Narendra Kumar and Devendra Singh received Indian Merchants' Chamber Association Award for the year 1970 for the development of Electrostatic Photocopying Machine.

5. Dr. P.K. Ghosh, S/Sh. H.P. Narang and R.K. Kapoor received NPL Merit Award for the year 1972 for the development of Phosphors.

6. Sh. S.K. Kapur, Dr. S.S. Chari and Sh. C.L. Verma received NPL Merit Award for the year 1972 for the development of Cinema Arc Carbons.

7. Dr. A.P. Mitra, Scientist, presided over Physics Section in the Indian Science Congress, Calcutta (1972).

8. Sh. V.P. Kukreja was awarded Ph.D. Degree by Delhi University.

9. Sh. S.C. Mehta was awarded Ph.D. Degree by Delhi University.

LECTURES DELIVERED

S. No.	*Speaker*	*Subject*	*Date*
1.	Dr. Sobha Singh Bell Telephone Labs., USA	Non-Linear Optical Behaviour of ferro-electrics	1.9.71
2.	Dr. G.C. Kennedy, USA	Studies in High Pressures and Origin of Earth	3.9.71
3.	Dr. Sobha Singh Bell Telephone Labs., USA	Non-Linear Optical Behaviour of ferro-electrics	14.9.71
4.	Prof. G.W. Brindley Professor of Mineral Sciences, Pennsylvannia State University, USA	Thermal Reactions in some oxide systems	15.9.71
5.	Dr. Subramanian Bell Telephone Labs., USA	Laser Communications	13.10.71
6.	Dr. S.N. Vaidya Indian Inst. of Science, Bangalore	High Pressure Techniques	24.11.71
7.	Prof. F. Abeles Institute of Optics University of Paris	Optical properties of thin films	30.11.71
8.	Dr. Rishi Ray Asstt. Prof. of Materials Science, Dept. of Mechanical Engg., University of Colorado, Boulder, Colorado, USA	Some Aspects of High Temperature Deformation	23.12.71
9.	Mr. V.K. Gundetora A.M.F. Inc., USA	Hybrid Microcircuits	31.12.71
10.	Dr. R. Krishnan N.P.L. (DPEC) New Delhi	Megneto-Optical Effects in Ferrimagnetic Materials	6.1.72
11.	Dr. Motoharu Kimuru Director, Lab. of Nuclear Science, Tohoku University, Japan	Analysis of single crystals, powders, magnetic materials and amorphous substances using pulsed thermal neutrons	10.1.72

S. No.	Speaker	Subject	Date
12.	Dr. Indradev Bharat Electronics Ltd. Bangalore	R and D in B.E.L.	14.1.72
13.	Mrs. J. Nemcova State Research Institute of Material Protection Czchoslovakia	Activities of State Research Institute of Materials Protection	8.2.72
14.	Miss Gruffith Consultant to the British Electrical Research Institution	Cooling Effect in Refrigeration	7.3.72
15.	Prof. E.H.S. Burhop, F.R.S.	The responsibility of the Scientist in Contemporary Society	30.3.72
16.	Dr. Praveen Chaudhry IBM, USA	Mechanical Properties of Thin Films	20.4.72
17.	Shri A.V. Bapat Central Water and Power Commission, New Delhi	Formulation and Evaluation of Scientific and Technological Projects	14.6.72
18.	Dr. A.K. Bhatnagar USA	Study of fluctuation Effects on resistive transition to superconductivity in thin films above Tc	23.6.72
19.	Dr. John H. Hubhell	The activities of N.B.S.	16.9.72
20.	Prof. Ashok Ratnam	Super Conductivity at room temperature	23.9.72
21.	Dr. Waldo E. Smith	Geophysics in environmental problem	9.10.72
22.	Dr. G.C. Jain	Ferrites and their Parameters	11.10.72
23.	Astronaut Wally Schirra	Space Programme for the 70's	12.10.72
24.	Dr. M.M. Pradhan	External vibrations in some hydrated crystals	28.10.72
25.	Dr. Krishan Lal	Personal views on organization of scientific research in America	10.11.72
26.	Prof. E.W. Mueller	Field ion microscopy	4.11.72
27.	Mr. Simon Bourgin	U.S. Experience in Environmental control	9.11.72

S. No.	Speaker	Subject	Date
28.	Dr. V.J. Rao	Light emitting diodes	15.11.72
29.	Dr. S.Z. Ali	An outline of the standard Reference Materials at the NBS, USA	20.11.72
30.	Dr. K. Srinivasa Rao	Work done at Mat. science	24.12.72
31.	Dr. P.J. Deoras	Pollution	9.1.73
32.	Dr. V. Premanand	Integrated circuit fabrication	15.1.73
33.	D.C. Sharma	Fabrication and Uses of channel Electron Multiplier	17.1.73
34.	Prof. N. Nath	Ion implantation	20.1.73
35.	J.A.D. Mathews	Bands and Bonds	24.2.73
36.	Dr. Rustom Ray	Recent Development of Material Sciences and Engineering and Research in USA	24.2.73
37.	Dr. Krishan Lal	Diffusion of Radio Isotopes Traces of silver, indium and zinc in magnesium	2.3.73
38.	Dr. J. Szilard	Ultrasonics at Lough borough University of Technology	9.3.73
39.	Dr. P.N. Tiwari	Measurement of quantity and saturation of seed oil by pulsed N.M.R. spectroscopy	14.3.73
40.	Dr. R. Suryanarayanan	Optical and electrical properties of some semiconducting compounds	30.3.73

MEMBERS OF THE EXECUTIVE COUNCIL

Chairman

Prof. S. N. Bose, F.R.S.,
National Professor
22, Iswar Mill Lane
Calcutta-6.

MEMBERS

1. Dr. J. N. Bhar
   Director
   Institute of Radio Physics
   92, Acharya Profulla Ch. Road
   Calcutta-9

2. Prof. B. Ramachandra Rao
   Professor of Physics
   Andhra University
   Vishakhapatnam (A.P.)

3. Dr. D. S. Kothari
   Chairman
   University Grants Commission
   Bahadur Shah Zafar Marg
   New Delhi-1

4. Prof. B.D. Nag Chaudhuri
   Scientific Adviser,
   Ministry of Defence
   Govt. of India
   New Delhi-1

5. Prof. P. K. Kelkar
   Director
   Indian Institute of Technology
   Bombay

6. Dr. A. N. Ghosh
   Director-General (Retd.)
   Indian Standards Institution
   Manak Bhavan
   9, Bahadur Shah Zafar Marg
   New Delhi-1

7. Dr. Kartar Singh
   Chief Scientist
   Ministry of Defence
   Govt. of India
   New Delhi-1

8. Dr. R. K. Asundi
   Spectroscopy Division
   Bhabha Atomic Research Centre
   Trombay
   Bombay

9. Dr. A. Ramakrishnan
   Director
   Institute of Mathematical Sciences
   Central Polytechnic Buildings
   Madras-20

Ex-Officio Members

10. Director-General
    Scientific & Industrial Research
    New Delhi

11. Financial Adviser
    Council of Scientific & Industrial Research
    New Delhi

12. Director
    National Physical Laboratory
    New Delhi

Non-member Secretary

Administrative Officer
National Physical Laboratory
New Delhi-12

SUB-COMMITTEE FOR THE DEVELOPMENT-CUM-PRODUCTION UNIT OF ELECTRONIC COMPONENTS

Chairman

Dr. A. R. Verma
Director
National Physical Laboratory
Hillside Road
New Delhi

MEMBERS

1. Dr. A.N. Ghosh
Director-General (Retd.)
Indian Standards Institution
9, Bahadur Shah Zafar Marg
New Delhi

2. Dr. D.Y. Phadke
Head, Technical Physics Division
Tata Institute of Fundamental Research
Colaba, Bombay-5

3. Shri P.N. Deobhakta
Development Officer
Dte. of Technical Development (DGTD), Udyog Bhavan
New Delhi

4. Dr. G.N. Acharya
Scientist
CEERI, Pilani

5. Representative of Director General Scientific & Industrial Research
Rafi Marg
New Delhi-1

6. Representative of Development Commissioner for Small Scale Industries

7. Col. V.M. Bhide
Chief Commercial Manager
Bharat Electronics Ltd.
Bangalore-13

8. Financial Adviser to CSIR
C/o Ministry of External Affairs
Room No. 61, South Block
New Delhi

Convener

Officer Incharge
D.P.E.C., N.P.L.
New Delhi.

MEMBERS OF THE SCIENTIFIC SUB-COMMITTEE

Chairman

Dr. A. R. Verma
Director
National Physical Laboratory
Hillside Road
New Delhi-12

MEMBERS

1. Dr. J.N. Bhar
   Director
   Institute of Radio Physics
   92, Acharya Profulla Ch. Road
   Calcutta-9

2. Dr. B. Ramachandra Rao
   Prof. of Physics
   Andhra University
   Vishakhapatnam (A.P.)

3. Dr. A.N. Ghosh
   Director-General (Retd.)
   Indian Standards Institution
   Manak Bhavan
   9, Bahadur Shah Zafar Marg
   New Delhi-1

4. Prof. B.D. Nag Chaudhuri
   Scientific Adviser
   Ministry of Defence
   Govt. of India
   New Delhi-1

5. Dr. Kartar Singh
   Chief Scientist
   Ministry of Defence
   Govt. of India
   New Delhi-1

6. Dr. R.K. Asundi
   Bhabha Atomic Research Centre
   Modular Laboratories
   2nd Floor
   Trombay, Bombay

Non-member Secretary

Scientist-in-charge
Planning & Liaison Division
National Physical Laboratory
New Delhi

SUB-COMMITTEE FOR THE GLASS TECHNOLOGY UNIT

Chairman

Dr. A. R. Verma
Director
National Physical Laboratory
Hillside Road
New Delhi

MEMBERS

1. Shri V.P. Gupta
   Managing Director
   M/s Hicks Thermometer Ltd.
   Mussoorie U.P.

2. Shri K.D. Sharma
   Director
   C.G. & C.R.I.
   Calcutta-32

3. Dr. M.L. Joshi
   Glass & Ceramic Expert
   JG Glass Industries Pvt. Ltd.
   Atur House
   16-A, Wellesley Road
   Poona-1

4. Shri J.N. Sharma
   Proprietor
   Indian Neon Signs
   25/1-Asaf Ali Road
   New Delhi

5. Shri Harbans Singh
   S. Paul & Co.
   42, Basti Harphool Singh
   Delbi-6

6. Representative of Director-General
   Scientific & Industrial Research
   New Delhi

7. Shri Lalit Mohan
   Administrative Officer
   National Physical Laboratory
   New Delhi

8. Financial Adviser to CSIR
   C/o Ministry of External Affairs
   Room No. 61, South Block
   New Delhi

Convener

Glass Technologist
National Physical Laboratory
Hillside Road
New Delhi

MEMBERS OF THE BUILDING & FINANCE SUB-COMMITTEE

Chairman

Dr. A. R. Verma
Director
National Physical Laboratory, New Delhi

MEMBERS

1. Secretary
   C.S.I.R.
   Rafi Marg
   New Delhi

2. Principal Architect
   C.S.I.R.
   Rafi Marg
   New Delhi

3. Dr. Kartar Singh
   Chief Scientist
   Ministry of Defence
   Govt of India
   New Delhi

4. Financial Adviser to CSIR
   C/o Ministry of External Affairs
   Room No. 61, South Block
   New Delhi

Non-member Secretary

Administrative Officer
National Physical Laboratory
Hillside Road
New Delhi