



THE INDIAN ASSOCIATION  
FOR THE  
CULTIVATION OF SCIENCE



*Annual Report for the Year 1937*

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INDIAN ASSOCIATION  
FOR THE  
CULTIVATION OF SCIENCE

*Annual Report for the Year 1937.*

*Report of the Committee of Management for the year 1937.*

MEMBERS

At the beginning of the year there were 133 members of whom 124 were life-members, 4 resident and 5 non-resident ordinary members. During the year under review one non-resident member was enrolled. The Association has lost through death two of its life-members, the Hon'ble Mr. B. K. Bose and Mr. Lalji Srivastava, M.Sc. The total number of members at the end of the year was 132, of which 120 are life-members, 6 non-resident and 4 resident ordinary members.

FINANCIAL

In pursuance to the resolution adopted at the Annual General Meeting for 1935 the following accounts were finally opened in the Imperial Bank of India with regard to the several funds of the Association.

- (a) Ripon Professorship Fund.
- (b) Coochbehar Professorship Fund.
- (c) Hare Professorship Fund.
- (d) Victoria Professorship Fund.
- (e) Nikunja Garabini Prize Fund.
- (f) Jatindra Chandra Prize Fund.
- (g) Dr. Sircar Research Medal Fund.
- (h) Joy Kissen Mookerjee Medal Fund.
- (i) Woodburn Medal Fund.
- (j) Building Fund.
- (k) Viharilala Mitra Fund.
- (l) Mahendralal Sircar Professorship Fund.

2. The position of these and the other funds at the end of the year 1937 is shown in the Auditor's report.

3. The unallocated amount belonging to these funds now shown in the Plain Account will be adjusted during 1938.

4. A loan of Rs. 3,000 had to be incurred in December in order to meet payments. The loan has been since repaid early in January 1938.

5. The Government of India has been pleased to restore the 10% cut from the year 1938-39.

6. The recognition of the Employees' Provident Fund, referred to in last year's report is still pending with the Commissioner of Income-tax but the Trust Deeds have been executed and the rules modified according to his suggestions, and these documents have been deposited with him. It is hoped that the recognition will be obtained during 1938.

7. A sum of Rs. 500 was provided for in the budget estimates for 1937 sanitary fittings etc. but the work was not completed last year. A re-grant of the amount was made for 1938 of which Rs. 412-12 has actually been spent.

8. The Auditor's report showing the receipts and payments during the year 1937 and the balance sheet for 1937 as also the budget estimates for 1938 are given in Appendix I.

#### STAFF

Applications were invited in 8 leading newspapers at different parts of India for research scholarships and the following awards were made for the year 1938.

1. Mr. A. Chandrasekhariah, M.Sc.
4. „ Dwijesh Chandra Chakravarty, M.Sc.
3. „ Baidyanath Mukhopadhayya, M.Sc.
4. Dr. Hirendranath Pal, Ph.D.
5. Mr. S. L. Chorghade, M.Sc.
6. „ Nripendralal Ganguli, M.Sc.
7. „ Jyotirmoy Bhattacharyya, M.Sc.

2. Dr. S. C. Deb, D.Sc., has been appointed a Research Fellow on Rs. 125 in place of Dr. Debi Prasad Ray Chowdhuri, D.Sc., who resigned on his appointment as a Professor of Physics, Scottish Churches' College, Calcutta.

3. Reference was made in the Annual Report for 1936 that Prof. K. S. Krishnan, D.Sc., was granted study leave for the period, 18th February to 5th July, 1937. He rejoined on expiry of the leave.

4. Leave on full pay as follows was granted during the year :—

Nalinaksha Sinha - One month and seventeen days.

Sachi Nath Banerjee—One month.

Dwijapada Ray—Fifteen days.

INDIAN JOURNAL OF PHYSICS AND PROCEEDINGS OF THE INDIAN  
ASSOCIATION FOR THE CULTIVATION OF SCIENCE

On a representation from the President and the Council of the Indian Physical Society and with a view to ensure closer co-operation with the Indian Physical Society the Committee of Management adopted the following resolutions based on the recommendations of a sub-committee and on the legal advice of Mr. J. N. Basu, M.A., M.L.A.

(a) "That the idea of making it clear that the journal is being published with the collaboration of the Indian Physical Society be adopted but at the same time it was decided that such collaboration should not in any way affect the proprietary right of the Indian Journal of Physics."

(b) "That the title page of the journal would be Indian Journal of Physics, Vol. Part and the Proceedings of the Indian Association for the Cultivation of Science, Vol. Part edited with the collaboration of the Indian Physical Society."

(c) "That the Indian Physical Society be requested to suggest one name of an eminent physicist outside Bengal for appointment by the Association as one of the editors of the Indian Journal of Physics, that the appointment shall be made for a period of three years at a time."

(d) "That the Honorary Secretary be requested to issue permit cards to the members of the Indian Physical Society to use the library of the Association."

(e) "That the matter of placing a room at the disposal of the Indian Physical Society for its use for office work be considered when space becomes available for the purpose."

2. Altogether forty three papers consisting of 432 pages have been published in the Indian Journal of Physics and the Proceedings of the Association, Vol. XI., of which the first five parts were issued in 1937 and the last part has been issued in January, 1938. Of these papers two were contributed by authors from Bombay, one from Kolhapur, one from Guntur, six from Patna, two from Agra, one from Lahore, one from Benares, one from Waltair, three from Allahabad, four from Dacca, two from America and the remaining nineteen from authors working at the different institutions in Calcutta.

3. Two of these papers are on Magnetism, two on Hyperfine Structure, five on Spectra, five on Wireless, eight on X-rays and Crystal Structure, seven on the Raman Effect, and the remaining fourteen are on miscellaneous subjects.

4. A list of the papers published in the Indian Journal of Physics and the Proceedings of this Association is given in Appendix II.

#### LIBRARY

Permission was granted to the Superintendent, Government Test House, Alipore to borrow books from the Association library subject to the rules. Permission was also granted to some members of the staff of the Test House to consult the library in the evening. Arrangements have been made to keep the library open from 11 A.M. to 4 P.M. and from 6 to 8 P.M.

2. An accession register for the books belonging to the library has been started and when this accession register will be ready it is proposed to bring all the books and journals of the library under Dewy's system of classification and finally to publish a catalogue.

3. Rules : The following rules were framed for the library :—

(a) All books and journals purchased or received by exchange or as a free gift, shall be entered into books specially kept for the purpose.

(b) No person shall be allowed to take away any journal or books before it is entered in the register.

(c) Current issues of journals must not be removed from the table until replaced by the next issue and no book shall be removed from the counter before a fortnight has elapsed after the book has been received and entered in the register.

(d) No books or journals will be issued from the library except to the Members of the Association, who are resident in Calcutta, the M.L.S. Professor, the Research Fellow or Fellows, Research Scholars and other Research workers and such other persons as may be authorised by the Committee of Management from time to time under such conditions as may be specified by them. The library shall be open to use by persons mentioned above subject to these rules which may be modified by the Committee of Management from time to time. Any violation of these rules shall be reported immediately to the Honorary Secretary.

(e) All journals issued out of the library shall be returned within a week from the date of issue.

(f) All books issued out from the library shall be returned within ten days and may be re-issued to the person who has returned them unless required in the meantime by any other person.

(g) Books and journals which are valuable on account of rarity, or which belong to a series, and which, being out of print, it may be difficult or impossible to replace if lost, or, books required for constant reference shall not be removed from the library.

A list of the works excluded from removal under this rule shall be drawn by the Committee of Management as advised by the M.L.S. Professor and will be subject to revision and extension from time to time.

- (h) Research students or Research Assistants and members\* of the Public who have been specially authorised by the Committee of Management will be entitled to take out not more than two volumes at a time, and, in order to be allowed this privilege, will, save as regards the members of the Association and such other persons\* who may be permitted by the Committee of Management, have to make a deposit of Rs. 10. The Committee of Management may, in the case of specially valuable books ask for a special deposit or prohibit its issue out of the library.
- (i) No books or Journals shall be issued and delivered except to the authorised borrower in person or to some one having written authority from him to receive it on behalf of the authorised borrower.
- (j) If a book or journal called for after the expiry of the date of return be not returned within one week after the receipt of notice from the Honorary Secretary, the Committee of Management may take such steps as it may deem fit.
- (k) The privilege of any person to use the library shall be suspended so long as he retains any book or journal which, under these rules, he is not entitled to retain, and so long as he leaves unpaid any charges which he might have been asked to pay.
- (l) Subject to the rules in force at the time the M. L. S. Professor shall be in charge of the library and shall report with relevant details to the Honorary Secretary all cases in which books and journal have been lost, mutilated, disfigured by writing on the margin or otherwise injured while in the possession of readers. The Honorary Secretary shall on the basis of the above information cause to be prepared a statement on the loss or mutilation of books and journals and on the cost of their replacement for the consideration of the Committee of Management towards the end of every year. Any person guilty of such an offence shall be required to replace the injured by an uninjured copy of the book, and shall be liable to the cost of its proper binding and such other charges which the Committee of Management may consider necessary. The privilege of using the library may be withdrawn from such

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\*N.B.—The Committee of Management has authorised the Honorary Secretary to issue free-permit cards for the use of the library to the Fellows of the Indian Physical Society certified to be so by the Honorary Secretary, Indian Physical Society.

persons by the Committee of Management for such period as they may decide upon.

(m) A general inspection of the library and of the records of books purchased, issued and returned, shall be caused to be made by the Honorary Secretary annually in the first week of May with the co-operation of one or more members of the Committee of Management deputed by them for that purpose. All books and journals borrowed by any person shall be returned to the library by the 31st March of each year and the library shall be closed for stock taking for a fortnight.

(n) The library shall be closed on Sundays and on all holidays approved by the Committee of Management and subject to the exception under (m) it shall be open on all other days between 11 A.M. to 4 P.M. and from 6 to 8 P.M. Members of the Association and persons working in the Association may, with the permission of the Committee of Management, use the library between 7 and 11 A.M. provided the M. L. S. Professor of Physics is in the premises of the association.

4. The subscriptions for the following publications were continued :—

1. Scientific American.
2. Nature.
3. Science Abstracts. A & B.
4. Philosophical Magazine.
5. Philosophical Transactions of the Royal Society, A.
6. Physical Review.
7. Zeitschrift fur Physik.
8. Proceedings of the Royal Society, A.
9. Annalen der Physik.
10. Physikalische Zeitschrift.
11. Journal of the American Chemical Society.
12. Proceedings of the National Academy of Science, Washington.
13. Zeitschrift fur Physikalische Chemie, A & B.
14. Zeitschrift fur Kristallographie, A.
15. Annales de Physique.
16. Comptes Rendus.
17. Chemical Abstracts.
18. Science Progress.
19. Transactions of the Faraday Society.
20. Naturwissenschaften.
21. Journal of Chemical Physics.
22. Review of Modern Physics.
23. Journal of Physical Chemistry.
24. Physikalische Berichte.
25. Journal of the Chemical Society, London.
26. British Chemical Abstracts, A.

27. Physics.
28. Astrophysical Journal.

The Managing Committee acknowledge with thanks the presentation of Journals and Periodicals in exchange of our proceedings and journals from the following Societies and Institutions.

1. Abhandlungen der Bayerischen Akademie der Wissenschaften.
2. Acta Physica Polonica.
3. Acta Literrum Ac Scientiarum Regiae Universitatis Hungaricae Francisco-Josephinae.
4. Acta Societatis Scientiarum Fennicae.
5. Annales de L'Institut Pasteur.
6. Arhiv za Hemiju I Farmaciju.
7. Atti della Accademia Nazionale dei Lincei.
8. Annales de L'Institut Henri Poincare.
9. The Biological Bulletin.
10. Bulletin of Calcutta Mathematical Society.
11. Bulletin of the National Research Council of the National Academy of Sciences Washington.
12. Bulletin de la Societe Royale des Sciences de Liege.
13. Bulletin de la Societe Vaudoise des Sciences Naturelles.
14. Bulletin de la Societe Roumaine de Physique.
15. Chinese Journal of Physics.
16. Communication and Broad-casting Engineering.
17. Communication from the Kamerlingh Onnes Laboratory of the University of Leiden.
18. Comptes Rendus des Sciences de la Societe de Physique D'Histoire Naturelle de Geneve.
19. Current Science.
20. Det. Kgl. Danske Videnskabernes Selskab (Mathematisk-Fysiske).
21. do do do do (Biologiske).
22. Economic Proceedings of the Royal Dublin Society.
23. Helvetica Physica Acta.
24. Il Novo Cimento.
25. Indian Journal of Agricultural Science.
26. Industrial and Engineering Chemistry.
27. Japanese Journal of Engineering.
28. do do Mathematics.
29. do do Physics.
30. Journal of the Asiatic Society of Bengal.
31. do of Chemical Engineering (China).
32. do of Chemie Physique.
33. do of the Chinese Chemical Society.
34. do of the Faculty of Sciences (Imperial University, Tokyo).
35. do of the Franklin Institute.
36. do of the Indian Chemical Society.

37. Journal of Mathematics and Physics. (America)
38. do de Physique.
39. do of Research, National Bureau of Standards.
40. do of the Institute of Science, Bangalore.
41. do of Science of the Hiroshima University.
42. do of Scientific Instruments.
43. Lotos.
44. Manchester Literary and Philosophical Society's Publications.
45. Memoirs of the College of Science (Kyoto).
46. do do Faculty of Science of the Taihoku Imperial University.
47. Memoirs of the l' Academie Royale des Sciences et de letters de Danemark.
48. Memoirs of the Societe Vaudoise des sciences Naturelles.
49. Monthly Weather Review.
50. National Physical Laboratory Report, London.
51. National Research Council of Japan.
52. Nederlandsch Tijdschrift voor Naturkunde.
53. Natur und volk.
54. Physica.
55. Die Physik, Leipzig.
56. Physikalische Zeitschrift der Sowjetunion.
57. Proceedings Koninklijke Akademie van Wetenschappen te Amsterdam.
58. Proceedings of the American Philosophical Society.
59. do of the Cambridge Philosophical Society.
60. do of the Indian Academy of Sciences. A & B.
61. do of the Imperial Academy, Tokyo.
62. do of the National Academy of Sciences of India, Allahabad.
63. Proceedings of the National Institute of Sciences of India.
64. do of the Physical Society, London.
65. do of the Physico-Mathematical Society of Japan.
66. do of the Royal Society of Edinburgh.
67. do of the University of Durham Philosophical Society.
68. Quarterly journal of the Royal Meteorological Society.
69. Records of the Geological Survey of India.
70. Revue Generale des Sciences, Paris.
71. Report of Radio Research in Japan.
72. Review Trimestrelle Cannadienne.
73. The Scientific Proceedings of the Royal Dublin Society.
74. Science and Culture.
75. Scientific Papers of the Institute of Physical and Chemical Research, Tokyo.
76. Scientific Papers of the National Research Institute of Physics Academia, Sinica.

77. Science Reports of National Tsing Hua University, A & B.
78. Science Reports of the Tohoku Imperial University.
79. Scientific Notes. Indias Meteorological Department.
80. Science Reports of the Tokyo Bunrika, Daigaku, A & B.
81. Sencken Bergiana.
82. Sitzungsberichte der preussichen Akademie der Wissenschaften.
83. do Philosophy, History.
84. do Akademie der Mathematisch-naturwissenschaft,  
Munchen.
85. Technical Physics of the U. S. S. R.
86. Terrestrial Magnetism and Atmospheric Electricity.
87. Tohoku Mathematical Journal.
88. Transactions of the Society of Mechanical Engineering, Japan.
89. do of the National Institute of Sciences of India.
90. do of the Canadian Institute.
91. do of the Royal Society of Canada.
92. University of California Press Publications.
93. do of Illinois Bulletin.
94. do of Washington Publications.
95. Vierteljahrsschrift der Naturforschenden Gesellschaft in Basel.
96. Vierteljahrsschrift der Naturforschenden Gesellschaft in Zurich.
97. Wissenschaftliche Veroffentlichungen aus den Berlin.
98. Nova Acta Regial Societatis Scientiarum Upsaliensis.

#### RESEARCH IN THE ASSOCIATION

The Report of the Mahendralal Sircar Professor on the researches carried out in the Association, including those by the Research Fellow and the research scholars is published herewith in Appendix III.

#### POPULAR LECTURES

A popular lecture on 'Silk Industry' was delivered in June, 1937 by Mr. C. C. Ghosh, Deputy Director, Sericulture, Bengal, Berhampur.

#### OTHER ACTIVITIES

For the benefit of the students of the Calcutta Medical School a regular course of lectures in physics and chemistry was delivered at the lecture hall with the aid of the apparatus and demonstrators of the Association.

2 Regular facilities were given during the year to the 'Teachers' Training Department of the Calcutta University for taking meteorological observations and teaching work in this connection.

5 Meteorological Reports were sent daily to the following newspapers :—

1. The Statesman,
2. The Amritabazar Patrika,
3. The Advance.

4. The Vasumati.
5. The Hindusthan Standard.
6. The Anandabazar Patrika.

The names of the last two were added to the list during the year at their request.

#### PROFESSORSHIPS, MEDALS AND PRIZES.

**A. The Joykissen Mookerjee Medal and the Ripon and Coochbehar Professorships.** The following eminent scientists, who attended the Silver Jubilee Session of the Indian Science Congress Association, accepted the invitation of the Committee of Management to address the Association as follows :—

- (a) Sir James H. Jeans, D.Sc., Sc.D., L.D.D., F.I.C., F.R.S.  
on the occasion of the award to him of the Joykissen Mookerjee Gold Medal for 1937.
- (b) Dr. F. W. Aston, Sc.D., D.Sc., LL.D., F.R.S., Nobel Laureate on the occasion of the award to him of the Joykissen Mookerjee Gold Medal for 1938.
- (c) Sir Arthur Hill, K.C.M.G., D.Sc., F.R.S., Director, Royal Botanic Gardens, Kew, the Ripon Professorship lectures for 1938.
- (d) Sir Lewis L. Fermor, D.Sc., F.R.S., lately Director of the Geological Survey of India, the Ripon Professorship lectures for 1937.
- (e) Prof. J. E. Lennard. Jones, Ph.D., D.Sc., F.R.S., the Coochbehar Professorship lectures for 1937.

2. The Addresses and Lectures were delivered as follows :—

Names	Subjects	Dates.
Sir James H. Jeans, D. Sc., Sc. D., LL. D., F.I.C., F.R.S.,	The Origin of Planets. ... ..	6-1-38.
Dr. F. W. Aston, Sc. D., D. Sc., LL. D., F.R.S., Nobel Laureate	Separation of Isotopes ... ..	6-1-38.
Sir Arthur Hill, K.C.M.G., D.Sc., F.R.S.	(1) The Royal Botanic Gardens, Kew in relation to the Empire, and to India in particular.	4-1-38.
	(2) The Study of Seedlings and their modes of Germination.	5-1-38.
	(3) The Germination of Seeds enclosed within a Stony Endocarp.	5-1-38.
Prof. J. E. Lennard-Jones, Ph. D., D. Sc., F.R.S.	Advances in the Theory of Interatomic Forces. (3 lectures)	6-1-38. 8-1-38.
	Sir Lewis L. Fermor, D. Sc., F.R.S.,	Garnets as Minerals ... ..
	Garnets as Constituents of Rocks and of the Infra-Plutonic Shell of the Earth.	24-2-38.
	The Relationship of Vulcanicity, Isostasy Earthquakes, Continental Drift and Stony Meteorites to the Infra-Plutonic Shell.	25-2-38.

3. Prof. Sir Arthur Harden and Prof. N. Vaviloff also accepted the invitation of the Committee of Management to address the Association but were unavoidably unable to come to India.

#### B. OTHER MEDALS AND PRIZES.

It was decided to award the Dr. Sircar Research Medal to Mr. Santilal Banerjee, M. Sc., a Research Scholar of this Association. Applications were invited from all over India and the award was made on the recommendation of experts.

2. It was also decided to make the following awards :—

Jatindra Chandra Prize to Mr. Santilal Banerjee, M. Sc., Nikunja Garabini Prize to Mr. Asutosh Mookerjee, M. Sc., research workers of the Association. The awards will be made at the Annual General Meeting.

#### ACKNOWLEDGMENTS

The Committee of Management have great pleasure in recording their grateful thanks to.

- (a) The Government of India for their grant of Rs. 18,000 for the year 1937-38 and for the restoration of the 10% cut on the Government of India grant from the year 1938-39.
- (b) The University of Calcutta for printing the journal free of cost.
- (c) The Corporation of Calcutta for exemption of municipal taxes for premises No. 210.

They also express their grateful appreciation of the honorary services rendered by

- (a) Messrs. J. N. Basu, N. C. Chunder and J. C. Pal as Trustees.
- (b) Mr. M. N. Mukerji, B.E., on engineering matters.
- (c) Prof. J. N. Mukherjee, D.Sc., F.R.A.S.B., F.N.I., Honorary Secretary.
- (d) Prof. P. N. Ghosh, M.A., Ph.D., Sc.D., F.N.I., Honorary Secretary, Editorial Board, Indian Journal of Physics and Proceedings of the Association.
- (e) Messrs. B. N. Basu & Co., solicitors on all legal matters.

In presenting this report on behalf of the Committee of Management the Secretary expresses his thankfulness for the support and encouragement he has received from the President, Sir Nilratan Sircar, Kt., M.A., M.D., D.C.L. (Oxon), Mr. J. N. Basu, M.A., M.L.A., and other members of the Committee of Management including Dr. W. A. Jenkins, the representative of the Government of India on the Executive Committee.

J. N. MUKHERJEE,  
*Honorary Secretary,*  
Indian Association for the  
Cultivation of Science.

**APPEN**

**INDIAN ASSOCIATION FOR THE**  
*Receipts and Payments Account for the*

RECEIPTS	Rs. As. P.	Rs. As. P.
To Opening Balance as at 1. 1. 37.		
In hand (Imprest Cash) . . . . .	100 0 0	
In Imperial Bank of India . . . . .	12,351 2 4	
(*) In Postal Savings Bank . . . . .	5,503 0 11	
(*) In Postal Cash Certificates (Cost) . . . . .	7,331 4 0	
		25,285 7 3
" Subscriptions from Members . . . . .		115 0 0
" Dr. Sircar Memorial Donations . . . . .		150 0 0
" Indian Journal of Physics—Sales and Subscriptions . . . . .		2,976 10 11
" Rent from Tenants . . . . .		5,007 8 0
" Municipal-Tax from Tenants . . . . .		277 5 9
" Demonstration Allowance . . . . .		600 0 0
" Sale of Old Materials . . . . .		1 2 0
" Advertisement . . . . .		9 0 0
" Special Scholarships . . . . .		160 0 0
" Staff Income-Tax . . . . .		403 6 0
" Interest.		
Ripon P. F. . . . .	750 0 0	
Joykissen M. F. . . . .	399 0 0	
Victoria P. F. . . . .	35 0 0	
Dr. Sircar R. M. F. . . . .	140 0 0	
Cooch Behar P. F. . . . .	962 8 0	
Woodburn M. F. . . . .	35 0 0	
Hare P. F. . . . .	35 0 0	
Jatindra Ch. P. F. . . . .	17 8 0	
Building Fund . . . . .	262 8 0	
Nikunjagarabini P. F. . . . .	17 8 0	
General Fund . . . . .	1,066 13 0	
		3,720 13 0
" Loan . . . . .		3,000 0 0
" Advance realised from M. L. Professor- ship A/c.		
Salary . . . . .	5,627 6 0	
Provident Fund Contribution . . . . .	562 8 0	
		6,189 14 0
" Loan realised from Prof. K. S. Krishnan . . . . .		1,666 14 0
" Suspense Account (A/c. 1936) . . . . .		0 7 0
" Mahendralal Sircar Professorship Account		
Interest on V. L. Mitra Fund . . . . .	4,620 0 0	
do M. L. Sircar Prof. Fund . . . . .	5,145 0 0	
	9,765 0 0	
" Advance from the General Fund :		
Salary . . . . . Rs. 6,085 11 0		
Provident Fund Contri- bution . . . . . " 625 0 0		
	6,710 11 0	
		16,475 11 0
Amount Carried over . . . . .		66,039 2 11

## DIX I

## CULTIVATION OF SCIENCE

year ended 31st December, 1937.

PAYMENTS	Rs.	As.	P.	Rs.	As.	P.
By Library . . . . .	.	.	.	217	12	0
„ Indian Journal of Physics—Publication Expenses.	.	.	.	1,858	13	3
„ Establishment . . . . .	.	.	.	2,127	11	3
„ Research Staff . . . . .	.	.	.	10,103	9	6
„ Municipal-Tax . . . . .	.	.	.	703	6	0
„ Advertisement . . . . .	.	.	.	59	14	0
„ Special Scholarships . . . . .	.	.	.	160	0	0
„ Postage . . . . .	.	.	.	90	11	3
„ Staff Income-Tax . . . . .	.	.	.	403	6	0
„ Provident Fund Contribution (Association)	.	.	.	433	0	0
„ Telephone . . . . .	.	.	.	216	10	0
„ Printing . . . . .	.	.	.	198	2	0
„ Office Contingency . . . . .	.	.	.	195	4	3
„ Travelling Allowance . . . . .	.	.	.	439	11	0
„ Science Congress Ticket . . . . .	.	.	.	10	2	0
„ Donation . . . . .	.	.	.	350	0	0
„ Audit Fee . . . . .	.	.	.	150	0	0
„ Insurance . . . . .	.	.	.	125	0	0
„ Laboratory Charges . . . . .	.	.	.	1,694	9	9
„ Gas and Electricity Charges . . . . .	.	.	.	1,075	1	0
„ Laboratory Contingency . . . . .	.	.	.	397	7	0
„ Bank Commission :						
Jatindra Ch. P. F. . . . .	0	8	0			
Victoria P. F. . . . .	0	8	0			
Ripon P. F. . . . .	5	4	0			
Dr. Sircar R. M. F. . . . .	7	12	0			
Hare P. F. . . . .	0	8	0			
Woodburn M. F. . . . .	0	8	0			
Nikunja Garabini P. F. . . . .	0	8	0			
Cooch Behar P. F. . . . .	3	0	0			
Joykissen M. F. . . . .	3	12	0			
Building Fund . . . . .	1	8	0			
General Fund . . . . .	9	4	6			
				33	0	6
„ Loan to Prof. K.S. Krishnan . . . . .	.	.	.	4,000	0	0
Amount Carried over . . . . .	.	.	.	25,093	2	9

## INDIAN ASSOCIATION FOR

*Receipts and Payments for the*

RECEIPTS	Rs. As. P.	Rs. As. P.
To Amount Brought forward . . . . .	. . . . .	66,039 2 11
„ <b>Employees Provident Fund Account :</b>		
Staff Contribution . . . . .	483 0 0	
Prof. K. S. Krishnan Contribution . . . . .	750 0 0	
Association Contribution . . . . .	1,233 0 0	
Interest . . . . .	112 13 3	
Repayment of Loan by Members . . . . .	630 0 0	
Miscellaneous . . . . .	0 5 0	
		3,209 2 3
„ <b>Joykissen Medal Fund Account ;</b>		
Amount transferred from General Fund (as per contra).	. . . . .	329 2 6
		Rs. 69,577 7 8

1B, Old Post Office Street,  
CALCUTTA  
25th March, 1938.

# THE CULTIVATION OF SCIENCE

year ended 31st December, 1937—contd.

PAYMENTS	Rs. As. P.	Rs. As. P.
By Amount Brought forward . . . . .	. . . . .	25,093 2 9
<b>By Advance to M. L. S. Professorship Account :</b>		
Salary . . . . .	6,085 11 0	
Provident Fund Contribution . . . . .	625 0 0	
		6,710 11 0
„ <b>Mahendralal Sircar Professorship Account:</b>		
Salary . . . . .	9,000 0 0	
Association Provident Fund Contribution . . . . .	750 0 0	
Bank Commission . . . . .	27 8 0	
Advance Repayment to General Fund :		
Salary . . . . . Rs. 5,627 6 0		
Provident Fund Contribution . . . . . „ 562 8 0		
	6,189 14 0	
		15,967 6 0
„ <b>Dr. Sircar Research Medal Fund (Advertisement).</b>	. . . . .	24 8 0
„ <b>Employees Provident Fund Account (Loan to Member).</b>	. . . . .	62 13 0
„ <b>Amount Transferred to Joykissen Medal Fund (As per contra).</b>	. . . . .	329 2 6
„ <b>Suspense Deposit (Cheque pending Collection).</b>	. . . . .	15 0 0
„ <b>Suspense Account (A/c. 1936)</b> . . . . .	. . . . .	9 7 0
„ <b>Joykissen Medal Fund Account (Cost of Medal awarded).</b>	. . . . .	329 2 6
„ <b>Closing balances as at 31. 12. 37 :</b>		
In hand (Imprest Cash) . . . . .	115 0 0	
In Imperial Bank of India . . . . .	1,876 14 9	
„ (on Interest Account) . . . . .	3,063 10 0	
(*) In Postal Savings Bank . . . . .	8,649 6 2	
(*) In Postal Cash Certificates (Cost) . . . . .	7,331 4 0	
		21,036 2 11
		Rs. 69,577 7 8

\* On Employees Provident Fund Account.

Examined and found correct.

S. N. MUKHERJI, R.A.,

Incorporated Accountant.

## INDIAN ASSOCIATION FOR THE

*Balance Sheet as at*

LIABILITIES	Rs. As. P.	Rs. As. P.
General Fund . . . . .	...	1,94,031 4 1
Government of India Grant Account . . . . .	...	5,114 14 9
Depreciation Reserve . . . . .	...	1,69,099 10 3
Investment Reserve . . . . .	...	6,173 8 0
Employees Provident Fund . . . . .	...	15,980 10 2
Loan . . . . .	...	3,000 0 0
Endowment Funds (As per enclosed "Schedule" Col. II) . . . . .	...	3,31,519 8 5
Mahendralal Sircar Research Professorship (Adjustment) . . . . .	...	508 5 0
	...	7,25,427 12 8

1B, Old Post Office Street,

CALCUTTA

25th March, 1938.

# CULTIVATION OF SCIENCE

31st December, 1937

ASSETS		Rs.	As.	P.	Rs.	As.	P.
Land and Building . . . . .					31,680	11	9
Lecture Hall and Gallery . . . . .					23,465	5	3
Vizianagram Laboratory . . . . .					40,900	14	0
Observatory Rooms . . . . .					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
Durwans' Quarters . . . . .					303	13	9
Scientific Instrument (Including Rs. 25,000/- on K. K. Tagore Account) . . . . .					1,18,532	5	2
Botanical Instrument . . . . .					2,329	6	0
Workshop Instruments . . . . .					9,861	5	9
Tools and Implements . . . . .					225	7	3
Furniture . . . . .					19,218	2	6
Library . . . . .					60,935	9	10
Investments in G. P. Notes (As per enclosed "Schedule"—Col. III) . . . . .					3,84,900	0	0
Interest Accrued on above (As per enclosed "Schedule"—Col. IV) . . . . .					3,063	10	0
Advance to Mahendralal Sircar Research Professorship A/c (Net) . . . . .					520	13	0
Loan to Prof. K. S. Krishnan . . . . .					2,333	2	0
Suspense Account (Cheque pending Collection) . . . . .					15	0	0
Employees' Provident Fund : Investments (At Cost) . . . . .							
Postal Cash Certificates . . . . .		7,331	4	0			
Post Office Savings Bank . . . . .		8,649	6	2			
					15,980	10	2
Closing Balances :							
Cash in hand (Imprest) . . . . .		115	0	0			
Cash in Imperial Bank of India (Current Account) . . . . .		1,876	14	9			
					1,991	14	9
					7,25,427	12	8

Examined the Balance Sheet as at 31st December 1937 of the Indian Association For the Cultivation of Science as set forth above with the books and vouchers of the Association and found it correct.

S. N. Mukherji, R. A.

*Incorporated Accountant.*

# INDIAN ASSOCIATION FOR "SCHE

*Statement showing the position of the Endowment Funds of Indian Association*

Description of the Fund.	Amount of Fund as at 31-12-37.		
I.	II.		
	Rs.	As.	P.
Jatindra Ch. Prize Fund . . . . .	925	6	0
Victoria Prof. Fund . . . . .	1,347	14	0
Ripon Prof. Fund . . . . .	23,541	14	3
Dr. Sircar Research Medal Fund . . . . .	4,711	4	0
Hare Prof. Fund . . . . .	1,347	14	0
Woodburn Medal Fund . . . . .	1,384	6	0
Nikunja Garabini Prize Fund . . . . .	937	9	2
Coochbehar Prof Fund . . . . .	29,397	5	0
Joykissen Medal Fund . . . . .	12,634	11	0
Building Fund . . . . .	8,091	5	0
Mahendralal Sircar Prof. Fund . . . . .	1,47,200	0	0
Veharilala Mitra Fund . . . . .	1,00,000	0	0
General Fund . . . . .	...	...	
<b>Total (As per Balance Sheet, Dated 31.12.37.)</b>	<b>3,31,519</b>	<b>8</b>	<b>5</b>

(\*) Note :—The amount held with the Association, viz., Rs. 5,564-3-5, is included specifically indicated in the Balance Sheet as at 31st December 1937.

1B, Old Post Office Street,  
CALCUTTA.

25th March, 1938.

# THE CULTIVATION OF SCIENCE DULE"

for the Cultivation of Science, as on the 31st December, 1937.

Held in G. P. Notes (Face Value)			Held in Imperial Bank of India.			Held with the Association.		
III.			IV.			V.		
Rs.	As.	P.	Rs.	As.	P.	Rs.	As.	P.
500	0	0	17	0	0	408	6	0
1,000	0	0	34	8	0	313	6	0
22,000	0	0	718	12	0	823	2	3
4,000	0	0	107	12	0	603	8	0
1,000	0	0	34	8	0	313	6	0
1,000	0	0	34	8	0	349	14	0
500	0	0	17	0	0	420	9	2
27,500	0	0	959	8	0	937	13	0
11,400	0	0	370	13	0	863	14	0
7,500	0	0	261	0	0	330	5	0
1,47,000	0	0	216	2	0	200	0	0
1,32,000	0	0	292	3	0	...	...	
29,500	0	0	...	...		...	...	
3,84,900	0	0	3,063	10	0	5,564	3	5(*)

in the general assets pending final allocation. Accordingly, the said sum is not

Examined and found Correct

S. N. MUKHERJI, R.A.,

*Incorporated Accountant.*

## INDIAN ASSOCIATION FOR General Fund Account for the

INCOME	Rs. as. p.	Rs. as. p.
Fund at the beginning of the year ...	...	2,03,060 4 5
Amount transferred from "Government of India Grant Account" ...	...	13,488 7 3*
Subscriptions ...	115 0 0	
Do. Dr. Sircar Memorial ...	150 0 0	
Indian Journal of Physics...	2,976 10 11	
Rent ...	5,007 8 0	
Interest ...	1,066 13 0	
Municipal-Tax ...	277 5 9	
Demonstration Allowance ...	600 0 0	
Sale of Old Materials ...	1 2 0	
Advertisement ...	9 0 0	
Special Scholarships ...	160 0 0	
Income-Tax ...	403 6 0	10,766-13-8
	...	2,27,315 9 4
<b>*Appropriation of "Government of India Grant Account" in 1937 :—</b>		
Opening Balance as at 1-1-37 ...	...	18,603 6 0
Less, Appropriations in 1937 :		
Research Staff ...	10,103 9 6	
Laboratory Charges ...	1,694 9 9	
Do. Contingency ...	397 7 0	
Gas and Electric Charges ...	1,075 1 0	
Library ...	217 12 0	
		13,488 7 3
Closing Balance as at 31-12-37 (As per Balance Sheet)...	...	5,114 13 3

1B, Old Post Office Street,  
CALCUTTA  
25th March, 1938.

FOR  
or the

# THE CULTIVATION OF SCIENCE

year ending 31st December, 1937

Rs. as. p.		OUTGO	Rs. as. p.		Rs. as. p.	
4	5	Establishment	...	...	2,127	11 3
7	3*	Research Staff	...	...	10,103	9 6
		Indian Journal of Physics...	...	...	1,858	13 3
		Municipal-Tax	...	...	703	6 0
		Advertisement	...	...	59	14 0
		Special Scholarships	...	...	160	0 0
		Bank Charges	...	...	9	4 6
		Postage	...	...	90	11 3
		Income-Tax	...	...	403	6 0
		Provident Fund Contribution	...	...	483	0 0
		Telephone	...	...	216	10 0
		Printing	...	...	198	2 0
		Office Contingency	...	...	195	4 3
		Travelling Allowance	...	...	439	11 0
		Science Congress Ticket	...	...	10	2 0
		Donation	...	...	350	0 0
		Audit Fee	...	...	150	0 0
		Insurance	...	...	125	0 0
4		Laboratory Charges	...	...	1,694	9 9
		Gas & Electric Charges	...	...	1,075	1 0
		Laboratory Contingency	...	...	397	7 0
		Amount transferred to :				20,851 10 9
		Depreciation Reserve	...	...	6,330	0 0
		Investment Reserve	...	...	5,773	8 0
		Joykissen Medal Fund...	...	...	329	2 6
		Fund at the end of the year	...	...	...	12,432 10 6
						1,94,031 4 1
						2,27,315 9 4

Examined and found correct,

S. N. Mukherji, R. A.

Incorporated Accountant.

# INDIAN ASSOCIATION FOR PROVIDENT

*Balance Sheet as at*

LIABILITIES	Rs.	As.	P.
Prof. K. S. Krishnan . . . . .	6,049	1	3
Mr. Ashutosh Dey . . . . .	5,391	0	9
Mr. Nalinaksha Sinha . . . . .	1,989	13	9
Mr. S. N. Banerjee . . . . .	75	0	0
Dhirendra Nath Das . . . . .	1,466	12	9
Subodh Kumar Chakravarty . . . . .	213	14	0
Satish Chandra Das . . . . .	840	3	9
Mr. B. M. Bhattacharyya . . . . .	13	12	9
Mr. B. C. Mullick . . . . .	308	10	3
Interest up to 1936 (Undistributed) . . . . .	76	0	8
Do 1937 do . . . . .	99	1	3
	Rs. 16,523	7	2

1B, Old Post Office Street,

CALCUTTA

25th March, 1938.

# THE CULTIVATION OF SCIENCE FUND

31st December, 1937

ASSETS	Rs.	As.	P.
<i>Loan</i>			
Mr. Ashutosh Dey . . . . .	480	0	0
Prof. K. S. Krishnan : Payment to National Insurance Co., for premium on Life Insurance . . . . .	62	13	0
Balance in the Post Office Savings Bank . . . . .	8,649	6	2
Post Office Cash Certificate in the Safe-Custody . . . . .	7,331	4	0
	Rs. 16,523	7	2

Examined and Found Correct,

S. N. MUKHERJI, R.A.,

*Incorporated Accountant.*



## APPENDIX II

### *List of papers published in Indian Journal of Physics, Vol. XI.*

1. Anomalous Diamagnetism of Selenium—By Mata Prasad and S. S. Dharmatti.
2. Investigations in the Infra-Red, Part II. Absorption Spectrum of Boric Acid.—By M. K. Sen.
3. A Ray-Displacement Refractometer for accurate Work—By K. Prasad and R. P. Gupta.
4. Structure of Aromatic Compounds, Part I. Acenaphthene—By K. Banerjee and K. L. Sinha.
5. Dielectric Constant of an Electronic Medium for Ultra-Short Waves—By Ali Imam and S. R. Khastgir.
6. On N. R. Sen's Derivation of the Lorentz Transformation—By Zahur Husain.
7. A Reply to Husain's Note—By N. R. Sen.
8. Raman Effect at Low Temperature; Phosphorous trichloride, Cyclohexane and Chlorobenzene—By S. C. Sirkar and J. Gupta.
9. Studies on some Indian Vegetable Oils, Part IV. Absorption of Air By G. N. Bhattacharyya.
10. Semi-optical Lines in X-ray Spectra—By A. T. Maitra.
11. High-Frequency Modulation of Ultra-short Waves—By S. S. Banerjee, and B. N. Singh.
12. Lattice Energy of KBr and NaBr and the Electron Affinity of Bromine—By Amarnath Tandon.
13. Meteors and Upper Atmospheric Ionisation—By J. N. Bhar.
14. A Note on the Crystal Structure of Solid  $H_2S$ —By S. C. Sirkar and J. Gupta.
15. On possible Electronic Transitions in  $ND^{+++}$  Ions and the Absorption Spectra of the same in Solution and in Crystals—By P. C. Mukherji.
16. Constitution of Water in Solutions of Strong Electrolytes, II—By C. Samba Siva Rao.
17. Group Velocity Curves for Radio-Waves Propagation in the Ionosphere—By R. R. Bajpai and K. B. Mathur.
18. Determination of Latent Heats of the Selenides of Cadmium and Mercury and Telluride of Zinc from the Absorption Spectra of their Vapours—By L. S. Mathur.

19. An X-ray Study of Potassium Bicarbonate  $\text{KHCO}_3$ —By Jagattaran Dhar.
20. On Delay in Transmission through Telephone Apparatus and Net-work—By P. B. Ghosh.
21. On the Polarisation of Raman Lines of some Organic Compounds—By Binoy Kanta Chowdhuri.
22. On the Hyper-fine Structure of the  $4436.89, sp^3 \ ^3D_2 - 5p^3 \ ^3D_1$  Line in the First Spark Spectrum of Arsenic and its Nuclear Spin—By S. K. Mukerji.
23. X-ray Studies on Electro-deposited Chromium and Gold—By Sudhendu Basu and M. Hussain.
24. Free Rotation in the Oxalate Group and the Resonance Bond of Carboxyl—By Jagannath Gupta.
25. Derivation of the Latent Heat Equation from the Principles of Dilute Solution—By B. N. Biswas.
26. Spin Doubling in  $^2\Sigma$  States of AIO—By M. K. Sen.
27. On the Crystal Structure of Dichlorobenzene at different Temperatures—By S. C. Sirkar and J. Gupta.
28. Investigations on the Release of Electrical Charges under moderate Pressure from Photographic Plates and other Materials—By K. Prosad and L. M. Chatterjee.
29. On the Relation between the Emission Spectra of  $\text{Nd}^{+++}$  ions in Phosphores and the Absorption Spectra of the same in Crystals—By P. C. Mukherji.
30. Verification of Stokes' Theory of a Sphere Oscillating in a Liquid—By D. S. Subrahmanyam.
31. On the Theory of Semi-Conductors in Magnetic Field—By M. Sen Gupta.
32. A Note on  $\delta(\text{CH})$  Vibration in Sodium Formate—By Jagannath Gupta.
33. Technique for making Collodion Filter for the  $k\alpha$  Chromium Radiation—By Surain Singh Sidhu.
34. An Application of the Ray-Displacement Refractometer to the Study of Anomalous Dispersion of Didymium Glass—By K. Prosad and R. P. Gupta.
35. On the Intensities of Raman Lines due to Lattice Oscillations—By S. C. Sirkar.
36. The Calculation of Interplanar Spacings of Crystal System by Vectors—By Surain Singh Sidhu.
37. A method of Measuring Radio-Frequency Alternating Current and its Application to the absolute Measurement of Field Strengths of

Weak Radio Signals—By Ali Imam, Sukhamaya Gangopadhyaya and S. R. Khastgir.

38. Fine Structure of the First Spark Spectrum of Arsenic in the visible Region—By S. K. Mukherji.
39. Magnetic Properties of Tellurium on Collodisation—By Mata Prasad and S. S. Dharamatti.
40. On Possible Electronic Transitions in  $\text{Pr}^{+++}$  Ions and the Absorption Spectra of the same in Solution—By P. C. Mukherji.
41. Structure of Aromatic Compounds, Part II: Benzil—By K. Banerjee and K. L. Sinha.
42. On the Raman Spectra of Mixed Crystals—By S. C. Sirkar and Ishwar Chandra Bishui.
43. Nuclear Structure of Light Atoms—By B. M. Sen.

### APPENDIX III

#### *Report by the Mahendralal Sircar Professor of Physics on the Scientific work of the Association*

##### 1. Magnetic Studies on Organic Crystals

In a previous report we gave an account of the extensive magnetic studies made in our laboratory on single crystals of organic compounds, particularly of the aromatic class. These magnetic studies have a two-fold interest. (1) Complete analyses of the structures of some of the crystals have recently been made by Robertson and others at the Royal Institution, London. For these crystals we are able from the magnetic data to calculate the principal susceptibilities of the constituent molecules, which are important molecular constants; they figure prominently in the recent theoretical discussions by Pauling in America, and by London and Frenkel in Europe, on the electronic structures of these molecules. (2) When once the magnetic constants for some typical aromatic molecules have been determined, either in the above manner, or experimentally from studies on the magnetic double-refraction of these substances in the liquid state or in the state of solution in suitable solvents, we can deduce therefrom the constants for many related molecules. By correlating these data deduced for the molecules with the observed magnetic data for the corresponding crystals, we can obtain information regarding the orientations of the molecules in the lattices of these crystals. Such information will be very helpful in any attempt at structural analysis of the crystals by X-ray methods. Often it will save much labour in the preliminary stages of locating the approximate molecular orientations by the trial and error method, and will in any case offer an effective, independent check on some of the results obtained by the X-ray analysis. Thus the magnetic method forms a useful supplement to the X-ray method of structural analysis of crystals. For a detailed account of the method, and the results obtained by it, the reader may be referred to the original papers by Mr. Santilal Banerjee and the present writer in the Philosophical Transactions of the Royal Society.

In view of the fruitfulness of the magnetic studies Mr. Banerjee has now extended the magnetic measurements to a large number of aromatic compounds of special structural interest; among which are several derivatives of benzene, benzoquinone, diphenyl, fluorene, naphthalene, anthracene and phenanthrene; and several condensed ring compounds, naphthacene, triphenylene, and its derivative duodecahydro-triphenylene, perylene, dimethyl dibenzphenanthrene, the well-known carcinogenic compound 1, 2-benzpyrene, etc. The magnetic results throw much light on the structures of these compounds.

### Magnetic Double-Refraction of Molten Substances

Much work has been done in this laboratory during previous years on the magnetic birefringence of liquids, and we obtain therefrom information regarding the magnetic anisotropy of the molecules, which, as we mentioned in the previous section, is very helpful in interpreting the magnetic data for the crystals. But many of the substances for which we should like to have such information are solids at room temperature, and their magnetic birefringence had therefore to be studied in the state of solution in suitable solvents. But this method has its limitations. In the choice of the solvents we are limited to those which do not themselves show a large magnetic birefringence, like carbon tetrachloride, hexane, alcohol; and many of the organic crystals are only sparingly soluble in them. The result is that the observed birefringence is predominantly that of the solvent, and the contribution from the solute is relatively so small that it can not be determined in this manner with accuracy. Recently W. J. John has developed a method for measuring the magnetic birefringence of the substance in the molten state, and he has determined in this manner the birefringence of a number of substances for which we possess magnetic data for the crystal state. The results are of interest, and they support generally those obtained by Chinchalkar and Mahajan from their measurements on solutions. For example in diphenyl and its derivatives the molecular birefringence is roughly 4 times that of benzene, in naphthalene and its  $\beta$ -methyl derivative 7 times, in phenanthrene 16 times. The birefringence of diphenylene oxide is nearly 12 times that of benzene, and is thus closer to that of phenanthrene than to that of diphenyl, as should be expected from the presence of an extra ring in diphenylene oxide which is absent in diphenyl, and from the condensed nature of the rings.

### X-Ray Analysis of Crystal Structure

Along with the magnetic studies some work has also been done on the structural analysis of crystals, both organic and inorganic, by X-ray methods, by Dhar, Guha, Chorghade and Rao. Among these studies we may specially refer here to the analysis of the interesting four-ringed compound triphenylene, which has a symmetrical structure; and of potassium bicarbonate,  $\text{KHCO}_3$ , in which the  $\text{CO}_3$  group is found to have the same planar structure as in the carbonates of the calcite and the aragonite series, which have been studied in detail previously.

### Magnetic Studies on Graphite

Reference has been made in a previous report to the unique structure of graphite, and the abnormal, and almost unidirectional, diamagnetism of this crystal. Its susceptibility along the normal to the basal plane is about  $-22 \times$

$10^{-6}$  per gm., whereas the susceptibility along directions in the basal plane is only  $-0.5 \times 10^{-6}$ , less than one fortieth of the former susceptibility. The latter value is practically that of diamond. It is well known that any chemical, or quasi-chemical, treatment of graphite, e.g., allowing it to "swell" to blue graphite, does not affect the hexagonal net work of carbon atoms in the basal plane, but only separates the adjacent layers along the hexagonal axis. Closely associated with this result is the observation that the diamagnetism for directions in the basal plane, which is normal, is not appreciably affected by such a treatment, whereas the abnormal diamagnetism along the normal to the basal plane diminishes rapidly, tending to reach very low values, and becomes almost comparable with the basal susceptibility.

Mr. Ganguli and the present writer have now studied the effect of treating graphite with alkali vapours, when copper-coloured, metallic-looking, "alloys" with graphite are formed. The magnetic results obtained are very similar to those observed by us previously in the progressive oxidation of the crystal.

We have also studied the temperature variation of the principal susceptibilities of graphite crystal. The results are very striking. Denoting by  $K_{11}$  the susceptibility of the crystal along the hexagonal axis and by  $K_1$  that along perpendicular directions, we find that  $K_1$  changes only slightly with temperature (being of the order of  $-1 \times 10^{-6}$ ), whereas  $K_1 - K_{11}$  has a value of about  $8 \times 10^{-6}$  per gram at  $1000^\circ\text{C}$ ., and rises as the temperature is lowered, reaching  $21 \times 10^{-6}$  at room temperature, and further increases, and very rapidly, to about  $40 \times 10^{-6}$  at the temperature of liquid oxygen. Graphite is indeed unique in its magnetic properties!

### Magnetic Studies on Paramagnetic Crystals

During the year under report Messrs. Asutosh Mookerji, Akshayananda Bose and the present writer have made extensive studies on the magnetic anisotropies of paramagnetic crystals also, both of the rare earth and the iron groups. The magnetic anisotropies of these crystals are remarkable for the variety of information one can obtain from them under favourable conditions, on such apparently disconnected topics as the entropy of the crystal at very low temperatures, the magnitude and the asymmetry of the electric field acting on the paramagnetic ion in the crystal, the nature of the splitting of the energy levels under the action of this field, the geometry of distribution of the atoms surrounding the paramagnetic ion, and its coordination number, the coupling between the orbital and the spin angular momenta of the ion, etc. Indeed our magnetic studies on single crystals of these compounds offer striking illustrations of all these aspects, and we give below some typical examples.

(1) **Asymmetry of crystalline fields in rare earth salts** :—The absorption spectra of some of the hydrated rare earth salts have been studied in great detail, at different temperatures; and from an analysis of the spectra

the positions of the low lying energy levels of the rare earth ions in these crystals have been deduced. From the distribution of these levels it has been concluded that the crystalline electric fields acting on the rare earth ions, which are responsible for the separation of these levels, should have nearly cubic symmetry.

Now one direct result of such a cubic symmetry for the fields would be a magnetic isotropy for the crystal; whereas actually the crystals are all strongly anisotropic, showing that the crystalline fields should deviate considerably from cubic symmetry.

Indeed a closer study of the absorption spectra also points to the same conclusion.

(2) **The crystal structure of copper sulphate pentahydrate:**—This crystal is of interest historically as it was the first crystal with which Laue, Friedrich and Knipping demonstrated the diffraction of X-rays. The crystal being triclinic, the analysis of its structure is difficult, and was completed only recently, by Beevers and Lipson in W. L. Bragg's laboratory. Before the X-ray analysis was made, it had been concluded, purely from the results of magnetic measurements on the powdered crystal at different temperatures, that the crystalline electric fields acting on the  $\text{Cu}^{++}$  ion in the crystal should be predominantly cubic in symmetry, and further, from the sign of the potential due to this field which fits the magnetic data, that the field should correspond to an octahedral distribution of six equal negative charges around the  $\text{Cu}^{++}$  ion. This result is not obvious from general structural considerations, since the crystal is triclinic, and there are five molecules of water and one  $\text{SO}_4$  group associated with each  $\text{Cu}^{++}$  ion. The result, however, has been beautifully verified later by the X-ray studies of Beevers and Lipson referred to above. The  $\text{Cu}^{++}$  ion is actually found to be at the centre of an octahedron of six negatively charged oxygen atoms. Four of them belong to four water molecules, and they form a square with the  $\text{Cu}^{++}$  ion in the centre. The other two, which are contributed by two sulphate groups, are located centrally above and below this square.

Now this octahedron is only approximately regular, the oxygens of the water molecules being closer to the  $\text{Cu}^{++}$  ion than the other two. The crystal field acting on the  $\text{Cu}^{++}$  ion should therefore deviate considerably from cubic symmetry, and its intensity along the normal to the plane of the water molecules should be less than for directions in the plane. Now there are two such  $\text{Cu}^{++}$  ions in the unit cell of the crystal, and the two corresponding squares of water molecules make with each other an angle of  $82^\circ$ , which is nearly a right angle. One should therefore expect: (1) that the crystal should be magnetically anisotropic, which is a trivial result since the crystal is triclinic; (2) that two of the principal susceptibilities of the crystal should be nearly equal, and greater than the third; that is, the magnetic ellipsoid should be approximately an oblate spheroid; (3) that the axis of this spheroid should lie along the line of intersection of the planes of the two squares of water

molecules in the unit cell. All these conclusions have been verified by our experiments.

The directions of the two nearly equal axes of the ellipsoid can also be predicted from the fine structure of the crystal: the shorter of them should lie in the plane bisecting internally the two squares of water molecules. From a study of the magnetic anisotropy for a number of planes in the crystal, Mr. Mookherji and the present writer have recently determined these two magnetic axes, and they too lie nearly as predicted from the structure.

(3) **The anisotropies of six-coordinated and four-coordinated cobalt ions in crystals contrasted**:—The strong contrast between the magnetic anisotropies of hydrated sulphates and selenates of cobalt on one side, and the corresponding nickel salts on the other, is well known; the anisotropies of cobalt are nearly ten times those of the corresponding nickel salts. This striking difference has been explained elegantly by Van Vleck in the following manner. Under the influence of the crystal fields, the energy levels of  $\text{Co}^{++}$  or  $\text{Ni}^{++}$  spread out, and the pattern of spread for  $\text{Co}^{++}$  is inverted with reference to that of  $\text{Ni}^{++}$ .

The field referred to above arises from a distribution of 6 equal negatively charged oxygens around the ion in the form of an approximately regular octahedron. If instead of an octahedron, the  $\text{Co}^{++}$  or the  $\text{Ni}^{++}$  ion is surrounded by four equal negative charges at the corners of an approximately regular tetrahedron, theory shows that the pattern of energy levels should be the reverse of that obtaining in the octahedral distribution. Cobalt salts in which such a tetrahedral arrangement obtains should have a feeble anisotropy.

Such a tetrahedral distribution may be expected to occur in salts in which the  $\text{Co}^{++}$  ion has, in the chemist's language, a coordination number four, in place of the usual six; as for example in the blue double halides of cobalt. Recently one such compound, viz.  $\text{Cs}_3\text{CoCl}_5$  has been analyzed for its structure by X-ray methods by Powell and Wells. They find that each  $\text{Co}^{++}$  ion is associated with a group of four negatively charged Cl atoms, which form a tetrahedron around it, the fifth Cl standing apart at a much larger distance.

The anisotropy of this crystal is actually very feeble; in agreement with the predictions of the mathematical theory. The other blue double chloride of cobalt and caesium, namely  $\text{Cs}_2\text{CoCl}_4$ , is also feebly anisotropic.

(4) **The coupling between the orbital and the spin angular momenta of  $\text{Ni}^{++}$  evaluated from magnetic measurements**:—In a salt of the iron group, though the spin angular momentum of the paramagnetic ion is not directly affected by the crystalline electric fields acting on the ion, yet indirectly it is, owing to its coupling with the orbital angular momentum of the ion, which is easily affected by these fields. The magnetic anisotropy of the crystal, and the deviations of the temperature dependence of its principal susceptibilities from the Curie law, are the results of such an

indirect influence of the crystal fields on the spin angular momentum exerted through the spin-orbit coupling, and should be the greater the stronger the coupling. Conversely, from the observed anisotropy or the deviations from the Curie law it should be possible to calculate the strength of the spin-orbit coupling in the ion; *i.e.*, purely from magnetic measurements on the crystal at different temperatures, it should be possible to calculate the magnitude of this important spectroscopic quantity.

The theoretical expressions necessary for such a calculation come out simple for nickel salts. Mr. Bose and the present writer have studied the magnetic anisotropies of  $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$  and  $\text{NiSeO}_4 \cdot 6\text{H}_2\text{O}$  at different temperatures, down to the temperature of liquid air. The strength of the spin-orbit coupling calculated from these magnetic data agrees well with that determined spectroscopically.

#### Magnetic Properties of Mixed Tutton Salts

The series of interesting double salts of the type  $\text{M SO}_4 \cdot \text{A}_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$ , where M is a divalent atom like Fe, Co, Ni, Cu, Mg, or Zn, and A is a monovalent atom of the alkali group, is well known. The crystallographic properties of these salts have been studied extensively by Tutton, and the salts are named after him. Since their crystallographic constants are very similar, many of them form "mixed crystals" among themselves. When one of the components is paramagnetic and the other diamagnetic, by varying the proportions of the two, it is possible to study the anisotropy at various magnetic dilutions. The chief advantage in such a dilution is that the electric fields acting on the paramagnetic ions remain practically unaltered by the dilution. The results are of importance in connection with the theory of magnetic anisotropy in crystals. Mr. Joglekar has studied a number of mixed crystals from this point of view.

#### Directional Properties in the Fluorescence of Aromatic Molecules

Pure chrysene, synthetically prepared, has a slightly violetish tinge, whereas ordinary "pure" chrysene is slightly yellowish green. The yellowish green colour has been shown by Winterstein to be due to the presence of a trace of naphthacene as impurity. Its amount may be of the order of one part in 10 millions, but it is quite sufficient to show in appreciable intensity the characteristic absorption and fluorescence bands of naphthacene. While studying the absorption spectra of single crystals of ordinarily pure chrysene, with polarized light, Mr. P. K. Seshan and the present writer found that the naphthacene bands were strongly polarized, and from the direction of polarization it was concluded that the naphthacene molecules present as impurity take up orientations in the crystal nearly parallel to those of the host molecules, of chrysene, that

accommodate them. Such a medium containing regularly oriented parasitic molecules is very suitable for studying the *directional* properties in the fluorescence of the latter. The concentration of the parasitic molecules can be made as small as may be desired, which is a great advantage when they are strongly absorbing.

Studies on the fluorescence of naphthacene in the vapour state or in solution in suitable liquids, in which the fluorescing molecules are oriented at random, naturally do not give us the same information regarding the directional properties of the molecular fluorescence, and in the crystal state naphthacene does not seem to fluoresce at all

Using such a medium of oriented naphthacene molecules Mr. P. K. Seshan and the present writer have studied the directional properties in the fluorescence of the latter. An account of the work was presented before the last International Conference on Photoluminescence, and for the details the reader may be referred to the Proceedings of the Conference. We shall mention here only one interesting result. When the incident light-vibrations, of suitable wave-length, lie in the plane of the naphthacene molecule, the fluorescence of the molecule is excited strongly, and the fluorescent light is strongly polarized, in the same direction as the exciting light. If on the other hand the incident light-vibrations are along the normal to the plane of the molecule, there is practically no fluorescence at all excited !

*List of papers published*

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2. Crystal Structure of Triphenylene,  $C_{18}H_{12}$ —By S. Banerjee and A. C. Guha, *Zeitschrift fur Kristallographie*, vol. 96, pp. 107-110.
3. Temperature Variation of the Abnormal Unidirectional Diamagnetism of Graphite Crystals—By K. S. Krishnan and N. Ganguli, *Nature*, vol., 139, pp. 155-156.
4. The Magnetic Anisotropy of  $Cs_2 [Co Cl_4]$ —By K. S. Krishnan and A. Mookherji, *Physical Review*, vol. 51, p. 528.
5. The Magnetic Anisotropy of Four-Coordinated  $Co^{++}$  Ions in Crystals—By K. S. Krishnan and A. Mookherji, *Physical Review*, vol. 51, p. 774.
6. An X-Ray Study of Potassium Bicarbonate,  $KHCO_3$ —J. Dhar, *Indian Journal of Physics*, vol. 11, pp. 187-192.
7. Magnetic and Optical Properties of Crystals—By K. S. Krishnan (Abstracts of three lectures given in the Cavendish Laboratory, Cambridge, April, 1937), *Nature*, vol. 139, p. 810.
8. The Magnetic Anisotropy of Rare Earth Sulphates and the Asymmetry of their Crystalline Fields—By K. S. Krishnan and A. Mookherji, *Nature*, vol. 140, p. 549.
9. Magnetic Birefringence of Some Aromatic Compounds in the Molten State—By W. J. John: *Transactions of the Faraday Society*, vol. 34, pp. 275-8.
10. The Magnetic Anisotropy of Some Mixed Tutton Salts—By M. S. Joglekar, *Zeitschrift fur Kristallographie*, vol. 98, pp. 411-417.
11. The Crystal Structure and the Magnetic Anisotropy of  $CuSO_4 \cdot 5H_2O$ —By K. S. Krishnan and A. Mookherji, *Nature*, vol. 140, pp. 896-7.
12. The Coupling between the Orbital and the Spin Angular Momenta of Paramagnetic Ions from Magnetic Measurements.—By K. S. Krishnan and A. Bose, *Nature*, vol. 141, p. 329.
13. Investigations on Magne-Crystallic Action V. Paramagnetic salts of the Rare Earth and the Iron Groups—By K. S. Krishnan and A. Mookherji, *Transactions of the Royal Society of London, A*, vol. 237, pp. 135-159.

*Report on the work of Dr. S. C. Deb, D.Sc., Research Fellow***1. Band Spectra of Certain Sulphides**

In investigations of molecular structure by spectroscopic methods the study of NO molecule has yielded very important results. Other mono-oxides of the nitrogen group of elements have subsequently attracted the attention of various workers. But sulphides remained practically untouched. I took up the problem of a systematic study of the sulphides of this group of elements in absorption as well as in emission. The first molecule studied was AsS. The absorption spectrum obtained is very similar in structure to that of NO and NS. There are two sets of bands, one lying in the range  $\lambda 3500$ - $\lambda 2900$  and the other in the range  $\lambda 2700$ - $\lambda 2400$ . They are found to be similar to the  $\rho$  and the  $\lambda$  bands respectively found in NO and NS molecule, that arise from transitions  ${}^2\pi - {}^2\Sigma$  and  ${}^2\pi - {}^2\Sigma$ . The work with other sulphides is in progress.

**2. Analysis of the Spectra of Higher Ionised States of Iodine Atom**

L. and E. Bloch published sometime back necessary data concerning spectrum of iodine for the visible and quartz regions in different states of ionisation. They have recently supplemented their previous work with spectral data covering the Schumann region, from beyond the quartz region to about  $\lambda 500$ . I have started to analyse these data with a view to classify the lines.

**3. Problems relating to the Upper Atmospheres.**

One of the problems relating to the upper atmospheric phenomena is the cause of the stratification known as E and F layer. The problem is believed to be connected with the distribution of elements in these layers. It is pointed out that the ionisation of the F-layer is somewhat connected with the intensity of the auroral green line of the night skylight (B. Mukerji, *Science & Culture*, Nov. 1937), with the obvious conclusion that the F-layer is intimately connected with the oxygen atoms, the emitters of the green line.

Another important problem relating to the upper atmosphere is its temperature distribution with height. It is believed that the temperature of the upper atmosphere is maintained by absorption of particular solar radiations by particular constituent of the atmosphere. The extreme smallness of pressure at those heights does not allow the hot gas to bring the entire atmosphere in a temperature equilibrium. As a result of this the temperature is found to be different if the observation is made on different constituents. With these ideas as starting point the temperature distribution of the ozone and other layers is being calculated.

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