ANNUAL REPORT

1970-71

ONAL PHYSICAL LABORATORY - NEW DELHI

CONTENTS

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INTRODUCTION

The report presents highlights of the laboratory for the year 1970-71. Significant achievements and many forward marks were made in the scientific activities of the laboratory. Maintenance of national standards for physical measurements is a statutory obligation of the NPL. The laboratory continued to maintain the primary standards for base and derived units to internationally accepted accuracy. Efforts were put to envolve new standards and to improve the accuracy of the standards being maintained. The laboratory also supplies secondary standards to the industries, research laboratories and various Government organisations for use at their premises.

NPL being the custodian of national standards has the responsibility to undertake testing and calibration for industries, research laboratories, Defence, Govt. Deptts., etc. The increasing importance of the activity could be judged from the fact that 2724 test certificates/reports were issued during the year compared to the last year's figure of 2436. There was increase in the earnings also from Rs. 1.450 lacs in the year 1969-70 to Rs. 2.007 lacs in 1970-71

Applied research and developmental work continued to receive emphasis. This year, as many as nine processes were developed and passed on to the NRDC for commercial exploitation, of which seven processes were released to industry. These are cinema arc carbons, electrostatic photocopying machine, film thickness monitor and controller, ultrasonic interferometer for velocity measurements in liquids, linear drive for Mossbauer spectrometer, Microwave components (C/XN band), broad band ferrite isolators for microwave applications. The technology of fabricating Cathode Ray Tubes and T.V. Picture Tubes has been developed which will help the TV manufacturers in the country to produce cheaper TV sets. The phosphor used for cathode ray tubes and TV picture tubes has also been indigenously developed at the NPL.

The scientists entrusted with the task of developing photocopying machine received an Award from the Inventions Promotion Board.

As a result of indigenous production due to the processes developed by the laboratory, foreign exchange to the tune of

Rupees 40 lacs was saved during the year bringing the tangible foreign exchange saving to a total of of Rs. 3.50 crores. In addition to savings in foreign exchange, the laboratory has rendered benefits to the nation, by way of, maintenance of standards, testing and calibration, generation of knowledge through publication of papers, patents, advisory services, training facilities, etc. which are not quantifiable.

In the field of oriented basic research problems relating to standards, testing and R&D were pursued. Special mention could be made of Mossbuaer studies on ferroelectrics and anti-ferroelectrics, Brownian Motion, Josephson radiation for establishing voltage standard and transport properties of dilute magnetic alloys.

The NPL has a strong group carrying out research in the area of Radio Science. The group renders active data propagation services in the fields of solar, geophysical and ionospheric Physics. Investigations carried out in aeronomy, ionospheric physics and solar terrestrial physics revealed significant results. A new riometer with a fairly narrow beam of 10° at 40 MHz has been designed and fabricated to study the absorption at oblique incidence. A symposium on 'Ionosphere-Magnetosphere Interactions' was organised which was attended by a large number of Indian as well as International delegates.

In pursuance of the recommendations of the Executive Council, the laboratory was reorganised into the following groups for better internal coordination and administration.

(i) Standards and Testing ;
(ii) Test and Evaluation Centre, Electricity and Electronics ;
(iii) Specialised Techniques ;
(iv) Materials and Carbon ;
(v) Developmental Projects ;
(vi) Oriented Basic Research ;
(vii) Radio Science ; and
(viii) Pilot Plants

DR. A. R. VERMA
DIRECTOR

STANDARDS

In order to achieve uniformity and reproductibility in the measurement of physical quantities all over the world, the international organisation, the General Conference on Weights and Measures defines from time to time standards for physical measurements. There are six base standards of length, mass, time, electric current, temperature and luminous intensity. The standard for each of these quantities has to be maintained or realised according to the specifications laid down by the international organisation. The maintenance of standards is a time-consuming, highly skilled and expensive activity justifiably undertaken by all major countries because the ultimate accuracy achieved in any industrial product is determined essentially by the accuracy with which the national standards are maintained. The maintenance of standards has an equally important role to play in every day commerce. The maintenance of standards as per international specifications is not a static activity like storing an article in a museum, but a highly dynamic scientific activity requiring highest competence in physics. Internationally, there is a trend to replace physical objects as standards by relating them to fundamental quantum phenomena. Outstanding examples of these are the definition of metre in terms of wavelength of light of krypton 86 and definition of time by the Caesium atomic clock.

Besides these base standards, a need is felt for derived standards such as those for voltage, force, power, pressure, etc. These standards are derived with reference to the primary standards. Primary concern in maintaining standards at NPL has essentially been the need of the industry. Thus, for example, with the rapid growth of electronics industry in the country a need was felt both by industry and defence to have electronic standards especially, microwave power, frequency and r.f. voltage. Realising these pressing needs of the country, the NPL has recently established the radio frequency voltage, microwave power and microwave impedance standards.

Electrical Standards

Resistance Standard : 24 sets of readings of eleven '1' ohm, standard resistances are maintained under controlled temperature at 20°C and intercompared periodically. The accuracy of the standard so maintained is better than one part in a million. Resistors of 0.01, 0.1, 1, 10, 100, 1000 ohm already fabricated are also maintained. The accuracy of the standard is 1 part in a million.

M.E.F. Standard : The standard consisting of 13 Weston Cadmium Cells is maintained under controlled temperature at 20°C. The accuracy of the standard is 1 part in a million.

Capacitance Standard: A national standard is being set up for capacitance. Thompson-Lampart type of computable standard capacitor has been designed and it is under fabrication. A number of 3-terminal temperature-compensated type capacitors of different denominations have been fabricated. Some standard capacitors are being procured from abroad. These standard capacitors which are being fabricated and are being procured will be set up in a dust free, temperature-humidity controlled chamber.

Derived Standard of Electrical Energy : A standard is being set up for electrical energy. Several million energy meters (watt hrs/kilo watt hrs) used for domestic and industrial purposes are being checked against precision energy meters for the calibration of which proper facilities are not available in the country. It is estimated that 1500 precision energy meters may be received every year by NPL for calibration against the standard. Instrumentation connected with this has been almost completed. At present single phase and three phase watt hour-meters can be calibrated with an accuracy of 0.25 per cent.

Electronic Standards : R.F. voltage standard is being maintained with 2% accuracy. The R.F. voltage is correlated with D.C. voltage, the standard for which is available in the form of standard Cadmium Cells. To improve the accuracy further, a R.F. voltage standard similar to the National Bureau of Standard, USA is being set up. The equipment has been designed and fabricated and efforts are being made to make thin film coated holovac discs which have a positive temperature coefficient of resistance.

Microwave Power Standard (10GHz) is being maintained with accuracy of ±2% and it is being used to calibrate bolometer mounts and power meters for various organisations.

Facilities exist at present for measurement of impedance and calibration of V.S.W.R. meters to an accuracy of ±2%. Work is in progress to improve the accuracy so that impedance can be measured with an overall accuracy of ± 0.5% and standing wave ratios can be measured upto the lowest value of 1.005.

Time and Frequency : A chain of three quartz oscillators is maintained at 100 KHz and frequency multiplication and division is done to obtain 10 MHz for broadcast and 1000 Hz tone and 1 second pulse for modulation. The foreign stations are monitored daily and time signals are matched and broadcast. The accuracy of the standard is one in 10^8.

Radiometric Standard: It is aimed at building up an absolute radiometer to serve as a standard of irradiance measurement. Design of the absolute radiometer has been made and some of its components are under fabrication.

Spectro-radiometric Standard: The country is on the threshold of large scale production of photo-receptors of all the three types, photo-voltaic, photo-conductive and photo-emission. To specify spectral sensitivity of photo receptors, it is essential to calibrate them against a standard for relative spectral radiance. Work is in progress to set up this standard based on absolute irradiance measurement.

Photometric Standard: There is a growing demand from the lamp industry in the country for the supply of working standards for the quality control of their products. Calibrated lamps are being supplied to industries, research laboratories, etc.

TESTING AND CALIBRATION

With the rapid industrialisation of the country it has become necessary to enforce quality control of industrial products. The need for quality control is more essential in the context of generating export potential. Since the NPL is the custodian of the national standards, the laboratory undertakes developmental testing and calibration work in various spheres of industrial activity. The testing undertaken by the laboratory is classified into three categories :

1. Testing and Calibration against S.I. system of units and against standard specifications laid down by ISI and other standard specifications.

2. Life and Environmental Testing.

3. Testing of the purity and perfection of materials.

During the year, the laboratory undertook testing for performance of a wide variety of industrial products, measuring instruments, prototypes, etc. and issued 2724 test certificates and earnings on account of test fees amounted to Rs. 2,00,750.15. The scientists of the laboratory advised the industry to improve their products on the basis of performance evaluation.

As the technology develops it becomes important to undertake life and environmental testing in addition to performance and calibration. India is a vast country having extreme climatic conditions at different locations and as such it is essential to carry out simulated tests for equipment, components etc. under tropical conditions. To start with facilities are being set up for testing electrical and electronic components. The Test and Evaluation Centre is being set up on the recommendations of the Electronic Committee to cater to the needs of the industry in the Northern Region. Many East European countries like USSR, Czechoslovakia, Hungary, Bulgaria and Rumania have expressed interest in the investigations proposed to be taken up by the field stations in various parts of the country to study the behaviour of the various products under tropical conditions. NPL has been requested to render assistance in setting up these field stations, collecting the field test data and correlating them with accelerated test data.

As technology develops, need for purer and still purer material is felt. In addition, in certain industries there is a demand for newer materials with required specifications. Thus, for example, in the technology of solid state devices it is essential to know the purity and perfection of materials to a very great accuracy. An impurity of the order of few parts per billion is at times enough to shelve the material useless for device fabrication. The stringency on the tolerance of properties of materials used in aeronautical industry is even greater. Indeed in almost all sections of industry it has now become necessary to know the purity of materials to a high degree of accuracy. At times it is not enough to know the impurity content but it is essential to know in what state it exists, what is the site symmetry etc. Various sophisticated techniques have been developed to facilitate investigations, such as, X-ray diffractography and spectroscopy, electron spectroscopy, Mossbauer spectroscopy, mass spectroscopy, infrared spectroscopy, etc. The laboratory provides specialised facilities to industry and to research institutions besides itself for the development of new materials. The type of samples investigated include MnO_2, ores, devitrified glass, diatomaeous earth sample, ferrites, graphitized carbons, ZnS phosphors, TiO_2, clays, filter aids, bacteria phage & fungal virus, metal samples, biochemicals, etc.

Consultancy

In addition to developmental testing and calibration work, the laboratory also helps the industry to set up their own testing facilities. Advice is rendered in regard to selection of test equipment, training of personnel, development of test procedure etc. Some of the special equipment which are not commercially available, are designed and fabricated for supply to industry. Examples are equipment for testing helmets, set up for clinical thermometers, resistance thermometers, integrating sphere, thermal conductivity apparatus, thermocouple comparator etc.

Collaboration with ISI

The scientists of the laboratory actively collaborate with ISI for framing specifications. They are represented on a large number of ISI committees. Advice rendered by the NPL scientists to ISI in framing specifications is backed by a large amount of experimental work. Methods developed by NPL have been incorporated in the ISI specifications.

STATEMENT SHOWING THE TEST FEES EARNED AND THE NUMBER OF TEST REPORTS ISSUED DURING THE YEAR 1970-71

Name of the Division	*No. of Test Reports Issued*	*Testing Fees Earned*
Acoustics	53	7,519.00
Analytical Chemistry	129	12,935.00
Basic Physics (Low Temperature)	1	3,200.00
Carbon Plant	4	321.50
D.P.E.C. Unit	43	3,843.68

Electricity	226	18,232.34
Electronics	20	2,394.34
Electron Microscope	7	3,236.00
Heat Standards	113	2,500.00
Infra-red	1	60.00
Mechanics	504	34,690.00
Microwave	462	10,525.00
Optics	94	19,471.35
Platinum Thermometry	1	600.00
Weights & Measures	1058	75,221.94
X-ray	8	6,000.00
Total	2724	2,00,750.15

STATEMENT SHOWING THE MISCELLANEOUS SALES DURING 1970-71

S.No.	*Particulars*	*Amount*
1.	Acoustic Interferometer	3850.00
2.	Alkali Halide Crystals	323.90
3.	Chemicals for colour transmission on Glass	2035.00
4.	Coating of mirrors	806.85
5.	Distilled water	12.60
6.	Helium-Neon Laser	3000.00
7.	Ice Point apparatus	506.90
8.	Photometric Integrating Sphere	7550.00
9.	Jobs done by workshop	7570.70
10.	Lapping of spinerrettes	400.00
11.	Liquid Air	4900.50
12.	Liquid Nitrogen	561.00
13.	Microwave Components	43062.75
14.	Moire Grids	359.80
15.	Mossbauer Linear Drive Unit	5000.00
16.	Process Carbons	39969.60
17.	Projector Carbons	15692.27
18.	Repairs and Rennovation of Traffic Signals	3653.00
19.	Repairs and Servicing of Instruments	3125.00
20.	Sample Holders for Dielectric Cell	1500.00
21.	Sale Service and Repairs of Metal Detector	2616.98
22.	Triple Point of Water Equipment Cell	1750.00
23.	Calibration Block for Ultrasonic Flaw Detector	766.00
	Total	149012.85

APPLIED RESEARCH AND DEVELOPMENTAL WORK

Instead of choosing short term problems in applied physics, sustained efforts are made to develop technologies which would suit Indian conditions utilizing as far as possible indigenous raw materials. This requires a high degree of scientific competence. The laboratory has concentrated its efforts in the past 5-6 years on electronic components, materials ana sophisticated equipment and instruments.

Metrological and Diffraction Gratings

The development of metrological gratings is a part of the more comprehensive project that the NPL has taken up under the more general title, 'Development of metrological and diffraction gratings'.

Metrological gratings are amplitude gratings and have a line density ranging from 4 lines/mm to 100 lines/mm. Such gratings are used essentially for accurate measurements of linear and angular displacements and as such find extensive applications in strain analysis and machine tool control. Machine tool control gratings are gratings made on high resolution photographic plate by the flash technique and are strips about 40 mm wide and 250 mm to 400 mm long.

Apart from linear gratings, radial gratings also are used in machine tool control. For purposes of strain analysis the useful range is from 20 lines/mm to 40 lines/mm. Gratings for strain analysis have large size ranging from 200 mm × 300 mm to 400 mm × 500 mm and are made on photographic film. In strain analysis it is found useful to use also orthogonal, triangular and circular gratings.

The first phase of the work at NPL consisted of making large size linear gratings for strain analysis. The starting point for making these gratings is the grating strip with the required line density. A linear machine has been designed and fabricated which uses these grating strips to make large size gratings. The machine is shown in Fig. 1.

The Laboraiory is now in a position to supply gratings of 20 and 40 lines/mm for strain analysis work.

The laboratory has itself taken up a research project entitled 'strain investigation on round over size inclusion in flat plates'. Both plastic and metallic specimens have been used in these investigations. For metallic specimens the KPR technique of reproducing gratings on the surface has been developed.

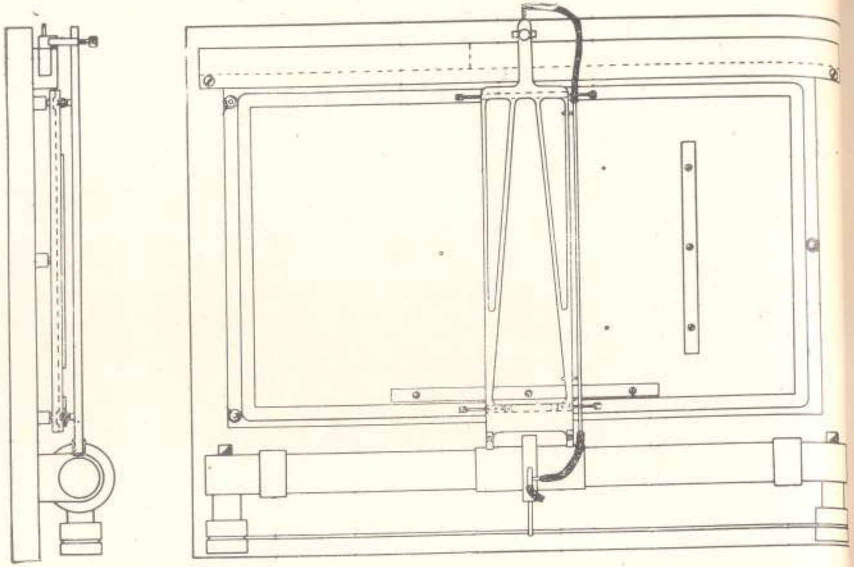


Fig. 1 Linear Machine designed and fabricated at NPL can make gratings of 20 and 40 lines/mm for strain analysis work.

Work on the design of the circular machine for producing circular gratings and the crossing jig for making orthogonal and triangular gratings is in progress.

Lang Camera for X-ray Diffraction Topography

In the present day semiconductor technology information about the nature and amount of lattice imperfections at a microscopic scale has become vital to improve the quality of devices. This information about lattice imperfections has become even more important than the macroscopic physical parameters like electrical conductivity. X-ray diffraction topography is a high resolution non-destructive tool used in point to point study of lattice imperfections in nearly perfect crystals. Therefore fabrication of a Lang Camera for X-ray topographic studies has been undertaken. The following investigations can be carried out using this camera :

1. The detection of grain boundaries and determination of the angle of misorientation between adjacent grains;
2. The detection of low angle boundaries in crystals and determination of the amount and direction of misorientation between adjoining subgrains;
3. Observation of individual dislocations and their classification into edge and screw dislocations; determination of density of dislocations;
4. Study of impurity aggregates in nearly perfect crystals.

A Lang Camera for recording section topographs has been successfully designed and fabricated. A schematic view of the camera is shown in Figure 2. The camera essentially consists of the following parts :

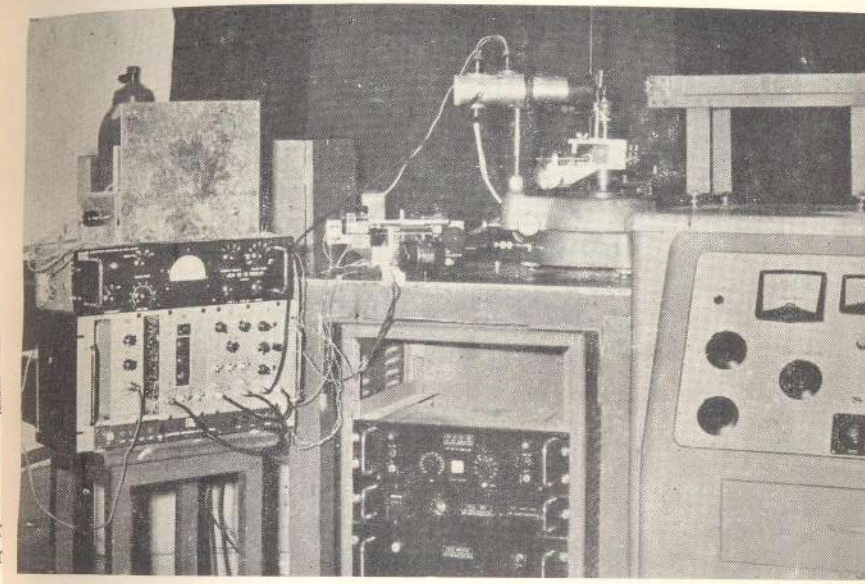


Fig. 2(a) The X-ray Diffraction Topography Camera designed and fabricated at NPL.

1. *Collimating Slit System :* It is a 50 cm long lead clad aluminium conduit whose one end is open and other end has two slits. One of the slits is a verticle slit of fixed width, which defines the width and angular divergence of X-ray beam irradiating the crystal. Three such slits with width 12 μm, 50 μm and 100 μm have been fabricated. The other slit is a horizontal slit of variable width varying from 0 to 25 mm. This second slit defines the height of the incident X-ray beam. The whole system has been designed and fabricated.

2. *Crystal Rotation Unit* : A research spectrometer manufactured by an Indian Manufacturer has been converted into a crystal rotation unit by suitable modification. The crystal is mounted on a goniometer head which is mounted on the central spindle of the Crystal Rotation Unit. It can provide measurable rotations of the central spindle and one radial arm of—20" of arc.

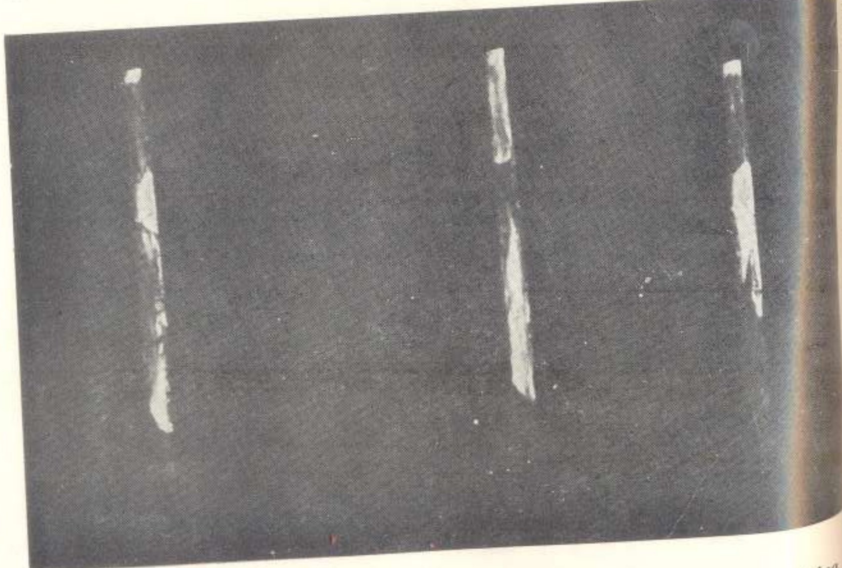
3. *X-ray Detector :* X-rays are being detected by using a scintillation counter. The scintillation counter was fabricated here starting with a 13 stage photomultiplier tube (EMI 9415B). ZnS (Ag) phosphor made in the National Physical Laboratory was used as a scintillating material. The photomultiplier tube with phosphor coated glass is mounted in a casing whose back part houses the cathode follower. The intensity is measured with indigenously available counting system.

4. *The plate holder and Second Slit Systems :* The plate holder to suit the size of X-ray dental films and nuclear emulsion plates has been mounted on a slide. By moving the slide, more than one topographs can be recorded on the same film or plate. This is of great help when comparative studies are to be made. The second slit is placed between the crystal and the photographic film or plate. It permits to pass through only that diffracted beam for which crystals have been oriented. This improves the resolution in final image. Similar to plate holder this slit is also mounted on a slide.

5. *Traversing mechanism :* This mechanism provides a to and fro motion to crystal and the photographic plate. In this way entire crystal of diameter upto 25mm can be scanned. The mechanism has been designed completely and is being fabricated.

Section topographs of Si, LiF, KBr and NaCl crystals have been successfully recorded in transmission and reflection. Detailed studies of lattice misorientations in some Si crystals have been made.

Figure 2b shows section topographs of a LiF crystal. The right hand side topograph was recorded after rotating the crystal by $\approx 2'$ of arc, from the position at which the left hand side topograph was recorded, Both the topographs can be roughly divided into three regions. In the left side topograph the upper and the lower regions are diffracting and in the middle a small portion is not diffracting. In the right side topograph, it is the small portion in the middle a small portion in the middle that is diffracting and the upper and the lower portions are not



Fig, 2(b) Section topographes of a Lithium Fluoride Crystal taken after giving small incremental rotation to the crystal. These topographs were recorded by the camera developed at the laboratory.

diffracting. Therefore, a rotation of $-2'$ makes the non-diffracting portion in left topographs, diffract and vice. This shows that the misorientation between the middle and the other portions of this section of the crystal (i.e. the upper and lower portions of the crystal) is approximately—2' of arc. Further variation of intensity is obvious within the diffracting portion of the topograph. This shows the presence of defects like low angle boundaries which have smaller misorientations of the order of few seconds of arc.

Thin Films

The purpose of this project is to develop the technical know-how for the preparation of various types of thin film optical devices and also to carry out oriented basic research wherever necessary, The thin film optical devices operate mainly on the principle of interference between light beams satisfying certain conditions of amplitude, phase and frequency. While analysing the operation of such devices one has to keep in view three basic characteristics of light beams reflected normally at the boundary separating two media of different refractive indices. The most important step in the fabrication of thin film optical devices is to control precisely the thickness and uniformity of the film layers. This is the basic requirement of any thin film optical application. Techniques have been developed to obtain uniform coatings by suitable orientation of the source and substrate geometry and also by introducing planetary rotation of each substrate during the process of film deposition. The film thickness is monitored by allowing a beam of white light to pass through the growing layer of dielectric, which after passing through a filter of desired wavelength is received on a photomultiplier, the output of which is fed to a detector. Each minima and maxima indication on the detector corresponds to a film thickness change by a quarter wave. This is the optical method of monitoring the thickness.

The films are prepared by evaporating successively desired materials under vacuum. After the preparation of a device, its optical characteristics are tested using a spectro-photometer.

Technical know-how has been developed for the fabrication of following devices :

(1) Metal-dielectric-metal filters
(2) Induced filters
(3) All dielectric filters
(4) High reflection coatings, both metallic and all dielectric type
(5) Beam splitters
(6) Single layer and double layer anti-reflection coatings
(7) Colour coating of sunglasses
(8) Electronic Thin Film Thickness Monitor and Controller

Phosphors

During the last few years, much emphasis was given to preparati and development of pure materials used in the electronic industry f the manufacture of electronic and photo-electronic devices. The materials are the Group IV elements (Si, Ge, C etc.) Group II- compounds (Zns, CdS, ZnSe etc) Group III-V compounds (GaAs, Ins GaSb etc.). Among these, group II-VI compounds form a spec class of materials called phosphors which, suitably treated with impurity, can emit light of different colours under excitation w invisible radiation e.g. ultraviolet rays, electrons etc. This proper is extensively utilized in photoelectronic devices such as CRO scree television picture tubes, image converters and radar display tub In all these devices, phosphor screen is excited by a modulated electr beam thereby making the modulations (TV picture, CRO waveform radar trace) visible. Energy conversion efficiency of such phospho is very small but luminous efficiency is infinitely large since invisi radiation is converted to visible radiation. For practical purpos the luminous efficiency of a phosphor is measured with respect to t sensitivity of the eye and is. therefore, an arbitrary measure. T brightness, decay and colour of a phosphor are chosen keeping in vi comfort and appeal to the viewers eyes.

In NPL, the main activities of the phosphor group are indigen preparation of the sulphide (e.g. Zns, CdS), selenide (ZnSe) and silic (Zn_2SiO_4) type of phosphors, and testing of these phosphors under l and cathode ray (electron) excitation for their performance. Elect luminescent phosphors which emit visible radiation under the act of an applied field have also been made.

The method of preparation of the phosphors consists of th stages, purification, processing and activation. The starting material varying purity is invariably indigenous. A purification procedure has b developed which includes group separation technique and ion excha purification to purify the starting material to the same level of pu for reproducibility of the final phosphor. The starting material for ZnS is ZnO which is converted to its highly water-soluble chloride fo purified and then precipitated with H_2S. The procedure for CdS similar. Zn_2SiO_4 is prepared from ZnO and SiO_2 by high tempera reaction after individual components are separately purified. Zn prepared from pure $ZnSO_4$ solution and Se by precipitation.

First of all, the pure material is heated at high temperature quartz boats and tubes in different atmospheres with a view to rem some impurities and thereby improve its stoichiometry.

In the final stage, suitable impurities are introduced in the mate at high temperatures in suitable atmospheres. ZnS (cubic) activ with copper ($\approx$ 100 ppm) produces an intensly green, medium de ($\sim$ 1 ms) phosphor. Ag in ZnS produces a fast decay ($\approx$ 200 μS) phosphors. Varying amounts of CdS in Ag activated ZnS prod phosphors of colours ranging from blue to red. ZnSe with Cu is phosphors of colours ranging from blue to red.

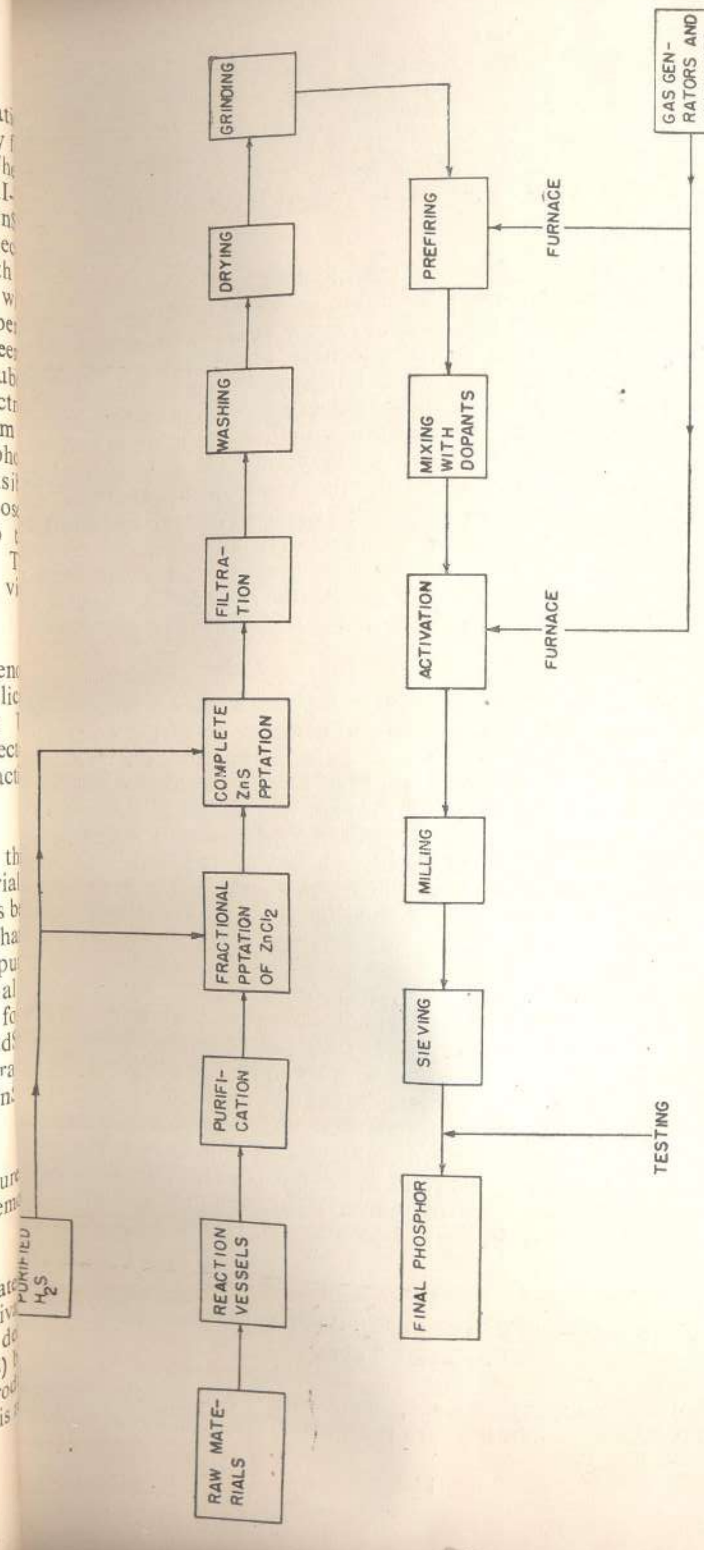


Fig. 3 Process Flow Sheet for the production of Sulphide Type Phospors.

Zn_2SiO_4 is a medium decay ($\approx$ 1 ms) green phosphor which is speciall suitable for low voltage cathode ray oscilloscope. A mechanical mixtu of blue and yellow Ag-activated phosphors produces a white materi used for television screens. A two layer phosphor screen is used fo radar using a first layer of ZnS-Ag and a second layer of ZnS-C (hexagonal). Figure 3 gives a process flow chart for the sulphide typ phosphors.

Testing the phosphor for brightness, colour and persistence, is a integral part of the preparation. Preliminary testing of the materi under ultraviolet radiation is conducted at every stage of the preparatio by visual means. More precise measurement of brightness (total ligh output), persistence (decay time) and colour (peak wavelengths) is don under U.V. or electron excitation in conjunction with a spectromete and photomultiplier. A microvoltmeter or oscilloscope is deployed fo the final checking of the light output in terms of photomultiplie currents. For decay time measurements the electron beam from th gun is modulated by a fast square pulse and the corresponding modula tion of the phosphor light output yields the transcient decay chara teristics of the phosphor. For absolute measurement of the brightne a standard source (Tungston filament lamp) may be used. Studies a also carried out on developed and imported phosphors for compariso of their output efficiency.

The average particle size is an important parameter which decid phosphor performance as regards screen coating, uniformity, pictu resolution etc. Different phosphors have different particle si requirements depending upon the nature of their use. As an exampl for ZnS:Cu (American code P-31) particle size should be 10-15 micron The phosphor has a size of about 100 microns after the activatio stage. It has, therefore, to be ground and sieved to 10-15 micron Grinding reduces the phosphor efficiency. A gentle ball-milling of th phosphor in a suitable suspending medium (water or acetone) h therefore been done.

The expertise available at NPL has now reached a stage whe any compound of group II-VI phosphor can be prepared havi characteristics of users' choice. For such materials a complet indigenous know-how has been evolved which can be used for large sc production by the industry. Country's requirement of phosphors quite large. For television alone, present requirement of Bhar Electronics Ltd. is about 1000 kg/year. Defence requires large amou of phosphors in CRO, image converters and radar tubes. Hospitals ha a fair consumption in X-ray viewing plates. This demand of phospho is certainly to go up as television becomes more popular througho the country.

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

In many scientific applications, including medical sciences, it sometimes necessary to visually see the wave-form of a signal or so

information. The electronic instrument used for visual display of information is cathode-ray oscilloscope and cathode-ray tube is a special type of valve on which the pattern is seen. Television picture tube is also a special type of cathode-ray tube. These tubes basically consist of an electron gun (source of electrons in the form of a beam), mounted inside a glass envelope whose front surface is coated with luminiscent material called phosphor, which gives out light when electrons hit the screen.

The technology of fabricating various types of Cathode-ray tubes and Television Picture tubes has been developed at the laboratory. It involves various operations like deposition of phosphor inside the glass bulb, aquadag coating, aluminizing the bulb, electron gun fabrication, sealing of the gun to the bulb, evacuation, processing and testing of the complete tube. All these techniques have been perfected.

(1) Cathode-ray Tubes

Cathode-ray tubes of the type 5UP1 useful for general purpose oscilloscopes have been successfully fabricated. They are being batch-produced for oscilloscopes to be assembled by the students themselves based on the design of an oscilloscope kit, also developed at NPL. These tubes have been supplied to various universities, colleges etc. as part of the oscilloscope kit. Based on this technology, Cathode-ray tubes including radar display tubes which become unserviceable due to poor vacuum, burnt heaters, poor emission, bad source etc., can be re-conditioned.

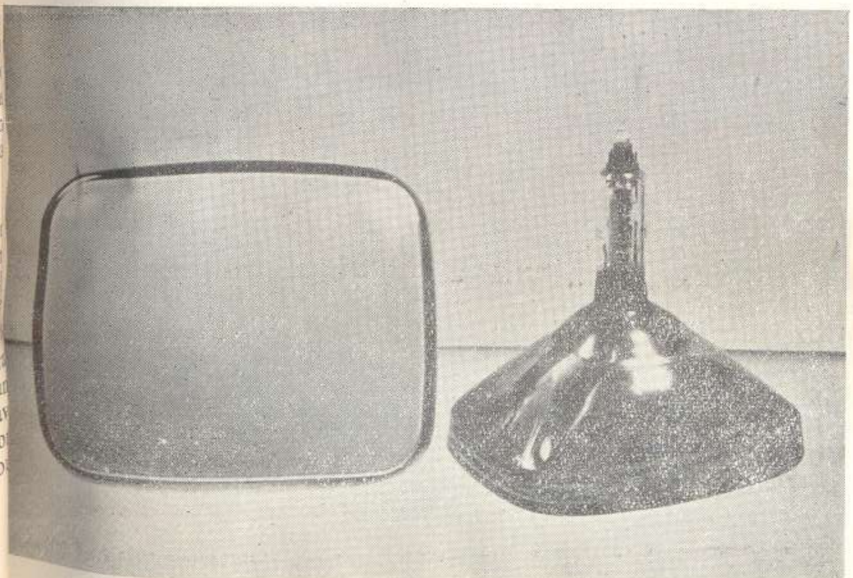


Fig. 4 Television Picture Tubes can be manufactured on a considerably low price by the indigenous know-how developed at the laboratory. Techniques have also been perfected for reconditioning of these tubes.

(2) **Television Picture Tubes**

The technology of fabricating Television Picture tubes has al been developed. T.V. Picture tubes of 9", 12" and 16" screen size ha been fabricated and tested. The manufacture of these T.V. pictu tubes, based on the indigenous know-how developed at NPL, w give a boost to the local T.V. manufacturing industry and the pr of T.V. sets, using indigenous tubes, may come down, since picture tu is the most expensive component in a television receiver.

With the production of T.V. sets going up for use in Delhi, t opening of a few more T.V. Stations and T.V. broadcasting throu satellites, the number of T.V. sets would considerably increase duri the next five years and the demand for re-conditioning will go proportionately. These picture tubes can be re-conditioned based the techniques developed at NPL. It may be pointed out here th re-conditioning of T.V. picture tubes is a well-established industry advanced countries.

The process has been referred to the NRDC for transfer of 'no how to industry for commercial exploitation.

Design and Development of Optical Systems

To help the small manufacturers, who have been making effo in the manufacture of optical instruments, a project on design a development of optical systems has been taken up at NPL. High sophisticated methods of lens design have been devised with the use computers in the advanced countries. In order to serve the intere of the indigenous industry, which is in its infancy, a different approa from conventional one based on the assumption that positive le systems are derivatives of single lens, was followed. It s be shown, on the basis of the research work done at NPL ario types of lens systems can be gradually evolved from th e l (positive) system.

The consultancy service provided by NPL in this regard is especia organised to help the industry to keep down the cost of production optical instruments and at the same time reach the highest standar so as to enable it to compete with other industries in the internation market. Optical glass types produced at the Central Glass and Ceram Research Institute, Calcutta are being used in the designs; the r commendations of the ISI and other international standard institutio are incorporated in these designs and efforts are also made to rational glass types, glass working tools and moulded blank specifications ensure long range economy in production.

Designs for the following optical components/instruments have b supplied to industries for commercial production: Eyepieces for mic scopes & telescopes Objectives for microscopes & telescopes Cam objectives, Projection objectives Enlarger objectives, Microscope cond sers, Projector condensers, Level optics, and Biocular optics etc.

DEVELOPMENT OF MICROWAVE COMPONENTS & INSTRUMENTS

The use of microwaves is increasing day by day in India in radar systems, microwave communication links, satellite communication, navigation and scientific research, and so the need for indigenous manufacture of microwave components has always been felt. Components used in these applications are highly specialized and sophisticated in their design and fabrication, with close mechanical and electrical tolerances in their performance. Keeping in view the object of self-sufficiency and saving of foreign exchange, work was started in the National Physical Laboratory, New Delhi a few years ago on the design, development and batch-production of microwave components required in various microwave systems. Some of the major activities in this field are described below :-

(1) **Waveguides**

Waveguides suitable for X-band (8.2 to 12.4 GHz), XN-band (5.8 to 8.2 GHz), and K-band (18.0 to 26 4 GHz) have been successfully drawn using the drawing machine fabricated indigenously. Work is in progress on S-band waveguides. These waveguides are needed for component fabrication as well as for connecting the microwave antenna to the ground station in radars, communication links, satellite earth stations etc.

(2) **Microwave Components**

...t from straight waveguides, a variety of microwave components like ...unctions, directional couplers, attenuators, pyramidal horns, matched ...rminations, twists, bends etc. are used in the above-mentioned systems. Design and fabrication technique of thirty different types of components have been perfected here. These components include highly specialized items like slotted-lines with probe for measurement of impedance, broad-band circulators and isolators for non-reciprocal transmission, frequency meters and variable attenuators for adjusting the microwave power-level. These components have been developed for X-band (8.2 to 12.4 GHz), C/XN-band (5.8 to 8.2 GHz), S-band (2.4 to 3.95 GHz), K-band (18.0 to 26.4 GHz). Complete list is given in the end.

The batch production unit working at N.P.L. has produced microwave components costing more than Rs. 300,000/-. It is currently producing components of the order of Rs. 100,000/- per year. The technical know-how has already been passed on to two private companies. They have gone into production with an estimated output of Rs. 300,000/- per year.

Apart from the conventional microwave components, several defence jobs of very special nature have been undertaken and completed.

(3) External Cavity Reflex Klystrons

Reflex klystrons are used as sources of microwave power in rad receiver, microwave links, and as a signal source in microwave test benches. Prototypes of external cavity reflex klystron equivalent t 2K28 for 10 cm wavelength have been successfully fabricated at N.P.L Typical power output is of the order of 90—100 milliwates at 3,00 Mc/s. These klystrons are now being batch-produced for typ approval to meet the requirement of defence and also for signal source in 10 cm test-benches which are being fabricated here.

(4) Microwave Instrumentation

Work, in fairly advanced stage, is going on the development o voltage standing wave ratio meters for impedance measurements with slotted section and an universal Klystron Power Supply, capable of operating Klystrons in all frequency ranges from 1 GHz to 26.4 GHz.

LIST OF MICROWAVE COMPONENTS

1. Slotted Sections.
2. Tunable Probe.
3. Wide-band Probes.
4. Cross Directional Couplers (20 db).
5. Multihole Directional Couplers (3, 10, 20 db).
6. Fixed Attenuators.
7. Variable Attenuators.
8. E-Plane, H-Plane tee junctions.
9. E-H Tee and Matched Hybrid tee.
10. E-Plan and H-Plan Bends.
11. Coaxial to waveguide adapters.
12. Cavity Frequency Meters.
13. E-H Tuners.
14. Slide Screw Tuners.
15. Twists.
16. Broad-band Isolators.
17. Broad-band Circulators.
18. Klystron Mount.
19. Tunable Crystal Mounts.
20. Broad-band Crystal Mounts.
21. Low Power Matched Terminations.
22. Mixer Mounts.
23. Flanges.
24. Pyramidal H rns.
25. Universal Waveguide Stand.
26. Coaxial Two-stub Tuner.

Development of Electronic Desk Calculator

For the past many years NPL has been doing considerable research work in the field of digital and logic circuitry and various types of digital instruments were fabricated. Also facilities like production and testing of memory cores, preparation of printed circuit modules were available. As a result of the base already existing, work on development of the desk calculator was undertaken. In the first phase of the project, work on six digit two function calculator (adding and subtracting) was undertaken with emphasis on maximum use of indigenous components. The first prototype was fabricated from all indigenous discrete components.

The machine affords the possibility of carrying out computation in ny arbitrary manner. The advantages of an electronic adding machine ver its electrical counterpart are formidable. They are not only produced at a large scale at lower cost, but they also operate more quickly, r more quietly and are easier to use. The electrical power in-put is 30 atts. Furthermore, modular construction in the form of printed ircuit boards renders easy serviceability and also reduces the inoperative me to a minimum.

Gas Lasers

The gas laser development was started primarily for application f the laser for precision physical and engineering measurements. The se of laser, specially the He-Ne laser, has resulted in the improvement f the precision of many measurements by at least one order of magniide, such as, length standardization and calibration, measurement of hase change including optical testing, holographic stress analysis, ignment and other optical tooling. The first requirement is dependble He-Ne laser and the work in the project has been directed mainly o its development. Some applications have also been made of the Ie-Ne lasers developed. specially for precision testing of optical omponents.

In the previous year both the Brewster window and internal mirror He-Ne lasers were successfully fabricated. Of these, the internal mirror aser is more rugged and dependable. Efforts were, therefore, made r the improvement of its efficiency and life and for development f its prototype.

The efficiency of these lasers is determined largely by the losses at the resonator mirrors. During the year considerable improvements have been made to the reflectivity and durability of the dielectric coating of the mirrors. It is now possible to operate the laser with 11 and 13 layer mirrors as against 15 layer mirrors used earlier. This has resulted in an increase of the laser output by a factor of two. Improvements have also been made to the cleaning and outgassing of the laser tubes, thereby increasing their operating life from 100 to 250 hrs. Further work is in progress in this direction. A prototype of the 0.5 to 1 mw He-Ne laser was made and such lasers were supplied to universities. The users reported that the laser ten ed to go out of alignment. To eliminate this defect a new coaxial laser tube has b designed and it is under trial.

Pulsed argon-ion lasers have been developed as a first step tow the development of high power ionic lasers. These were operated w achromatic dielectric mirrors developed in the laboratory and la action could be obtained simultaneously at four ionised argon li of wavelengths 5145, 4965, 4880 and 4765 A. Work is now in progr for the fabrication of a continuous wave argon-ion laser.

Applications

(a) *Holography :* A more powerful, one metre long He-Ne la giving an output of 5 milliwatt was fabricated and successfully us for holography. Holograms of transparencies were obtained on l resolution commercial films.

(b) *Interferometry :* The He-Ne lasers developed at NPL h been used for optical testing and alignment. For optical testi a compressive shear interferometer has been developed in which interfering beam is compressed and the other expanded and then two are recombined. The special features of the interferometer that the amount of compression is variable and that the compressi can be given in both the meridians (radial compression) or in merdian (linear compression). With radial compression the interfe meter is suitable for the measurement of aberrations of camera a similar objectives, whereas with linear compression it is useful the measurement of resolution of photographic emulsions. A sim unequal path inverting interferometer has been developed for precisi alignment with the laser. Here, interference is obtained between two wavefronts reflected from the two surfaces of a glass hemisphe Any displacement of the axis of symmetry of the hemisphere from centroid of the laser beam gives rise to a fringe shift and can measured accurately. This instrument is now under trial.

Cryogenic Equipment – Fabrication of Low Pressure Air Liquefier

Low temperature facility has become an essential part of research establishment these days. The equipment required to create t facility is rather sophisticated and is not manufactured in India present except a limited number of liquid air containers. The he of cryogenic equipment is a gas liquefier which is imported at prese There is no doubt that many research and industrial organisati would like to have cryogenic facilities of their own if the requi equipment is available indigenously. The development activity in direction is all the more important at the present juncture when country is striving for self-sufficiency in the technological fields. the development of air liquefier (low pressure) and the fabricatio metallic dewars for storage of liquefied gases a start in this direc has already been made.

Low Pressure Air Liquefier : The liquefaction of the air can achieved by three well known processes namely (i) Lin

process, (ii) Claude's process and (ii) Kirk's cycle (reverse stirling cycle). Development of low pressure air liquefier using Claude's cycle was undertaken in which air compressors giving pressure of the order of 425 psi manufactured within the country are used. In the Claude liquefier, 60 percent or more of the air at more than 200 psi pressure is expanded in a reciprocating type engine which transfers the energy produced by the expansion out of the system. The energy thus removed from the expanding air represents extra refrigeration produced in the cycle. This is then used to pre-cool the remaining high pressure air in a heat exchanger as close to its critical temperature as possible and then expanded through an expansion valve for liquefaction.

A low pressure air liquefier based on Claude cycle has been esigned for the production of 8 litre/hr. liquid air. Heat exchangers f finned type and the expansion engine, consisting of two expansion ylinders working at different temperature, have been fabricated longwith various other parts like J. T. expansion valve and storage essel for the liquid air. The temperature thus obtained was within 0°C of the liquefaction temperature of the air. The improvement by e use of hard chromium plated cylinders and plastic sleeved pistons as marginal. As a consequence, a new engine with single expansion ylinder has been designed and is under fabrication at present.

Metallic dewars : Metallic containers for storage of liquid r/nitrogen are double walled evacuated spheres. The inner sphere is onnected with thin walled tube of stainless steel or cupro-nickel aving low conductivity to reduce the heat influx down the filling ube. The spheres are assembled from spun copper hemispheres ith surfaces facing the vacuum space, cleaned and polished to achieve e high intrinsic reflectivity of the metal. Activated charcoal is placed the vacuum space in intimate contact with the surface of the inner here to ensure absorption of the residual gases after the vacuum seals ff the dewar. The inner space between the spheres is pumped down a vacuum of 10-5 torr.

The metallic containers of the above pattern have been designed, abricated and supplied to some universities. At present, the capacity f these containers is limited to 5 and 10 litres but it is planned to ake bigger vessels of 25 litre capacity in the near future.

Electrostatic Photocopying Machine

The importance of developing Electrostatic Photocopiers was felt ecause of the non-availability in the country of document copying acilities, essential for libraries, commercial concerns, big offices and rganisations for rapid, accurate and economical dissemination of ientific, technical and educational information in the form of letters, ports, abstracts, specifications, catalogues, bulletins etc.

Electrophotography is a novel process having a number of chara- eristics which distinguish it from other processes in vogue. The rocess is completely dry. No chemical reactions are involved. It is a direct positive-to-positive operation for copying documents, di and half-tone pictures. The process is economical and versatile may be made on almost any type of paper or material having r ably smooth surface. Finished, permanent prints may be obtai a matter of minutes and at a fraction of the cost of a photocopy.

The process of electrophotography involves the formation electrostatic latent image of the document/object on a layer of conductive insulater and the development of the image with a nized thermoplastic powder, which adheres to the electrically c areas of the photoconductive layer.

The photoconductive layer is sensitized by depositing an ele static charge on its surface. The sensitized photoconductive la then exposed to the object whereby an electrostatic latent im developed by dusting the layer with the micronized charged po Prints are made by transferring and fixing the powder image paper.

Based on the above principles an Electrostatic Photocopying Mac has been developed at the laboratory. It consists of a re-usable ph conductive plate ; an electrostatic charging system for sensitizing photoconductive plate ; an optical system for exposing the sensi photoconductive plate to the object-document to be copied ; a deve ing system for the development of the latent image on the plate a fixing system for fixing the powder image on the paper.

The photoconductive plate used for obtaining an electros latent image of an object/document, consists of a thin uniform l of a photoconductive insulator such as S, Se, Te etc., deposited vacuum by thermal evaporation on a suitable conductive substrate as Zn, Al etc.

The upper surface of the photoconductive plate is exposed to object/document in a usual photographic plate camera. On exposur light, hole-electron pairs are formed. These holes and electrons migra the negatively and positively charged surfaces of the plate, respecti thus decreasing the charge of the areas of the plate exposed to light. charge decreases in proportion to the intensity of light falling on charged photoconductive plate. If the light incident on the plate i the form of an image pattern, an electrostatic latent image is forme the surface of the plate.

After the latent electrostatic image is formed, a suitably char pigmented, micronized thermoplastic powder or "toner" as it is c alongwith relatively large particle size granular carrier, is casca over the photoconductive material surface. The materials of the t and carrier are selected in such a way that the charge on the t powder particles is opposite to the corona charge deposited on photoconductive plate. During cascading, the toner adheres onl the charged areas of the photoconductive material surface, the developing the latent image.

The toner powder adhering to the photoconductive plate as an image is transferred to a paper or any other reasonably smooth surface for permanent record. The paper is placed over the toner image and is charged with the same polarity as that of the plate with corona discharge. The toner powder (adhering on the plate as an image) is thus transferred from the plate to the paper. The paper is now taken off gently from the photoconductive plate and exposed to heat or to the vapours of organic solvents. Since the micronized toner powder is a thermo-plastic material, it gets fused to the paper at temperatures a little above the room temperature or when exposed to the vapours of organic solvents, thereby fixing the toner powder on the paper for a permanent record.

The machine developed at the laboratory can make copies of documents in a matter of minutes. 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 12,000 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 thousands of copies.

During the period following two patents were taken :

1. A process for making a print of a document with an electrophotographic machine (126506).
2. A process for making multiple prints with an electrophotographic machine (127748).

The know-how was released to M/s. Advani Oerlikon Pvt. Ltd., Bombay for the commercial exploitation of the machine.

Development and Production of Cinema Arc Carbons and Process Carbons

Efforts were continued to improve upon the know-how already developed for Carbon Products using indigenous raw materials. The plant was also used for handling production batches of cinema and process carbons to establish the commercial viability of the process.

Statistical studies of the batches of arc carbons processed during the previous year were undertaken.

A technical report on production of 1000 pairs of Cinema Arc Carbons per day was prepared. The report includes preliminary information, brief details of the process, raw materials, details of equipment, energy consumption, man-hours, costing and quality control techniques etc. The copies of the report were sent to National Research Development Corporation of India, New Delhi, for the benefit of firms taking up the process.

The optimum capacity of the plant was studied by operating of the equipment for 12 hours/day, during all the days of the Two large size furnaces have been designed and fabricated to i the baking capacity of the existing plant. The baking sched been studied for production batches.

Carbon products worth Rs. 56,643/- were produced and su to the users thereby saving foreign exchange.

Development of Microphonic Carbon Granules

The carbon granule is a small but essential component o telephone transmitter weighing hardly 1.5g and exhbiting r behavior in its task of responding to sound pressures with tole fidelity and high sensitivity.

The starting raw material in the production of microphonic ca granules is selected refined anthracite coal. The material is heat tr in the range of 950 — 1200°C in an atmosphere of 'self-gene gases or a gas such as hydrogen, argon or nitrogen. The proce is so adjusted that it results in partial graphitization of the bulk ma and deposition of film of carbon on the surface by pyrolysis.

Microphone carbon is an extremely hard material which rem hard even at high temperatures. Its ratio of thermal to electrical ductivity is very high compared to other materials as a result of w practically much less heat is generated at minute points of cont The combination of strength, heat elastic modulus, surface characti as regards roughness, absence of film formation, heat and electrical ductivity are important to make carbon granules more satisfac than any other material.

The carbon granule is an imported item, its consumption at pre is about 500 kg per year which will certainly increase with the escala demand for more telephone connections due to expansion of busi and industrial activities in the country.

Development of Carbon Brush Blocks

Brushes in general may be classified into natural graphite, h carbon, carbon graphite, copper graphite and electro-graphite c gories. Each of these categories has several grades and a judic selection is necessary to find a proper grade suitable for a partic machine. A number of corresponding grades have been developed u a phased programme which has been pursued for the past many y Brushes pertaining to the class of natural graphite, hard carbon, carb graphite and copper graphite have been developed and passed o the industry for commercial exploitation.

The technology is analogous to powder metallurgy. The materials such as calcined coke, graphite and carbon black are blen together and mixed with a suitable carbonaceous resinuous bin

The mixed mass is either extruded or moulded according to the nature of he product and then heat-treated in a non-oxidizing atmosphere at tem- eratures in the range of 900-1100°C. For copper carbon series, an oxide ree copper powder of certain shape and size distribution is mixed with raphite or calcined coke with or without binders and moulded into ompacts which are sintered in a non-oxidizing atmoshere. The additives, f necessary, are introduced direct or by impregnation to modify the roperties of the product.

Improvement of the Performance of Simultaneous Extrusion Process

For the first time six batches of Cinema Arc Carbons of about 000 rods each were made from the same raw materials and under the ame processing conditions to evaluate the properties from batch to atch. The parallel plate viscometer, which was fabricated earlier, was sed to determine the viscosity and the rubber like modulus of four andom samples taken from the roll mix for both the shell and core mixes. The projection test was also undertaken for the composite rods or each batch.

The percentage variation of viscosity for each batch has been orrelated with the final projection performance. Percentage of viscosity ess than a particular value for the core mix in all batches agreed with he percentage of bad rods in the final performance. The parallel plate method of determining viscosity has been found very useful in judging uniformity of wet mixing, especially for the core mix. So far no method existed to determine the uniformity of wet mixing.

Development of Viscometers

The laboratory has developed various types of viscometers such as, extrusion viscometer, parallel plate viscometer and angle of repose apparatus which were hitherto used to be imported. All these instru- ments were released for commercial exploitation. Associated Instruments Private Ltd. has applied for licence to commercially exploit these instruments.

Special investigations were carried out for Govt. & private organi- sations. The properties of grease were measured with extrusion viscometer and that of cheese with the parallel plate viscometer. Angle of repose of fertilizers was measured with the apparatus made in the laboratory.

Preparation of Polycrystalline Silicon

Tetraiodide method : The complete know-how for the manufacture of polycrystalline silicon by the Iodide Method has been established in all the three iodide processes which the laboratory took up. In the first process which involves least number of steps, production line has been established on experimental plant scale. The material is being produced for use in Norton Crystal puller for pulling single crystals.

Trichlorosilane method : Optimum conditions have been estab for the preparation of *crude* trichlorosilane by fixed bed techn Further improvement has been obtained in reducing the Boron le complexing and mixing. After cracking material obtained is of N of 50-100 ohm cm resistivity. Experiments are still being conti to increase the cracking efficiency of trichlorosilane.

Cracking of Silicon on Silicon : In the iodide process the cra of silicon tetraiodide on silicon rod has also been perfected. Ro more than 32 mm dia have been prepared in the cracking unit.

Silicon Single Crystal Growth

Single crystals of silicon of 10-11 mm diameter were prepare float zone technique and were supplied to various universities and developmental research work on epitaxial growth of silicon.

The technique of casting thin silicon rods of 3-4 mm diameter use in cracking silicon on silicon was developed. The testing of sili made by tetraiodide as well as by trichlorosilane method, to determ the boron content was also carried out. This included casting, z refining and measurement of electrical properties.

Development of Electronic Components

In modern technology electronics is almost basic to several fi such as communication, defence, data processing, aerospace resear and plays a key role in controlling and recording in all industr Because of this, electronics is the most rapidly developing industry in the countries; this is true of India as well. The growth of electron industry is possible only if a strong base is laid for development production of electronic components. It also means that intens systematic studies have to be made on the availability of materials.

NPL has been the pioneer institution in developing electro components and producing them on a pilot plant scale from indigen raw materials. In the last 15 years, DPEC Unit of the Laboratory licensed processes for production of :

1. Silver Mica Capacitors
2. Ceramic Capacitors
3. Soft Ferrites
4. Hard Ferrites
5. Piezoelectric Ceramics
6. Machineable electronic ceramics.

Following projects were pursued during the year :

MnZn ferrites (Medium wave) : Antenna rods that are used radio receivers are usually of compositions based on the use of nic

oxide. NPL in its early experiments developed the process technology for manufacture of antenna rods using nickel oxide as one of the constituents. Since nickel is imported, concerted attempts were made to substitute nickel by a suitable indigenous material such as manganese. These experiments, carried over a long period to stabilise the process parameters to ensure uniform electrical characteristics, have resulted in the successful development of antenna rods in which nickel oxide has been completely replaced by manganese oxide. The process has been released to the industry and they have successfully manufactured MnZn ferrite rods. This would save a considerable amount of foreign exchange which is at present being spent on the import of nickel or its salts.

Short-cum-medium wave ferrites : In recent experiments carried out it has been possible to replace nickel to a considerable extent even in the short-cum-medium wave ferrites which are used as antenna rods in multiband receivers. The nickel content has been brought down to 5 % without sacrificing the electrical performance of the antenna rods. After stabilising the process it has been passed on to the NPL licencees who are supplying the product to the radio industry in substantial quantities.

MnZn ferrites with medium Permeability : The permeability of the compositions used in the antenna rods is generally of the order of 150 to 200. Attempts have been made to develop MnZn ferrites with permeability in the range of 700 to 1000 using beneficiated mineral iron ore. One of the requirements for producing high permeability MnZn ferrites is a closely controlled atmosphere. In the experiments undertaken at the NPL it has been sought to simplify the process of sintering by processing under ordinary atmospheric conditions and to get the permeabilities of the order of 1000. Ferrite products made out of this composition are also used in professional equipment in telecommunication industry.

Manganese ferrites with high permeabilities : Ferrites with permeabilites in the range of 1500 to 3000 have been developed by sintering manganese-zinc ferrites under controlled atmospheric conditions. Dies and tools for making complicated shapes of pot cores, E-cores and U-cores for EHT transformers have been designed and made and products have been supplied to TV manufacturers, space research and defence organisations. The starting materials for high permeability ferrites have to be very pure and as they are not available commercially, pure material preparation has also been undertaken successfully.

Mn-Mg-Zn ferrites : These are used in the form of extremely small ring cores of sizes varying from 20 mils to 50 mils, as memory storage elements in computers. NPL has recently, successfully developed memory cores in the 50-80 mils range conforming to the international standard specifications. Sample cores were sent to some institutions for evaluation and it has been reported that the cores are fully satisfactory and can be used in the building of memory planes.

Thermoplastic process : The industries that use professional ferrites demand a close adherence to the dimensions and also need complicated shapes. Ferrite being a hard material makes almost impossible the machining of it to complicated shapes. A process has been developed where a raw ferrite powder is mixed with a plastic binder and moulded into desired shapes at ordinary temperatures. This process can be used both for the manufacture of magneto and electro ceramics. The process simplifies a great deal the manufacture of complicated shapes and sizes and follows the well known thermoplastic moulding technique. Simple thermoplastic moulding machines can be used with dies which are made out of inexpensive materials for moulding and extruding ferrites and other electro-ceramic products. The process does not in any way affect the electrical and high frequency properties of the components that are moulded using this technique.

Piezoelectric ceramics : Barium titanate Lead zirconate type of polycrystalline PZT ceramic materials which are extensively used in pressure transducers, ultrasonic transducers and many other novel applications have been developed and the process has been standardised.

PZT ceramic bimorphs have been supplied to the Central Electronics Engineering Research Institute (CEERI), Pilani for use in pick-up heads developed by them. CEERI has licensed three parties to manufacture the pick-up heads using PZT elements developed at NPL. The ceramic pick-up bimorph elements have also been supplied to a large manufacturer producing record players. They have approved the PZT elements after exhaustive test, and NPL has undertaken batch production of these to stabilise the process.

NPL had licensed the process for the manufacture of ceramic capacitors used extensively in the radio and the electrical industry to a public sector factory on an exclusive basis. Since the production of this factory was not enough to meet the country's demand it was decided to licence additional capacity. In order that the new licencees would be in a position to acquire the technical knowhow, NPL has revived the manufacture of ceramic capacitors of all types on a small scale and all the process parameters have been stabilised.

It has been, recently, decided that NPL should undertake the manufacture and supply of professional grade high permeability MnZn ferrites to the ITI and BEL. Based on this decision NPL is organising the setting up of a production unit.

In the processes that have been detailed above it may be emphasised that only indigenous raw meterials either from mineral ore or from the materials industry have been used for developing components which conform to the national and international standards.

STATEMENT OF SALE OF FERRITE PRODUCTS BY DIFFERENT SECTIONS DURING THE YEAR 1970-1971

Soft Ferrite :		Rs. 3,52,173.86
(a) Antenna Rods (NPL-5C)	1,59,896.85	
(b) Antenna Rods (NPL-3)	4,398.75	

(c) I.F. Cores & Tubes (NPL-3)	64,009.71	
(d) Oscillator Cores (NPL-5C)	17,534.10	
(e) Toroids (NPL-3 & 5C)	18,259.75	
(f) Ferrite Beads	17,560.70	
(g) Prefired Powder (NPL-3)	70,514.00	
	3,52,173.86	
Hard Ferrite :		20,141.60
Professional Ferrites :		9,659.00
Piezoelectric Ceramics :		3,364.50
Technical Ceramics :		4,875.50
Silver Paint & Gamma Ferric Oxide :		5,031.00
Total...		Rs. 3,95,245.46

GLASS TECHNOLOGY

The Glass Technology Unit has been rendering active service to industry, research organisations, medical institutes etc. for their requirements of sophisticated glass apparatus.

Instruments like reaction kettles, fractionating assemblies, Kerr cells for high speed cameras, Vanslyke Blood analysis apparatus, Haldin gas analysis apparatus, high vacuum system for thermometers, apparatus for cracking semi-conductor grade silicon etc. have been made in the NPL. Also, NPL has started making apparatus with Teflon stoppers for the first time in India. Facilities for making silica apparatus have been developed and the laboratory is in a position to cater to the needs of modern industry, The unit is rendering valuable service in reconditioning of mercury arc rectifiers which used to be sent abroad.

NPL accepted the challenge to recondition mercury arc rectifiers and has already reconditioned about 300 units. Average cost of each bulb is 10-15 thousand rupees while NPL charges Rs. 3,000—4,000 for reconditioning. As a result of the services of this unit foreign exchange of the order of about 4 million rupees has been saved.

Fig. 5 Reconditioning of Mercury Arc Rectifiers being done at NPL.

ORIENTED BASIC RESEARCH

The laboratory undertakes oriented basic research on problems concerning standards, developmental testing, applied research and development work. Following major investigations were undertaken during the year.

Mossbauer investigations on ferrites

Various ferrite compositions were studied using Fe^{57} Mossbauer spectroscopy. The Mossbauer spectrum above the Curie temperature, gives three distinct peaks which could be easily identified with Fe^{3+} in tetrahedral sites ; Fe^{3+} in octahedral sites and Fe^{2+}. From the knowledge of the relative intensities of Mossbauer resonance for Fe^{3+1} in tetrahedral and Fe^{3+} in octahedral sites, it is immediately possible to determine the inverse parameter. Thus these investigations have provided a ready method for the determination of the ionic distribution and this method is now being used daily for the examination of professional ferrites that are being developed in the laboratory. It may be mentioned that the information that is so readily made available through Mossbauer techniques, cannot be directly obtained through X-ray methods. This information can be obtained by neutron diffraction studies or by magnetic permeability studies at very low temperatures. Both these are complicated techniques to work. With a view to understand the role of sintering atmosphere and through it develop methods to control the ionic distribution in a given sample, detailed investigation of the solid state reactions involved in the preparation of a ferrite was undertaken. Detailed investigations have been carried out on the $MgO:Fe_2O_3$ system yielding $MgFe_2O_4$—magnessio-ferrite.

Mossbauer studies of ferroelectrics and antiferroelectrics

Ferroelectrics are a class of substances which exhibit reversible spontaneous polarization. Consequently, they show dielectric hysteresis, exhibit piezoelectricity and pyroelectricity. Because of their unique properties, ferroelectrics and antiferroelectrics are being investigated extensively employing variety of techniques. The laboratory has a developmental programme for these materials and with a view to understand the mechanism of ferroelectricity and antiferroelectricity in crystals, a detailed investigation of these materials using Mossbauer effect was undertaken. Investigation on $BaTiO_3$, $PbTiO_3$ lattices using Fe^{57} and Sn^{119} Mossbauer probes were carried out. The Mossbauer spectra of these substances below the transition temperature indicates the existence of quadrupolar interaction. The temperature variation of the quadrupolar interaction has given considerable information about spontaneous polarization and birefringence in these crystals. Whereas in $BaTiO_3$, the quadrupolar interaction, spontaneous polarization and birefringence follow similar variation with temperature, in

$PbTiO_3$, the birefringence increases initially, reaches a maximum at about 400°C and then decreases to zero at and above the transition temperature (490°C). The quadrupolar interaction on the other hand is practically constant till a few degrees close to the Curie temperature. The results have clearly shown that oxygen ion polarizability contributes to the negative birefringence whereas the spontaneous polarization as determined by the tetragonal strain contributes to the positive birefringence. The data has been analysed to give temperature variation of spontaneous polarization anisotropy of oxygen polarizibility. It may be mentioned that this is the only direct measurement on spontaneous polarization in $PbTiO_3$ In both these lattices it has been found that the Lamb Mossbauer factor increases as the temperature is decreased from the high temperature side till a few degrees close to the transition temperature. As the Curie temperature is approached, the Lamb Mossbauer factar decreases, reaches a minimum value at Tc (transition temperature) and increases again as the temperature is lowered further. These results have yielded a direct evidence of the existence of the temperature dependent mode which is responsible for ferroelectricity in crystals.

Antiferroelectric $PbZrO_3$

Mossbauer effect for Sn^{119} in $PbZrO_3$ has been studied from 27°C to 320°C with particular emphasis on the region near the Curie temperature. The Lamb Mossbauer factor changes by 40 $\pm$ 8% at the transition temperature Tc. This may be compared with the corresponding change of 10% in ferroelectric $BaTiO_3$. Detailed evidence has also been adduced to suggest that the entire optical branch in this antiferroelectric has an anomalous temperature dependence.

Mossbauer studies of localised $\rightleftharpoons$ collective electron transition

Several transition metal oxides have been investigated with a view to ascertain whether we can observe localized electron $\rightleftharpoons$ collective eletron transition. Out of these compounds $LaCoO_3$ has some speciae properties. The Mossbauer investigation has shown unequivocally the coexistence of low spin Co^{III} and high spin Co^3 ions in $LaCoO_3$. The relative concentration of these ions is both temperature and pressure dependent. A phase transition for collective electron to localised electron has been detected at 937°C. By observing the relative concentration of low and high spin cobalt ions at various temperatures it has been possible to explain the very interesting semiconducting and magnetic properties exhibited by $LaCoO_3$. In this compound ECoIII state lies lower than Co^3 by 0.05 eV. Isomorphous $NdCoO_3$ has also been investigated in detail. In this compound the transition has been found at 535°C. These studies have clearly brought out the possibility of the coexistence of localized and collective d electrons and has shown that these are two limiting descriptions of the outer d electrons.

Mossbauer studies of Brownian Motion

Investigations were carried out theoretically as well as experimentally to study the effect of Brownian motion of a particle on the

Mossbauer line shape. The theoretical treatment included the general solution of Langevin equation, thereby revealing the important role played by the characteristic time of the liquid. It has been shown that when the characteristic time is very small, then the line broadening is given by $\triangle = 2hK^2D$, where D is the diffusion coefficient, and K is the γ-ray wave vector. In the other extreme case, i. e. when the characteristic time is small, one obtains a Gaussian with a line width given by

$$\triangle = 2\lambda[\beta(\Gamma + 2\alpha\beta) \log z]^{\frac{1}{2}} \text{ where } \beta = \frac{6\pi\eta a,}{m} \qquad d = \frac{h^2D}{\beta}$$

It is seen through the theoretical analysis that by studying the line broadening one can obtain, the diffusion coefficient as well as characteristic life time of the liquid.

Investigation of the line shape of Josephson radiation

The Josephson effect which is essentially the tunneling of a Cooper pair from one superconductor to the other across a thin barrier can be used for establishing voltage standard. Since NPL is the custodian of National Standards a detailed theoretical and experimental investigation of Josephson effect has been undertaken.

Transport properties in dilute magnetic alloys :

Electrical and thermal conductivity measurements are being made on dilute binary copper alloys containing chromium (32 and 50 ppm) and Iron (120 and 380 ppm) at liquid helium temperatures and in transverse magnetic fields of strength 0 to 17 Kilo-Oersteds. Earlier studies of this type concerned silver-manganese and copper-manganese alloys which had much lower ($\lll 1^\circ$k) Kondo temperatures. The data are being analysed to obtain the lorenz number and its variations with temperature and magnetic fields for comparision with theoretical predictions.

(ii) Electrical conductivity and Thermo Electric Power (TEP) measurements are also being made in zero field from liquid helium temperature upto room temperature on drawn wires of pure copper, Copper-chromium, copper-iron and silver-manganese alloys. The diffusion and phonon-drag components of the TEP are separated at temperatures above 50°K. At lower temperatures, there is a large negative TEP anomaly. The additional electrical resistivity due to alloying with magnetic solutes has a negative temperature coefficient in the region 200 to 300°K. This can be traced to the fact that with the rise of temperature, the resonant levels which are symmetrically situated on both sides of the Fermi level recede from it, thereby reducing conduction electron scattering.

(iii) A cryostat has been constructed for measurement of conductivities above the refrigerant bath temperature. This will be used to measure thermal conductivity of metals and alloys between 4 to 20°K and from 80° K to room temperature.

X-ray K absorption Studies

X-ray K-absorption studies were extended to various oxides of second transition series elements. The position and fine structure of X-ray K-absorption edge of second transition metals in their respective oxides such as $Y_2 0_3$, $Zr0_2$, $Nb0$, $Nb0_2$, $Nb_2 0_5$, $M_o 0_2$, $H_o 0_3$, $Ru0_2$, $Rh_2 0_3$ and $Rh0_2$ has been investigated. The position of the K-absorption edge of transition metals in these oxides always lies on the higher energy side with respect to their respective metals. Moreover, X-ray K-absorption edge shifts towards high energy side with increase in valence state of transition metal. To study the effect of chemical bonding, the position and fine structure of K-absorption edge of molybdenum was studied in a large number of molybdenum compounds, namely, selenide, tellurides, silicide, nitride etc. From the magnetic susceptibility data and the results obtained from this study, it has been possible to predict the chemical bonding in $MoSe_2$, as d^4 S p for the metal ion and p^3 for metalloid ion. This bonding picture is compatible with crystal structure of $NbSe_2$.

Magnetic Susceptibility measurements of Re C_0O_3 where Re is Gd, Nd, Dy, Sm, Pr, Ho.

Magnetic susceptibility of the above compounds was studied in the range of 77°K to 1200°K. In all these compounds magnetic susceptibility varies anomalously with temperature. Such an anomalous magnetic susceptibility variation can be explained by supposing the coexistence of Co^3 (3d) ion both in diamagnetic low spin state and in paramagnetic high spin state. The equilibrium of Co^3 ions of diamagnetic and paramagnetic ones can be changed by temperature. This is the cause of the anomalous magnetic properties. In order to evaluate the magnetic properties of materials two susceptibility measurement set up to cover measurements from 77°K to 1200°K have been made.

On S-d interaction : Kondo Problem for dilute magnetic alloys

A Green's function treatment of this problem was presented in earlier reports. The Kondo expression for resistivity holds good in the limit of extreme dilution of magnetic impurities. The contribution to the self-energy from multiple scattering from a single impurity are linear in concentration while the terms involving multiple scatterings from different impurities are proportional to higher powers of the concentration. Kondo and Fischer have considered the influence of potential scattering on exchange scattering. They have treated the self-energy as linear in concentration neglecting multiple scattering contributions. When the concentration is finite multiple scattering has to be considered. In order to estimate the contribution of multiple scattering, the problem is being tackled in two different ways, (i) by using complex potential and imaginary phase shifts; (ii) by considering the RKKY inter-action between two magnetic impurities via the conduction electrons of the host metal.

RADIO SCIENCE

The scope of the programmes carried out at Radio Science Division is broadly speaking, three-fold :

(i) Radio propagation services and associated regional warning centre (ARWC)

(ii) Other application programmes

(iii) Research programmes on earth's near space environment, including the ionosphere and the magnetosphere

Propagation Data Services

Ionospheric and Solar Geophysical data collected from the network of Indian Stations is printed and disseminated to all research workers and the organisations in the country as well as abroad. To help the various communication systems in and around India Sunspot and Ionospheric Propagation forecasts on radio propagation conditions via Ionosphere are provided. Organisations like Overseas Communication Service, Defence, P&T, Civil Aviation benefit from the service.

An Associate Regional Warning Centre at NPL has been active for the collection and dissemination of Solar, Geophysical and Ionospheric Data. Messages of Flares, SIDs, Kp-indices & foF_2 values for Moscow and Alma Ata are being received through the CSIR telex system and broadcast via AIR, IMD and NPL Standard Time and Frequency Transmissions.

Aeronomy, Ionosphere Physics and Solar Terrestrial Relationships

Incoherent-scatter measurements of electron and ion temperatures and electron concentration were used to obtain the neutral temperature and the number density of atomic oxygen in the upper thermosphere. The neutral temperature was derived from the ion temperature measurement at 250 km and also from the ion temperature gradient in the height range 400-600 km. While the neutral temperature showed the diurnal maximum at 1600 L.T., the atomic oxygen maximised at 1400 L.T., thus establishing a phase difference between the density and temperature maximum.

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

Theoretical studies of the influence of magnetospheric heat flux on the height profile of the plasma temperatures and composition in the topside ionosphere are made for different latitudes. It is found that the topside heat flux, which increases with latitude, causes an increase in temperature and in O^+ percentage with latitude, which are similar to the observed behaviour.

Rocket measurements of eV range electrons made during the total solar eclipse of March 7, 1970 over Wallops Island, have shown clear evidence of the existence of conjugate photo-electrons. They are observed in the energy range of 2 eV to at 30 eV at altitudes of about 200 km. The conjugate flux is found to be about 1/10 of the normal local daytime flux, which is probably sufficient to maintain the observed electron densities and temperatures during the total solar eclipse.

Utilising the data received from instrumented rockets launched from THUMBA, the D-region electron density distribution and the behaviour of the equatorial D-region is being examined.

A study correlating the large and rapid changes in electron content in the afternoon and dusk sectors in mid-latitudes has been made using published analysis for the storm of May 25-26, 1967. These variations are shown to be related to the occurence of polar substorms which initiated the main phase of the magnetic storm. Computer programmes are being evolved for partial differential equations needed to generate models of quiet and disturbed F-region and lower ionosphere. Electron density distribution derived from Alouette top-side ionograms are also being used to study ionosphere-magnetosphere coupling and interactions.

A project has been taken up to carry out satellite studies of the Topside Ionosphere (between 300 km-3000 km). A beginning has been made by studying the sun rise and sun set behaviour of the topside electron density profiles at various latitudes using the Aloutte I data.

Study of topside ionosphere during magnetic storms by using simultaneous measurements of electron density and electron temperature has revealed that the behaviour of topside ionosphere is entirely different from that of the bottomside ionosphere and the magnetosphere. The winter enhancements are consistent with the high energy particle measurements at the polar caps. A study of the total electron content measurements during magnetically active periods shows that the marked changes in the topside are not consistent with a mere vertical redistribution of ionization but involve production and large-scale horizontal movements.

Continuous, round the clock, soundings of the Ionosphere at 15 min. intervals were carried out regularly. Selected records were specially scaled and reduced to true heights using electronic computer and supplied to interested organisations.

Rocket studies of the Lower Ionosphere are being continued and the further detailed reduction of data obtained from the rocket flight ISRO 30.01 is being continued.

Morphological study of the ionospheric electron content has been made using transmissions from the satellites Cosmos V Explorer-22 and Explorer-27. The electron content data are being used for the study of the ionosphere-magnetosphere relationships and for the study of ionospheric refraction error in satellite navigation system.

LF & VLF propagation studies

A number of SIDs accompanying solar flares have been detected and reported in URSIGRAM code to India Meteorological Deptt. for transmission to various national and international organisations for use in short term forecasting of radio propagation conditions. The information is published in Solar Geophysical Data series of NPL and Solar Geophysical Data published by ESSA Laboratories.

Studies were carried out on D & F region effects during normal and flare times with frequency deviations, phase anomalies and LF/VLF amplitude changes. This project is sponsored under PL-480 scheme. An H.F. doppler equipment that was installed at Calcutta is working satisfactorily. Instrumentation work has been carried out to make further explorations.

RIOMETER

A new riometer with a fairly narrow beam of above 10° at 40 MHz has been designed and fabricated to study the absorption at oblique incidence. Routine measurements are being carried out at 30 MHz and the data is being analysed to determine which flares give off noise and the noise characteristics as part of International study for the solar flares.

High Latitude Rocket Experiment

A payload consisting of the following has been launched atop a petrol rocket from the ESRANGE, KIRUNA, Sweden on 10.8.1970 at 0040 hours into a noctilucent cloud display as a part of the international rocket campaign for the study of the NCL phenomena :

Gerdien condenser probe ;

DC Probe ;

Faraday rotation ;

L.F. receiver &
Surface barrier semi-conductor electron detector in the energy range of 10 KeV to 150 KeV.

This payload was successfully launched and useful data was obtained.

Space exploration, since the international Geophysical Year, has contributed to a spectacular and rapid development in the areas of the ionosphere and the magnetosphere. Undoubtedly, the development of these two fields proceeded almost independently and it is only in recent years that there has been a growing awareness of the importance of the ionosphere-magnetosphere coupling in the context of solar-terrestrial relationships. It was, therefore, felt that the time is opportune to focus attention on this area to gain a better understanding of the role of the coupling and interaction between the ionosphere and the magnetosphere, by bringing together workers in diverse fields, such as ionosphere, magnetosphere, solar wind, geomagnetism, airglow, plasma physics, etc. It is hoped that such an exposure would promote appreciation of the overlapping interests and problems and help to identify gaps in our existing knowledge for directing efforts more intensively and effectively in a coordinated way, wherever possible and desirable, in order to make them more fruitful in the coming years.

The idea of holding such a symposium was readily supported by the Radio and Telecommunication Research Committee (RTRC) of the Council of Scientific and Industrial Research, and the Indian Space Research Organisation (ISRO). The symposium was held at the National Physical Laboratory (NPL), New Delhi, during 8-11 February, 1971.

Fig. 6 Dr. Vikram Sarabhai giving inaugural address in Symposium on Inosphere—Magnetosphere Interactions.

The symposium was inaugurated by Prof. Vikram A Sarabhai, Chairman, ISRO with a talk on the significance of the fluctuations of the earth's magnetic field.

The symposium was organised into seven scientific sessions as follows :

1. Solar wind and magnetosphere.

2. Plasmasphere and ionosphere-magnetosphere coupling

3. Ionosphere—magnetosphere interactions—

   I. "Dynamics of the neutral atmosphere, ionosphere and magnetosphere"

4. Ionosphere-magnetosphere interaction—

   II. "Storms"

5. Ionosphere-magnetosphere interactions—

   III. "Wave-particle interactions"

6. Ionosphere-magnetosphere interactions—

   IV. "Ionospheric irregularities and scintillations"

7. Air glow and other topics.

At the end of the scientific sessions, a panel discussion, chaired by Dr. J. W. King, was organized to highlight the areas which needed to be pursued with coordinated and intensified effort in the context of the scientific manpower and facilities available in India. Delegates from all over the country and abroad participated in the symposium.

PLANNING AND LIAISON

Industrial Liaison

The importance of communication between the industry and the laboratory has been well recognised. While the processes developed by the laboratory are released to industry on premia/royalty basis, the laboratory also undertakes projects sponsored by industry for the development of products/processes in the related fields. During the year processes on Bent Crystal spectrograph, Linear drive for Mossbauer spectrometer, Electrostatic Photocopying Machine, microwave components (C-band), ultrasonic interferometer for velocity measurements in liquids, polycrystalline silicon, constant stress rotation viscometer, photocells, CR and TV picture tubes, ice shaving machine, ice point apparatus were developed and communicated to the NRDC for commercial exploitation. Non-technical notes were prepared for each process developed for circulation through NRDC in order to create the confidence of the entreprenuers taking up the processes. As a result, the following new processes were released to industry :

1. Projector and Process Carbons
2. Technical Machinable Ceramics
3. Film Thickness Monitor and Controller
4. Microwave Components (C-Band)
5. Broad Band Ferrite Resonance Isolators for Microwave Applications
6. Electrostatic Photocopying Machine
7. Linear Drive for Mossbauer Spectrometer.

A memeographed report incorporating non-technical notes on processes/products developed by laboratory having export potential was prepared and sent to CSIR for dissemination to the industry.

Negotiations were made with industries for undertaking sponsored projects and many projects are likely to be finalised.

Research Planning and Coordination

Effective coordination was maintained for flow of information between project leaders and the Director. The projects in hand were reviewed quarterly and steps were taken to step up the pace of work. Progress reports were compiled twice for consideration and advice of Scientific Sub-Committee/Executive Council. Fourth Five Year Plan and Annual Plan of the laboratory were prepared in accordance with the requirements of the CSIR/Planning Commission. Research Programme of the laboratory was circulated to other national laboratories/ institutes of the CSIR in accordance with decision taken during Director's Conference.

Publicity

Following publications were brought out during the year :

1. Scope and Functions-NPL
2. Annual Report 1969-70
3. 'Self Reliance in Electronic Industry and National Physical Laboratory' by Dr. A. R. Verma, MBI's Indian Industries Annual-1970.
4. 'A Step to Self Reliance at NPL' by Dr. A.R. Verma, Industrial Thought.
5. 'Planning—Key to Success in Research' by M.S. Virdi, MBI's Indian Industries Annual-1970.
6. National Physical Laboratory-1971, A memeographed report.

Participation in Industrial Fairs

To popularize its achievements, the laboratory participated in the following industrial/scientific fairs :

1. Exhibition of Electronic Equipment and Instruments organised by Institute of Telecommunication Engineers, New Delhi, 22-24 Jan., 1970.
2. Indian Industrial Exhibition at Kuala Lumpur—Sept-Oct. '70.
3. 15th All India Science Teachers Conference and Exhibition, 26-28 Dec. 1970.

Open Day

The laboratory was kept open on 25th, 26th and 28th March, 1971 to scientists, engineers, industrialists, students and general public so as to provide an opportunity to see for themselves the work being done and the achievements of the laboratory. Over 5000 visitors were taken round the laboratory. An exhibition of NPL developed processes/ products was also organised on the occasion. The exhibits such as TV picture tube, desk calculator, microwave components, electrostatic photocopying machine, gas lasers, ferrites and ceramics, etc. highly attracted the visitors. Planetarium was a great attraction to the students.

On the occasion Dr. A.R. Verma, Director of the National Physical Laboratory, briefed the press about the achievements of the laboratory in terms of its well defined objectives. There was a remarkable response from the press. The activities of the laboratory were high lighted by all leading dailies of the country.

Fig. 7 Visitors on the open day in the Weights and Measures Section

Krishnan Memorial Lecture : As in the past Krishnan Memorial Lecture was arranged this year too. Prof. S.N. Bose, National Professor of Physics delivered the lecture on 25th March, 1971 among the large and distinguished gathering of eminent scientists, scholars and the citizens of Delhi.

Training : During the year training was provided to a number of students and scientists from academic organisations and engineers from industries in the various fields dealt by NPL (Appendix III).

A ten day Science Orientation Course was organised for officers of the Border Security Force during November, 1970. Scientists of this laboratory and other academic organisations delivered the lectures. The course was found much useful by the participants.

LIBRARY

Some improvements were brought into Library services during the year. "Current Titles" a fortnightly bulletin listing project oriented annotated titles from various journals received in the library to help the scientists in keeping themselves abreast with the recent developments was started for the first time this year. Since its first issue, June 1970, it is being regularly brought out. Another publication of the library viz. "List of Additions" is also being brought out regularly.

Efforts were made to render efficient service to readers in all possible ways.

A new section comprising of reports, standards, patents, translations, photocopies, etc. is being organised.

Library data interalia on purchase of books, journals, photocopies, translations, etc. are given below :

1.	Publications accessioned during 1970-71	...	1987
2.	Number of journals subscribed during 1970-71.	...	400
3.	Number of new journals subscribed during 1970-71	...	10
4.	Photocopies, translations accessioned during 1970-71	..	84
5.	Publications issued during 1970-71 (including inter-library loan)	...	12172

INSTRUMENTATION & SERVICING

The two major activities of this department have been the *Repair* of sophisticated imported apparatus and *Instrumentation Consultation* Service i. e. discussing specific problems concerning a measurement or the availability of specific apparatus or modifications in existing apparatus to suit a particular need.

In addition to repair of instruments of the laboratory itself, the department received a number of requests for its services from Public Institutions all over the country. Medical institutions continued to be the major users of the laboratory's expertise. Incidence of inquiries about the servicing of equipment from the farthest corners of the country reveal that this type of service is not available anywhere else.

An article "Instrument Servicing at the NPL" was published in "Indsearch", Feb. '71.

A paper on the "Classification of Scientific Instruments" is ready for publication.

KRISHNAN MEMORIAL LECTURE 1971

Krishnan Memorial Lecture was delivered this year by Prof. S. N. Bose, National Professor of Physics. In his talk Prof. Bose dealt with the history of development of scientific research in India specially at the Indian Association for Cultivation of Science, Calcutta.

The laboratory facilities at that time were so meagre that even the post-graduate students of science would be allowed only to have a rationed look into some shelved equipment, for all their practical knowledge. The Indian Association for Cultivation of Science was started with a modest building at 210, Bowbazar Street, Calcutta, having only modest laboratory facilities—even to that day's standard, out of a magnificent gift from lawyer Sir Mahendra Lal Sarkar. For the aspirants of scientific knowledge the only laboratories available for experimentation were of some government degree colleges. Science was

Fig. 8 Professor S.N. Bose delivering the 1971 Krishnan Memorial lecture at the laboratory.

not very fashionable at that time. Consequently, the brightest people and the graduates of science from Britain like Sir Mahendra Lal Sarkar had to start law practice. The Indian Association was set up in such a background. It created facilities for a scientist to do his own work and to be able to handle his own equipment. To this laboratory, students from many colleges would flock to do their little bit of practical work.

Prof. Bose as a young student felt pride in attending lectures on problems of advanced physics delivered by an Indian teacher. Many of the teachers were Europeans.

A young officer of the Indian Revenue Department could be seen spending long hours after sunset studying scientific books and journals or in keenly observing some physical phenomena demonstrable with ordinary equipment at the association building. The young man had rented his residence so close to the Association building that he could reach it through the back door of his residence. The young man was C. V. Raman who won the Noble Prize in physics later.

About this time the University of Calcutta started post-graduate department in science subjects. Prof. P.C. Ray was Head of the Chemistry Department. His research work in Chemistry led to the early start of chemical industry in Bengal. Sir J. C. Bose was another physicist active at that time in research work on plant life. The vice chancellor of Calcutta University, Sir Ashutosh, who himself had started his life with research work on mathematics but had gone to law because of lack of research facilities and dim prospect of a scientific career, was looking for the bright brilliant and young men to take charge of the two posts vacant in Physics Department instituted by two lawyers Sir Taraknath Palit and Sir Rashbihari Ghosh. Since, only Indians could be made Professors according to the University rules (the then European teachers in India were at best second rate) Sir, Ashutosh's eye fell on the young finance department official, whom he had found so keenly interested in scientific research and in whom he could see a great promise. Sir Ashutosh would in fact tell others that he was sure that that young man would go far, very far indeed. Thus was started the scientist's life for Prof. C. V. Raman, Incharge of Physics at the University Science College and a keen scientific researcher at the Association building.

Talking about the discovery of Raman Effect which brought world wide fame to India and Nobel Prize to Sir C. V. Raman, Prof. Bose highly appreciated the commendable contribution by Dr. K.S. Krishnan to the discovery of the effect. Dr. Krishnan's contribution was so significant that this effect could asw ell be called Raman-Krishnan effect.

Krishnan, an almost equally qualified and keen experimenter, continued work on Raman effect for sometime even at Dacca in the early 30's, where he was a Reader in Physics, and then became a Professor. Later, he started his well-known research work on crystal magnetism and its anisotropy. Sir Krishnan had also to build up very sensitive instruments for accurate magnetic measurements with the help of the modest technical expertise available at that time, with ordinary monetary and technical resources. The Indian genious was able to accept modern science, study it under most adverse conditions and excel in it. However, Prof. Bose regretted, the Indian scientists have not been able to maintain the name which their predecessors built for India. For some reason, a few Indian scientists who gave some early promise, later on faded out, inspite of the fact that technical facilities were much better now. It was a great surprise, he felt in modern times with well equipped universities in large numbers and with laboratories like the NPL we had not been able to produce scientists of that leval.

He, however, hoped that this evil star would recede from the sky of Indian science. If the Indian talent was properly organised, rightly guided and amply encouraged, he was sure, Indian young men would bring back the glory of the past to the country again. He concluded with the question "for how long can we wait for that ?"

Earlier Dr. A. R. Verma, Director, National Physical Laboratory, introducing the learned speaker told the audience about the giant stature of Prof. Bose in Physics. Of the two kinds of particles permeating the universe, one was the 'Boson' named after Prof. Bose.

PATENTS 1970-71

Accepted

An apparatus for cracking silicon tetraiodide	Pat. No. 122692	F. Kiss P.K. Gupta V.K. Amar	31.10.1970
A Distillation Flask	Pat. No. 123527	F. Kiss	31.10.1970
Improvements in or relating to Soft Ferrites for use in the medium and short wave frequencies	Pat. No. 122217	C.V. Ganapathy G. Govindaswamy K. Narayana S M. Khullar Ramadevi H.S. Kalsi T. Potikunju	23.7.1970
Improvements in or relating to nozzles	Pat. No. 124994	G.D. Joglekar C.L. Verma	10.12.1970
Improvements in or relating to hard ferrites	Pat. No. 123838	T.V. Ramamurti S.C. Gupta N.R. Nair B.S. Khurana	2.1.1971

Filed

A process for making a print of a document with electrostatic photocopying machine	Pat. No. 126506	P.C. Mehendru G.D. Sootha D.C. Parashar Narinder Kumar Davinder Singh	5.5.1970

Sealed

A process of preparation of—ferric oxide	Pat. No. 114829	C.V. Ganapathy S.M. Khullar R. Ramachandran	26.12.1969
An intercommunication system	Pat. No. 112675	R. Parshad	7.5.1970

PAPERS PUBLISHED

Foreign Journals

1. "Influence of plastic deformation on the growth of highly pure KCl crystals", P.C. Mehendru, J. Phy. C. Solid State Physics, 1970, Vol. 3, U.K.

2. "A Re-examination of Collision frequency estimates in the ionospheric F & E layers from Deviative absorption measurements", A.K. Saha; R. Venkatachari, J. At. & Terres. Phys., 1970, Vol. 32, 303-314.

3. "Effect of heat treatment and background Divalent Cation impurity on the growth of F Centres in highly pure KCl crystals", P.C. Mehendru, The Physical Review B, Vol. 1, No. 2, 809-14, 1970.

4. "Transistor Metal impurities in Alkali Halides", G.D. Sootha, Phys. Stat. Solidi, 363, 1970.

5. "Study of Bottchers formula for Dielectric Correlation between powder and bulk", D.C. Dube & Ram Parshad, J. Appl. Phys., 677-84, 1970. Vol. 3.

6. "X-ray K Absorption Edge of Niobium in Niobium Metal and its oxides", V.G. Bhide & M.K. Bahl, J. Chl. Phys., Vol. 52, No. 8, 4093, 1970.

7. "Daily Variation of Equatorial Electroject current system", J.C. Gupta, J. of At. & Terres. Phys., 1970, Vol. 32, pp 1159-64.

8. "Optical absorption and electrical conduction in KBr crystals containing diffused Mg", G.D. Sootha, N. Kumar, J. Physics C, Solid Stat. 1970, Vol. 3.

9. "Study of Landau Lifshitz Looyenga's formula for Dielectric correlation between powder and bulk", D.C. Dube, I Phys. D Appl. Phys., 1970, Vol. 3, U.K.

10. "Thermal expansion of In_20_3", S.Z. Ali, K.D. Kundra ; J. Appl. Cryst. Phy., Vol. 3, No. 6, 1970.

11. "The concentration dependence of resistivity anomaly in dilute magnetic alloys at low temperatures", M.S.R. Chari, Physik Der Materie, 11, 317-25, 1970.

12. "Recrystalization and grain growth in vacuum evaporated Bismuth films", S.K. Sharma & O.P. Bahl, Thin Solid Films, 6 (1970), 239-48.

13. "Cation Diffusion & Electrical Conduction in KCl crystals", D.C. Parashar, JPCS, Vol. 31, No. 12. 1970

14. "Optical & Thermoluminiscence studies in X-irridiated additively colored KCl crystals", S.C. Jain, P.C. Mehendru, Solid State Physics, 1970, Vol. 3, U.K,

15. "Some geographic and geophysical effects of electron content of the ionosphere" Tuhi Ram Tyagi and A.P. Mitra, J. Atmosph. Terrest. Phys , **32,** 1807-1818, 1970.

16. "A polar maximum of electron concentration at 1000 Km altitude" L.H. Brace, H.G. Mayr and K.K. Mahajan, J. Atmosph. Terrest. Phys., **32,** 1945-1957, 1970.

17. "Night time response of the topside ionosphere to magnetic storms" D.R. Lakshmi and B M. Reddy, J. Geophys. Res., **75**, 4335-4338, 1970.

18. "A re-examination of collision frequency estimates in the ionospheric F & E layers from deviative absorption measurements" A.K. Saha and R. Venkatachari, J. Atmosph. Terrest. Phys., **32**, 303-314, 1970.

19. "Daytime ionospheric effects associated with X-ray flare from SCO X R-1" Y.V. Ramanamurthy, A.P. Mitra and V.C. Jain, J. Atmosph. Terrest. Phys., **32,** 1721-1726, 1970.

20. "Effect of ozone content on the pre-sunrise fall in amplitude of LF radio waves" Y.V. Ramanamurthy and M. Nalnimohan Rao, J. Atmosph. Terrest. Phys., **32**, 1319-1324, 1970.

21. "Daily variability of the equatorial electrojet current system" J.C. Gupta, J. Atmosph. Terrest. Phys , **32**, 1159-1164, 1970.

22. "Observations of electron density during a solar flare" J.N. Rowe, A.J. Ferraro, H.S. Lee, R.W. Kreplin and A.P. Mitra, J. Atmosph. Terrest. Phys., **32,** 1609-1614, 1970.

23. "HF and VHF absorption techniques in radio wave probing of the ionosphere" A.P. Mitra, J. Atmosph. Terrest. Phys., **32**, 623-646, 1970.

24. "The chemistry of the D-region" A.P. Mitra, *Solar Eclipses and the ionosphere*, Plenum Press, pp 45-64, 1970.

25. "Photochemistry of Ozone" A.P. Mitra, *Stratospheric circulation*, Academic Press, 263-310, 1970.

26. "Geophysical implications of electron content and absorption measurements at Delhi" A.P. Mitra, Tuhi Ram Tyagi, S.B.S.S. Sarma and M.C. Sharma, Proc. Sympos. "Future Application of satellite Beacon Experiments", *Max Planck Institute for Aeronomy, Lindau,* pp 19-1 to 19-7, 1970.

27. "Seasonal variation in the F2 region" H.G. Mayr and K.K. Mahajan, J. Geophys. Res. **76**, 1017-1027, 1971.

28. "Sub-auroral red acrcs and associated ionospheric phenomena" S. Chandra, E.J. Maier, B.E. Troy. Jr. and B.C. Narasingha Rao, J. Geophys. Res. **76**, 920-925, 1971.

29. "Some preliminary results of the rocket sounding of the D-region at geomagnetic equator" Y.V. Somayajulu, M.B. Avdhanulu, K.S. Zalpuri and S.C. Garg, Space Res. **11**, 1131-1137, 1971.

30. "Models for the effective recombination coefficient of the ionosphere" A.P. Mitra and P. Banerjee, Space Res., **11,** 1019-1025, 1971.

31. "Models of lower ionosphere electron density profiles" A.P. Mitra and D.C. Chakrabarty, Space Res., **11**, 1013-1018, 1971.

Indian Journals

1. "Seven segment in line digital read out for a binary quinary decade counter", S.P. Suri & Ram Parshad, Jour. Inst. Telecom. Engrs. 1970, Vol. 16, pp 359-61.

2. "9th Thermal Conductivity Conference", M.S.R. Chari, Jour Sci & Indus Res. 1970, Vol. 29, No.5, pp 216-19.

3. "Demerit or Geometrical spread values of Lens System", Ram Prasad, J. of Opt. Society of India, Sept 70.

4. "Measurement of impedance at Microwave frequencies using directional coupler", A.K. Agarwal, Ram Parshad & Kailash Chandra, J. of Institution of Tele-communication Engrs, 1970, Vol. 16, No. 8, 581-86.

5. "Electron content measurements using Faraday Fading of beacon transmissions during low and high solar activity" Tuhi Ram Tyagi, and Y.V. Somayajulu, I.J. Pure & App. Phys. **8,** 577-580, 1970.

6. "Large scale ionospheric irregularities" Tuhi Ram Tyagi, Y.V. Somayajulu, Sant Prakash and J.B. Lal, I.J. Pure & App. Phys., **8**, 55-59, 1970.

7. "Electromagnetic probing of the atmosphere - the mesosphere and the lower thermosphere" A.P. Mitra, I.J. Pure & App. Phys., **8**, 507-515, 1970.

8. "Electromagnetic probing of the atmosphere - the upper ionosphere" B.M. Reddy and D.R. Lakshmi, I.J. Pure & App. Phys., **8**, 516-522, 1970.

9. "Flare effects on LF radio wave propagated over a distance of about 1600 Km" Y.V. Ramanamurthy, I.J. Pure & App. Phys., **8**, 569-572, 1970.

10. "Cosmic noise absorption measurements in Delhi" M.C. Sharma, S.B.S.S. Sarma and S.L. Juneja, I.J. Pure & App. Phys., **8**, 529-532, 1970.

11. "Calculations of ionospheric absorption Part-I Contributions from different regions and effect of solar activity" Sudesh Kumari, K.K. Mahajan and A.P. Mitra, I.J. Pure & App. Phys., **9**, 183-186, 1971.

12. "An Integrating Phase Comparator for Frequency Standardization and other Applications", P.N. Taneja, T.N. Ghosh & R. Parshad, Jour. Inst. Telecom. Engrs. 1971, Vol. 17, No. 9, pp. 331-333.

13. "Synthesis of Lens System by Evolution Method", Ram Prasad, Indian Journal of Technology, Vol. 9, Feb. '71.

GUEST WORKERS

S. No.	*Institution*	*No.*	*Field of Trg.*
1.	Regional Engg. College, Kurukshetra.	12	Workshop/Mechanics / Air-conditioning
2.	Thappar Institute of Engg. & Technology, Patiala.	5	Mechanics/Refrigeration
3.	Birla Institute of Technology & Science, Pilani.	5	Electronics
4.	J.K. Institute of App. Physics, Allahabad.	5	Electronics/Materials/Low Temperature
5.	Delhi College of Engg., Delhi.	12	Electronics/Electricity/Microwaves/Materials
6.	I.I.T., Kharagpur.	2	Electronics
7.	Punjab Engg. College, Chandigarh.	3	Electronics/Materials.
8.	Banaras Hindu University, Varanasi	9	Electronics
9.	I.I.T., Kanpur.	5	Electronics/Materials/Radio Propagation
10.	Madras Institute of Technology, Madras.	4	Electronics/Workshop
11.	I.T.I. Delhi.	1	Materials
12.	Ajmer Military School, Ajmer.	1	Electronics
13.	I.I.T., Delhi	1	Microwaves
14.	M.S. University of Baroda	1	Electronics

15.	M.M.H. College, Ghaziabad	1	Optics
16.	Cotton College, Gauhati	1	Materials
17.	Weights & Measures Dte., Bhopal	2	Weights & Measures
18.	Ministry of Education & Youth Services, Kanpur.	10	Electronics/Workshop/Materials/Analytical Chemistry
19.	Shri Krishnapuri Muzafarpur Bihar.	1	Optics
20.	Nagpal Traders, Delhi.	1	Optics
21.	Anil Jain, Kamla Nagar, Delhi.	1	Materials

LECTURES DELIVERED BY SCIENTISTS AT NPL

S. No.	*Name of the Speaker*	*Subject*	*Dated*
1.	Prof. Farrigton Daniels, Wisconsin, USA	Direct use of Solar Energy	4.4.70
2.	Dr. Toffler, Russel Sage Foundation	Social Consequences of Science & Technology	21.4.70
3.	Dr. M.S. Iyenger, R.R.L. Jorhat.	Some impressions of Expo 70'	25.4.70
4.	Dr. A.J.W. Moore Melbourne, Australia	Geometrical view of surfaces	19.5.70
5.	Prof. F. A. Kroger University of S. California	Imperfections in Crystals & Phosphors	6.7.70
6.	Prof A. K. Ramdas Purdue University	General Survey of Phenomena and Experimental Techniques	6.7.70
7.	-do-	Intrinsic and extrinsic behaviour of Semiconductors	7.7.70
8.	-do-	Donors & Acceptors in Semiconductors	8.7.70
9.	-do-	Piezo-spectroscopy of impurity States in Semiconductors	9.7.70
10.	-do-	Laser Raman Spectroscopy of Solids : Diamond and Bengil	10.7.70
11.	Dr. K. H. Hart NRC, Canada	Length Metrology at N.R.C.	14.7.70
12.	Dr. R. G. Giovanelli N.S. Lab. Australia	Solar Magnetic Fields	30.7.70

13.	Dr. J. H. Schulman, Materials Research, Naval Res. Laboratory, Washington USA	Proposed optical memory system using colour centres in alkali halides	25.9.70
14.	Dr. K. L. Bhatia	Configuration inter action in the internal acceptor state in silicon	20.10.70
15.	Dr. G. C. Jain, NPL	Silicon Technology	26.10.70
16.	Prof. W. A. Gambling	Lasers and optical Communications	9.11.70
17.	Prof. I. P. Valko (from Hungary)	Reliability in micro-electronics	9.11.70
18.	Dr. B. S. Mathur IIT, Kanpur	Hydrogen Masers	25.11.70
19.	Dr. J. L. Kiss Budapest Technical University, Hungary	System of education and accommodation of students at Budapest Technical University	2.12.70
20.	Dr. Kwatra (U.S.A.)	Spin disordered scattering in magnetic alloys	29.12.70
21.	Prof. R. J. Friauf University of Kansas, U.S.A.	Physics of Photographic Process	18.1.71
22.	Dr. M. Narasimhan, IBM Corporation, New York, U.S.A.	Lambshift	25.1.71
23.	Dr. V.B. Chipalkatti Shri Ram Institute of Industrial Research, Delhi	Some aspects of industrial research in India	28.1.71
24.	Prof. Robert Olovier Drudhamme, Director, Physico-Chemistry Laboratory Inst., Pasteur	Work being done at Institute	28.1.71
25.	Prof. K. L. Chopra, I.I.T., New Delhi	Amorphous semi-conductors	30.1.71
26.	Dr. C. Prabhakar, NASA Goddord Space Flight Centre, Greenbelt Mel. U.S.A.	Remote sounding of atmosphere temperature and Ozone from NIM BUS-3 Satellite	5.2.71

27.	Dr. C.V.S. Ratnam, Managing Director, N.R.D.C., New Delhi	Steps for the utilisation of indigenous technology in India	15.2.71
28.	Dr. I.M. Bental I.I.T. Madras	Laser and laser Interferometer	19.2.71
29.	Prof. H. E. White, Professor Emeritus and Retired Director of Lawrence Hall of Science, University of California, USA	Science and Society	24.2.71
30.	Dr. G. Klipping Institute of Electron Microscopy, Max Planck Institute Berlin	New Developments in Cryogenics for experiments at low temperatures	25.2.71
31.	Dr. A. Jayaram Bell Telephone Lab., U.S.A.	High Pressure effects on solids	26.2.71

DEPUTATIONS DURING 1970-71

Dr. A.P. Mitra

1. To attend the Symposium on Solar-Terrestrial Physics-1970 in Leningrad. (Organized by Inter-Union Commission on Solar Terrestrial Physics (IUCSTP)—May 11-19, 1970, Leningrad.

2. To attend the meeting of the Committee on Space Research (COSPAR)—to act as Chairman of the COSPAR's Advisory Committee on Space Data Problems and Publication. Also to present three papers—May 22-29, 1970, Leningrad.

3. To attend the Symposium on 'Future Application of Satellite Beacons and present the results of satellite radio beacon experiments carried out in NPL, June 1-5, 1970, Lindau, West Germany (Max Planck Institute for Aeronomie).

4. To visit Ionosphere Research Laboratory, and Naval Research Laboratory, USA to undertake a collaborative scientific programme on sudden Ionospheric disturbances—June 7-21, 1970.

5. To visit Soviet Laboratories of Radio Research and give a series of lectures on an invitation from the Presidium of the Soviet Academy of Sciences—October 22 to November 13, 1970.

6. To visit the Radio and Space Research Station Slough (U.K.) and discussion with the authorities on new techniques on measurement of tropospheric water vapour content—November 13-16, 1970.

Dr. Y.V. Somayajulu

1. To attend the Symposium on Solar-Terrestrial Physics-1970 in Leningrad. (Organized by Inter-Union Commission on Solar Terrestrial Physics (IUCSTP)—May 14-19, 1970.

2. To attend the meeting of the Committee on Space Research (COSPAR)—May 22-29, 1970, Leningrad.

HONOURS AND AWARDS

1. Dr. V.G. Bhide elected President of the Physics Section of the Indian Science Congress, 1971.

2. Dr. V.G. Bhide elected Secretary, Indian National Science Academy, New Delhi.

3. Drs. P.C. Mehendru, G.D. Sootha, D.C. Parashar, S/Shri Narendra Kumar, Devendra Singh received Import Substitution Award for the development of Electrostatic Photocopying Machine.

4. Dr. K. Chandra, S/Shri V.K. Agarwal, Joginder Singh, T.R. Arora, H.M. Bhatnagar received first NPL Merit Award for the year 1971 for the development of Microwave Components, Reflex Klystron, Cathode-ray Tubes & Television Picture Tubes.

5. S/Shri C.V. Ganapathy, G. Govindaswamy, S.M. Khullar, S.S. Hanspal, K Narayanan received second NPL Merit Award for the year 1971 for the development of Thermoplastic Moulding Technique for making Magneto and Electro-ceramics.

6. Shri M.S. Hegde was awarded degree of Ph.D. by Bombay University.

7. Shri A. Prasad was awarded degree of Ph.D. by Delhi University.

8. Shri Dinesh Chander Dube was awarded degree of Ph.D by Delhi University.

9. Shri N.S. Natrajan was awarded degree of Ph.D by Delhi University.

LIST OF PROCESSES RELEASED FOR COMMERCIAL EXPLOITATION

S. No.	*Name of the Process*	*Name of the Licencees*
1.	Silver Mica	i) M/s. Indian Telephone Industries, Bangalore.
		ii) M/s. Manilal Mohanlal & Co., 20, Dhanji Street, Bombay-3.
2.	Ceramic Capacitors	i) M/s. Bharat Electronics Ltd., Jalahalli P.O., Bangalore-13.
		ii) M/s. Satellite Engg. Ltd., P.O. Maiz Products, Kathwada, Ahmedabad-2.
		iii) M/s. Micro Ceramics P. Ltd., A-8, Cooperative Industrial Estate, Balanagar, Hyderabad-37.
		iv) M/s. B.N. Bhaskar & Sons, P.O. Amar Nagar, 20.4, K.M., Mathura Road, Faridabad.
3.	Soft Ferrites	i) M/s. Semiconductors Ltd., Ahmednagar Road, Mile 4/5, Poona-14.
		ii) M/s. Morris Electronics P. Ltd., Functional Electronics Estate, Bhosari, P.O. Pimpri, P. F., Poona-18.
		iii) M/s. Ferro Electronics P. Ltd., Uppal, Hyderabad-39, A.P.
		iv) M/s. Cema P. Ltd., 5-B, Amar Building, Sri P.M. Road, Bombay-1.
		v) M/s. Delhi Cloth Mills, Bara Hindu Rao, Delhi.

iv) M/s. Ferrites & Electronics Components Ltd.,

Lakshmi Nivas, Sri Krishnarajendra Road, Fort, Bangalore-2.

vii) Indian Ferrite Industries, Bangalore.

4. Hard Ferrites	i) M/s. Power Agents, 42, Keeling (Tolstoy) Lane, New Delhi-1.
	ii) M/s. Matchwel Electricals P. Ltd,, Poona-14.
	iii) M/s. Elpro International Ltd., Chinchwad, Poona-19.
	iv) M/s. Bhilai Ceramics, C/o M/s. Heatwell Equipment Corporation, 19, Banarasi Estate, Lucknow Road, Delhi-7.
	v) M/s. Ferro Electronics P. Ltd., Uppal, Hyderabad-39, A.P.
	vi) M/s. Ferrites & Electronic Components P. Ltd., Lakshmi Nivas, Sri Krishnrajendra Road, Fort, Bangalore-2.
	vii) Delhi Cloth Mills, Bara Hindu Rao, Delhi.
	viii) Mr. G. Narayana, 55-9-22/16, Adarsh Nagar, Hyderabad-4.
	ix) M/s. Kumar Ferrites, C/o Dr. A. Kumar, Modern X-ray Clinic, Lucknow.
	x) M/s. Oblum Electrical Industries P. Ltd., 6-3-562, Erra Manzil, Somajiguda, Hyderabad-4.
5. Peizoelectric Ceramics	i) M/s. Piezoelectric Ceramics India, E-119, Greater Kailash, New Delhi.

	ii) M/s. Murphy India Ltd., Naupada, Thana.
6. Ceramic Rods for Carbon Resistors	i) M/s. Micro Ceramics P. Ltd., A-8, Cooperative Industrial Estate, Balanagar, Hyderabad-37.
	ii) M/s. Caledonian Jute Mills Co. Ltd. Khurja (U.P.).
	iii) M/s. Techno Ceramics, C-2, Industrial Estate, Khurja (U.P.).
7. Carbon Slabs and Rods	i) M/s. Beni Ltd., 1, Crooked Lane, Calcutta.
	ii) M/s. Best & Co. (P) Ltd., 13/15, North Beach Road, Madras-1.
	iii) M/s. Assam Carbon Co., Everest House, 46C, Chowranghee Road, Calcutta-16.
	iv) M/s. Leadslip Products Pvt. Ltd., Ahmedabad.
8. Duplicating, Printing & Allied Inks	M/s. Mysore Lac & Paint Works, Edega Mansion, Mysore.
9. Indelible Ink	M/s. Mysore Lac & Paint Works, Edega Mansion, Mysore.
10. Anti-rust Solution	M/s. Mysore Lac & Paint Works, Edega Mansion, Mysore.
11. Manufacture of Waveguide Components for Microwave Applications	i) M/s. K.L.B. Electronics, 1-E/17, Jhandewalan Extn., New Delhi.
i) Straight Waveguides ii) Microwave Components iii) Klystron Power Supply	ii) M/s. Scientific Instrument Ltd., 6, Tej Bahadur Sapru Road, Allahabad.
12. Sequential Switching Devices (Traffic Control)	i) M/s. Beegee Corporation Pvt. Ltd., 25, Factory Area, Patiala.
	ii) M/s. Controls & Switchgears Co., 25, Rohtak Road, New Delhi.
	iii) M/s. Beacon Electronics, 49, Shahzada Bagh, Old Rohtak Rd., Delhi-7.

13. Carlson Type Strain Meter	M/s. Precision Instrument Corpn., Railway Road, Gurgaon.
14. Sealing Devices for Containers	M/s. Indian Dye Casting Co., Calcutta.
15. Cheap Group Hearing Aid	M/s. Parco, Connaught Circus, New Delhi.
16. Magnetic Fluid for Crack Detection	M/s. Asia Engineering Works, Haily Mandi, Pataudi Road, Distt. Gurgaon.
17. Cinema Arc Carbons	i) Sh. Ram Kumar Gupta, 3-6-286/2, Hyderguda, Hyderabad.
	ii) M/s. Beni Ltd., 1, Crooked Lane, Calcutta.
	iii) M/s. Advani Oerlikon Pvt. Ltd., Radial House, 6, Rampart Row, Bombay-1.
	iv) Dr. C.N.S. Prasoda Varma, 21-B, Ranjit Co-op. Housing Society Ltd., Sarojini Naidu Rd., Mulund (West), Bombay-80.
	v) M/s. Bharat Carbons Pvt. Ltd., B/5/68, Safdarjung Enclave, New Delhi-16.
	vi) India Carbon Co., Ganesh Bagh, Nehru Road, Bombay-80.
18. Solar Cooker	M/s. Jeevan Lal (1929) Ltd., 103, Netaji Subhash Chander Road, Calcutta.
19. Thin Film Thickness Monitor & Controller	M/s. Shakti Vacuum Products, Nagindas Chambers, 2nd Floor, 167, P. D'Mello Road, Bombay-1.
20. Electrostatic Photocopying Machine	i) M/s. Macneill & Barry Ltd., Con. House, E-Block, Connaught Place, New Delhi.
	ii) M/s. Advani-Oerlikon Pvt. Ltd., 6, Rampart Row, G.P.O. Box 1546, Bombay.
	iii) M/s. Systronics, Naroda Industrial Area, Naroda, Ahmedabad.

21. Linear Drive for Mossbauer Spectrometer	M/s. Toshniwal Instruments & Engineering Co., 10-A, Najafgarh Road, New Delhi.
22. Rotational Viscometer	M/s. Associated Instruments Manufacturers (India) Pvt. Ltd., Sunlight Building, Asaf Ali Road, New Delhi.
23. Extrusion Viscometer	M/s. Associated Instruments Manufacturers (India) Pvt. Ltd., Sunlight Building, Asaf Ali Road, New Delhi.
24. Ultrasonic Interferometer for Velocity Measurements	M/s. Maheshwari Associates, 5, Scindia House, New Delhi.
25. Colour Coating of Sunglasses	M/s. Vacuum Coating Laboratories, 61/6, Ramjas Marg, Karol Bagh, New Delhi.
26. Design and Development of 25 Ton Universal Testing Machine	M/s. Associated Instruments Manufacturers (India) Pvt. Ltd., Sunlight Building, Asaf Ali Road, New Delhi.
27. Electronic Desk Calculator (Two Function)	M/s. K.L.B. Electronics, 1E/17, Jhandewalan Extn., New Delhi.
28. Laser & Thin Film Interference Filters	M/s. K.L.B. Electronics, 1E/17, Jhandewalan Extn., New Delhi.
29. Photoconductive Cells	M/s. K.L.B. Electronics, 1E/17, Jhandewalan Extn., New Delhi.
30. Metal Graphite Blocks	M/s. Moba Carbons, 48, Wodehouse Road, Colaba, Bombay-5.

BENEFITS DURING THE YEAR

Direct	Rs. (in lacs)
Sale proceeds of Development-cum-Production of Electronic Components	3.952
Sale proceeds of Glass Technology Unit	3.407
Sale proceeds of Carbon Products	.556
Sale proceeds of Microwave Components	.430
Miscellaneous sale proceeds	.504
Testing & Calibration fees	1.007
Royalties	.922
Sale proceeds of priced publications	.035
Optical Design Data Premia	.010

Indirect	Nos.
Papers published	38
Test Certificates issued	2724
Standards maintained	15
Patents accepted	5
Processes released upto 31.3.71	21
Ph.D. Awarded	4

BUDGET (1970-71)

		Rs. (in lacs)
Pay and Allowances		44.696
Contingencies		9.176
Maintenance		1.702
Chemical Apparatus & Equipment		7.738
Capital		14.021
T.E.C.		1.098
Pilot Plants		26.492
	Total	104.923

CATEGORIES OF STAFF

		No.
(i)	**Scientific**	
	Gazetted	92
	Non-gazetted	56
(ii)	**Aux. Technical**	
	Gazetted	17
	Non-gazetted	297
	Class IV	133
(iii)	**Administrative**	
	Gazetted	5
	Non-gazetted	103
	Class IV	86
	Glass Technology Unit	
	Scientific/Technical	
	Gazetted	4
	Non-gazetted	36
	D.P.E.C. Unit	
	Scientific/Technical	
	Gazetted	9
	Non-gazetted	99
	Administrative	9
	Carbon Plant	
	Aux. Technical	4
	Test & Evaluation Centre	
	Scientists	3
	Non-gazetted	10
	Total	963

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   Bangalore-13

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   Calcutta-32

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   Atur House
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