

ANNUAL REPORT

FOR

1930.

Annual Report for 1930.

The following report on the activities of the Indian Association for the Cultivation of Science during the year 1930 is respectfully submitted to the Committee of Management.

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PART I.**Report on Scientific Investigations.****1. *The Raman Effect.***

The outstanding event of the year under report was the award of the Nobel Prize for Physics to the Honorary Secretary of the Association for his researches on light-scattering which led to the discovery of the Raman Effect. The award was announced by the Swedish Royal Academy of Sciences at Stockholm on the 14th November, 1930, and soon after, Sir C. V. Raman left for Europe to receive it in person. After being present at the Nobel festivities on the 10th December and following days at Stockholm, he toured through Europe delivering lectures and visiting the leading laboratories. Among the institutions visited were those at Stockholm, Upsala, Goteborg, Oslo, Copenhagen, Munich, Strasbourg and London. He also attended the special Convocation of the Glasgow University, where the Honorary LL.D. degree was conferred upon him. The Hughes Medal for 1930 was also awarded to him by the Royal Society of London.

The work on the Effect continued vigorously in the laboratory throughout the year under report and new applications found for it to various problems in physics and chemistry. Some of the interesting results obtained in these investigations will be briefly described here.

The significance of the polarisations of the Raman lines in various liquids was studied by Mr. Bhagavantam in detail. The state of polarisation was different for each Raman line, the depolarisation factor ranging usually from 0 to 1. In the special case of SO_3 , however, one line was found to have a depolarisation greater than unity. As a general rule, liquids having a chemical similarity, like the various metallic trichlo-

rides or the tetrachlorides not only showed a similarity in the positions of the Raman lines but also in their states of polarisation. Another problem investigated by the same author was the dependence of the Raman lines on the polymerisation of a substance. Liquid SO_3 at ordinary temperature showed a number of lines, some of which diminished and some others increased in intensity when it was heated to about 100°C . This confirms in a remarkable way the well-known fact that sulphur trioxide exists as S_2O_6 at ordinary temperature which breaks up into the simple molecules of SO_3 at higher temperature. The Raman spectra of simple elements like phosphorus and chlorine, the former in the solid state and the latter liquefied, were also investigated. The single frequency obtained with chlorine agreed with that calculated from band spectra data for Cl_2 , while the three frequencies obtained for phosphorus showed that it was an atomic complex probably P_4 , each P atom being situated at each corner of a regular tetrahedron. The author has attempted in several simple cases like the tri- and tetra-halides, ammonia, sulphur dioxide, CO_2 , CS_2 etc., and also in the complex case of benzene, to explain all the observed Raman frequencies by considering the various possible modes of oscillations of atoms in suitable molecular models. The interesting case of diamond which was first studied by Ramaswamy was also investigated in great detail, and several fainter lines were recorded in addition to the single strong line.

An extensive series of investigations were conducted by Mr. Venkateswaran both by himself and in conjunction with Mr. Bhagavantam on the Raman spectra of representative aliphatic alcohols, amines, halogenated hydrocarbons, organo-metallic derivatives like the zinc alkyls, heterocyclic compounds like thiophene and pyrrol, and a class of very unpleasant smelling organic sulphur compounds known as the mercaptans. The Raman spectra of all these substances were accurately studied and tabulated, and several important conclusions

drawn regarding the chemical constitutions of the respective molecules from the observed Raman frequencies.

An important line of work which had not previously received much attention was the accurate measurement of the intensities of the Raman lines and their relationship to the exciting frequencies. This point has now been studied in great detail by Mr. Sirkar. We know very well that the unmodified or Rayleigh scattering is inversely proportional to the fourth power of the exciting wavelength. Mr. Sirkar found in the case of CCl_4 that the intensities of the Raman lines increased much more rapidly in the ultraviolet than what is indicated by the inverse fourth power law. This conclusion is also indicated by theory since the intensity of a Raman line is related to the absorption frequencies of the liquid in the ultraviolet, the intensity increasing rapidly as the exciting line approaches this absorption region. In another investigation, Mr. Sirkar has shown for benzene and cyclohexane that in each case there is much greater deviation from the inverse fourth power law for a Raman line with longer frequency shift than with a shorter one. In the case of nitrobenzene (a slightly coloured liquid and hence having absorption even in the visible region), the ratio of intensities of two neighbouring Raman lines is different when excited by 4358 and 5461 Hg lines respectively. This is because one of the Raman lines (that due to the NO_2 group) is scattered with abnormally great intensity by the 4358 line which lies in the region of absorption of the substance. The other Raman line is not related to this absorption frequency, and is hence scattered with normal intensity.

A different line of work was started in this laboratory, namely, the study of the Effect in crystal powders of various substances with varying degrees of opacity. As single, transparent crystals of many substances are not easily available, this method enabled a large variety of substances to be investigated. This at the same time enabled an exact comparison to

be made between the spectra of any substance in the crystalline and liquid states as well as in solution. These investigations were carried out by Dr. Krishnamurti who developed a method for the study of the crystal powders. The most interesting case studied by him was rhombic sulphur which gave exceptionally strong Raman lines excited by the green mercury line, and indicated also a complex grouping of atoms in the crystal, probably S_{16} . In another investigation, he examined some crystalline substances which were known to be bad conductors of electricity and very little ionised in solution, like mercuric chloride, mercurous chloride, antimony trichloride and obtained strong Raman lines in every case, whereas other halides like $NaCl$, CaF_2 , etc., known to be good conductors and highly ionised, gave negative results. Thus, a relationship was established between the nature of the valency bonds (whether they are co-valent or electro-valent) and the intensity of the Raman lines. The change from the solid to the liquid state was studied in the one case of benzophenone. The spectra were almost identical, with the exception of one frequency usually attributed to the polar $C=O$ bond, which shifted slightly in position and broadened out in the liquid. A series of crystalline metallic nitrates were also examined, and the strong line due to the NO_3 group found to vary slightly with each metal ion. A number of chlorates, bromates and iodates showed lines characteristic of the XO_3 group, the cyanides and sulphocyanides of the CN and CNS groups respectively, and hydroxides, especially $NaOH$ which was examined as small translucent pieces gave a strong line attributable to the OH group. Thus the crystal powder method served to bring out the characteristic frequencies of various chemical radicals and the way in which they are influenced by combination with different metal atoms.

Till now, the Raman spectra were obtained with instruments of relatively low dispersion and hence the values obtained were not very accurate. Mr. Dabadghao studied a

few liquids, *viz.*, benzene, CCl_4 , CHCl_3 with a Hilger E_1 spectrograph using iron arc comparison. Not only were accurate values obtained for the positions of the Raman lines, but also several new features regarding the broadening of the unmodified line, and the sharpness and resolution of the Raman lines were recorded by him.

2. X-Ray Diffraction.

Liquids :—Investigations on the diffraction of X-rays by pure liquids and by solutions of which a short account was given in the last year's report were continued during the current year. Dr. P. Krishnamurti examined a large number of substances, mostly hydrocarbons in the solid and molten states. Since the crystal structure of these substances had already been described, these studies led to a clearer understanding of the origin of the X-ray liquid halos. Previous investigations have shown that while the interpretation of the halos given by liquids with symmetrical molecules is fairly simple, the same cannot be said to be the case once they depart from spherical or cubic symmetry. It will be clear that while in the former case, perfect randomness of orientation is possible, in the latter, such randomness does not exist in the neighbourhood of the molecule, at any rate, with which we are primarily concerned. The arrangement of a certain number of molecules round any particular molecule (provided of course that they are not completely symmetrical) will be governed to a great extent by the following factors: (1) The geometric shape of the molecule, (2) thermal agitation, (3) rotation or vibration of the molecule and (4) the electric polarity of the molecule as a whole, and the positions occupied by the polar groups. In the case of the hydrocarbons, aliphatic or aromatic, since they are mostly non-polar, the X-ray pattern is almost solely determined by the geometric shape of the molecule. For instance, in the case of the long-chain aliphatic

hydrocarbons, an almost parallel arrangement of the molecules is indicated by X-ray data. An interesting case is that of hexamethyl benzene. It crystallises in the triclinic system, and contains only one molecule per unit cell. Moreover, Mrs. Lonsdale has shown that all the carbon atoms lie almost in the same plane, so that it is definitely disc-shaped. Now, the X-ray pattern of the liquid shows two spacings of which the smaller one could be identified with the thickness of the molecule, and the larger with its length or breadth (both of which are nearly equal). This indicates that the molecules which can be considered as discs are arranged in almost parallel sheets as in graphite. This parallel arrangement of the molecules is indicated by the crystal structure itself. The other substances investigated were naphthalene, acenaphthene, diphenyl, fluorene, phenanthrene, stilbene and dibenzyl, of which acenaphthene shows two well-defined rings as in hexamethyl-benzene, while fluorene and phenanthrene show two very broad ill-defined rings, barely resolved. The results also seem to show that while diphenyl is more rod-like in shape (showing one clearly-defined ring), the molecules of the other substances like naphthalene, fluorene and phenanthrene possess a decidedly flattened structure.

In addition to these liquids, Dr. Krishnamurti also studied the diffraction by colloidal solutions of starch, gum arabic and tannic acid as well as several liquid mixtures. The colloidal substances in every case gave a strong scattering at small angles to the primary beam, from which the approximate molecular weight could be ascertained. Even in the liquid mixtures, the pattern for the mixture was in no case a simple superposition of those of its constituents.

An attempt was made to study the diffraction phenomena in liquids quantitatively by Dr. V. I. Vaidyanathan, especially at different temperatures. He found that the small angle scattering in the case of benzene increased almost in the same ratio with increasing temperature as that observed in light

scattering. This is a necessary consequence of the Raman-Ramanathan theory of X-ray liquid diffraction. He also verified their formula with regard to the ratio between the intensities of the primary beam and that scattered at 4° , and found it to hold good approximately. In dilute aqueous solutions of glucose and canesugar, the measured intensity of scattering at 4° with reference to the primary beam was comparable with the calculated value assuming the molecules to be small isotropic spheres randomly distributed in the solvent.

A contribution to the theory of X-ray diffraction in liquids has been made by Dr. K. Banerjee. The original Raman-Ramanathan theory has been modified so as to take into account the nature of the field of force surrounding the the molecules. The liquid structure is considered as a degeneration of the crystal structure brought about by thermal agitation, which may explain why some crystal diffraction lines give rise to liquid diffraction maxima while the others are quenched out. Simple cases of Na, K, A and Hg for which data in both the crystalline and liquid states are available are shown by him to support his theory.

Amorphous Carbon and Coal :—Even though amorphous carbon has been studied by several investigators, notably by Debye and Scherrer and by G. Asahara, and shown by them to consist only of finely divided graphite, yet several important facts were overlooked as the investigations of Dr. Krishnamurti seem to show. All the samples of amorphous carbon examined by him show a strong scattering at small angles to the primary beam, usually not more than about 4 or 5° , and in most cases falls off as the first ring is approached. Secondly, the spacing of the first ring was found to be 3.8 A as compared to 3.4 A of graphite. These facts are interpreted by him as being caused by the random distribution of small particles (of colloidal dimensions) consisting on the average of 60 atoms of carbon arranged

approximately as in graphite. The end valencies are distorted, and this explains the peculiar adsorptive properties of charcoals.

The X-ray investigations on coal described in last year's report were continued by Mr. C. Mahadevan during the present year. Fusain and graphitic anthracite give the superposed diffraction patterns of carbon and of ash, while fibrous peat gives the characteristic 'fibre pattern.' A study of the patterns shows that the difference between peat and coal is rather one of structure than of composition. In addition to these a large number of vitrains have also been studied which led to some general conclusions regarding the distribution of moisture and volatile matter in the coals. These two factors are largely responsible for the general scattering between the direct spot and the first ring in the diffraction patterns. On dehydration, this scattering clears to some extent and disappears when the coals are freed from volatile matter. Such a change is also accompanied by an increase in the width of the principal halo.

An X-ray study of a number of natural and fossil resins by Mr. Mahadevan shows that softer resins give larger spacings than the harder resins. The incipient crystallisation in some of the resins is shown by the appearance of sharp outer halos. The decomposition products of two resins, *viz.*, resinic acids and resenes were isolated and studied. They show great similarity to the untreated resins, and argues for a structural similarity of the components.

3. X-Ray Analysis of Crystal Structure.

The space group to which the crystals of naphthalene and anthracene belong was determined by Bragg,¹ who also found

W. H. Bragg, Proc. Phys. Soc. 34, 33 (1921-22); Proc. Phys. Soc. 35, 167 (1922-23).

that the planes of the molecules lie nearer to the *ac* planes than to the *bc* planes of the unit cells. Investigations on the magnetic and optical properties of these crystals by Bhagavantam,² however, led to the conclusion that the planes of the molecules lie nearer to the *bc* plane than to the *ac* plane. Dr. Kedareswar Banerjee investigated the problem more thoroughly and comparing the intensities of X-rays reflected from different planes, he succeeded in determining the positions of the atoms in the unit cell by trial and error method. It was found by him that the correct positions of the molecules within the unit cells are obtained if the molecules are first placed with their planes parallel to the *bc* plane and then rotated successively through 25° and 12° about *b* and *c* axes respectively in the case of naphthalene and through 25° and 9° respectively in the case of anthracene. The rotations for the two molecules in the unit cell are equal and opposite about *b* axis and in the same direction in conformity with the symmetry of the space group C_{2h}^5 , about the *c* axis. He has thus found that the planes of the molecules are nearer to the *bc* planes than to the *ac* planes—a conclusion also arrived at by Bhagavantam from the investigation of the magnetic and optical properties of these crystals.

It is well known that beautiful iridescent crystals are very often obtained when potassium chlorate is crystallised from solution. It is also known that when a single colourless crystal of potassium chlorate is heated almost to its melting point and is then allowed to cool down, its reflecting power increases very much. The late Lord Rayleigh³ explained these phenomena with the assumption that they are produced by reflection at a great number of parallel planes of twinning and countertwinning existing at regular intervals inside these

² S. Bhagavantam, Proc. Roy. Soc. A, 124, 545 (1929).

³ Lord Rayleigh, Proc. Roy. Inst. 12, 447 (1839).

crystals, the distance between successive planes being of the order of wavelength of light. The present Lord Rayleigh⁴ examined these crystals under higher power microscopes, and using polarised light obtained photographs showing the presence of such planes of twinning and countertwinning inside the coloured as well as heated crystals. Mr. S. C. Sirkar studied the Laue patterns due to these crystals. It was found by him that some of the Laue spots appearing as single in the pattern due to a single crystal of potassium chlorate, become double in the case of the heated and coloured crystals. On determining the indices of the planes giving rise to these spots, he has found that the double spots are produced by the twinning of the crystal. The results of these investigations thus corroborate the theory put forward by the late Lord Rayleigh to explain the abnormal reflecting power of these crystals.

4. *List of Papers published during the year 1930.*

Indian Journal of Physics,

Vol. IV, Part V.

1. Are Black Soap Films Birefringent?—By K. S. Krishnan.

Vol. IV, Part VI.

2. X-Ray Diffraction in Liquid Hexamethyl Benzene—By P. Krishnamurti.

3. Further X-Ray Studies of Carbonaceous and Bituminous Materials—By C. Mahadevan.

4. The Vibration of the Pianoforte Soundboard—By L. D. Mahajan.

Lord Rayleigh, Proc. Roy. Soc. A, 102, 668 (1923).

Vol. IV, Part VII.

5. Liquid Structure and X-Ray Diffraction in Liquids—By Kedareshwar Banerjee.
6. Orientation of the Molecules in Naphthalene and Anthracene Crystals—By Kedareshwar Banerjee.

Vol. V, Part I.

7. The Raman Effect in Crystal Powders of Inorganic Nitrates—By P. Krishnamurti.
8. Raman Spectra of some Elements and Simple Compounds—By S. Bhagavantam.
9. Influence of Polymerisation and Molecular Association on the Raman Effect—By S. Bhagavantam.
10. Polarisation of the Lines in Raman Spectra—By S. Bhagavantam.
11. Raman Effect and Molecular Structure—By S. Bhagavantam.
12. Raman Spectra and Infra-red Absorption of Sulphur—By P. Krishnamurti.

Vol. V, Part II.

13. Raman Spectra of Crystalline Inorganic Chlorides—By P. Krishnamurti.
14. Interpretation of Raman Spectra: Some Aliphatic Amines and Alcohols—By S. Venkateswaran and S. Bhagavantam.
15. Raman Effect in some Organo-Metallic and Heterocyclic Compounds—By S. Venkateswaran.
16. On the Intensities of the Lines in Raman Spectra—By S. C. Sircar.
17. Relation of Raman Effect to Crystal Structure and Properties of Diamond—By S. Bhagavantam.

18. Raman Effect in some Crystalline Inorganic Sulphates : Influence of Paramagnetism on Raman Lines—By P. Krishnamurti.
19. Raman Spectra under High Dispersion—By W. M. Dabadghao.
20. Raman Spectra of the Mercaptans—By S. Venkateswaran.

Vol. V, Part III.

21. The Raman Effect : Its significance for Physics and Chemistry—By S. Bhagavantam.
22. On the Laue Photographs of Iridescent Crystals of Potassium Chlorate—By S. C. Sircar.
23. X-Ray Study of Natural and Fossil Resins—By C. Mahadevan.

Vol. V, Part V.

24. Studies in X-Ray Diffraction—Part I. The Structure of Amorphous Carbon—By P. Krishnamurti.
25. Studies in X-Ray Diffraction—Part II. Some Colloidal Solutions and Liquid Mixtures—By P. Krishnamurti.
26. X-Ray Diffraction in Heated Liquids and in Solutions—By V. I. Vaidyanathan.
27. X-Ray Study of Vitreins—By C. Mahadevan.
28. Studies in X-Ray Diffraction—Part III. Some Aromatic Hydrocarbons in Solid and Liquid States—By P. Krishnamurti.
29. Anomalous Diamagnetism and Crystal Structure—By V. I. Vaidyanathan.

Vol. V, Part VI.

30. Further Studies on the Raman Spectrum of Diamond—By S. Bhagavantam.

31. Raman Effect with Cadmium Arc Excitation—By P. Krishnamurti.

32. Further Investigation on the Intensities of Lines in Raman Spectra—By S. C. Sirkar.

33. The Polarisation of Raman Lines: Some Hydrocarbons—By S. Bhagavantam.

34. Forms of Oscillation of the Benzene Ring in Raman Effect—By S. Bhagavantam.

35. Raman Spectra of Inorganic Crystals: Part I. Substances containing XO_3 and XO_4 Groups—By P. Krishnamurti.

36. Raman Spectra of Inorganic Crystals: Part II. Some Hydroxides, Cyanides and Sulphocyanides—By P. Krishnamurti.

37. On the Relative Intensities of Different Raman Lines due to Different Exciting Frequencies—By S. C. Sirkar.

[Vol. V, Part VII.]

38. Pleochroic "Giant" Halos in Cordierite—By S. Krishnan and C. Mahadevan.

Proceedings of the Royal Society of London.

39. The Raman Spectra of Some Organic Halogen Compounds—By S. Bhagavantam and S. Venkateswaran.

40. The Raman Spectra of some Aldehydes and of Mesitylene—By S. Venkateswaran and S. Bhagavantam.

Proceedings of the Physical Society of London.

41. Diamagnetism and Molecular Structure—By Sir C. V. Raman.

The Journal of Physical Chemistry.

42. On the Raman Effect in Liquid Pyridine—By S. Venkateswaran.

Nature.

43. Raman Effect with Optically Active Substances—
By S. Bhagavantam and S. Venkateswaran.
44. Raman Spectra of Crystalline Powders—By P.
Krishnamurti.
45. Raman Effect in Metallic Halides—By P. Krishna-
murti.
46. Raman Effect in Paramagnetic Crystals—By P.
Krishnamurti.
47. Raman Spectra of Mercaptans—By S. Venkates-
waran.
48. Raman Effect in Hydrogen Sulphide—By S. Bhaga-
vantam.
49. Raman Effect, Fluorescence and Colour of
Diamonds—By S. Bhagavantam.
50. Raman Spectra of some Triatomic Molecules—By S.
Bhagavantam.

Quarterly Journal of the Geol. Min. Met. Society, India.

51. Geology of Vizagapatam Harbour Area—By C.
Mahadevan.

PART II.

Administrative Report.

5. *Our Research Workers.*

Facilities for research work in our laboratory were given during the year 1930 to 28 research workers belonging to different Provinces. The Universities of Nagpur and Madras and the King Edward Memorial Society of Nagpur have each deputed a research scholar at their expense to work in the laboratory of the Association.

6. *Lecture Arrangements.*

Regular courses of lectures in Physics and Chemistry for the benefit of students were delivered at the Association with the aid of our apparatus and demonstrators.

7. *Laboratory Equipment.*

The following additions have been made during the year to our stock of apparatus :—

1. One 500 C. P. Pointolite lamp.
2. One cylinder chlorine gas.
3. One cylinder ammonia gas.
4. One reflex camera complete, for $\frac{1}{4}$ size plate, with F. 3.5 Cook anastigmat lens.
5. Two oil-cooled transformers for X-ray work.
6. Two regulating resistances.
7. One 18" quartz burner.
8. One quartz mercury arc, universal type, with a stand and a fixed resistance.
9. Three plane parallel plate glasses by Zeiss.

10. One Salter's spring balance weighing up to 500 gms.
11. One quartz lamp with 8 per cent. cadmium amalgam.
12. One large high illumination glass spectrograph, Fuess No. 105.
13. Three Zeiss monochromatic filters.
14. One cylinder of argon.
15. Two neutral tint wedges.
16. Four table fans.
17. One glass prism for spectrograph.
18. One ammeter.

8. *Workshop.*

The following apparatus were manufactured during the year by the mechanics in the workshop of the Association :—

1. Three new spectrographs on massive bases.
2. One darkslide holder for spectroscope.
3. Two brass prism holders for constant deviation spectroscope.
4. One 1 metre steel tube for high pressure gas work with screw caps and inlet for gas.
5. One valve fitted in socket for air compressor (liquid air plant).
6. One pair round pole pieces for electro-magnet.
7. One brass jacketed tube for magnetic double refraction experiment.
8. Four pointed clips for holding glass threads.
9. One stand for supporting collimator to an Echelon spectrograph.
10. Mounting for a plateholder in the Echelon spectroscope.
11. One case for sputtering apparatus.
12. Two aluminium reflectors for mercury arc lamps.
13. One big ice box.

14. Two cone pulleys for small lathe.
15. One rectangular glass cell, brass bound.
16. Two valves for box-pump.
17. Two brass cells for filter.
18. Six V-shaped cells for studying scattering in crystals.
19. A small vacuum chamber for observing cathode luminescence.
20. Two adjustable slits of lead.
21. One lead box for X-ray camera.

Besides the above apparatus, numerous repairs and fittings for the laboratory were executed.

9. *Library and Reading Room.*

The following publications were subscribed for as usual:—

1. Scientific American.
2. Nature.
3. Science Abstracts, A and B.
4. American Journal of Science.
5. Philosophical Magazine.
6. Astrophysical Journal.
7. Chemical News.
8. Proceedings of the Royal Society, A.
9. Proceedings of the Royal Institution of Great Britain.
10. Transaction of the Royal Society, A.
11. Physical Review.
12. Physikalische Berichte.
13. Zeitschrift fur Physik.
14. Annalen der Physik.
15. Physikalische Zeitschrift.
16. Journal of the American Chemical Society.
17. Journal of Physical Chemistry.
18. Proceedings of the National Academy of Sciences, Washington.

19. Zeitschrift fur Kristallographie, A and B.
20. Zeitschrift fur Physikalische Chemie.
21. Annales de Physique.
22. Comptes Rendus.
23. Chemical Abstracts.
24. Revue de Optique.
25. Science Progress.
26. Naturwissenschaften.

The following journals have been newly subscribed for from the current year:—

27. Journal of the Chemical Society of London and British Chemical Abstracts, A.
28. Transactions of the Faraday Society.
29. Zeitschrift fur Astrophysik.

We have to acknowledge with thanks the presentation of journals and periodicals in exchange for our Proceedings from the following Societies and Institutions:—

1. The Smithsonian Institution.
2. Cambridge Philosophical Society.
3. Physico-Mathematical Society, Tokyo, Japan.
4. Manchester Literary and Philosophical Society.
5. American Philosophical Society.
6. University of Illinois.
7. Academie der Wissenschaften, Leipzig.
8. Franklin Institute.
9. South African Association for the Advancement of Science.
10. The Prussian Academy of Science, Berlin.
11. University of Philadelphia.
12. The Physical Society of France.
13. Bureau of Standards, Washington.
14. University of Iowa.
15. University of Calcutta.
16. Calcutta Mathematical Society.
17. Indian Chemical Society.

18. Reale Academia Nazionale Die Lincei, Rome.
19. Societe de Physique et D'Historie-Naturelle, Geneve.
20. Bayerischen Academie der Wissenschaften, Munchen.
21. Der Gessellschaft de Wissenschaften, Göttingen.
22. University of Allahabad.
23. Imperial Agricultural Institute, Pusa.
24. Asiatic Society of Bengal.
25. Indian Institute of Science, Bangalore.
26. The Geological Survey of India.
27. Indian Mathematical Society. (Presentation from Prof. Sir C. V. Raman.)
28. Academy of Sciences, Cracow.
29. University of Brazil.
30. University de la Bruno.
31. Academy of Sciences, Leningrad, Russia.
32. University of Durham.
33. Royal Academy of Sciences, Amsterdam.
34. Imperial Academy, Tokyo, Japan.
35. De La Facultad de Sciences, La Plata.
36. Royal Meteorological Society, London.
37. University of Frankfurt-a-main.
38. Royal Dublin Society.
39. Tohoku Imperial University.
40. Institute of Physical and Chemical Research, Japan.
41. Royal Academy of Sciences, Copenhagen.
42. Kodaikanal Observatory.
43. College of Science, Kyoto, Japan.
44. National Research Council, Japan.
45. Academy of Sciences, Vienna, Austria.
46. Proceedings of the Royal Society "B," London.
(Presentation from Prof. Sir C. V. Raman.)
47. Transactions of the Royal Society "B," London.
(Presentation from Prof. Sir C. V. Raman.)
48. Societe Chimique, Zagreb, Yougoslave.
49. Hungary University (Szeged).

50. Ungarische Akademie, Budapest.
51. American Chemical Society (Industrial and Engineering Chemistry).
52. Della Societa Italiana Di Fisica.
53. Societe De Chimie-Physique, Paris.
54. Matematikai es Fizikai Akademia, Budapest.
55. National Physical Laboratory of London.
56. Nederlandsch Tijdschrift Voor Naturkunde.
57. Physical Society of London.
58. Comite de Revue Generale des Sciences.
59. Editor of 'Physique Theorique.'
60. University of Upsala.
61. University of California.
62. Wissenschaftliche Veroffentlichungen aus dem Siemens Konzern.
63. Societe Polanaise de Physique, Warszawa.
64. Societe Vaudoise des Sciences Naturelles, Lausanne.
65. United States Department of Agriculture.
66. The Editor of Terrestrial Magnetism and Atmospheric Electricity.
67. De L'Institute Pasteur—Paris.
68. Swiss Physical Society.
69. Canada Geological Survey.
70. Societe Polonaise des Naturalistes Kopernik.
71. Royal Canadian Institute.
72. Deutschen Naturwissenschaftlich-Medizinischen Verein für Bohmen "Lotos" (Prag).

The following books were purchased during the year :—

1. Physics of the Air, Humphreys.
2. Photo Electric Cells, N. R. Campbell and D. Ritchie.
3. Wave Mechanics, A. Sommerfeld.
4. Atoms, Molecules and Quanta, Ruark.
5. La Diffusion Moleculaire de la Lumiere, Jean Cabannes.

6. Recueil d'Expose's sur des Ondes et corpuscules,
L. de Broglie.
7. A Text book of Sound, Wood.
8. Chamber's Seven Figure Logarithms, Pryde.
9. The Mechanics of the Atom, Max Born.
10. Elementare Quanten Mechanik, Born and Jordan.
11. The Conductivity of Solutions, C. W. Davies.
12. A Text book of Physical Chemistry, Spectroscopy,
Parts I, II and III, E. C. C. Baly.
13. Surface Chemistry, Rideal.
14. Das Ultrarot Spektrum, Schaefer and Matossi.
15. Handbuch der Experimental Physik Vol. X.
16. Do Do Vol. IV.
17. Do Do Vol. XXIV
18. Gmelins Handbuch der Anorganischen Chemie,
System No. 59, 26 & 58.
19. The Kinetics of Chemical change in Gaseous Systems,
Hinshelwood.
20. A Comprehensive Treatise on Inorganic and Theore-
tical Chemistry, Vol. X, Mellor.
21. Encyklopadie Mathematischen Wissenschaften; Band
VI, 2B, Heft 3.
22. Wavelength Tables, F. Twyman.
23. A Text book of Precious Stones, Wade.
24. Methods of Analysis of Coal, Report of the Fuel
Research Board.
25. The Microscopical Examination of Coal.
26. Organic Chemistry by Victor von Richter,
Vols. I, II, III.
27. Handbuch der Experimental Physik, XXV—3 Teil
(Geophysik).
28. Tables Annuelles Internationales de Constantes
et Donnees Numeriques, 1925-26. Vol. VII,
Pts. I & II.

10. *Financial Statement.*

GOVT. SECURITIES IN BANK—31ST DECEMBER, 1930.

	Rs.	As.	P.
General Fund	1,87,800	0	0
Ripon Prof. Fund	17,000	0	0
Cooch-Bihar Prof. Fund	21,500	0	0
Hare Prof. Fund	1,000	0	0
Nikunja G. Prize Fund	500	0	0
Jotindra Ch. Prize Fund	600	0	0
Joykissen Medal Fund	9,000	0	0
Woodburn Medal Fund	500	0	0
Dr. Sircar Research Medal Fund	3,000	0	0
Floating Balance in the Bank	1,13,215	2	8
Cash Balance in the office	1,520	12	0

GOVT. SECURITIES IN BANK—31ST DECEMBER, 1929.

General Fund	1,87,800	0	0
Ripon Prof. Fund	17,000	0	0
Victoria Prof. Fund	1,000	0	0
Cooch-Bihar Prof. Fund	21,500	0	0
Hare Prof. Fund	1,000	0	0
Nikunja G. Prize Fund	500	0	0
Jotindra Ch. Prize Fund	600	0	0
Joykissen Medal Fund	9,000	0	0
Woodburn Medal Fund	500	0	0
Dr. Sircar Research Medal Fund	3,000	0	6
Floating Balance in the Bank	3,787	3	11
Cash Balance in the office	937	13	6

11. *Acknowledgments.*

The thanks of the Association are due to the Honorary Engineers Rai Krishna Chandra Banerjee, Bahadur, and Babu Bhabadeb Chatterjee, the Honorary Legal Advisers, Babu Jatindranath Basu and Babu Nirmal Chunder Chunder, to the Honorary Secretary, Sir Venkata Raman and to the Honorary Assistant Secretaries Babu Jyotish Chandra Pal and Ashutosh Dey for their gratuitous services.

12. *Statement of Accounts for 1930.*

RECEIPTS AND PAYMENT ACCOUNTS

	<i>Receipts.</i>	Rs.	As.	P.
Subscriptions	...	243	0	0
Donations	...	650	0	0
Rent from shops	...	4,332	0	0
Miscellaneous Receipts	...	3,664	4	0
Dr. Sircar Memorial Fund	...	200	0	0
Building Fund	...	250	0	0
Government of India Grant	...	30,000	0	0
Maharaja of Darbhanga Fund	...	1,000	0	0
Sale of Publications	...	4,674	3	0
Veharilala Mitra Building Fund	...	1,00,000	0	0
Interest A/c. General Fund	...	6,542	8	0
" " Ripon P. Fund	...	575	0	0
" " N. G. Prize Fund	...	17	8	0
" " Jatindrachandra Prize Fund	...	21	0	0
" " Woodburn Medal Fund	...	17	8	0
" " Dr. Sircar Research Medal Fund	...	105	0	0
" " Victoria Prof. Fund	...	35	0	0
" " Maharaja of Cooch-Bihar	...	752	8	0
" " Hare Prof. Fund	...	35	0	0
" " Joykissen Medal Fund	...	315	0	0
Suspense Account	...	121	3	0
Provident Fund	...	748	3	0
Old Material Sale	...	48	1	0
P. O. Savings Bank—Withdrawn	...	1,000	0	0
Opening Balance on 1st January, 1930				
At Imperial Bank	...	3,787	3	11
At Office	...	937	13	6
	Total	1,60,071	15	5

Examined and Found Correct.

SAHA & MAZUMDAR,

Government Certified Auditors.

THE YEAR ENDED 31ST DECEMBER, 1930

Payments.

	Rs.	A.	P.
Commission a/c General Fund	...	27	5 0
" Ripon Prof. Fund	...	1	6 0
" Nikunja G. P. Fund	...	0	3 0
Establishment Account	...	6,504	6 0
Municipal Tax	...	685	12 0
Electrical Charges	...	3,951	4 6
Gas Charges	...	351	3 6
Building Repairs	...	1,927	3 0
Furniture Account	...	920	7 6
Laboratory Charges	...	5,575	3 0
Workshop Charges	...	1,181	15 0
Postage and Telegrams	...	1,372	15 9
Printing Charges	...	3,118	3 0
Miscellaneous Charges	...	2,201	7 3
Telephone Charges	...	254	7 0
Research Scholarships	...	6,396	4 0
Institute contribution to Provident Fund	...	153	2 9
Scientific Instrument Account G. Fund	...	5,251	3 9
Library Account	...	2,818	11 6
Electric Installation Account	...	21	0 0
" Accessories	...	826	6 0
P. O. Savings Bank, Deposit	...	1,394	12 3
Suspense Account	...	76	3 0
Provident Fund	...	250	0 0
Maharaja of Darbhanga Fund	...	75	0 0
Closing Balance on 31st December, 1930			
at Imperial Bank	...	1,13,215	2 8
At Office	...	1,520	12 0
		<hr/>	
		1,60,071	15 5

BALANCE SHEET

		<i>Liabilities.</i>		Rs.	A.	P.
General Fund	...	...	2,31,411	8	6	
Investment Reserve Fund	...	...	88,961	0	0	
Depreciation Reserve Fund	Property	...	50,269	6	3	
„	„ Instrument	...	52,401	7	8	
„	„ Furniture	...	4,522	0	0	
„	„ Library	...	17,221	12	4	
Provident Fund	...	...	2,327	8	7	
Victoria Prof. Fund	...	...	1,000	0	0	
Ripon Prof. Fund	...	...	17,000	0	0	
Maharaja Cooch-Behar P. Fund	...	...	21,500	0	0	
Hare Prof. Fund	...	...	1,000	0	0	
Nikunja-Garabini Prize Fund	...	...	500	0	0	
Jatindrachandra Prize Fund	...	...	600	0	0	
Joykissen Medal Fund	...	...	9,000	0	0	
Woodburn Medal Fund	...	...	500	0	0	
Dr. Sarkar Research Medal Fund	...	...	3,000	0	0	
Maharaja of Darbhanga Fund	...	...	925	0	0	
Veharilala Mitra Building Fund	...	...	1,00,000	0	0	
Dr. Sircar Memorial Fund	...	...	15,145	12	3	
Vizianagram Fund	...	...	40	0	0	
Building Fund	...	...	7,330	0	0	
Dr. Sircar Research Medal Fund, Interest	...	...	945	0	0	
Ripon Prof. Fund, Interest	...	...	2,212	0	3	
Nikunja-Garabini Fund, Interest	...	...	317	5	2	
Woodburn Medal Fund, Interest	...	...	229	0	0	
Jatindrachandra P. Fund, Interest	...	...	186	11	0	
Joykissen Medal Fund, Interest	...	...	1,284	0	0	
Victoria Prof. Fund, Interest	...	...	105	0	0	
Maharaja of Cooch-Behar Prof. Fund, Interest	...	...	2,257	8	0	
Hare Prof. Fund, Interest	...	...	105	0	0	
Government of India Grant	...	...	3,835	2	0	
			Rs. 6,36,132	2	0	

SABA AND MAJUMDAR,
GOVERNMENT CERTIFIED AUDITORS.

AS AT 31ST DECEMBER, 1930.

<i>Assets.</i>		Rs.	A.	P.
Land and Old Building	... ..	31,680	11	9
Lecture Hall and Gallery	... ..	23,465	5	3
Vizianagram Laboratory	... ..	40,900	14	0
Observatory Room	... ..	3,320	9	9
Range of Shops (East)	... ..	2,516	10	9
Range of Shops (West)	... ..	2,308	5	0
Servants' Quarters	... ..	1,024	0	0
Darwan's	... ..	303	13	9
Scientific Instruments (K. K. Tagore Fund)	...	25,000	0	0
" " (General Fund)	...	80,284	9	2
Botanical	... ..	2,329	6	0
Workshop	... ..	9,861	5	9
Tools and Implements	... ..	203	3	3
Library Account	... ..	42,475	14	1
Furniture	... ..	13,109	14	3
Suspense	... ..	32	9	0
Government Securities 3½ per cent. G. Fund	...	1,87,800	0	0
" Ripon Prof. Fund	...	13,000	0	0
" Victoria Prof. Fund	...	1,000	0	0
" Maharaja of Cooch-				
" Behar Prof. Fund	...	21,500	0	0
" Hare Prof. Fund	...	1,000	0	0
" N. G. P. Fund	...	500	0	0
" Jotindra Chandra P. Fund	...	600	0	0
" Woodburn Medal Fund	...	500	0	0
" Dr. Sircar R. M. Fund	...	3,000	0	0
" Joykissen M. Fund	...	9,000	0	0
" G. P. Notes 3 per cent.				
" Ripon Prof. Fund	..	4,000	0	0
Balance at P. O. Savings Bank	...	678	15	7
Imperial Bank of India	... ..	1,13,215	2	8
Office	... ..	1,520	12	0
		Rs. 6,36,132	2	0

C. V. RAMAN,
Hony. Secretary.