NPL

Annual Report 1969-70

NATIONAL PHYSICAL LABORATORY
HILLSIDE ROAD, NEW DELHI-12

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INTRODUCTION

The year 1969-70 was yet another year full of achievements in the existence of the laboratory. We can modestly claim our worthwhile contribution in R & D for the advancement of science & technology. The research programme of the laboratory was reoriented keeping in view needs of the country. The National Physical Laboratory has a statutory obligation of maintaining primary standards such as that of length, mass, time and derived standards of force, electrical resistance, voltage, etc. Standards of 15 physical quantities are being maintained at present to internationally comparable accuracies. Efforts were made to improve the accuracy of the existing standards and to set up new standards, for example, the accuracy of microwave power & microwave impedance standards has been considerably improved.

The second major activity of the NPL is the developmental testing and calibration service. The NPL undertakes testing of a wide variety of industrial products for their performance, calibration, life & environmental evaluation. A set of equipment for testing 5000 clinical thermometers in one shift has been developed and supplied to ISI. During the year 2436 test certificates/reports were issued and Rs. 1.463 lacs were realised as test fee.

This year has been very significant and quite a few applied research projects were completed, tried on the pilot plant scale or batch production scale and released to industry. As many as 14 major processes have been exploited by about 28 industrial enterprises (appendix IV). As a result of production based on NPL released processes, foreign exchange to the tune of Rs. 30 lacs has been saved this year. The cumulative saving in foreign exchange so far has been over Rs. 3 crores. The efforts of the laboratory have been responsible in setting up of several industries. Thus for example, the initiation and growth of ferrite industry in the country has been possible because of the efforts of the laboratory. The major applied research projects in progress during the year include—professional ferrites, carbon products, electrostatic photocopying machine, single crystal & polycrystalline silicon of semiconductor grade, CR tubes & oscilloscopes, microwave components, He-Ne laser, etc.

Some very useful oriented basic research investigations were made to augment our knowledge required in applied Research & Developmental Work, Standards & Developmental Testing. Mossbauer spectroscopic studies on ferrites and cermets; X-ray studies on semi-conductor materials such as ZnSe, ferrites, ceramics etc., transport properties of dilute alloys at low temperature, diffusion studies in silicon, dielectric studies of liquid mixtures and powders, influence of magnetic field on diodes.

Major activities of Radio Science Division during the year include Satellite Radio Beacon studies, Rocket studies of lower ionosphere, Rio-

meters, LF & VLF wave propagation, regular sounding of ionsophere by C-4 ionosonde etc.

During the year 4 staff members were awarded Ph.D. degree by the Indian & Foreign Universities.

Efforts were made to maintain closer collaboration with industries and as a result sponsored projects were initiated such as, the colour coating of sun glasses for M/s. Vacuum Coating Laboratories, New Delhi; Development of silver contact relays for R.D.S.O., Lucknow; Development of 25 tonne Universal Testing Machine for M/s. Associated Instruments Manufacturers etc. Direct returns of the laboratory were about Rs. 7.00 lakhs apart from intangible returns of the order of many millions.

DR. A. R. VERMA

Director,
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ANNUAL REPORT
1969-70

National Physical Laboratory, New Delhi

The main objectives of the National Physical Laboratory, the earliest in the chain of national laboratories under the Council of Scientific & Industrial Research, are:—

1. to maintain and do research on primary and derived standards useful for physical measurements;
2. to undertake developmental testing on behalf of the industry, government establishments, etc., and to collaborate with Indian Standards Institution to frame specifications;
3. to undertake applied research with a view to acquire the know-how of a product or a process and hand it over to the industry for commercial exploitation; and
4. to carry out basic research on problems flowing out of the activities connected with maintenance of standards, developmental testing and applied research.

STANDARDS

The National Physical Laboratory has a statutory obligation of maintaining primary standards such as that of length, mass, time and derived standards of force, electrical resistance, voltage, etc. Since its very inception, the National Physical Laboratory has been maintaining some of the basic standards. The maintenance of standards to the requisite accuracy is a time consuming and an expensive activity indulged in by most of the countries. Expensive and extensive as it may appear, the maintenance of standards in the country to the relevant accuracy is extremely important as the ultimate accuracy attained in any industrial production in the country is ultimately determined by the accuracy with which national standards are maintained. Our primary concern in maintaining standards at the NPL has essentially been the demand of the industry. Thus, for example, with the rapid development of electronic industry in the last few years, a need was felt by both the industry and defence to have electronic standards especially microwave power, frequency and r.f. voltage. Realising this pressing need of the industry, the National Physical Laboratory has recently established the high frequency voltage, microwave power and microwave impedance standards. It may not be out of place to mention here that the Electronics Committee has recommended the establishment of these electronic standards.

HIGH FREQUENCY VOLTAGE STANDARDS

Thermal convectors to be used as working standards up to 100 MH have been procured. These are being calibrated against d.c. to provide calibration facilities for signal generators, vacuum tube voltmeters, etc. Small thermistors mounted in coaxial mount are used as a reference standard of H.F. voltage, in conjunction with a precision d.c. self balancing bridge. Micropotentiometers for small H.F. voltages are also being fabricated.

MICROWAVE POWER STANDARDS

Bridge circuits have been constructed to measure microwave power up to 10 GH using calibrated coaxial thermistor mounts with an accuracy of $\pm$ 2%. Wave guide type bolometer mount duly calibrated by the Electrotechnical Laboratory, Japan has also been procured for power measurement in the X-band waveguide system. This would serve as a working standard.

For reference standards of microwave power, negotiations are being made with the National Bureau of Standards, USA to obtain precision d.c. self balancing bridge to be used with microcalorimeters for the absolute measurement of efficiency and calibration factor of bolometer mounts.

MICROWAVE IMPEDANCE STANDARDS

The differential coupler method already developed at NPL is being improved by incorporating matching turners etc. for absolute measurement of impedance in waveguide systems. The reference standards for these measurements are quarter wave short, standard waveguide, and movable method termination. Blue prints for these components are ready and these would be fabricated soon.

R.F. POWER AND VOLTAGE STANDARDS

During the year, the Laboratory succeeded in establishing the R.F. power and voltage standards to an accuracy of 2%. This accuracy is, for the present, enough to meet the requirements of the industry. We are, however, conscious that in coming years, this accuracy will have to be improved.

In addition to the above mentioned standards there are several other electronic standards which need be maintained. These are:—

I. High frequency standards (30 KH_z to 1 GH_z)

1. H.F. Voltage
2. H.F. impedance for lumped as well as distributed circuits
3. H.F. attenuation
4. H.F. power
5. H.F. noise.

II. Microwave standards (1 GH_z to 30 GH_z)

1. microwave power
2. microwave impedance
3. microwave attenuation
4. microwave phase shift
5. microwave noise.

Setting up all the above mentioned standards would require huge investment, time and effort. Further, the need for all these standards is not being currently felt. However, it is realised that with the development of electronic industry in the country, these standards will be required in future. To undertake perspective planning a field survey has been undertaken by the Laboratory regarding the requirements of Defence organizations, research institutions and the electronic industry. The results of the survey has shown that there is maximum demand for high frequency voltage standards and top priority is being given to this project.

A comprehensive report based on the analysis of the survey and the proposed plan of action will be placed before Electronics Committee for their comments and if approved, for their financial assistance.

ELECTRICAL STANDARDS

The National Physical Laboratory maintains the standard of absolute ohm and absolute volt to the international accuracy.

The precise measurement of these standards are done by substitution method so that only the difference between the standard resistance and another is measured. This, however, requires a resistance with which comparison is made known to a much greater accuracy. This is why it is necessary to maintain a bank of resistances. NPL resistance standard has three resistances 35 years old and two resistances 15 years old and the other resistances were added during the last five years.

Similarly, the e.m.f. standard consisting of 10 Weston Cadmium cells has been maintained in this Laboratory.

Some 1 ohm standard resistors were fabricated during the year. A set of standard resistances of the value 0·01, 0·1, 1, 10, 100 ohms was made. This set has been given to the University of Jammu.

INTERNATIONAL PRACTICAL TEMPERATURE SCALE

Most of the fixed points on the International Practical Temperature Scale have been realised. However, in the mean time the International Conference on Weights and Measures have recently changed a few fixed points and efforts are now under way to realise them.

PHOTOMETRIC AND COLORIMETRIC STANDARDS

The Laboratory does not maintain primary standards for photometry and colorimetry. Indeed only two or three countries maintain such

primary standards. The Laboratory maintains the secondary standards for photometry and colorimetry. During the year, intercomparison of the secondary standards of incandescent lamps was undertaken.

A three metre diameter integrating sphere has been designed and fabricated.

FORCE STANDARD

Two years back the Laboratory designed and fabricated a 3-ton dead weight machine. This has served as a standard of force. A need has now been felt to set up 10-50 tonne dead weight machine. A survey is being undertaken to assess the demand. If the survey brings out clearly the urgent need for such a dead weight machine then alone the design and fabrication of the machine will be undertaken.

SOUND PRESSURE STANDARD

The standard for sound pressure has been established. Along with this the calibration of standard microphone by the reciprocity method was undertaken.

The acoustic block with a well designed anechoic chamber is getting ready.

List of Standards maintained with their accuracy :

PRIMARY STANDARDS

Physical Property	*Standard*	*Accuracy*
Length	Metre	5 in 10^8
Mass	Kilogram	1 in 10^7
Time	Second	1 in 10^8
	Frequency	1 in 10^8
Current	Ampere	1 in 10^5
Illumination	Candella	2 in 10^3
Temperature	K	Average 0.002 in the range of 90 K and 770 K.

DERIVED STANDARDS

Physical Property	*Standard*	*Accuracy*
Resistance	Ohm (DC and AC)	1 in 10^6
E. M. F.	Volt (DC and AC)	1 in 10^4
	Volt (R. F.)	2 in 10^2
Power	Watt (DC and AC)	1 in 10^5
Power	R. F.	2 in 10^2
Force	Newton	4 in 10^5
Atmospheric pressure	mm of Hg Newton Bar	1 in 10^3
Sound pressure	Microbar dynes/sq. cm.	1 db.

It will be realised from the above report that Laboratory maintains only those standards for which need is felt and those also at a level of accuracy which is normally an order higher than the needs of the industry. The decision that which standards should be maintained and at what accuracy is almost entirely dependent upon the needs of the industry and not so much for the sake of prestige. The maintenance of standards is a time-consuming and very expensive activity. At the same time this activity cannot show any direct returns. However, as already mentioned this activity is very important and plays a silent role in the development of industry in the country. Indeed, the maximum accuracy which can be attained in any industrial production in the country is determined by the accuracy with which national standards are maintained.

DEVELOPMENTAL TESTING AND CALIBRATION

The second primary objective of the National Physical Laboratory is the developmental testing and calibration of industrial products. In the field of developmental testing the National Physical Laboratory undertakes a wide variety of industrial products such as radio and TV receivers, weights and balances, capacity measures, slip gauges, proving rings, dynamometers, motors, fans and cables, refrigerators, lamps and lamp fittings, etc. The Laboratory issues test certificates against nominal test fees. During the year 1968-69, the Laboratory issued as many as 2,000 certificates and realized 1·56 lakhs of rupees. This year also considerable amount of work has been carried on under this head. The division-wise break up of the test certificates issued and the test fees realised during April, 1969 to March 1970 is given below:

Name of Division	*No. of Test Reports Issued*	*Testing Fees Earned*
Acoustics	52	6378·00
Applied Mechanics	403	26099·50
Carbon Plant	6	723·00
DPEC Unit	40	2378·36
Electricity	313	17640·03
Electronics	46	4533·42
Heat	68	4345·34
Infrared	25	1770·00
Low Temperature	5	3600·00
Materials	4	75·00
Materials Analysis	160	16643·00
Optics	158	12427·69
Power Research	5	195·00
Weights & Measures	1145	47183·44
X-ray	6	2340·00
	2436	146331·78

In addition to the issue of test certificates, the scientists in the Laboratory advised the industry to improve their products. Fine growth of the balance industry owes substantially to the advice rendered by the scientists of the Laboratory. The indigenous manufacture of railway signal glasses in the country is to an extent due to the testing carried out in the Laboratory.

A complete set of equipment designed and fabricated at NPL to test 5000 clinical thermometers in a shift of eight hours was installed at the premises of the ISI. As in the case of lamp and lamp fitting industry, a request has been received from industry to establish test facilities at places where thermometers are being manufactured. Indeed, we have received a proposal from the Director of Industries, Haryana to establish test facilities at Ambala. Negotiations are going on in this respect.

In addition to the testing and calibration, the Laboratory has been undertaking the testing of purity and perfection of materials. As technology develops the testing of the perfection of materials is bound to increase and the Laboratory is being geared up to undertake this activity. In fact, at several conferences on electronics a feeling has been voiced to have a national centre for characterization of materials.

An outstanding work in this field was carried out on behalf of the Customs department. The Customs department wanted to determine for the purposes of charging import duty as to whether a given sample of diamond dust was of natural diamonds or artificial diamonds. In the growth of synthetic diamonds, nickel is normally used as a catalyst. The X-ray investigation following the work of Prof. Lonsdale brought out the fact that in the X-ray diffraction photographs of artificial diamonds one gets additional lines due to nickel carbide. The existence of these lines confirms that the given sample is an artificial diamond. Besides, work was done on the testing of crystallinity of silicon crystals, nature of epitaxial layer on behalf of CEERI, Pilani, etc.

ENVIRONMENTAL TESTING

In addition to the testing of the purity and perfection of materials it is necessary to carry out the life and environmental testing of various optical, mechanical, electrical and electronics instruments. The science of environmental testing has developed rapidly during the last few years. The Electronics Committee has designated National Physical Laboratory as one of the centres to undertake life and environmental testing of electronic components, systems and instruments. A grant of Rs. 18·49 lakhs has been sanctioned by the Electronics Committee for Capital Equipment and the centre will be established during the course of next year. Initially, this centre will devote almost entirely to the life and environmental testing of electronic components, systems and appliances but as experience is gained the activities would be extended to other fields such as optical instruments, electric machines, etc.

Neither the industry nor the consumers are really quality conscious. As Professor Blackett has rightly pointed out that the industry should be compelled to get their products tested by persuasion admonition, coercion or even by legislation. It is planned to achieve this by convening group meetings of different industries in the coming years.

APPLIED RESEARCH

This year has been very significant and quite a few applied research projects were completed, tried on the pilot-plant or batch production stage and handed over to the industry. The National Physical Laboratory has a proud record in the field of applied research. It has developed as many as 14 major processes which have been exploited by as many as 28 industrial concerns, which include both, public undertakings and private enterprises. The processes and the licensees to whom these processes have been released are shown in appendix IV.

The process know how is released through NRDC/CSIR against royalty ranging from 2—7% depending upon nature of product. The total production undertaken in the country on the processes released by the National Physical Laboratory exceeds Rs. 3·0 crores. Besides, the saving of foreign exchange, this activity has generated confidence in the industry and in many cases the industry is prepared and at times keen to take the process from the bench. In addition, the efforts of the Laboratory have been responsible in setting up of several industries. Thus, for example, the initiation and growth of the ferrite industry in the country has been possible because of the efforts of the Laboratory.

FERRITES

The National Physical Laboratory has been interested in the study and development of the process for the manufacture of different kinds of ferrites which are used in radio and TV receivers, telecommunication equipment and several electrical appliances. Initially work was undertaken on soft ferrites used in radio receivers as antenna rods. In a short time, the process was perfected.

As mentioned in earlier reports, this process has already been released to five licencees. Also the costly imported constituent material nickel has been replaced by the indigenously available manganese. This has not only reduced the cost but also improved the quality of the ferrite antenna rods.

By controlling the composition, the Q properties at high and medium wave frequencies have been improved. It may be mentioned that the Q properties are even better than those of imported rods at high frequencies. Over 50,000 rods of short-cum-medium wave ferrite (NPL-5C) have been already made and supplied to various parties; M/s. Murphy, Telefunken, Chopra, GEC, Eastern Electronics and Wireless House have tried new rods and approved the product. Oscillator cores made from this material have also been approved and supplies to the tune of 50,000 pieces have been made to CEERI, JK Industries and Telerad. The process data has now been given to two of our licensees: M/s. Semiconductors Ltd. and Ferro Electrics Private Limited.

PROFESSIONAL FERRITES

A couple of years back the Laboratory undertook the work on the development of professional ferrites which are extensively used in telecommunication and TV industry. The urgency and the importance of the developmental work on professional ferrites was essentially due to the fact that the Laboratory committed itself to the P & T Department to develop the material and produce it on batch production scale, within a certain period of time so as to discontinue the import of this item. The P & T Department wanted NPL to develop material equivalent to Philips 3B7. The specifications for this material are very stringent and the tolerances are also limited. The Laboratory undertook intensive work on developing the know-how of the process. In this effort several testing techniques such as X-ray analysis, optical microscopy, spectrochemical analysis, Mossbauer spectroscopy, etc., were brought to bear on the problem. Under this concerted interdisciplinary approach, the process for the professional ferrites was developed within a short time. The joint testing carried out at the Telecommunication Research Centre has shown that the material developed at the NPL meets all the requirements and can substitute the imported material. The table below gives the comparative properties of 3B7 and the ferrites developed at NPL

MATERIAL CORRESPONDING TO 3B7
TEST RESULTS CONDUCTED IN TRC ON 6.9.69 ON NPL SAMPLE

Sample No.	*μi*	*D.F.*	*H.F.*	*L.F. 4Kc/s.*	*L.F. 100 Kc/s.*	*T.F.*
208-104-1	2375	$1{\cdot}90\times10^{-6}$	1·11	$0{\cdot}89\times10^{-6}$	$2{\cdot}54\times10^{-6}$	$+0{\cdot}069\times10^{-6}$
208-104-2	2311	$1{\cdot}79\times10^{-6}$	0·98	$0{\cdot}90\times10^{-6}$	$2{\cdot}56\times10^{-6}$	$+0{\cdot}215\times10^{-6}$
208-104-3	2283	$2{\cdot}04\times10^{-6}$	0·91	$0{\cdot}66\times10^{-6}$	$2{\cdot}50\times10^{-6}$	$+0{\cdot}217\times10^{-6}$
208-104-4	2416	$1{\cdot}69\times10^{-6}$	0·93	$\cdot80\times10^{-6}$	$2{\cdot}84\times10^{-6}$	$+0{\cdot}232\times10^{-6}$
209-104-1	2460	$2{\cdot}46\times10^{-6}$	0·78	$\cdot68\times10^{-6}$	$2{\cdot}27\times10^{-6}$	$+0{\cdot}472\times10^{-6}$
209-104-2	2382	$2{\cdot}15\times10^{-6}$	0·73	$\cdot72\times10^{-6}$	$2{\cdot}34\times10^{-6}$	$+0{\cdot}576\times10^{-6}$
Philips 3B7	$2300\pm20\% \leqq 4.3\times10^{-6} \leqq 1.8$			1×10^{-6}	5×10^{-6}	$-0{\cdot}6\times10$ $-0{\cdot}6\times10$

μi = Initial permeability
D. F. = Disaccommodation factor
H. F. = Hysterisis factor
L. F. = Loss factor
T. F. = Temperature factor

Sd/- R. C. Mohan (TRC)
Sd/- P. S. Shambavi Devi (NPL)

The demand of telecommunication industry is roughly of the order of 10 tonnes per year which is likely to go upto 25 tonnes in the next few years. These ferrites are also used in TV receivers.

Indeed the weight of the ferrite material used in a TV receiver is roughly 400—500 gms. As the TV industry is gradually growing the demand for this type of ferrite material is bound to increase. The approximate price of the corresponding imported material is Rs. 1,50,000 per tonne. Thus, taking the needs of the P & T Department alone, the turnover would be roughly Rs. 15 lakhs a year.

THERMOPLASTIC PROCESS

Thermoplastic process for making ferrite bodies of complicated shapes has also been developed. In this process close tolerances in dimensions become possible. Further, the die design and production become simpler. Hitherto, even in Japan such bodies are made to the desired shape by grinding with diamond wheels making the process laborious and expensive. The thermoplastic process is much more novel, simpler and cheaper. I. F. cores, screw cores, dumbels and pot cores have been made using this process. Production procedure is being standardised for manufacture.

TUNNEL KILN

The NPL designed tunnel kiln has been tested and NPL Manganese Zinc Ferrites (NPL-3) have been produced in this kiln to the tune of over one lakh rods. Medium-cum-Short (NPL-5C) wave ferrites have also been successfully produced by using this Tunnel kiln. Kanthan wire, grade A-1, wound over ceramic former has been used successfully in place of usual silicon carbide element which is imported. It may be noted that Kanthal wire is being made in India now. The life of the wire element is 3-4 months and hence it is quite economical compared to the silicon carbide type heating elements. The Tunnel Kiln is estimated to cost less than Rs. 50,000 and a furnace of similar design is being constructed by an Indian firm against order from one of our licensees. A second tunnel kiln is being fabricated in the unit for use in development-cum-production of ceramic capacitors. It has already been reported that there is a large saving of power consumption in tunnel kiln compared to Batch furnaces, especially when large scale production is involved.

SALE STATEMENT DPEC PRODUCTS MANUFACTURED IN PILOT PLANT FOR THE YEAR 1969-70

		Qty.	*Value in Rupees*
1.	NPL-5C (Antenna Rods)	21962	50099·80
2.	NPL-3 (Antenna Rods)	41982	55,923·60
3.	I. F. Cores & Tubes	600446	44,498·78
4.	Oscillator Cores	40131	6,910·24
	,, Coil Formers	133	372·40
5.	Ceramic Coil Formers	1282	1,695·90
6.	Pot Cores	181	1,756·00
7.	Hard Ferrites	50741	13,701·62
8.	P.Z.T. Discs	922	3,008·21
9.	Trimmer Rings & Plates	682	1,510·75
10.	Toroids (High Permeability)	103	395·10
11.	Toroids	772	1,571·50
12.	Silver Cement	7505 gms	4,825·50
13.	C. Cores	3441	2,354·25
14.	E. Cores	1063	3,247·50
15.	Ferrite Beads	36428	9348·10
16.	Sintered Powder	3560 gms	3,560·00
17.	Cup Cores	75	18·75
18.	Dumbels	75	18·75
			2,04,816·75

GLASS TECHNOLOGY UNIT

The unit continued its manifold services to research institutes, medical institutions and the industry. A large number of complicated equipment were fabricated and supplied. The unit developed a cracking unit to crack silicon tetra-iodide for the preparation of polycrystalline silicon. Three patents were filed during the year.

Nearly 40 mercury arc rectifiers were reconditioned.

The sale proceeds of the unit during the year 1969-70 are Rs 1,22,325·85. The unit catered the needs of various divisions of the laboratory for glass-apparatus worth more than Rs. 2·5 lakhs.

CARBON PRODUCTS

The unit continued its developmental activities. A new method of extruding complicated shapes of carbons has been successfully developed. The split die method has been patented.

The Laboratory has successfully developed the know-how of variety of carbon products. These include cinema arc carbons, process carbons, searchlight carbons, blocks and brushes. Out of these several processes, the process for making blocks and brushes has been leased to M/s. Beni Ltd., who have successfully exploited the process. In order to demonstrate the consumer acceptability, batch production of process and projector carbons has been undertaken. During the year projector & process carbons worth Rs. 26,000 were sold. The demand for these projector and process carbons is very large and quite a number of industrial concerns have been agitating for foreign collaboration. At the instance of the Department of Industrial Development and Company Affairs, a joint testing of NPL made carbon rods along with those of some of the imported rods was undertaken. The representative of M/s. India Carbon was present at the time of testing. The joint test report brought out the fact that NPL carbons are in no way inferior to the imported carbons. Since this joint testing a number of concerns have approached NPL for the process know-how. Negotiations are being made through NRDC for licensing the process.

In the field of blocks and brushes, a firm which desired to enter into foreign collaboration was asked to request NPL to develop a few grades to their specifications. The NPL accepted this work and it has now successfully developed a grade equivalent to GH530 which the firm wanted. The firm has been informed and has been requested to suggest a suitable date for joint testing of this grade.

ELECTROSTATIC PHOTOCOPYING MACHINE

One of the notable achievements of the year has been the successful development of the electrostatic photocopying machine. The National Physical Laboratory has successfully developed an electrostatic photocopying machine. This machine works on the principle of electrophotography and

copies documents on any ordinary paper or on a reasonably smooth surface by a dry process. It employs a photoconductive plate which can repeatedly be used several thousand times. It is a direct, positive to positive and rapid process for copying documents, diagrams and half-tone pictures at a fraction of the cost of a photocopy. One can get a copy made with this process in about one minute. It is possible under certain circumstances to get as many as 150 copies. The machine can also be used for a variety of other uses such as printed circuits, etc.

Fig. 1 Electrostatic Photocopying Machine

Complete technical know-how for the fabrication of this machine from the indigenous materials has been developed. The scientists of this Laboratory have already made three prototypes and the fourth prototype which is an improved version is almost getting ready. The machine has been put to all sorts of rigorous tests and is found to be working successfully under varying conditions.

So far the document copying facilities which are essential for the libraries, commercial concerns, big offices and organisations for rapid, accurate and economical dissemination of scientific, technical, commercial and educational information in the form of letters, reports, abstracts, specifications, catalogues, etc. were being achieved by the imported machines. The cost of an imported machine is around Rs. 60,000 (Polish make) and around Rs. 1 lakh of the RANK Xerox. As against this, the estimated price of

the machine that has been designed and fabricated at the NPL would range between Rs. 15,000 to Rs. 20,000.

The Electrostatic Photocopying Machine developed at the National Physical Laboratory is comparable in quality, performance and efficiency with any similar imported machine. Keeping in view the utility, low cost and non-involvement of foreign exchange, it is expected that almost all the universities, degree colleges and schools of higher learning would be in a position to possess such a machine and it would make great impact on the educational, scientific and technological growth of the country. The demand for this machine is very high and enquiries for quite a few thousands of these machines have been received.

A number of industrial concerns have already approached the laboratory for acquiring the technical know-how for commercial exploitation against the usual terms of premium and royalty. The product has apromising market potential.

SEMICONDUCTOR GRADE POLYCRYSTALLINE AND SINGLE CRYSTAL SILICON

Silicon is a basic material for transistor and rectifier industry. The NPL took up a project to develop the complete know-how for the production of silicon in Mach 1967. The project involved two major steps: (1) Preparation of high purity silicon, (2) Growing of single crystals of requisite quality from the polycrystalline material produced. In the following, an uptodate report on the work is given:

I. Preparation of polycrystalline silicon

There are three standard methods for producing polycrystalline silicon of high purity known as the semiconductor grade silicon. These are the silicon tetra-iodide method, the trichlorosilane method and the silane method. The NPL took up the first two methods. The current status of these methods is given below:

(a) Tetra-iodide method

In the silicon tetra-iodide method three processes for manufacturing three different grades of silicon have been standardised. The three processes are:

i) Preparation of crude silicon tetra-iodide, fractional distillation of crude tetra-iodide and cracking of silicon tetra-iodide. This yields N-type silicon of resistivity around 10 ohm-cm.

ii) Preparation of crude silicon tetra-iodide, fractional distillation of silicon tetra-iodide, zone-refining of silicon tetra-iodide and cracking of silicon tetra-iodide. This yields N-type silicon of resistivity of 50 ohm-cm.

iii) Preparation of crude silicon tetra-iodide, fractional distillation of silicon tetra-iodide, crystallisation of silicon tetra-iodide in N-heptane, further distillation of silicon tetra-iodide and cracking of silicon tetra-iodide. This method yields N-type silicon of resistivity 100 ohm-cm.

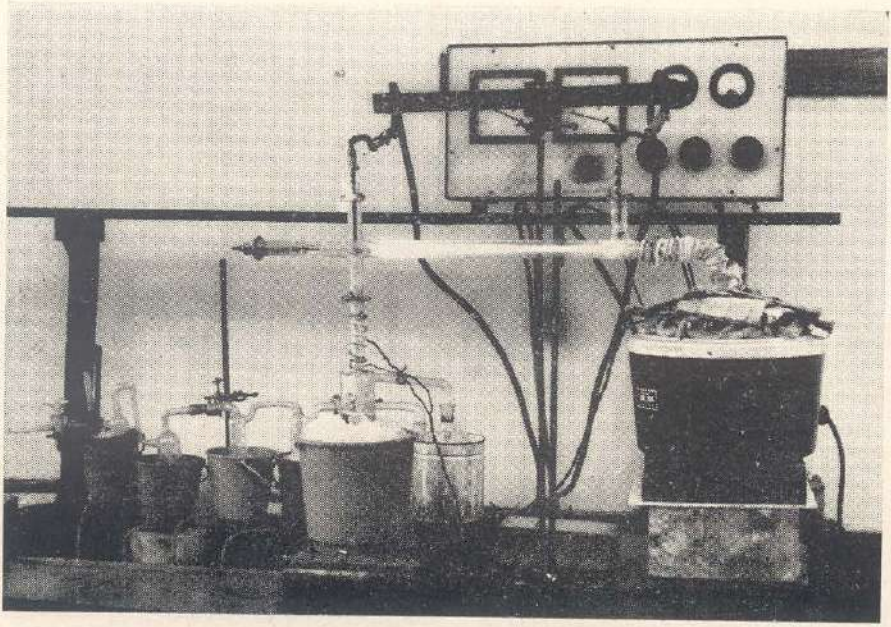

Fig. 2 Cracking apparatus for Silicon

(b) **Trichlorosilane process**

In the trichlorosilane process crude trichlorosilane is prepared, fractionally distilled and cracked. This yelds N-type silicon of about 1 to 10 ohm cm resistivity.

II. TESTING OF POLYCRYSTALLINE SILICON

In the initial stages the polycrystalline silicon was tested by spectrochemical analysis at BARC. Later refinements have brought down the impurity level so low that impurities are not detectable by spectrochemical analysis. The only way one can estimate the impurities is by electrical measurements, which is being done at the NPL. The polycrystalline material produced in the NPL is absolutely scum free.

Single crystals of silicon

There are two methods for growing single crystals of silicon:

(1) Pulling single crystals of silicon from a melt,

(2) Casting silicon into rods and float zoning the cast rods with seed.

The NPL chose to work on the second method. In this method polycrystalline silicon is first melted in a quartz crucible and by pressure differential suction technique cast into rods. Because of the limitation of size of the available crucible, only to a maximum charge of about 90 grams can be fed and as such the cast rods have a maximum weight of 80 grams. The casting

technique has been perfected. It is now possible to cast any diameter rod of silicon in NPL, only limitation being that the total weight of the rod is limited by the charge in the crucible and the diameter of the crucible. The next step of seeding these polycrystalline rods with single crystals and float zoning them to convert them from polycrystalline to single crystals has been perfected. Because of the limitations of the equipment it is easier for us to handle 11 mm diameter crystals at the moment. The crystals produced in the NPL are monocrystals from one end to another and have etch-pit density less than 10^4 per square centimetre. The radial variation of the resistivity on slices is within ± 15 per cent. The single crystals of silicon processed at NPL are now being tested by the rectifier industry. As soon as the satisfactory reports are received the process will be passed on for production.

CATHODE RAY TUBES AND OSCILLOSCOPES

Another significant development during the year is the successful fabrication of cathode ray tubes and the construction of the CRO kit. The project of cathode-ray tube fabrication was started in October 1968 following a training programme given by Mr. M. E. Russell of Hewlett Packard Co., USA. Details of techniques perfected here are given below:

1. Deposition of phosphor in glas bulbs

Phosphor is being deposited by settling technique. Two types of phosphors viz. Pl and P31 have been used. In some tubes, NPL made phosphor has also been deposited. Clean-room facilities for phosphor deposition, gun assembly, etc. have been established.

2. Aquadag coating inside the bulbs

Aquadag is coated inside the bulb using a sponge brush while the tube is mounted on a revolving chuck. A simple machine has been fabricated for this purpose.

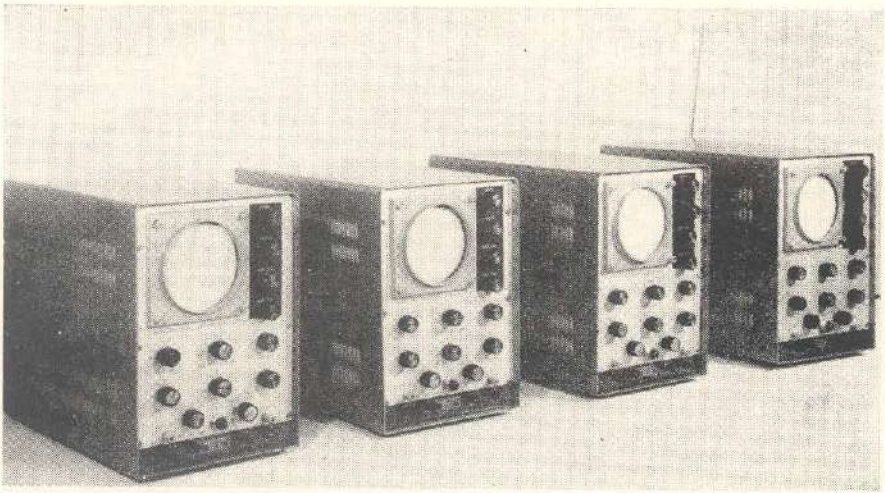

Fig. 3 Cathode Ray Oscilloscopes Kit using CR tube developed at NPL

3. Electron gun assembly

So far imported guns have been used. Now, the dies for making gun parts of 5UP1 have been designed and six dies have already been fabricated. Techniques have been perfected for sealing the gun to the glass bulb. This operation is being done on a glass lathe. Now a simple machine is being designed for this purpose also.

4. Evacuation, breakdown and processing of tubes

A demountable sealing system has been made for evacuating the cathode-ray tubes. Power supplies for breakdown and activation of the cathode, etc. have been fabricated. Arrangements have been incorporated to degas the parts by induction heating. A tip-off oven has been fabricated and is being used for sealing of the tubes after processing.

5. Testing of complete tube

After aging tubes are tested on a test console for their deflection sensitivity, intensity, etc.

Now the facilities are set for fabricating one tube per day. Two types of tubes, viz. 5UP1 and 5AQP31 having accelerating voltages of 1500 and 3000V respectively have been fabricated. 5UP1 are under batch production now to meet the demand of University Grants Commission. Some industries have also asked for samples of 5UP1.

Reconditioning of old cathode-ray tubes has been tried. Defence have expressed a desire for reconditioning of radar-display tubes which are usually of bigger size screen. Baking oven to accommodate these tubes is being fabricated now for reconditioning purposes.

Electronic circuitry for a general purpose oscilloscope using 5UP1 has been perfected. Six oscilloscopes have been assembled to test their performance and 12 more sets are being assembled for supply to summer schools. All indigenous components have been used.

Cathode ray oscilloscope kits have been developed. This is a general purpose oscilloscope and uses all the indigenously available components.

The University Grants Commission has requested NPL to supply 500 oscilloscope kits for use in their summer institute programme. A function was held in September 1969 when one kit was presented to Dr. D. S. Kothari, Chairman, University Grants Commission.

DESIGN AND DEVELOPMENT OF MICROWAVE COMPONENTS

The development work started few years back on microwave components was continued this year also with some significant achievements. The use of microwaves is increasing day by day in India, in radars, microwave communication systems, navigation and scientific research. Most of the microwave

components used in these applications were being imported. Keeping in mind the object of self-sufficiency and saving of foreign exchange, work was started at the National Physical Laboratory on the design, development and fabrication of waveguide components required in microwave systems. The efforts made at the NPL in this direction during the last two years are described here.

Microwave components are generally of three types, viz. (1) waveguide type, (2) stripline type, and (3) coaxial line type. So far we have been concentrating only on waveguide type of microwave components covering the frequency range 2 GH_z to 26.5 GH_z. The following sections describe briefly the fabrication of waveguides, design and batch production of various components including ferrite devices and simple systems like microwave testbenches and an apparatus to study diffraction, absorption, etc., at microwave frequencies.

Fabrication of waveguides

Seamless waveguides required for microwave components are generally extruded using high power extension machines which are quite expensive. The process developed at the National Physical Laboratory is based on the drawing technique of changing the available pipes of circular cross section into rectangular cross section. The drawing machine designed and developed for this purpose is capable of drawing wave-guides upto a maximum length of two metres and costs only Rs. 10,000 approximately. Two sizes of waveguides suitable for X-band (8.2 to 12.4 GH_z) and XN-band (5.8 to 8.2 GH_z) have been successfully drawn on this machine using copper and brass pipes. The dimensions and other characteristics meet the ISI specifications. Dies for making K-band waveguides are being fabricated at present. For S-band waveguide, brazing of two L-shaped pieces is being tried.

Fabrication of microwave components

Various methods like precision casting, metal spraying, soldering and brazing of waveguides, electroforming etc., are used for manufacture of waveguide components. Two methods have been adopted at the National Physical Laboratory. Components like T junctions, directional couplers, attenuators, horns, short circuits, etc., have been fabricated by brazing pieces of straight waveguide which was drawn at the Laboratory. Complex shapes like bends, transitions from circular to rectangular waveguide or from one size of waveguide to another, etc., have been fabricated by electroforming.

Ferrite devices like broadband resonance isolators and three port junction circulators (both T and Y type) have been perfected. Microwave ferrites used in these devices have also been made at the National Physical Laboratory. Typical characteristics of isolators and circulators are given below:

a. **Broadband circulators**

(i) Frequency band for 20 db isolation	8.2 to 10.2 GH_z
Insertion loss	0.5 db
Maximum isolation	35 db
Maximum V.S.W.R.	1.2

(ii) Frequency band for 70 db	10.2 to 12.4 GH_z
Insertion loss	0.5 db
Maximum isolation	35 db
Maximum V.S.W.R.	1.2

b. **Broadband resonance isolators**

(i) Frequency band for 70 db isolation	5.8 to 8.2 GH_z
Maximum forward loss	10 db
Maximum V.S.W.R.	1.1
Maximum isolation	35 db
(ii) Frequency band for 20 db isolation	8.2 to 12.4 GH_z
Maximum forward loss	1.1 db
Maximum isolation	35 db
Maximum V.S.W.R.	1.1

So far thirty complete microwave test-benches for X-band each comprising these 27 components have been supplied to various universities, colleges, research institutions and Governments departments at a cost of Rs. 2,55,000 thereby saving a foreign exchange equivalent to about Rs. 7,00,000. The technical know-how for X-band components has now been passed on to M/s. KLB Electronics, New Delhi.

An apparatus to study diffraction, reflection, absorption, etc., at microwave frequencies was also fabricated. One experiment using this set-up is to study Bragg's diffraction at microwave frequencies using a model crystal with metal balls replacing the atoms. Gain and polar patterns of horns, etc., can also be studied on this set-up. This apparatus has been batch-produced and 5 units have been supplied to universities at a cost of Rs. 6,000.

REFLEX KLYSTRON

Sufficient progress has been made in the direction of fabricating external cavity type reflex klystrons. Few prototypes of klystrons equivalent to 2 K 28 for 10 cm are under fabrication now. Harmonic generators to give second and third harmonic of 3,000 Mc/s have alredy been developed at the National Physical Laboratory. These harmonic generators along with klystron 2 K 28 could serve as oscillators in XN and X-bands for which other components have already been developed as described above. Several Defence jobs for special components have also been started. Work on flexible waveguide is also in progress.

GAS LASER

The work on developing a gas laser that was started last year, was continued and the Laboratory successfully fabricated a He-Ne gas laser. The laser tube was built with Brewsters' windows and external confocal mirrors. The active length was 25 cm and its bore 2 mm; the confocal mirrors used had a radius of 60 cm. The mirrors were coated with 15 alternate layers of ZnS and M_gF_2 and had a reflectance of over 99% at 6328A. Mirror mounts of kinometic design with sensitive control of tilts were developed. After filling the discharge tube with the required He-Ne mixture, the laser assembly was

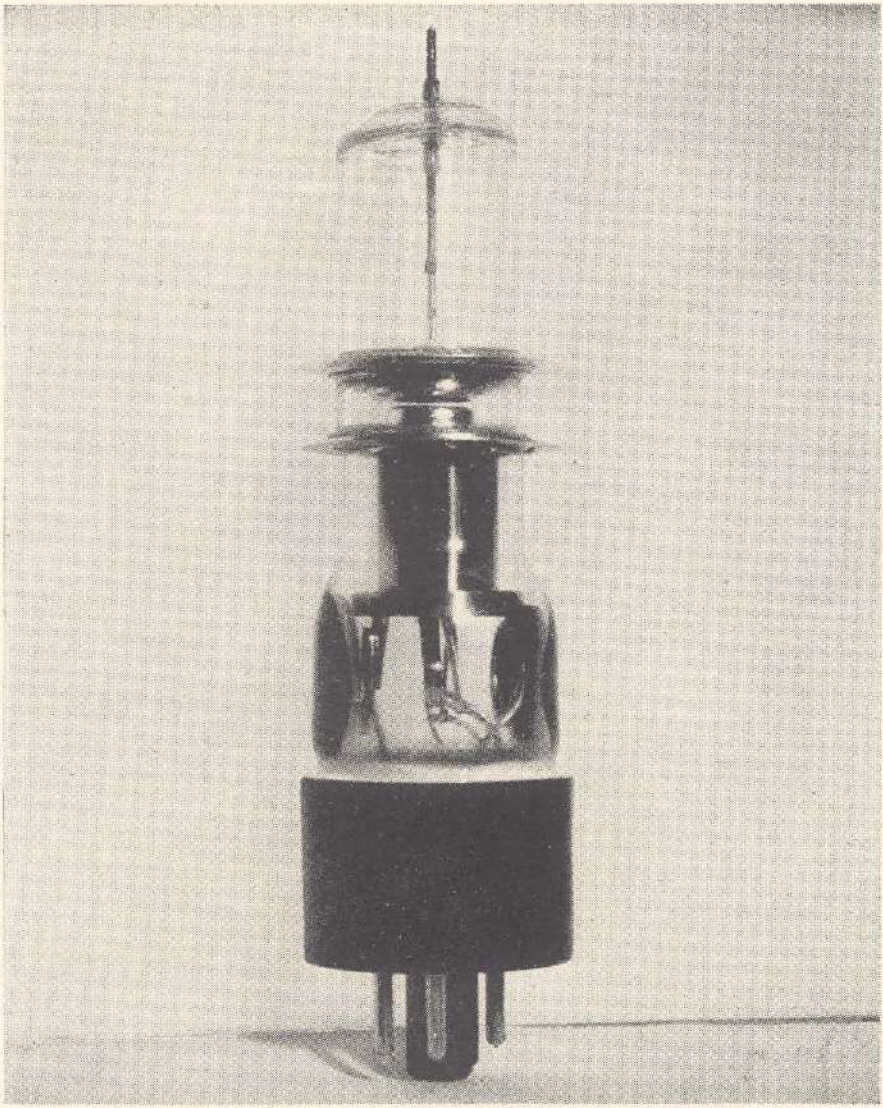

Fig. 4 Reflex Klystron equivalent to 2 K 28 developed by the Laboratory

tried out on an optical bench. The lasing action was first obtained on August 27, 1969, after several trials. The parameters of our first experimental laser are given below:

Beam power	0.1 milli watt
Beam divergence	1.0 milli radian
Spot size at mirror	0.35 mm
Coherence length	Over 3 metres.

A number of such lasers have been made with power in the range of 0.1 to 0.3 milliwatt and with increasing life. The maximum life obtained with unsealed tube is about 100 hours. Both hot and cold cathode excitation of the discharge and confocal as well as hemispherical configurations for the resonator have been used. To obtain higher output, 13 layer mirrors have been used. A prototype of the laser has been developed.

The next significant modification has been the development of a laser with integral mirrors without Brewster's windows. Hemispherical configuration with 13 layer mirrors has been used and beam power obtained is about 1 milliwatt.

The stages of development are summarised as below:

1. Development of multilayer coatings for mirrors.
2. Construction of high vacuum gas purification and filling unit.
3. Development of Brewsters' windows and mirrors.
4. Design and development of laser tube and jigs for testing the alignments.
5. Development of 0.1-0.3 milliwatt He-Ne lasers with Brewsters windows:
   (a) with confocal resonator configuration
   (b) with hemispherical resonator configuration
   (c) with hot as well as cold cathode for discharge.

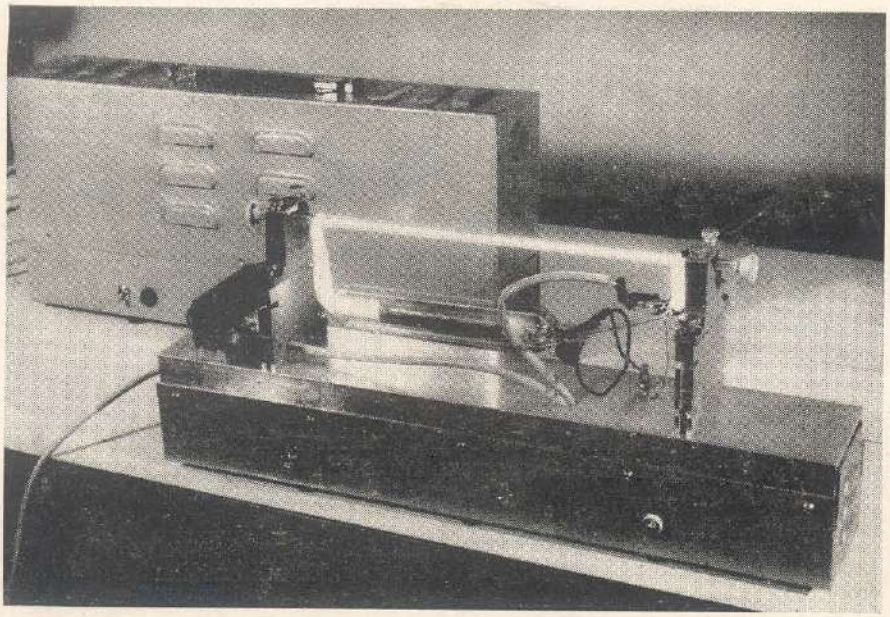

Fig. 5 He-Ne laser of 0.1 milliwatt power developed by Laboratory

6. Development of 1 milliwatt He-Ne laser with integral mirrors of hemispherical configuration.

The University Grants Commission has requested NPL to supply 15 He-Ne gas lasers for their use in the summer institute programme.

THIN FILMS

Quartz crystal film thickness monitor and controller was developed. The following patents were taken:

1. Improved thin film thickness monitor.
2. Improved thin film thickness monitor with superior pulse shaper.
3. Improved thin film thickness monitor with feed back network.
4. Electronic controller for controlling thickness of thin films during evaporation.

The process for making thin film monitor and controller has been passed on to NRDC for commercial exploitation.

Technical know-how has been developed for extremely hard and durable coating of different colour shades on sunglasses. The know-how is being passed on to M/s. Vacuum Coating Laboratory, New Delhi who sponsored the project.

LIQUID AIR CONTAINERS AND LIQUID AIR MACHINE

The Laboratory made few liquid air containers for universities. A small prototype of liquid air machine was also made to test the validity of calculations. The machine worked satisfactorily. An improvised model is being designed now.

ELECTRONIC DESK CALCULATOR

On the recommendation of the Scientific Sub-committee the work on an electronic adding machine was also started in the month of October 1969. The experimental work on the above machine has been successfully completed. The work on the fabrication of prototype model of an electronic adding and subtracting machine with six digits for use in shops will be completed shortly.

ORIENTED BASIC RESEARCH

To carry out basic research to augment other scientific activities is one of the objectives of the laboratory. The group on basic research has been actively engaged in studies like Mossbauer investigations on ferrites, cermets, ferroelectrics and anti-ferroelectrics, Mossbauer studies of Brownian Motion, Electron transport properties of metals & alloys, X-ray spectroscopic investigations on intermetallic compounds, diffusion studies in silicon, dielectric studies of liquid mixtures and powders, influence of magnetic field on diodes etc.

X-Ray Spectroscopy

The X-ray K-absorption edge of niobium in niobium metal and its various compounds has been photographed using 40 cm bent crystal X-ray spectrograph designed and fabricated at the NPL. This element is of particular interest because it can exist in various valence states. The position and fine structure of X-ray K-absorption of niobium in niobium metal and its oxides namely NbO, NbO_2 and Nb_2O_5 have been investigated. The comparison of the structure of K-asborption edge of niobium and that of yttrium gives reasonable correlation with the total density of states curve obtained from the specific heat data of these metals. The analysis of absorption edges of these metals implies that there is considerable overlap of 4d-5s band with the 5p band. This inference that there is considerable overlap of 4d-5s band is also substantiated by the soft X-ray emission studies of Holliday. It was found that K-absorption edge of niobium in its oxides shifts towards higher energy with respect to that in niobium metal. The shift being greater, higher the valence state of niobium. In addition to the shift of the absorption edge. it was found that the structure of the absorption edge changes in going from niobium metal to its oxides. A shoulder K′ appear in the absorption edge of various oxides. The shoulder K′ is attributed to the decrease of overlapping of 4d-5s band with 5p band as one moves from niobium metal to its oxides and corresponds to the transition of s electron to hybridized 4d-5s band. A paper entitled 'X-ray K-absorption edge of niobium in niobium metal and its oxides' has been accepted for publication in Journal of Chemical Physics (Vol. 52, Jan. 1970). X-ray K-absorption edge of niobium in a number of other compounds, i.e. Halides, Selenides, Tellurides, Carbide, Nitride, Hydride and niobates has also been studied. In halides, position of the absorption edge is related to the covalency of the chemical bond.

The study of the X-ray K-absorption edge of second transition series elements was extended to the case of Molybdenum. The position and fine structure of X-ray K-absorption edge of Molybdenum in molybdenum metal in its few compounds have been investigated. A preliminary study of oxides shows that the X-ray K-absorption edge shifts towards higher energy side with increase in valence state of molybdenum as has been found in various oxides

of niobium. The position of the K-absorption edge in a number of other compounds, i.e. sulphide, selenide, telluride and silicide has been taken. A paper embodying selenides and tellurides of niobium and molybdenum is being sent for publication.

The X-ray K-fluorescence spectra (K_{α_1}, K_{α_2}, K_{β_1} lines) of some of the niobium compounds has also been investigated. An attempt is being made to correlate these studies with the absorption work.

Mossbauer Spectroscopy

The nuclear hyperfine structure corresponding to the crystal field split states of trivalent iron in SnO_2 have been observed by ^{57}Fe Mossbauer effect. These hyperfine effects disappear with the increase in iron concentration. The effects of heat treatments on SnO_2:^{57}Fe system, namely, the production of metallic iron in hydrogen treated absorbers, and production of Fe^{2+} state in addition to the normal Fe^{3+} state on vacuum firing, are also studied. In the low concentration region, these changes, caused by thermal treatment, are associated with the change in the relaxation time so that the hyperfine structure almost disappears.

The MgO:Fe system as subjected to a variety of heat treatments has been studied using the Mossbauer effect for ^{57}Fe. On firing the MgO:Fe samples in air, iron initially dissolves in the lattice in its ferric state and is associated with a charge compensating vacancy. However, on exceeding a certain concentration, magnesioferrite precipitates out. Hydrogen firing of these samples tends to create clusters of metallic iron and Fe^{2+} at Mg^2 sites. On refiring the samples in air, metallic iron is converted to Fe_2O_3 and Fe^{2+} to Fe^{3+} which subsequently reacts with the lattice to give magnesioferrite and a small fraction of Fe^{3+} dissolved in the lattice. These changes are found to be completely reversible. In some cases magnesioferrite particle size is so small that it exhibits superparamagnetism. Although there is a limit to the solubility of Fe^{3+} in MgO, Fe^{2+} can be dissolved to any extent.

The effect of diffusive motion on the Mossbauer line width has been investigated theoretically as well as experimentally. Fine particles of $FeSnO_3$, containing two Mossbauer isotopes were used in the present studies. Our present theoretical calculations showed that the line width of the resonance spectrum depend upon the life time of the nucleus in the excited state. Results obtained experimentally agree very well with theory. Part of these results have been presented at the Nuclear Physics and Solid State Physics Symposium held at Roorkee. A detailed paper is being sent for publication to the Physical Review.

TRANSPORT PROPERTIES

Since we were able to analyse the thermal and electrical conductivity data in transverse magnetic fields by the methods of Gruneisen and de Haas we have started making similar measurements on Palladium and Zirconium. Measurement on Palladium would be particularly interesting becauseit differs from other transition elements in that it is nearly ferromagnetic. Electrical resistivity of Zirconium has been carried out in zero field from 4°K to 473°K. The magneto-thermal conductivity measurement on Palladium has been

does not rotate under an a.c. field and that their atomic and electronic polarizability are much less than that of the dipoles in the free state. It is inferred that the water molecules in the salts are under strong crystalline fields. Conclusions have been supported by investigations by NMR and neutron scattering.

A paper on "Application of Bottcher's formula to dielectric behaviour of liquid mixtures and a new method of deducing dipole moments in liquid and vapour states" was published in Jour. Phys. Chem. In this investigation, the dielectric behaviour of liquid mixtures, non-polar in non polar and polar in non-polar has been discussed leading to a new method of deducing dipole moments at infinite dilution, and in the vapour state, of molecules showing negative solvent effect.

Looyenga's dielectric correlation formula has been applied to liquid mixtures and new results have been obtained about treatment of mixtures of polar in non polar.

The behaviour of dipoles showing positive solvent effect has been distinguished from that of dipoles showing negative solvent effect. The present treatment of liquid mixtures also yields a new method for dipole moment determination of molecules showing positive solvent effect.

RADIO SCIENCE DIVISION

Satellite transmissions of Explorer-22 were recorded regularly upto May 1969. Electron-content values obtained from Faraday fading of these transmissions during low solar activity were compared with those of high solar activity. The main result was that though there was no seasonal anomaly in electron content at Delhi during low solar activity, but the anomaly appeared during high solar activity.

Work on the fabrication of the payload for D-region rocket sounding progressed and was completed (The rocket flight is designated as ISRO 30.01). The payload consisted of the following experiments:

1) Riometer
2) Lyman experiment
3) Propagation experiment
4) D. C. probe

The objective was to measure the electron density distribution, electron temperature and collisional frequencies at the equatorial location.

The rocket was successfully launched from Thumba range at 1235 hrs on 2nd Jan. 1970. The total payload weight was about 60 kg and rocket reached an altitude of about 125 km. All experiments aboard worked satisfactorily. Analysis of data is under way.

A riometer at 40 MHz has been constructed to study the absorption at oblique incidence as well as at Zenith. The data obtained a^* zenith will be utilized for a new type of riometer analysis. This equipment will also be utilized to study the radio star scintillation.

The data of cosmic radio noise absorption at 20, 22.4 and 30 MHz has been analysed for the period 1957 to 1965. It is found from this analysis that there is a strong dependence of total absorption with foF2 and the F region contribution is found to vary with square of foF2 during the low sunspot years. There is a strong correlation between total absorption and the total electron content during the low sunspot period which also indicates that the F region contribution predominates towards total absorption.

The total absorption, foF2 and the total electron content for this latitude do not show any winter anomaly in low sunspot year. The total absorption depends on latitude, sunspot number, and magnetic activity.

Rocket and satellite measurements of X-ray and U.V. flux during two eclipses in the year 1966 (Greece and Brazil) have been studied in D-region. The variation of ionization during both the eclipses has been explained on the basis of variation of minor neutral constituents O and O_3. A complete picture of variation of different parameters has also been given.

The dopplometer equipment which is located at the field station of Calcutta University is working very satisfactorily. A new double dipole broadside array has been put to improve the recording and to reduce noise. The records were checked for the sudden frequency deviations, and published (vide RSD/S/2) in Solar Geophysical Data.

A detailed study of the observations of the O-3A° and O-8A° X-ray measurements by NPL satellite has been made to obtain spectral information of X-rays below 8A° during a flare.

Ionospheric effects caused by celestial X-ray sources are being studied. Observable changes in nocturnal LF propagation associated with the meridian transist of Sco X-1, Tau X-1 and sources in the Cygnus region have so far been discovered. The physical implications of the X-ray flare from celestial X-ray source Sco X-1 are being studied.

From the amplitude recordings at LF, indirect methods of deducing phase height variations during the day are being explored. For this purpose besides 164 kHz transmission from Radio Tashkent another transmission on a closely spaced frequency 182 kHz, from Alma Atta is being monitored. Attempts are also being made to deduce the change in the height of reflection caused by a solar flare.

Besides this work at LF, VLF transmission on 22.3 kHz from NWC, Australia is being monitored to study the propagation of VLF radio waves.

GET-TOGETHER ON LAMP, LIGHTING FITTING & COLOUR GLASSES

In order to bring the industry closer to the working scientists in the Laboratory, get-together of the lamp industry and the scientists of the laboratory and other laboratories was organised. The get-together was inaugurated by Professor V. K. R. V. Rao, Vice President of the CSIR. This get-together was very largely attended and for the first time there was get-together of the representatives of organised sector, small sector, the government departments such as DGTD, department of Foreign Trade, Research, Designs and Standards Organization of the Railways, Indian Standards Institution, scientists of NPL and other research organisations. Various problems faced by the industry were discussed freely. The opportunity was also utilized in pointing out to various agencies the testing and calibration facilities that are available at the NPL. At this get-together it was suggested that the NPL along with CGCRI should establish test facilities for the small sector near about the network of industrial estates. Feasibility of establishing such test centres is being examined.

Fig. 6 Participants to the Get-Together Visiting the Exhibition Organised on the Occasion

KRISHNAN MEMORIAL LECTURE

The sixth Krishnan Memorial Lecture on "Molecular Biophysics & Crystallography" was delivered by Prof. G. N. Ramachandran, Jawaharlal Nehru Fellow & Director, Centre of Advance Study in Biophysics, University of Madras, Madras, at the National Physical Laboratory, New Delhi on 16th February, 1970. The lecture was attended by a large gathering of scientists from educational and research organisations.

Prof. Ramachandran observed that molecular biophysics is a field of comparatively recent origin and the methods of approach adopted by molecular biophysicists have turned out to be immensely fruitful in evolution of new methods in crystallography not only in the solution of crystal structure, but also in understanding the stability of periodic structures occurring in crystals.

The lecture has been published in the form of a booklet in view of its popular demand.

Fig. 7 Prof. G. N. Ramachandran delivering the Krishnan Memorial Lecture

INSTRUMENTATION SERVICING

The repair or servicing of expensive scientific instruments from NPL and many other organisations was undertaken during the year. Instruments repaired include nuclear scintillation apparatus, E.C.G. machines, pH meter, Fluorolume apparatus, Tissue maton, spectrometer, oscilloscopes, etc. Besides this a large number of enquiries concerning instrument application, availability, repairability etc. from universities, medical institutions & government establishemnts were attended to.

SERVICE TO INSTITUTIONS/INDUSTRY

(i) Regular Ionospheric Soundings and True Heights

Routine round the clock soundings of the Ionosphere at 15 mm. intervel were continued satisfactorily. Routine hourly scaled data were provided for radio propagation services. Weekly summary data were supplied to interested users in India and abroad.

Selected records were specially scaled and reduced to true heights with an electronic computer programme and given to other laboratories on request and for the project on Satellide Radio Beacon Studies.

(ii) Solar Geophysical and Propagation Data Service

The data was supplied to various organisations in the form of reports, i.e.

i) Ionospheric Data ...RTRC-A, Part I.

ii) Solar Geophysical Data ...Data — RTRC-A, Part II.

PROCESSES RELEASED AS ON 3-13-1970

Names of the process and patent No.	*Names of the Licensees*
1. Silver Mica Capacitors 53528	i) M/s. Indian Telephone Industries, Bangalore. ii) M/s. Manilal Mohan Lal & Co., Ltd., Bombay.
2. Ceramic Capacitors 533372, 53462, 53528, 53817, 54263	i) M/s. Bharat Electronics Ltd., Bangalore ii) Matchwell Electricals P. Ltd., Poona-14. iii) Micro Ceramics P. Ltd., A-8, Cooperative Industrial Estate, Balanagar, Hyderabad-37. iv) M/s. Satellite Engg. Ltd., P.O. Maiz Products, Kathwada, Ahmedabad.
3. Soft Ferrites 87993, 101626	i) M/s. Semi-Conductors, Poona. ii) M/s. Morris Electronics Ltd., Poona. iii) M/s. Ferro Electric Pvt., Ltd., B-1-174, Fateh Maidan Road, Hyderabad, A.P. iv) M/s. Cema Private Ltd., 5-B, Amar Building, Sir P.M. Road, Bombay-1. v) M/s. Indian Ferrite Industries, Bangalore. vi) B. Ramakrishna Rao, Bombay. vii) M/s. Delhi Chemical Mills, Delhi.
4. Hard Ferrites 9372	i) M/s. Power Agents, New Delhi. ii) M/s. Swastik Rubber products, Poona. iii) M/s. Ceramic Magnets & Electronics Co., Madras. iv) M/s. Matchwell Electrical Ltd., Poona. v) M/s. Elpro International Ltd., Poona. vi) M/s. Bhilai Ceramics, Delhi.

5.	Piezoelectric Ceramics 103201, 107157	M/s. Piezoelectric Ceramics India, E-119, Greater Kailash, New Delhi-14.
6.	Ceramic Rods for Carbon Resistors 92277	i) M/s. Micro-Ceramics Ltd., Hyderabad. ii) M/s. Mahaliram Lachmandas Chemical Porcelain Factory, Khurja.
7.	Carbon Slabs and Rods	i) M/s. Beni Ltd., Calcutta. ii) M/s. Assam Carbon Co., Calcutta. iii) M/s. BEST & Co. iv) M/s. Leadslip Products Pvt. Ltd., Ahmedabad.
8.	Duplicating, Printing & Allied Inks 40257	M/s. Mysore Lac & Paint Works, Mysore.
9.	Indelible Ink	—do—
10.	Anti-rust Solution	—do—
11.	Manufacture of waveguide components for microwave applications: i) Straight waveguides ii) Microwave Components iii) Klystron Power Supply	M/s. K.L.B. Electronics, New Delhi.
12.	Sequential Switching Devices (Traffic Control)	i) M/s. Beegee Corporation Pvt. Ltd., Patiala. ii) M/s. Controls & Switchgears Co., New Delhi.
13.	Carlson Type Strain Meter	M/s. Precision Instrument Corporation, Gurgaon.
14.	Sealing Devices for Containers 58785, 58382	M/s. Indian Dye Casting Co., Calcutta.

(A) PATENTS ACCEPTED — 1969-70

1.	Improvement in or relating to a process of depositing pyrolytic carbon film on ceramics	110876	Shiv Saran & others
2.	A process for the preparation of γ ferric oxide	114829	C. V. Ganapathy S. M. Khullar Mrs. R. Ramachandran
3.	A paint suitable for manufacture of magnetic tapes	118901	C. V. Ganapathy & others
4.	An intercommunication system	112675	Ram Parshad
5.	Improvements in or relating to manufacture of resistors	113507	Shiv Saran & others
6.	Improvements in viscometer	118034	S. S. Chari
7.	Improvements in or relating to carbon composition resistances and compositions thereof.	115127	T. V. Ramamurthi N. R. Nair
8.	Improved Thin Film Thickness Monitor	119805	V. V. Shah S. P. Suri
9.	Ultrasonic transducers for automation & remote control applications	116564	V. N. Bindal

(B) PATENTS FILED — 1969-70

1.	Improved Thin Film Thickness Monitor	120706	V. V. Shah S. P. Suri
2.	Improvements in or relating to soft ferrites for use in medium and short wave frequencies	12217	C. V. Ganapathy & others
3.	A new unit for cracking silicon tetraiodide	122692	F. Kiss & others
4.	A device to study Bragg's Diffraction	122862	V. N. Bindal

5.	Improvements in or relating to megneto ceramics	123139	C. V. Ganapathy & others
6.	A process for electro-static charging of photo-conductive machines.	123641	P. C. Mehendru & others
7.	Distillation flask	123527	F. Kiss
8.	Improvements in or relating to hard ferrites	123838	T. V. Ramamurthi & others
9.	Improvements in or relating to techniques for the manufacture of products of complicated shapes by extrusion method	124994	G. D. Joglekar C. L. Verma

(C) PATENTS SEALED — 1969-70

1.	Improvements in or relating to the manufacture of soft ferrites	101626	C. V. Ganapathy & others
2.	A new method for manufacturing barium titanate material with improved characteristics	107057	T. V. Ramamurthi, C. V. Ganapathy & others
3.	A method for the production of lead zirconate titanate	103201	T. V. Ramamurthi, C. V. Ganapathy & others
4.	High Permeability Mn Zinc Ferrites	105896	T. V. Ramamurthi, C. V. Ganapathy, R. Krishnan, & others
5.	Improvements in or relating to the manufacture of soft ferrites	111274	C. V. Ganapathy & others
6.	Electronic controller for controlling the thickness of thin film during evaporation	113945	V. V. Shah S. P. Suri

BUDGET 1969-70

		Rs. (in lacs)
1.	Pay of Officers	10.148
2.	Pay of Establishment	11.502
3.	Allowances & Honoraria	15.072
4.	Contingencies	10.850
5.	Maintenance	5.224
6.	Chemicals & Apparatus	6.491
7.	Test & Evaluation Centre	0.062
8.	Capital Expenditure	8.887
9.	Pilot Plants	22.815
		91.041

PAPERS PUBLISHED 1969-70

A. In Indian Journals

1. "Tolerances for constructional parameters of Hygenian & Ramsdan eye piece systems", Ram Parshad, Oct. '68, I.J.P.A.P.

2. "Primary aberrations of two Lens Systems of Hygenian Type", Ram Parshad, Oct. '68, I.J.P.A.P.

3. "Torque measuring device for hand driven sirens", M. Pancholy, V. N. Bindal, I.S.I. Bulletin, 21, 131 (1969).

4. "On the paralleling of Transistors for High AF Power output and other applications", Ram Parshad, C. B. L. Gautam, J.I.T.E., 5, 206-209 (1969).

5. "Temperature coefficient of resistance in Thin Vanadium Films", S. C. Jain, Ramesh Chandra, Journal of App. Phy., Vol. 39, No. 11, 5343, Oct. '68.

6. "A simple modification of the pipette used for the determination of the particle size of powders", P. T. John, J. N. Bohra, ISI Bulletin, Vol. 21, No. 5, pp. 218-219 (1969).

7. A scientific note, (Miss) K. Bhagyalakshmi, Students Journal, Vol. 10, No. 2, 1969, pp. 86-88.

8. "Study of shapes of diffracting planes by X-ray Laue Techniques", K. Lal, S. K. Peneva, J. App. Phys., Vol. 39, No. 12, 5474-78, Nov. '68.

9. "Ultrasonic study of ionic dissociation equilibria in salts & complexes", M. Pancholy & T. K. Saxena.

10. "A new technique for the measurement of dielectric loss at very high frequencies of solids & liquids", K. Bhagyalakshmi, J.I.T.E., 1969, 15, No. 5, 355-363.

11. "X-ray Spectroscopic Study of Zinc Selenide", V. G. Bhide, N. V. Bhat, Journ. of Appl. Phys., 39, No. 10, pp. 4744-45, Sept. '68.

12. "Separators for Cap Lamp Battery: Causes of High Resistance", G. D. Joglekar, J. N. Bohra & P. T. John, ISI Bulletin, Vol. 21, No. 6, pp. 262-64 (1969).

13. "Improved gravimetric & volumetric methods for the determination of florides", M. R. Verma, Indian Journal of Chemistry, 1969, Vol. 7, No. 2, pp. 178-79.

14. "Determination of Magnetic Field using VI. characteristics of solid state diodes", R. Prashad, S. K. Bansal, I.J.P.A.P., 1969, Vol. 7, No. 3, 210-211.

15. "Primary aberrations of Single Lens positive system", Ram Parshad.

16. "Thermoluminiscence Studies in Mn doped KCl crystals", P. C. Mehendru, Ved Mitra, I.J.P.A.P., 1969, Vol. 7, No. 4, pp 285-287.

17. Eddy current Dynamometer", R. K. Tandon, ISI Bulletin, Vol. 21, No. 9, Sept. 1969.

18. "Effect of Variation of collector and base voltage on transistor free running multi vibrator & its applications to VCO", R. Parshad, V. K. Jain & V. P. Kulkarni, J.I.T.E., 1969, Vol. 15, No. 6, pp 391-394.

19. "Dielectric constants of air, oxygen & nitrogen in the liquid state at microwave frequencies", R. S. Yadav, D. C. Dube & R. Parshad, I.J.P.A.P., 1969, Vol. 7, No. 6, pp 442-443.

20. "On the determination of transistor action at low temperatures", S. C. Mehta & Ram Parshad, I.J.P.A.P., 1969, Vol. 7, No. 8, pp 581.

21. "Time lag of thermometer: Effect of Humidity & Pressure", P. T. John & J. N. Bohra, I.J. Geophysics, Vol. 20, No. 3, July, 69.

22. "Effect of magnetic field of the deploration layer capacitance of Ge & Si Diodes", Ram Parshad & S. C. Mehta, I.J.P.A.P., Vol. 7, Sept. '69, pp 621-623.

B. In Foreign Journals

1. "Ferroelectric properties of Lead Titanate", V. G. Bhide, M. S. Hegde, K. G. Deshmukh, pp 565-568, October '69' American Ceramic Society Journal.

2. "Thin layer chromatographic method for the Selenium & Tellurium", J. Rai, V. P. Kukerja, pp 18, Chromatographia, 2, 1969.

3. "Thin layer chromatography of Diketonates of metals", J. C. Trehan, Chromatographia 2, 1969, pp 17.

4. "The Development of a solar water heater and its field trials under Indian Tropical Conditions", M. L. Khanna, Solar Energy, Vol. 12, pp 255-261, 1968.

5. "Conference on water desalination", M.L. Khanna, Solar Energy, 12, 273-277 (1968).

6. "Effect of optical & thermal bleaching on UV Band in pure & Mn doped KCl crystals", P. C. Mehendru, Ved Mitra, Physical Rev., 176, 1089-1092, 1968.

7. "Effect of Impurities on the growth of F & M Bands in KCl", J. of Phys. Chem. Solids, P. C. Mehendru, G. D. Sootha, Vol. 30, pp 1012-1015.

8. "F Centre Growth & Thermoluminiscence in Mn doped KCl crystals", P. C. Mehendru, Ved Mitra, J. Phys. Chem, Solids, Vol. 30, pp 1021-23.

9. "Ionic conductivity of Potassium Iodide Crystals", S. C. Jain & D. C. Parashar, J. Phys. C. (Solid St. Phys) 1969, Ser. 2, Vol. 2.

10. "Structural Transformations in thin films of Binary alloys", S. K. Sharma, J. Mat. Science, 4(1969), 189-194.

11. "Structural Dependant Axial Vector form factor in charged pion Radiative Decay", J. S. Vaishya, Vo. 173, No. 5, 1757-59, 25-9-68.

12. "X-ray investigations on the growth of Cadmium whiskers", A. R. Verma, S. K. Peneva, Crystal Growth, Vol. 3/4.

13. "Fine structure of X-ray K-absorption edge of Yttrium", V. G. Bhide, N. V. Bhat, J. Chl. Phys., Jan. 1, 1969, p 42.

14. "Current Algebra Dispersion Relations & Mass Difference", J. S. Vaishya, The Physical Review, Vol. 177, No. 5, Part II, 2512-14, 25-1-69.

15. "Some ESR Studies in highly pure & doped KCl crystals", S. C. Jain, G. D. Sootha, V. K. Jain.

16. "Thermoluminiscene of pure & impurity doped KBr & NaCl crystals", P. C. Mehendru, S. Radhakrishna, J. Phys. C. (Solid St. Phys.) 1969, Ser. 2, Vol. 2.

17. "Resolving power of Infra-red spectrographs", B. D. Saxena, D. R. Pahwa, M. M. Pradhan & K. Lal, Infrared Physics, 1969, Vol. 9, pp 11-19, Pregamon Press.

18. "Time lag in occurrence of QT Point on faraday rotation records at widely spaced frequencies", Tuhi Ram & V. P. Bhatnagar, J. of Atmospheric & Terrestrial Physics, 1969, Vol. 31, 943-49, Pergamon Press.

19. "Recrystallization in Vacuum Deposited Thin Films", S. K. Sharma & O. P. Bahl, Thin Solid Films, Elsevier Sequioia, S. A. Lanssane 4, 1969, p 1416.

20. "Optical ESR & Electrical Studies of additively colored KCl doped with Mg", G. D. Sootha & Devendra Singh, The Physical Review, Vol. 183, No. 3, 842-45, July, 1969.

21. "Effect of ionic bombardment cleaving on epitaxial growths", S. K. Sharma, R. P. S. Kushwaha, Surface Science, Vol. 18, No. 2, Dec. '69.

DEPUTATIONS & CULTURAL EXCHANGE

1. Shri P. C. Jain, Scientist, was deputed to U.K. under Colombo Plan for training in linear standardization & engineering metrology from 29-5-69 to 21-12-69.

2. Shri K. D. Baveja, Scientist, was deputed to Germany under German Academic Exchange Service to study latest technique of low-temperature thermometry for 3 months w.e.f. 6th Oct., 1969.

3. Dr. M. Pancholy, Scientist, was deputed to U.K. under the British Council Scheme for the exchange of scientists for four weeks w.e.f. 13-1-70 for study, observation & development in various branches of acoustics.

4. Prof. Peter Ivan Valko, Head of Faculty for Flourescent Tubes & Semi-conductors, Technical University of Budapest worked on semi-conductors for 30 days w.e.f. 12-11-70 under Indo-Hungarian Cultural Exchange Programme.

5. Dr. M. S. R. Chari, Scientist, attended the IX Thermal Conductivity Conference held at the Iowa State University, Iowa (USA) during October 6-8, 1969. Also visited University of Pennsylvania, USA for a week after the Conference.

HONOURS & AWARDS

1. Shri Rabindranath Dhar was awarded degree of D. Phil. by University of Calcutta.

2. Shri Krishan Lal was awarded degree of Ph.D. by University of Delhi.

3. Shri A. K. Sarkar was awarded degree of Ph.D. by University of Delhi.

4. Shri M. Sidkey, Researcher from UAR awarded the Ph.D. by Cairo University.

5. Dr. A. R. Verma, Director, NPL, nominated member of the Reviewing Committee to review the working of the Indian Institute of Science, Bangalore.

6. Dr. A. R. Verma, Director, NPL, nominated representative of CSIR on the official level committee of the Small Scale Industries Board, Govt. of India.

7. Shri S. K. Suri, Scientist, invited by UNESCO to act as Consultant for six months at Fine Instruments Centre, Seoul, S. Korea.

LECTURES BY VISITING SCIENTISTS

S. No.	Name of speaker	Subject	Date
1.	Prof. Kurt R. Stehling USIS	Practical Applications of Space Flight.	15-4-69
2.	Prof. A. B. Stewart, Antioch College, Ohio.	Gaseous Electronics	12-6-69
3.	Dr. Kenneth Trolan, University of Rellands	Surface studies utilizing Pulsed Field Emission Microscopy.	24-6-69
4.	Prof. Greenwood, University of Newcastle-on-Tyne	Some recent applications of Mossbauer Spectroscopy to Chemical Problems	10-7-69
5.	Dr. Peter Dyson, Latrobe University, Melbourne	Ionospheric Foregion irregularities	24-7-69
6.	Dr. K. C. Gulati, I.A.R.I., New Delhi.	Pesticides	24-9-69
7.	Prof. Bruce Mckeller, University of Sydeny, Australia.	Nuclear Physics as a Probe of of Weak Interaction.	3-10-69
8.	Dr V. Duorak, Ceskos Pouenska Akademic Ved.	Raman & Brillouin, Sccattering in ferroelectric twinning.	3-10-69
9.	Dr. J. Fousek, Ceskosloуenska, Akademic Ved.	Ferro-electric and anti ferroelectric twinning.	3-10-69
10.	Dr. V. Janovee, Ceskosloуenska, Akademic Ved.	Ferroelectric critical points in crystals.	4-10-69
11.	Prof. E. Budavski, Bulgarian Academy of Science.	Growth mechanism of single crystal—in electrocrystallization of metals.	6-12-69
12.	Prof. Ram Swarup	Spectroscopy & field Theroy	16-12-69
13.	Prof. K. Mendelssohn, University of Oxford.	Science & Technology in Developing countries.	5-1-70

S. No.	Name of speaker	Subject	Date
14.	Dr. (Miss) T. M. Zimkina, Leningrad.	Applications of ultrasoft X-ray Spectroscopy to the study of Electron States in Solids.	12-1-70
15.	Dr. Miroslav Rychtera Prague, Czechoslovakia.	Prognosis of Atmospheric deterioration of Electrical Equipment	28-1-70
16.	Dr. Patrick Ritchic Glasgow, U.K.	Egineering uses of Polymeric Materials.	28-1-70
17.	Mr. John Janson, N. P. Philips Hollan	Trends in Modern Lighting	3-2-70
18.	Dr. T. R. S. Goel, Electronics & Computors	Problems of the Electronics Industry in India	6-2-70
19.	Dr. J. T. Henderson, N. R. Council, Canada	Development of Standards in in Canada	11-2-70
20.	Dr. Roland, University of Waiwick, England	Gunn Effect	2-3-70
21.	Dr. Sushil Chandra, NASA, U.S.A.	The Diurnal Phase Anomaly in the Thermosphere	26-3-70
22.	Prof. Farrigton Daniels, Wisconsis, U.S.A.	Direct use of Solar Energy	4-4-70
23.	Prof. A. C. Smith, M. I. T., U.S.A.	Nuclear Magnetic Resonance in Solids	17-3-70

GUEST WORKERS

Sl. No.	*Institution*	*No.*	*Placement Divn.*
1.	M. M. H. College, Ghaziabad	2	Electronics
2.	Chemistry Deptt., College of Engg. & Technology, Aligarh Muslim University	1	X-ray
3.	Madras Instt. of Technology, Madras	5	Electronics
4.	Punjab Engg. College, Chandigarh	4	—do—
5.	I. I. T., Kharagpur	1	—do—
6.	National Council of Educational Research & Trg., New Delhi	3	Basic Physics & Materials
7.	Thapar Instt. of Engg. & Technology, Patiala	2	Electronics
8.	J. K. Instt. of Applied Physics, Allahabad	3	—do—
9.	Saugar University, Saugar	1	Optics
10.	Regional Engg. College, Kurukshetra	7	Electronics
11.	Banaras Hindu University, Varanasi	4	—do—
12.	Regional Engg. College, Tiruchirapalli	1	Mechanics
13.	Birla Instt. of Technology & Science, Pilani	2	Electronics
14.	I. T. I., New Delhi	1	—do—
15.	Laccadives Admn. Controller, Weights & Measures, Kavaratti	2	Weights & Measures
16.	Nagpur University, Nagpur	1	Optics
17.	Regional Engg. College, Srinagar	2	Electronics
18.	Delhi College of Engg., Delhi	8	Electronics & Materials
19.	Ministry of Education & Youth Services, Northern Regional Office, Kanpur	20	Materials Electricity, Workshop, D.P.E.C. Unit & Electronics
20.	I. I. T., New Delhi	1	Solid State Physics
21.	British Council, New Delhi	1	Instrumentation & Servicing
22.	Indian Institute of Science, Bangalore	1	Electronics
23.	Gwalior University, Gwalior	1	—do—

LIBRARY

1.	No. of Additions to the Library during 1st April, 1969 to 31st March, 1970	2,363
2.	Total Number of accessioned publications in the Library as on 31-3-70	68,233
3.	No. of Periodicals received	380

BENEFITS DURING THE YEAR

	(Rs. in lakhs)
Sale proceeds of Development-cum-Production of Electronic Components Unit	2.048
Sale proceeds of Glass Technology Unit	1.223
Sale proceeds of Carbon, Microwave & other products ...	1.295
	4.566
Testing & Calibration fees	1.450
Royalties	0.777
Premia	0.200
	Nos.
Papers published	43
Test certificates issued	2437
Standards maintained	15
Patents accepted	7
Processes released upto 31-3-70	14
Ph.D. awarded	4

CATEGORIES OF STAFF

	No.
i) *Scientific*	
Gazetted	93
Non-gazetted	45
ii) *Aux. Technical*	
Gazetted	18
Non-gazetted	299
Class IV	139
iii) *Administrative*	
Gazetted	5
Non-gazetted	102
Class IV	87
Glass Technology Unit	
Scientific/Technical	
Gazetted	2
Non-gazetted	31
Administrative	2
DPEC Unit	
Scientific/Technical	
Gazetted	10
Non-gazetted	109
Administrative	8
Class IV	1

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The Laboratory welcomes requests for advice or information from Institutions and Industries on subjects dealt with by N.P.L. You are requested to contact the Scientist Incharge, Division of Planning and Liaison, N.P.L., New Delhi-12.