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FIFTY YEARS AGO—SOME THOUGHTS ON C. V. RAMAN AND *CURRENT SCIENCE*

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THE discovery of the phenomenon now known as the Raman Effect was first announced to the scientific world fifty years ago this week at a lecture entitled "A New Radiation" delivered by Raman at the South Indian Science Association, Bangalore, on Friday, the 16th of March 1928. Some of those present still recall vividly the excitement which Raman was able to convey to the audience. They remember the demonstrations that accompanied the lecture, of fluorescence, of molecular scattering of light by a liquid, and also of the experiment so crucial to the discovery of the Effect: that when the incident light had a blue-violet filter in its path the cone of scattered light was visible even when viewed through a complementary green-yellow filter which should have completely cut off all the normally scattered light. The written up version of the lecture was published in the *Indian J. Phys.* [2, 387 (1927–28)]. It ends with.

> "The line spectrum of the new radiation was first seen on the 28th of February 1928. The observation was given publicity the following day".

The date of publication was 31st March 1928.

Raman, during his career, is never known to have read out a lecture from a manuscript. It is certain that the written version is by no means a verbatim report of the lecture. The paper is clear, concise and restrained, but one can perceive in it the suppressed excitement that a leader must have felt when the persistent efforts of his school, for over seven years, culminated in such a remarkable discovery which opened up new vistas of knowledge. We see this in the "Conclusion".

> "We are obviously only at the fringe of a fascinating new region of experimental research which promises to throw light on diverse problems relating to radiation and wave theory, x-ray optics, atomic and molecular spectra, fluorescence and scattering, thermodynamics and chemistry. It all remains to be worked out".

I must confess that when I agreed to write this article I still believed that Current Science and the South Indian Science Association (where the Raman Effect was first announced) were connected in some way. The same scientists were involved in both organisations and apparently I was not the first to make this mistake. *Current Science* [2, 463 (1934–35)] issued the disclaimer.

> *"Current Science* is not an organ of the South Indian Science Association but an independent all India journal".

I have been delving a bit into the history of this journal which has held its own for the past 45 years in India. The idea of starting the journal first germinated in the minds of some scientists in Bangalore (mostly from the Indian Institute of Science and the Central College). Even in the early stages they seem to have involved Raman (who was then at the Indian Association for the Cultivation of Science in Calcutta).

"The matter was discussed at length with Sir C. V. Raman during one of his visits (1931) to Bangalore from Calcutta" writes a chronicler. Prof. Raman once said that he gave his support to the starting of *Current Science* as he felt that such a scientific journal. covering, diverse fields of knowledge, could help much to consolidate science in India. An

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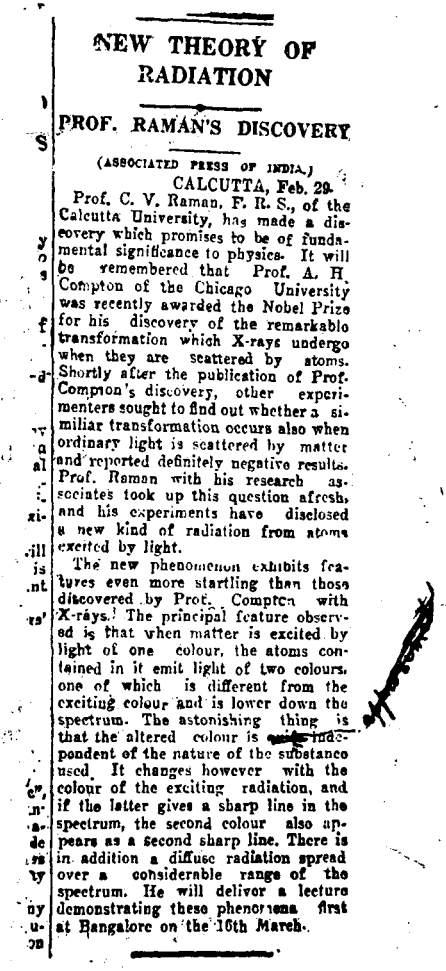

NEW THEORY OF RADIATION

PROF. RAMAN'S DISCOVERY

(ASSOCIATED PRESS OF INDIA.)

CALCUTTA, Feb. 29.

Prof. C. V. Raman, F. R. S., of the Calcutta University, has made a discovery which promises to be of fundamental significance to physics. It will be remembered that Prof. A. H. Compton of the Chicago University was recently awarded the Nobel Prize for his discovery of the remarkable transformation which X-rays undergo when they are scattered by atoms. Shortly after the publication of Prof. Compton's discovery, other experimenters sought to find out whether a similiar transformation occurs also when ordinary light is scattered by matter and reported definitely negative results. Prof. Raman with his research associates took up this question afresh, and his experiments have disclosed a new kind of radiation from atoms excited by light.

The new phenomenon exhibits features even more startling than those discovered by Prof. Compton with X-rays. The principal feature observed is that when matter is excited by light of one colour, the atoms contained in it emit light of two colours, one of which is different from the exciting colour and is lower down the spectrum. The astonishing thing is that the altered colour is quite independent of the nature of the substance used. It changes however with the colour of the exciting radiation, and if the latter gives a sharp line in the spectrum, the second colour also appears as a second sharp line. There is in addition a diffuse radiation spread over a considerable range of the spectrum. He will deliver a lecture demonstrating these phenomena first at Bangalore on the 16th March.

FIG. 1. A photocopy of the first newspaper report of the discovery of the Raman Effect (February 29th, 1928). It is clear that the observations made with the direct vision spectroscope on 28th could not distinguish the differences in the colour (wavelength) of the new radiation emitted by different liquids. Hence the statement "the altered colour is quite independent of the nature of the substance used". The changing of the word "quite" to "approximately" (in ink) is almost certainly in Prof. Raman's handwriting made probably on the 1st or 2nd of March 1928. The lecture to be delivered in Bangalore is referred to.

overwhelming response to a circular letter issued to many Indian scientists by Dr. Martin O. Forster (the Director, Indian Institute of Science), followed by a meeting in January 1932 of a large number of scientists who had come to Bangalore to attend the Indian Science Congress, resulted in the starting of *Current Science*.

> "The journal is run with the editorial cooperation of S. S. Bhatnagar, J. C. Ghosh, C. V. B. Normand (The Director-General of Meteorology), C. V. Raman, K. R. Ramanathan, M. N. Saha, Birbal Sahni and B. Venkatesachar".

The first Secretary was K. S. Varadachari and the first Editor C. R. Narayana Rao. The first issue appeared in July 1932.

I have browsed through many of the early volumes. The first volume contains such interesting material that I thought I would share some of my gleanings with my readers. The very first issue has a short note from Raman's Laboratory from Calcutta. Young Bhagavantam, who was later to succeed Raman as the President of the Current Science Association is the author of a paper entitled "The Raman effect in liquid carbon doxide". A. S. Ganesan later to be editor of *Current Science* from 1958–1973 also has a paper in the first volume "The Raman effect of fused inorganic nitrates".

The first signed article by Raman is a review of Max Planck's "Theory of Light" [1, 147 (1932)]. Three other volumes by Planck were reviewed by M. N. Saha (heat and thermodynamics), S. N. Bose (Electromagnetism) and N. Venkatesachar (mechanics of deformable bodies). It would appear that the senior scientists of those days did have time to read scientific books, write detailed reviews and make appropriate topical comments. For example after reviewing Planck's book, Raman says

> "The fact that the present book is the fourth of a series of five volumes by its

SOUTH INDIAN SCIENCE ASSOCIATION, BANGALORE

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MR. S. SANJEEVA RAO, B.A., A.I.A.SC.
MR. M. SREENIVASAYA, B.A., A.I.A.SC.

8th March 1928.

Dear Prof.Raman,

On behalf of the Managing Committee, permit me to thank you warmly for honouring us by kindly accepting to deliver the Inaugural address to the Eighth Annual of the Association. I am enclosing herewith a typed copy of the programme for your kind perusal. On Friday the 16th March 1928 at 6-15 P.M. the Inaugual address comes off in the Central College, Bangalore.

Yours sincerely,

M Sreenivasaya

Prof.C.V.Raman, F.R.S.,
210, Bow Bazaar Street,
CALCUTTA.

FIG. 2 (*a*). Letter from the Joint Secretary of the South Indian Science Association to Prof. Raman.

SOUTH INDIAN SCEINCE ASSOCIATION, BANGALORE.

EIGHTH ANNUAL SESSION.

FRIDAY - 16th March 1928: -

6 P.M. Welcome Address by the President of the Association.

6-15 P.M. Inaugural Address by Prof.C.V.Raman, F.R.S.,

SUBJECT: -

"A new Radiation".

FIG. 2 (*b*). Copy of the Programme

distinguished author suggests certain reflections on the subject of the teaching of physics in Indian Universities which may not inappropriately find a place here. The astonishing rate of development of physics in recent years has made the adequate teaching of the subject a task of peculiar difficulty. It is quite natural and appropriate that much attention should be paid to the study of modern developments and the most promising students should exhibit enthusiasm for taking up "research" as part of their syllabus of study. At the same time it should be remembered that an edifice of ill-digested knowledge erected on insufficient foundations of preparative study is worse than useless. A broad based knowledge of mechanics, thermodynamics and electromagnetism with an adequate mathematical discipline such as furnished by the published lectures of Prof. Planck, should be compulsory for every advanced student of physics. Only on such a foundation of knowledge can the study of modern developments and the participation in research, possess any real educational and intellectual value".

In later years Raman strongly deplored the depletion of talent from universities. Even in those days he felt that universities must change their attitudes if they are to be a live and creative.

"Sir C. V. Raman defined true scholarship as contrasted from scholasticism. In a trenchant criticism of Indian Universities he pleaded for the abolition of the present scholasticism practised by them and suggested a revolution in our educational outlook wherein the human spirit, intellect and genius would manifest themselves at their highest". (Report of Raman's convocation address to the Bombay University, 16th August 1932); [*Curr. Sci.*, 1, 83 (1932)].

Raman in later life was repelled by the growing idea that science was an institutional enterprise rather than a personal activity. To him science was a creative activity of individuals.

"Speaking about the relations between science and human life he suggested that a false sense of values underlies the common belief that science was justified by its power to create wealth or new comforts or conveniences for humanity. Science was equally capable of furnishing methods for the destruction of wealth and of multiplying human misery and suffering. The true justification of science lay in its success in opening out a new vision of the universe; in giving us an insight into the origin and development of human life, and in fact in its enabling man to perceive himself in his proper relation to the universe he lived in. The progress of the human race would depend on the success attained in applying the method of science to the *study* and the *control* of human activities in all their varieties. Science is creating a new religion and a new philosophy which surely would replace beliefs that were founded not on demonstrable truth but were merely vestiges of man's animal ancestry. [Dacca University Convocation—*Curr. Sci.*, 1, 50 (1932–33)]

Another small note [1, 82 (1932)] says

"A few bronze medallions struck by the South Indian Science Association, Bangalore in commemoration of the Nobel Prize award to Sir C. V. Raman are available from the Secretary at Rs. 2 each", and an announcement, "The Indian Chemical Society conferred its Honorary Fellowship on two eminent scientists A. Sommerfeld and C. V. Raman".

PREFACE.

WE are deeply indebted to Dr. Arnold Berliner for the idea of publishing Special Numbers on the most outstanding scientific discoveries for furthering the aims and objects of *Current Science*. Early in 1936, he suggested to us the necessity and desirability of inviting eminent scientists to contribute articles for the Special Numbers on *Laue Diagrams* and *Canal Rays*. Prof. Max Born to whom our grateful thanks are due, drew up for us a scheme of subjects and authors. Both Dr. Berliner and Prof. Max Born were so deeply interested in the idea that they used their personal influence with their friends for contributions.

The ready and cheerful response to our invitation, we are glad to record, far exceeded our most sanguine expectations and the authors who have contributed articles have laid us under an obligation which we cannot hope to redeem. The general spirit underlying the encouragement given to the undertaking is worthy of the noblest tradition of science. We are greatly thankful to Sir C. V. Raman, Kt., F.R.S., N.L., for exercising general supervision over the preparation of this number and the introduction he has written.

We have received numerous acts of assistance from Messrs. T. S. Subbaraya, N. S. Nagendra Nath, P. Krishnamurti, M. N. Ramaswami, S. Rama Swamy and N. G. Chokkanna to whom we acknowledge our sense of gratefulness.

We hope that this volume will be received by the scientific workers in India and abroad with the same enthusiasm with which we laboured in collecting the material for it. Other numbers on Canal Rays, Genetics and Organisers in Animal Development will be issued shortly and we expect that each of them will be as full and representative as the present number, which we now have the pleasure to offer to scientific readers.

FIG. 3

Current Science in the early days brought out special numbers. Figure 3 shows a photocopy of the Preface of the Special Number on "Laue Diagrams" published in January 1937 (Priced Re. 1–8–0 or 2¼ Sh!), to commemorate Prof. Max von Laue's discovery. Max Born and C. V. Raman actively cooperated in bringing out this issue. The Introduction is by Raman. The other authors are von Laue, W. H. and W. L. Bragg, P. P. Ewald, Manne Siegbahn, Linus Pauling, C. G. Darwin, Hermann Mark, J. A. Prins, S. K. Allison, H. A. Kramers, and S. Ramaswamy!

The obituary of Ronald Ross (who was awarded the 1902 Nobel Prize for Physiology and Medicine) by Col. Stimson IMS makes interesting reading [*Curr. Sci.*, 1, 109, (1932–33)].

> "India with her estimated death rate of one million per annum from this disease (Malaria) is especially indebted to Sir Ronald Ross whom she can proudly claim as her own—for he was born at Almora in the Kumoan hills on the 13th of May 1857, of a family with many associations with this country. He spent 18 years as an officer of the Indian Medical Service and it was in India that he made his great discovery".

In his Presidential Address at the 20th Science Congress, Patna, Dr. L. L. Fermor, Director-General of the Geological Survey of India refers to the starting of *Current Science*.

> "An event of major importance to the development of science in India during the past year was the decision made by a group during the last session of the Indian Science Congress at Bangalore to publish a science journal on the lines of *Nature*".

He also refers to the retirement of Dr. Martin Forster from the Indian Institute of Science and the appointment of Raman as its Director.

"He is to be succeeded by Sir C. V. Raman, your President at the 16th Congress at Madras in 1929. The high quality of Sir Chandrasekhara's work at the Indian Association for the Cultivation of Science in Calcutta and as the Palit Professor of Physics at the University of Calcutta and his inspiring leadership in the development of the school of workers in physics is a happy augury to the application at Bangalore of a further stimulus to scientific research at the southern centre. Calcutta's loss will be Bangalore's gain. At present Calcutta may be regarded as the centre of scientific research in India; but with the transference to Bangalore of one of her leading investigators she will have to guard her laurels".

One reads with interest that the budget of the Indian Institute of Science for scholarships, equipment, and books and periodicals respectively were Rs. 4,700/–, Rs. 22,600/– and Rs. 2,100/– in 1917, and Rs. 53,800/– Rs. 65,100/– and Rs. 16,000/– in 1932 just before Prof. Raman took charge as Director of the Indian Institute of Science.

Prof. K. S. Krishnan is appointed the Mahendralal Sircar Professor at the Indian Association for the Cultivation of Science (a position created by Prof. Raman before his departure from Calcutta). Prof. Krishnan has instituted three prizes to be given to the most successful students of the Dacca University with a view to commemorating the services of S. Ramanujam, C. V. Raman and P. C. Ray in the cause of Mathematics, Physics and Chemistry.

An interesting letter to the editor by Prof. H. Mohanty from the Ravenshaw College, Cuttack appears under the title "Viscosity of Liquids" [*Curr. Sci.*, 1, 314 (1933)].

"The letter by Prof. E. N. da C Andrade in *Nature* (March 1 and April 12, 1930) on the variation of viscosity of liquids with temperature; on the conception of a transitory and fluctuating crystallisation occurring in the body of a liquid, has created a good deal of interest in the subject and the publication of his full theoretical discussion is eagerly awaited. Log $\eta = A + B/T$ is the formula put forward by Andrade. The same formula has been put forward by C. V. Raman in *Nature* (April 12, and May 5, 1923) on the assumption that the liquid state is composite in character, being composed in part of molecules rigidly attached to each other somewhat as in a crystal and may be termed "Crystalline" molecules and in part of molecules which are relatively free and mobile as in the gaseous state and may be termed vapour molecules. Raman not only outlined a physical mechanism of the phenomenon of liquid viscosity but also pointed out the theoretical significance of the constants occurring in the above formula".

A strong editorial condemns the cut in the annual grant to the Indian Association for the Cultivation of Science from Rs. 20,000/– to Rs. 18,000/–.

"We have always thought it is an extremely short sighted policy to curtail subsidies to research institutions in general and in particular to those whose work has earned for India a distinct international position in International Science".

Later that year one reads a plea* for the formation of an Academy of Sciences [*Curr. Sci.*, 1, 335 (1932–33)].

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* These are a few samples of the boldness that existed in scientific journalism and amongst scientists to express views about subjects that do matter–which, alas, seems to have decayed in recent years!

"It is true that individual scientific workers in India have by their indefatiguable industry achieved great distinction for themselves but the prestige of both official and non-official research is still slow in attaining that status of international importance reached by most European countries. This unsatisfactory position is, in our opinion, partly due to the tendency of many scientific men to export their more important contributions for publication in foreign journals with a proportionate impoverishment of Indian archives. Perhaps if the resources of an all India journal, such as we contemplate in connection with the Academy of Science had been available, for giving Indian scientific work suitable international publicity, the outflow of memoirs from this country would have been more restrained and less voluminous. Continuance of this practice will retard the process of building up a scientific tradition for India and keep her in a position of semi dependence in the world of science".

How true and yet it might have been this editorial which provoked the unfortunate formation of two Academies in India !

We leave the first volume and proceed to find that after 10 years, a request has been made to form the *Current Science Association* as a Registered Society; the first signatories of this request are J. C. Ghosh, C. V. Raman, L. Rama Rao, M. Srinivasaya, Birbal Sahni, M. A. Govinda Rao and P. Ramaswamy Ayyar. Raman became the President of the Current Science Association in 1947 which office he held till his death in November 21, 1970.

During these 38 years of his association, Prof. Raman wrote 133 articles, 15 major books reviews and hundreds of short notices for *Current Science*.

It is not my intention to quote from *Current Science* volume by volume—although as in the first volume one could get a great deal of historical information in them. I shall just touch upon a few articles that Raman wrote.

Perhaps the most famous and the most controversial paper he published in *Current Science* was the paper on "A New X-ray Effect". which he published along with P. Nilakantan. [*Curr. Sci.*, 9, 165 (1932-33)]

In his lecture "A New Radiation" referred to earlier he says.—

"If a quantum of radiation can be absorbed in part and scattered in part in the optical region of the spectrum, should not a similar phenomenon occur in X-ray scattering. The type of scattering discovered by Prof. Compton may possibly be one of numerous other types of scattering with modified frequencies, some with a line spectrum and some in the nature of continuous radiation".

Since then Raman was constantly on the look out for this effect. In March 1940, Raman and Nilakantan observed "sharp specular" X-ray reflections in diamond whose intensity was practically independent of temperature. According to Raman and Nilakantan, "a diamond crystal in which the atoms oscillate with any one of its infrared frequencies continues to be a three dimensionally periodic structure in space. Thus for the same reason which enables the crystal planes of a static crystal to give the well known Laue and Bragg reflection of unaltered frequency, the crystal planes of a vibrating crystal should give dynamic reflections with an altered frequency". They were convinced that the dynamic reflection seen around the (111) reciprocal point is due to the 1332 cm^{-1} vibration which corresponds to one face-centred lattice of diamond vibrating against the other and that it was caused by the type of Raman Effect envisaged in the above quotation from

the 1928 paper. They published these results also in *Current Science* and it raised a very heated controversy in the scientific world. In retrospect the explanation given by Raman, however simple and elegant, may be in error. It is however now recognised that the discovery of these temperature independent reflections did provoke the scientific world to examine the question of dynamic reflections in crystals and their origin which resulted in significant advances in this field and that of thermal diffuse scattering.

It is interesting that Raman was led on to the discovery of his effect because of his intuitive belief dating back from 1922 that the "weak fluorescence" that was observed in light scattering in liquids was not due to impurities but was of molecular origin. It must have been this unshakable conviction that made him drive his students and collaborators into purifying and repurifying hundreds of liquids to look for specific characteristics in the scattered light which would distinguish it from the normal molecular scattering or fluorescence due to impurities. However, the same feeling seems to have played him false in the case of diamond. Unable to purify his diamonds, he studied hundreds of diamond plates, unwilling to believe that this "Prince of Solids" could have major impurities in it. Years later it was established that many of the phenomena he and his students discovered arose due to impurities (like nitrogen) in the diamond lattice. It is ironic that the symmetry changes induced by these are similar to those that Raman proposed to explain the observed phenomena and which he believed intrinsic to the carbon atom.

One particularly elegant paper published by Raman in *Current Science* in the field of optics where he was a master, was entitled "The Phenomena of Conical Refraction" [*Curr. Sci.*, 11, 44 (1942)]. One of his students (T. M. K. Nedungadi) had prepared a crystal of naphthalene (1 cm × 1 cm × 0·5 cm) by the Bridgeman technique for studying its Raman spectrum [*Curr. Sci.*, 11, 226, (1942)]. Raman used this crystal to expound some of the wave optical properties of conical refraction.

> "Several years ago I noticed and described a remarkable optical effect [*Nature*, 107, 742 (1921); *Phil. Mag.*, 43, 510 (1922)] associated with conical refraction which is observed when a small luminous object faces a parallel plate of aragonite suitably orientated and held a little distance from it..... The same effect is shown in a much more striking way in a naphthalene block. .....The effect is illustrated by Fig. 4 (*c*) which is a human profile scratched with a needle on a plate covered by black varnish and placed in front of the naphthalene plate while Fig. 4 (*d*) reproduces the image of the same received on a photographic plate placed behind the crystal. It will be noticed that features of the profile are recognisable in this image".

One sees from the figure that Raman's research assistant (V. S. Rajagopalan) scratched a profile clearly resembling that of Raman on the glass plate for these experiments, although Raman for a long time refused to accept that it was his profile!

Another gem is on "The Nature of the Liquid State" [*Curr. Sci.*, 11, 303 (1942)] where Raman describes the use by his group of the adiabatic piezo-optic coefficients to calculate the intensity of scattering. It also presents the elegant piece of work done at Bangalore of the measurement of the hypersonic velocities in viscous liquids using Brillouin scattering which resulted in establishing that viscous liquids behave almost like rigid solids at those high frequencies.

> "Einstein considered density fluctuations to be static and isothermal, while in the theory of Brillouin they are con-

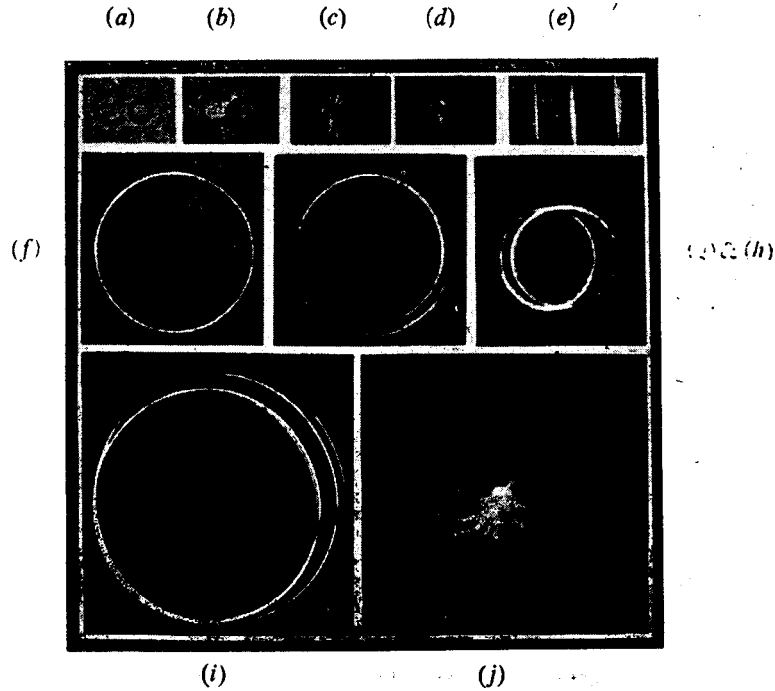

FIG. 4. A plate from the paper by Prof. Raman on **Conical Refraction.** (*Current Science,* February 1942).

sidered as dynamic stratifications or sound waves, and therefore adiabatic in character. The assumption that the fluctuations of refractive index arising from density fluctuations are connected with them by the well known Lorenz formula is neither necessary nor justifiable. The adiabatic piezo-optic coefficient of several common liquids has been recently determined at Bangalore by the present writer and K. Venkataraman. Using these coefficients, and assuming the density fluctuations to be adiabatic in character, Sunanda Bai has recalculated the intensity of light scattering given by the thermodynamic theory and compared it with her own observations. . . . . The observed intensities are found to support the adiabatic hypothesis. It must not however be concluded from this approximate agreement that the thermodynamic theory of light scattering is either correct or complete."

"Further striking confirmation of these ideas is furnished by Venkateswaran's measurements of the hypersonic velocities in viscous liquids for the special displacements in the Fabry Perot patterns. For ordinary or mobile liquids, the hypersonic velocity comes out practically the same as the ordinary ultrasonic velocity observed at much lower frequencies, but in the highly viscous liquids, glycerine and castor oil, there is a marked difference between the two velocities and it is noticed that this difference falls off with rising tempera-

ture. A very satisfactory explanation of these facts is furnished by the consideration that for sufficiently high frequencies of vibration a viscous liquid may for all intents and purposes be regarded as an amorphous solid and the hypersonic velocity should therefore depend on both its compressibility and the rigidity coefficient".

For almost seven years (1941–1948) Raman was deeply interested in diamond and its properties. His popular lectures on diamonds were famous. An article is *Current Science* reveals why he felt the study of diamond was important [11, 261 (1942–43)].

"It exhibits in a characteristically striking fashion many phenomena which are scarcely noticeable with other solids in ordinary circumstances. As an instance we may recall the variation of specific heat with temperature. This was known as an experimental fact in the case of diamond for at least fifty years before it was recognised as a universal property of the solid state. The data for diamond published by Weber in 1875 formed the basis of Einstein's epoch making paper of 1907 introducing the quantum theory of specific heats. History has a way of repeating itself, and the study of diamond should therefore appeal strongly to the experimenter seeking new avenues of research and to the theorist seeking new and fruitful lines of physical thought concerning the solid state".

Later his travails at getting at diamond specimens are related.

"I have since the year 1930, been deeply interested in physical investigation on the diamond. The difficulty of obtaining the material in a form suitable for exact studies has however, been a serious obstacle to progress. Indeed in the early days, I was reduced to the expedient of borrowing diamond rings from wealthy friends who, though willing to oblige, were slightly apprehensive about the fate of their property".

His excitement and joy on seeing the beauty of natural diamonds :

"Personal observation, however, is necessary to enable one to appreciate the remarkable beauty of these diamonds in their natural condition. With their exquisite geometric form and their smooth lustrous faces, they look absolutely fresh from nature's crucibles though actually taken from sedimentary formation which according to the geologists, are a thousand million years old. The strongly marked curvature of the faces and smoothly rounded edges of the octahedral forms are a surprising feature of these crystals. It is clear however from the symmetry of shape, the smoothness of the faces and the fact that forms more complex than the octahedron are represented by sharp edges, that the diamonds as we now see them are exactly in the same state as when they were first formed".

The following illustrates how Raman used to put forward sweeping tentative hypotheses which proved the starting point for many major investigation in his laboratory. In the present example the tentative theory related below sparked of the series of investigations on the surface energies and the cleavage properties of diamond which were quoted in the literature for sometime.

"I wish to put forward tentatively a suggestion which seems to me to offer a reasonable interpretation of the facts stated above. If carbon liquefied under suitable conditions of temperature and pressure when surrounded by molten silicious material, the form of the drops of the liquid diamond would be determined by the interfacial tension and be spherical, provided the valence

bonds between the atoms of carbon in the liquid were oriented completely at random. If, however, some regularity in the orientation of the valence bonds could be assumed, the condition within the liquid would roughly approximate to those in the solid crystal; in other words diamond in the molten state would be a *liquid crystal*. The interfacial tension would vary with direction and the surface of minimum energy would not be spherical but would tend to show some resemblance to forms exhibited by a cubic crystal. If the shapes assumed in the liquid crystalline state persisted on solidification or else suffered only minor changes we would have an explanation of the forms now observed".

Raman had a great admiration for Rutherford as a man and as a scientist. I remember that at one annual meeting of the Indian Academy of Sciences he broke down with emotion when he referred to Rutherford and his qualities. Hence the following extract from his review of Eve's biography of Rutherford [*Curr. Sci.*, 1, 474 (1940)] is of some interest.

"The writer of this review well remembers his meeting Rutherford at the Cavendish Laboratory on the occasion of his first visit to England in 1921 and again on various occasions in 1924 and in 1929. He takes the opportunity of referring with pleasure and gratitude to the generous and friendly spirit manifested by Rutherford in his contacts with the writer. Many of Rutherford's letters to his friends were in his well-known characteristic hand-writing. It was the magnificent personality of Rutherford and his readiness to help the cause of science in every way, quite as much as the greatness of his own scientific work, which evoked the enthusiastic admiration in his colleagues and made him the towering figure he was in the world of science. The story of Rutherford's life and career cannot fail to be an inspiration to all students of science".