SRINIVASA RAMANUJAN—A BIOGRAPHICAL SKETCH AND A GLIMPSE OF HIS WORK

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WHAT makes one a great mathematician? Usually a mathematician has a certain training in his background starting from his school education and going up to the university. A mathematician normally has been trained in the art of thinking mathematically, in using certain symbolisms to keep track of his thinking and finally in the use of correct logic to go from hypothesis and observation to conclusion. It is probably at the Ph.D. level he gets an opportunity and necessity to explore uncharted territories. His training includes not only a close contact with some books and original papers that have been written but also a close contact with mathematicians who are themselves established researchers or who have covered the territory before.

Among all these trained mathematicians some turn out to be great because the work they do, either at the Ph.D. level or most probably after, becomes significant — in the sense that other mathematicians find it useful to apply in their own researches or they find that what they have been looking for, all these years has now been attacked by the new researcher and a breakthrough has been made. In exceptional cases, the new mathematician not only breaks new ground but creates a whole-new field of study; he is prolific in his writing, and throws open vast vistas of knowledge on which whole generations of mathematicians can work and mathematics itself changes its character. To name only a few of these exceptional mathematicians whose names have gone down in history in the past two and a half centuries, we have Euler, Galois, Gauss, Weierstrass, Riemann, Cantor, Poincare, Hilbert, Banach, Von Neumann, Polya, Chevalley, Grothendieck, Laurent, Schwarz and Harischandra. These and others of their kind have created what mathematics is today.

Among all this great line of exceptional mathematicians, there have been three truly great Algorists. An algorist is a mathematician who is known for his manipulative ability in a jungle-like algebra of symbols. For him the solution of problems of unusual kinds comes very naturally. He can devise ingenious tricks like the replacement of one or more of the variables in an equation by functions of other variables and thus while apparently complicating the problem actually can throw light on difficult situations which have defied superb intellects of the past. He can manipulate formulae involving infinite processes without being constrained by the puristic need to pay attention to rigour, convergence and mathematical existence and through his extraordinary intuition can arrive most often at the right formulae. Even when he errs the resulting formula is so elegant that his successor mathematicians spend all their time in perfecting or salvaging that beautiful false result of his. He has an unexplainable faith in his own intuition. Ramanujan was one such mathematician. The other two algorists were Leonard Euler (1707–1783) and Carl Gustav Jacobi (1804–1851). But these two had the advantage of a complete university education behind them and unlike Ramanujan they went through the trodden path of academics to acquire their reputation. But Ramanujan did not have this good fortune of a formal university training. He became a mathematician before anybody could think of training him. It is well that he was not trained early because it is debatable whether he could have been so prolific if he had been trained to watch every mathematical step of his. One may say that he was 'uneducated' — if I may be permitted to use that word — compared to an Euler or a Jacobi or for that matter any mathematician in the world. Ramanujan was a self-taught genius. He could disperse with all the technical elaborations of the 18th and 19th century mathematics and still have much to say which continues to occupy the attention of several mathematicians in the world. His dramatic rise to world recognition and his very short career of formalized activity in the then-best of the universities of the world constitute a thrilling success story, so far as the world of mathematics and the pride of India are concerned. However, but for a succession of a few accidents which can be named, the world might have missed him altogether.

Born in 1887, Ramanujan was brought up in an orthodox traditional South Indian environment. He was an enigma to his teachers even at school because of his prodigious memory and unusual mathematical talent which began to show even before he was ten. That was the age when he topped the whole district at the primary examination and this procured him a half fee concession at school, namely Town High School, Kumbakonam. At the age of 12 he borrowed Loney's Trigonometry, Part II, from a student of the B.A. class who was his neighbour. That student was amazed to find that this young boy, about 7 to 8 years his junior, had not only finished mastering the book at one reading but he had taught himself to do every problem in it. This book though called Trigonometry, has some of the advanced topics of mathematics in it. The treatment of these subjects, is weak but the results belong to that part of mathematics called Analysis — which deals with continuous processess and expressions which grow in numerical values boundlessly. Topics such as the exponential function, logarithm of a complex variable, hyperbolic functions, infinite products and infinite series expansions of trigonometric functions are dealt with in the book. This book was Ramanujan's first contact with these advanced topics. It is an irony of fate that a better and modern treatment of these areas was not available to Ramanujan. Whittaker's modern analysis (1902) had just arrived but had not reached up to Ramanujan's environment. Bromwich's Infinite Series, Carslaw's Fourier Series and Integrals Pierpoint's theory of Functions of a Real Variable and Gibson's Calculus (1901) were just being written. If Ramanujan had had any one of these books at that age when he was gulping Loney's Trigonometry and Carr's Synopsis, would it not have made a difference in the mathematical style of Ramanujan? Perhaps. Mathematicians are divided on the answer to this question. There have not been enough geniuses in the world, on whom you can perform controlled experiments in order to answer such questions decisively!

I just mentioned Carr's Synopsis. It was this book, called 'A Synopsis of elementary results in pure mathematics' that created an imperishable record for itself in history, by passing through the hands of Ramanujan in his early teens. Ramanujan was captivated by its contents. It brought forth all his powers, not because it was a great book, but because it was just a compilation of about 6000 theorems with very sketchy proofs, if at all. The challenge to Ramanujan was irresistible and he started working out the proofs of results there in his own way out of his own thinking. Not only could he supply proofs to innumerable results there but he proceeded further to improve them and create his own theorems and results. He began writing theorem after theorem on the pages of Quarto notebooks which are today collectively called 'Ramanujan's Note-Books'.

He passed the Matriculation Examination of the Madras University in December 1903, secured a first class, and earned for himself the Subramaniam Scholarship in the FA (First Examination in Arts) class at Government College, Kumbakonam. His subjects were English, Mathematics, Physiology, Roman and Greek History and Sanskrit. But Mathematics absorbed all his time and energy and he duly failed in the annual examination because of poor marks in the subjects other than mathematics and thus lost his scholarship. He left Kumbakonam, got himself lost somewhere in Andhra region, came back to Government College, Kumbakonam after a year but could not get the necessary attendance certificate in December 1905 for the examination and thus was lost to Kumbakonam College for ever.

Later he completed the second year FA at Pachaiyappa's College, Madras and sat for the examination in December 1907. Again he failed for the same reason as before.

Prof. S. R. Ranganathan, the first Librarian of the University of Madras and a mathematician himself, calls the period 1907–11 the first period of super-activity in the life of Ramanujan, and writes: 'Inner light began to lead him. The urge for the pursuit of mathematics became irrepressible. The depression due to failure in the FA Examination could not repress it. Failue to get employed could not shake it. Poverty and penury could not obstruct it. His research marched on undeterred by environmental factors—physical, personal, economic or social. Magic squares, continued fractions, hypergeometric series, properties of numbers—prime as well as composite—partition of numbers, elliptic integrals and several other such regions of mathematics engaged his thought'. He had to do all this by discovering them de novo, because his immediate neighbourhood contained no person or book knowledgeable in these areas. He recorded his results in his notebooks. Proofs were often absent. The profundity of contents of these notebooks as they are being analysed today reveals more and more staggering complexities. Intuition played a large part in these researches. There are three such notebooks in all containing 212, 352 and 33 pages respectively. Exact fascimiles of these notebooks have now, since 1957, been published in two volumes by the co-operative effort of the University of Madras, the Tata Institute of Fundamental Research and Sir Dorabji Tata Trust.

It was during this period at the age of 22 that Ramanujan was married to Srimathi Janaki, then 9 years old. In 1910 Ramanujan heard of the Indian Mathematical Society which had been founded just three years earlier by Prof. V. Ramaswamy Iyer, a Deputy Collector by profession. Ramanujan ran to him at Tirukkovilur for help. To Ramaswamy Iyer goes the credit of being the first among the chain of discoverers of the genius that was Ramanujan. With his introduction Ramanujan went to Prof. Seshu Iyer and the latter put him on to Dewan Bahadur R. Ramachandra Rao, Collector of Nellore District. This historic meeting that took place in December 1910 between the genius and his patron, should be described in Ramachandra Rao's own words: 'Suspending judgement I asked him to come over again and he did. And then he had gauged my ignorance and showed me some of his simpler results. These transcended existing books and I had no doubt that he was a remarkable man. Then step by step he led me to elliptic integrals and hypergeometic series and at last his theory of divergent series not yet announced to the world converted me', Ramachandra Rao undertook to pay Ramanujan's expenses for a time. After a few months, being unwilling to be supported by any one for any length of time, Ramanujan accepted a clerk's appointment in the office of the Madras Port Trust. But mathematical work did not slacken. His earliest contribution to the *Journal of the Indian Mathematical Society* appeared in 1911. By this time, the Chairman of the Madras Port Trust, Sir Francies Spring, also took interest in him. The clerk in the Madras Port Trust office had become the subject of talk in the academic circles of Madras. Several attempts were made to get for him a regular scholarship from the University of Madras. Mr. R. Ramchandra Rao, Prof. C. S. T. Griffith of the Madras Engineering College, Prof. M. G. M. Hill, University College, London to whom some of Ramanujan's results had been communicated, Dr Gilbert Walker, a senior Wrangler and then head of the Indian Meteorological Department, Prof. B. Hanumantha Rao, Chairman of Board of Studies of the University of Madras, and Justice P. R. Sundram Iyer— all had a role to play in the succession of events that finally brought Ramanujan to the University of Madras as a Research Scholar on 1 May, 1913 at the age of 26 on a stipend of Rs.75/- per month.

Ramanujan thus became a professional mathematician and remained as such for the rest of his short life. He was now above want and had the academic setting to work on his mathematics. Upon the suggestion of Prof. Seshu Iyer and others Ramanujan began a correspondence with Prof. G. H. Hardy, then Fellow of Trinity College, Cambridge. His first historic letter to Prof. Hardy in January 1913, contained an attachment of 120 theorems, all originally discovered by him. Prof. Hardy's first reaction was to dismiss the letter. But later in the evening he and Prof. Littlewood spent two to three hours on the results in the letter. Several of the results completely floored the two experts. Even assuming that some of them were wrong they could not think of any other explanation but that here was a serious mathematical mind, though uninformed. They decided that the author was not a crack but a genius. History was made in that decision. They decided to encourage Ramanujan. Their efforts to bring him to England finally materialized in March 1914.

Ramanujan spent four very fruitful years at Cambridge, fruitful certainly to him, but more so to the world of Mathematics. Hardy records that the time he spent with Ramanujan from 1914 to 1918 was one of the 'most decisive events' of his life — Hardy's life. Later when Ramanujan died at the unexpected age of 32, Hardy in trying to assess Ramanujan's mathematical work before he arrived in England, finds it difficult to conclude whether Ramanujan had been aware of the mathematics contained in such and such well-known books. Hardy regrets that he could have easily asked Ramanujan these biographical questions in a straight-forward manner and 'Ramanujan would have answered them frankly'. But says Hardy, that was not to be. Hardy thought it ridiculous at the time to keep asking whether he had seen this book or that while 'he was showing me half a dozen or more new theorems each day': Such was the prolific nature of Ramanujan's creativity. Prof. Hardy did try to 'teach Ramanujan some of the existing mathematics which 'he ought to know', but Hardy was always in doubt whether by 'teaching' Ramanujan he was doing the right thing or not to the genius in him. This period of Ramanujan has been well chronicled and suffice it to say that out of this superactivity, Ramanujan published 27 papers, seven of them jointly with Hardy. In 1918 he was elected Fellow of the Royal Society and in the same year was also elected Fellow of Trinity College both these honours coming as a first to any Indian. The University of Madras rose to the occasion and made a permanent provision for Ramanujan by granting him an unconditional allowance of 250 pounds a year for five years from 1 April, 1919, the date of expiry of the overseas scholarship that he was then drawing. The University was also to be moved, by Prof. Littlehailes, the new Director of Public Instruction, who had just returned from the Bombay Conference of the Indian Mathematical Society, where Ramanujan's achievements had just been hailed by the Society, for the creation of a University Professorship of Mathematics and Ramanujan to be offered that Professorship, but alas, Fate decided otherwise.

The fifth year of Ramanujan in England had unfortunately to be spent in nursing homes and Sanatoria. He returned to India in April 1919 and continued to suffer his incurable illness. All the time his mind was totally absorbed in his Mathematics. Thus arose the so-called 'Lost Note-book' of Ramanujan, which has been discovered in the last decade. It contains 100 pages of writing and has in it a treasure-house of about 600 fascinating results. Prof. G.E. Andrews of Pennsylvania State University has started writing a series of papers editing this Lost Note-book of Ramanujan. Ramanujan's discoveries and flights of intuition contained in the four note books and in his 32 published papers as well as in the three Quarterly Reports which he submitted to the University of Madras in 1913–14, have thrilled mathematicians the world over. More than 200 research papers have been published in the world as a result of his discoveries. We shall therefore end this account of Ramanujan by attempting to record some glimpses of his mathematical achievements, even though in a laymanish and sketchy manner.

A partition of an integer N is a finite sequence a, b, c, d,...r of positive integers, called 'parts' of the partition, such that

$$a+b+c+\ldots+r = N.$$

For example, 4, 3, 3, 2, is a partition of 12. We write the partition as 4332 without even the commas separating the integers. 522111 is another partition of 12. Note that we always write a partition in such a way that as we read it, the parts do not increase. How many partitions are there of a given integer n?

The answer is $p(n)$ in standard terminology.

$p(1) = 1$

$p(2) = 2$, for 2 and 11 are the partitions of 2.

$p(3) = 3$, for 3, and 21, and 111 are the partitions of 3.

$p(4) = 5$, for 4, 31, 22, 211 and 1111 are the partitions of 4.

And so on. $p(5) = 7$; $p(6) = 11$; $p(10) = 42$; $p(20) = 627$ and $p(200) = 3972999029388$. Thus $p(n)$ becomes very large very rapidly.

Very little is known about the arithmetical properties of $p(n)$. Even questions like whether $p(n)$ is odd or even, for a given n, is difficult to answer. Ramanujan was the earliest mathematician to enquire into such properties. Ramanujan observed properties like the following: Whatever integer n might be, $p(5n+4)$ is divisible by 5; $p(7n+5)$ is divisible by 7 and similar ones. In connection with these properties, Ramanujan proved a number of identities, one of which is:

$$p(4)+p(9)x+p(14)x^2+\ldots\ldots = \frac{5\{(1-x^5)(1-x^{10})(1-x^{15})\ldots\}^5}{\{(1-x)(1-x^2)(1-x^3)\ldots\}^6}$$

This result has been considered to be representative of the best of Ramanujan's work by Hardy. Hardy says: 'If I had to select one formula for all Ramanujan's work, I would agree with Major Macmahon in selecting the above'.

The practical evaluation of $p(n)$ was, till the time of Ramanujan, done by a formula which goes back to the Euler-Jacobi tradition but was applicable to only small values of n. In 1918 Hardy and Ramanujan published a joint paper (40 pages) in the *Proceedings of the London Mathematical Society* on an exact formula for $p(n)$. It is very complicated to write for a lay audience. It is considered as a crowning achievement in the theory of partitions. The astonishing part of the discovery and establishment of this theorem is that, we can say, on the authority of the collaborator Prof. Hardy himself, we would be nowhere near the final theorem as it is known today but for Ramanujan's unusual intuition and stroke of insight, at two stages of breakthrough in the evolution of the theorem.

Dr P. C. Mahalanobis, who later in free India became Nehru's right-hand man for National Planning, was a student at Cambridge when Ramanujan joined it. As a senior student Mahalanobis used to visit Ramanujan. One day Ramanujan invited him for lunch in his room and Mahalanobis arrived when Ramanujan was still busy at the cooking. Mahalanobis pulled a chair, sat near where Ramanujan was cooking and began reading the Strand Magazine. The latter contained a Problem in its puzzle section and it attracted Mahalanobis. It related to two officers who were billetted in Paris in two houses in the same street. The door numbers, the problem went on, were related by a mathematical expression and the problem was to find the door numbers. Mahalanobis could easily solve the problem in a few minutes by trial and error and he wanted to share his excitement with Ramanujan. So Mahalanobis says, while Ramanujan was still stirring the pan, 'Ramanujan, here is a problem for you'. Ramanujan says, 'Tell me the problem'. Mahalanobis describes the problem and no sooner than he has finished describing it, Ramanujan while still stirring the pan, says: 'Take down the solution'. And Ramanujan dictates a Continued Fraction.

Here the reader must know what a continued fraction is. A simple infinite continued fraction, for example, is:

$$1+\cfrac{1}{2+\cfrac{1}{3+\cfrac{1}{4+\cfrac{1}{5+\ldots\ldots}}}}$$

If you truncate it at each step, you get what are called the successive convergents of the continued fraction: thus

$$\frac{1}{1}, \; 1+\frac{1}{2}=\frac{3}{2},$$

$$1+\cfrac{1}{2+\cfrac{1}{3}} = 1+\frac{3}{7}=\frac{10}{7}$$

$$1+\cfrac{1}{2+\cfrac{1}{3+\cfrac{1}{4}}} = 1+\cfrac{1}{2+\cfrac{4}{13}}$$

$$= 1+\frac{13}{30}=\frac{43}{30}$$

and so on. Now to understand Ramanujan's flash of an answer to the problem in Strand Magazine, though we do not have the exact problem which was the subject of conversation between Mahalanobis and Ramanujan, let us concoct a simplified version of it, for the lay reader to understand it. The problem is to find the door numbers of the two houses, call these numbers x and y, such that a mathematical relation, say,

$x^2 - 10y^2 = +1$ or -1.

is satisfied, Mahalanobis tries it, and comes out with the answer $x = 3$ and $y = 1$ in no time. Now Ramanujan, as soon as he hears the statement of the problem, dictates the following continued fraction:

$$3+\cfrac{1}{6+\cfrac{1}{6+\cfrac{1}{6+\cfrac{1}{6+\cfrac{1}{6+\ldots}}}}}$$

3/1 is the first convergent of this continued fraction and 3 and 1 are the first answers to x and y which Mahalanobis has himself first discovered by trial and error. Now Ramanujan's continued fraction answer not only gives this first elementary answer but gives an infinity of answers on the assumption that the street has an infinite number of houses in it. Thus the second convergent, $3+(1/6) = 19/6$ gives the pair, 19 and 6 for x and y, which can be verified to be true: for $19^2 - 10\times 6^2 = 361 - 360 = 1$. The third convergent,

$$3+\cfrac{1}{6+\cfrac{1}{6}} = 3+\frac{6}{37} = 117/37$$

gives the answer $x = 117$ and $y = 37$ which also satisfies the relation required. The fourth convergent can be found to be 721/228 and this pair $x = 721$ and $y = 228$ can also be verified to satisfy the relation. And so on it goes. The greatness of Ramanujan was that as soon as he heard the statement of the problem, without effort he decided that the answer could be given in the form of a continued fraction and immediately gave the continued fraction, which not only solves the problem but gives an infinity of solutions to it:

In the 120 theorems that he sent to Hardy, in his first letter from India, Ramanujan claimed as one of his theorems that the number of primes less than x is

$$\int_c^x \frac{dt}{\log t} - \frac{1}{2}\int_c^{\sqrt{x}} \frac{dt}{\log t} - \frac{1}{3}\int_c^{\sqrt[3]{x}} \frac{dt}{\log t}$$

$$-\frac{1}{5}\int_c^{\sqrt[5]{x}} \frac{dt}{\log t} + \frac{1}{6}\int_c^{\sqrt[6]{x}} \frac{dt}{\log t} - \ldots,$$

where $c = 1.4513\ 6380$ nearly.

Ramanujan, of course, had not merely guessed his theorems such as this. No flight of imagination could rise to such heights and to such precision. Actually the above result of Ramanujan is false, as shown elaborately by Hardy in his 'Lectures on Subjects suggested by the life and work of Ramanujan'. However, the very fact that Ramanujan discovered the above series, better known to Mathematicians as Riemann's series, all by himself is a stroke of genius and 'a very astonishing performance'. The error in Ramanujan's statement involves subtleties of Complex Function Theory, a nineteenth century development in the mainstream of Mathematics, of which he was not aware until Hardy ventured to teach him. The question about prime numbers that Ramanujan seeks to answer in the above theorem is one of the most fascinating in all of Mathematics and the very fact that Ramanujan, as a mere untutored explorer could rise to the heights of the maturity of Riemann, is Intuition Par Excellence!

Next we shall refer to Entry 29 of Chapter III of Ramanujan's Second Note Book. It is actually an entry cancelled by Ramanujan himself, and there lies the interest in this story. The entry reads as follows:

$$\frac{1}{(1-x^2)(1-x^3)(1-x^5)(1-x^7)(1-x^{11})}$$
$$\frac{1}{(1-x^{13})\ldots} = 1+\frac{x^2}{1-x}+\frac{x^{2+3}}{(1-x)(1-x^2)}$$
$$+\frac{x^{2+3+5}}{(1-x)(1-x^2)(1-x^3)}+$$
$$\frac{x^{2+3+5+7}}{(1-x)(1-x^2)(1-x^3)(1-x^4)}+\ldots.$$

Let us explain the genius of Ramanujan in cancelling this entry. Suppose both the expressions above are expanded in powers of x. We may have:

$$1 + c_2x^2 + c_3x^3 + c_4x^4 + \ldots =$$

$$1 + d_2x^2 + d_3x^3 + d_4x^4 + \ldots$$

One can calculate c_2 and d_2 and see that they are equal. Similarly $c_3 = d_3$; $c_4 = d_4$ and so on. A natural temptation is to generalize and question whether $c_n = d_n$ for every integer n. At this point it is necessary to digress and warn the non-mathematical reader on a culture that is unique to a mathematical mind and discipline. Consider the following statement:

(*): n is not divisible by both 2^8 and 5^8.

This statement (*) is true for all numbers $n = 1,2,3,4,\ldots\ldots.$ up to $n = 99,999,999$. For experimental scientists a rule which is valid for such a large number of cases, is valid for 'all practical purposes' as a general rule. But, for a mathematician, (*) is not true for all n; for it fails for $n = 10^8$ and all multiples of 10^8.

Thus, when Ramanujan wrote the above formula he immediately struck it off as not true, because surprisingly, though

$c_n = d_n$ for $n = 1,2,3, \ldots 20$

it happens that

$c_{21} = 30$; $d_{21} = 31$ and so $c_{21} \neq d_{21}$; ..

So the two sides of the formula are not qual! But then why did he write it all, in the first place? My only guess is that he did not work out his formulae on a separate sheet of paper and then transfer them to his note-book for then he would not have started writing the formula at all. As he wrote it thinking it is true, he must have had his own methods of verifying the truth mentally and by the time he finished writing it, he must have realized the falsity of the formula and he must have struck it off!

Incidentally even this entry has generated much research. Two sequences $\{c_n\}$ and $\{d_n\}$ are said to be a 'Ramanujan pair' nowadays if $\{c_n\}$ takes the place of 2,3,5,7,11,... on the Left-Hand side of the above formula and (d_n) takes the place of 2,3,5,7,11, ... on the Right-Hand side and the two sides are equal. As of today, it has been proved that there are on the whole only 10 Ramanujan pairs out of a theoretical possibility of an infinite number of pairs. This rarity of Ramanujan pairs shows how Entry 29 almost tantalized Ramanujan to write it and then cancel it in no time.

Such was Ramanujan and such was his genius. One may ask: In what sense his mathematics is relevant? Shall one reply that R. J. Baxter of the Australian National University has found that some of Ramanujan's work was exactly what he needed to solve the hard hexagon model in statistical mechanics? Or shall one quote Carlos Moreno of the City University of New York that Ramanujan's work in the area of modular forms is exactly what physicists need when they work on the 26–dimensional mathematical models of string theory? No. The question about relevance is irrelevent, as far as an assessment of Ramanujan's work is concerned. Ramanujan is great not because his work can also be used in modern technology but because his ideas and innovative genius have not been surpassed ever before or even 100 years after him. William Gosper of Symbolics Inc. while recently devising a new computer algorithm to calculate π for 17.5 million digits finds that his best ideas had already been discovered by Ramanujan. We shall only quote B.C. Berndt who has just completed editing and analysing the 21 chapters of Ramanujan's second note-book — Part I of Berndt's analysis was published by Springer Verlag in 1985 — and this will give the layman a quick glimpse of the phenomenon that was Ramanujan. Berndt writes:

'Paul Erdos has passed on to us Hardy's personal ratings of mathematicians. Suppose that we rate mathematicians on the basis of pure talent on a scale from 0 to 100. Hardy gave himself a score of 25, Littlewood 30, Hilbert 80 and Ramanujan 100.'

Ramanujan's birth, his super-activity in Madras and Cambridge, his glorious rise and his unfortunate death — all seem to have happened in a flash. He came and went like a meteor. We may be tempted to ask: When comes such another? Instead of waiting for the impossible to happen, each one of us may, in the year of his birth centenary, do some thing befitting his memory. As a teacher, one may decide to encourage talent, even when we recognize an iota of it somewhere. As a public citizen we may decide to improve our own mathematical literacy. As a philanthropist one may decide to institute funds for financial aid to the needy talented students. As a media man we may decide to go all out to popularize Ramanujan, mathematics and science. There is a responsibility for each one of us to keep the memory of Ramanujan as a living inspiration to posterity. May we all rise to the occasion!

ANNOUNCEMENT

3RD INTERNATIONAL CONFERENCE ON MOLTEN SLAGS AND FLUXES

The Ironmaking and Steelmaking Committee of The Institute of Metals, in collaboration with seven other co-sponsors, are organising the '3rd International Conference on Molten Slags and Fluxes', to be held at the University of Strathclyde, Glasgow, from 27 to 29 June 1988.

By providing a forum for scientists and technologists concerned with the nature and properties of molten slags, glasses, magmas and associated fluxes generally classified as polymeric melts, and their use in high temperature technology, the Conference will promote cross-fertilization between the different sectors dealing with polymeric melts and enable delegates to discuss the latest developments in these areas.

Eight technical sessions will cover the following topics: a. Industrial applications; b. Thermo-dynamics; c. Gases in slags; d. Kinetics of slag-metal reactions; e. Optical basicity; f. Structural properties; g. Physical properties; and h. Modelling studies.

Fifty-nine papers from the UK and overseas including Japan, Australia, the USA, Canada, Yugoslavia, Germany, France, Sweden and Czechoslovakia, investigate such areas as reaction between liquid steel and slag during furnace tapping, importance of slags on ladle treatment of steel, the activities of cobalt and copper oxides in silicate and "ferrite" slags, the physical chemistry of reduction of iron from liquid ferrous silicates, alternative methods of measuring optical basicity and constitution of continuous casting fluxes.

In addition to a Civic Reception and Conference Dinner, to be held on the 27th and 28th of June respectively, an Accompanying Persons Programme is also being organized and will include visits to the Glasgow Garden Festival and Loch Lomond.

Further information on the Conference is available from: Ms A. Knibb, Conference Department (MSF), The Institute of Metals, Carlton House Terrace, London SW1Y 5DB.