P. C. Mahalanobis.

PRASANTA CHANDRA MAHALANOBIS

(1893-1972)

Foundation Fellow 1935

MAHALANOBIS ERA IN STATISTICS

THE PROFESSOR, as Prasanta Chandra Mahalanobis was known in India, passed away on 28 June 1972 in a nursing home in South Calcutta three weeks after an abdominal operation. Born on 29 June 1893 he would have completed 79 years on the next day; his last rites were performed on his 79th birthday. At the time of his death he was actively engaged in research, in guiding the work of the Indian Statistical Institute as its Chief Executive, Secretary and Director, and in advising the Government of India on statistical problems as Honorary Statistical Adviser.

In India, statistics was practically unknown in the first quarter of this century. There was no teaching or research in statistics at the Universities, no statistical society and no journal of statistics. Official statistics were collected only as a by-product of the administration. A sudden spurt of statistical activity occurred about 40 years ago, which was to put India, in the course of a few years, in the centre of the statistical map of the world.

The Indian Statistical Institute was founded by Mahalanobis in 1931, with facilities for high level research, training and execution of large-scale project work. *Sankhya*, the Indian Journal of Statistics, was started in 1933. The new technique of estimating acreage and crop yield by random sampling was worked out and applied to jute in Bengal in 1937. The first Indian Statistical Conference was held in 1938. Post-graduate studies in statistics were opened for the first time in India at the Calcutta University in 1941 under the guidance of Mahalanobis. The Indian Science Congress, which had not recognised Statistics as separate discipline for a long time, included it in the section of mathematics in 1942 and created a separate Section for Statistics in 1945. A Central Statistical Unit was established by the Government of India in 1949 with Mahalanobis as Honorary Statistical Adviser to the Cabinet; two years later, the Central Statistical Organisation (CSO) was formed for coordinating all statistical activities of the Government, and soon after, the Department of Statistics was created. Based on the experience gained in Bengal, the National Sample Survey (NSS) was established in 1950 for the collection of socio-economic data through sample surveys covering the entire country, to provide information needed for government policy decisions and for the computation of national income. In 1954, the Prime Minister and the Planning Commission called upon Mahalanobis to initiate studies in planning at the Institute to find ways and means of increasing national income and solving the unemployment problem.

The Indian Statistical Institute was recognised as an institute of national importance and permitted to award degrees in Statistics by a Central Act in 1959.

Training of technicians for statistical quality control started in 1945 at the Indian Statistical Institute. A conference on standardization and quality control was held in 1948, which gave a start to the quality control movement in India. These significant achievements within a short span of time would not have been possible without the indefatigable energy of Mahalanobis.

With his death, the Mahalanobis era in statistics which started in the early twenties ended. Indeed, it will be remembered as the goden period of statistics in India, marked by intensive development of a new technology and its applications for the welfare of mankind.

Early Life and Education

Prasanta Chandra Mahalanobis was born in Calcutta on 29 June 1893 in a well-known family of *Brahmos* (a protestant theist movement within the fold of Hinduism, founded in 1828 by Raja Ram Mohan Roy). He was the eldest of six children, two sons and four daughters. His father, Probodh Chandra was a businessman, and his mother Nirodbashini was a sister of Sir Nilratan Sarkar, the famous physician, educationist and industrialist. Prasanta had his early education in Brahmo Boys' School. Later, he went to the Presidency College and obtained his B.Sc. degree with honours in Physics in 1912. Soon after, he left for Cambridge, U.K. for higher studies, where he took Part I of the Mathematics Tripos in 1914 and Part II of Physics Tripos in 1915. He was awarded a senior scholarship by the King's College, Cambridge; his intention was to work with the famous experimental physicist, C.T.R. Wilson, at the Cavendish Laboratory after spending a short vacation in India. But this did not materialise.

Mahalanobis married Nirmal Kumari on 27th February 1923. Rani, as Nirmal Kumari came to be known to friends of Mahalanobis, was a devoted wife. In the true Indian tradition she took up all the responsibilities of running the household, looked after the continuous stream of guests they had, relieved him of all the worries associated with his busy life, and made his life complete. She was constantly with the Professor throughout his life, and accompanied him on his frequent tours abroad and within the country.

Phenomenal Activity

Mahalanobis was offered a teaching position in the Physics Department of the Presidency College in Calcutta soon after his return from Cambridge. He joined the Indian Educational Service (IES) in 1915, held the post of Professor of Physics and later became Principal, Presidency College, from which he retired in 1948. During his life time he held several distinguished positions, several of them simultaneously. He was the chief executive of the Indian Statistical Institute, Calcutta, continuously since the founding of the Institute in 1931, Honorary Statistical Adviser to the Government of India since 1949; and was associated with the Plan-

ning Commission (1953-67). He also served as a Meteorologist in Calcutta (1922-26), General Secretary of Vishva Bharati (1921-31), the University founded by Rabindranath Tagore, Head of the Department of Statistics of the Calcutta University (1941-45) and Statistical Adviser to the Government of Bengal (1945-48). He was Member of U.N. Statistical Commission since 1946 and its Chairman (1954-58), General Secretary of the Indian Science Congress (1945-48) and Treasurer (1952-55), President of the Indian National Science Academy (1957-58) and Editor of *Sankhya*, the Indian Journal of Statistics, since its founding in 1933.

His work apart, the Professor was in the mainstream of Bengal's social, cultural and intellectual movements. He tried to reform the Brahmo Samaj by arguing against some of its rigid tenets. He wrote a number of literary and Philosophical articles in Bengali and English. He was associated with Rabindranath Tagore and edited the '*Quarterly of Vishva Bharati*'; he was acknowledged as an authority on the literary works of Tagore.

With all these activities, he could spend long hours arguing or discussing with his colleagues giving instructions to engineers and administrators, examining legal matters connected with the ISI, working out programmes for numerous foreign visitors to the ISI, and in between, giving time to his pet cat with whom he appeared to be able to communicate.

He was mentally alert and physically active throughout his life. Even after he was admitted to the nursing home in Calcutta he was constantly thinking of the new statistical tool he was developing, 'Fractile Graphical Analysis', and discussing with the present author some theories he had developed. He baffled the doctors by putting up a valiant battle for three long weeks after an operation before death overtook him.

Contributions to Statistics

While in Cambridge, Mahalanobis accidentally came across *Biometrika*, edited by Karl Pearson, in the King's College Library. He got so interested in the Journal that he bought a complete set of volumes and brought them to India. He soon discovered that statistics was a new discipline capable of wide application. In India, he tried to look for problems where he could apply statistics. Fortunately, he found some extremely interesting ones in Meteorology and Anthropology, and this marked a turning point in his career from a physicist to a statistician.

The Indian Statistical Institute

Genesis—The idea of starting the Indian Statistical Institute was conceived by Professor Mahalanobis and a group of young men who had gathered round him in the twenties (1920-31). There was already a workshop, in what came to be known as the Statistical Laboratory, located in the room of Mahalanobis, then Professor of Physics at the Presidency College, Calcutta. A public meeting, called over the signatures of Pramatha Nath Banerji (Minto Professor of Economics), Nikhil Ranjan Sen (Khaira Professor of Applied Mathematics) and Prasantha Chandra Mahalanobis was held on 17 December 1931, with the late Sir R.N. Mukherji in

the Chair. This meeting adopted a resolution which led to the establishment of the Indian Statistical Institute which was registered on 28 April 1932 as a non-profit distributing learned society under the Societies Registration Act XXI of 1860.

Phenomenal Growth—In the beginning, the Institute was located in the Physics Department of the Presidency College. During the fifties the present premises of the Institute on Barrackpore Trunk Road was built. At the time of the Professor's death, the Institute at Calcutta and its branches at Bangalore, Baroda, Bombay, Delhi, Ernakulam, Giridih, Madras and Trivandrum had a total staff of over 2000, and an annual budget of about twenty million rupees. The phenomenal development of the Institute was mainly due to the individual efforts and imaginative planning by Mahalanobis. Other factors contributing towards his success were the great encouragement and support he received from two men of vision, Jawaharlal Nehru (as Prime Minister) and Chintaman Dwarkanath Deshmukh (as Finance Minister and President of the Indian Statistical Institute), and the band of talented statisticians who gathered around him and who themselves made significant contributions to statistics. Among those who came under the influence of the Professor include such outstanding statisticians as the late S. S. Bose, J. M. Sengupta, R. C. Bose, the late S. N. Roy, K. R. Nair, R. R. Bahadur, G. Kallianpur and D. B. Lahiri.

A significant role in the development of the Institute was played by the late Shri Pitambar Pant. Pant was Secretary to Jawaharlal Nehru during the Independence Movement in India. He was deputed by Nehru to the Institute to learn statistics in 1946. He was associated with the Professor since then and constantly helped him in all negotiations with the government, which often turned out to be delicate and difficult. Although Pant was never an employee of the Institute, he took considerable interest in it and gave much of his valuable time to the Institute's work. He held the honorary positions of Joint Secretary and Vice-President of the Institute, and for a long time directed the activities of the Delhi Branch of the Institute.

Thirties and Forties—The present author was associated with the Professor for over thirty years, having joined the Institute in 1941 as a student in what was called the Training Section of the Institute. As there were no regular courses in statistics anywhere else in India at that time, the Institute attracted talented students from all parts of India. In addition, there were trainees deputed by government organizations and universities to take courses in statistics or to learn specific statistical techniques applicable to their problems. There used to be about ten students in the class and the duration of the training course was one academic year. The teaching was somewhat disorganized. Mahalanobis himself was too busy with the affairs of the Institute and his duties as Professor of Physics, and he never gave any regular lectures. There were others at the Institute (R. C. Bose, S. N. Roy, K. R. Nair, K. Kishen and A. Bhattacharya) doing research work and making fundamental contributions in specific areas of statistics, such as design of experiments and multivariate analysis. They discussed the students' problems in the classes but did not attempt to give any systematic treatment of statistics, as they themselves were engaged in learning the subject. There were two staff members, S. Sengupta and Chameli Bose who had degrees in Statistics from the London University, who

tried to cover the general area of statistics as developed by Karl Pearson. After completing training at the Institute and obtaining the Master's degree in statistics from Calcutta University, the present author was appointed to the staff in 1943.

Working in the Institute was an exciting experience. One had the freedom to pursue one's own ideas, to participate in the projects of the Institute, to accept administrative responsibilities or to devote time to research.

The Institute was engaged in conducting several sample surveys, consumer expenditure, public opinion, forecasts of acreage and yield of crops. Under the leadership of Mahalanobis, much pioneering work was done in the design of sample surveys, organization of field work and tabulation of results, for which the Institute received wide recognition. Some of the mathematicians in the Institute concentrated more on theoretical problems based on the research work initiated by Sir Ronald Fisher and Professor Mahalanobis in field experimentation, anthropometry and meteorology. Significant contributions were made in the areas of multivariate analysis, design of experiments, combinatorial mathematics and estimation by the workers of the Institute.

There was also the training section already referred to, which started in July 1938 where courses were given in theoretical and applied statistics spread over an academic year leading to a 'Certificate of Training.' A scheme of external professional examinations was started in 1938 for the award of the Computer's Certificate and Statistician's Diploma of the Institute on the same lines as the external examinations leading to the Fellowship of the Institute of Actuaries in England.

Fifties and Sixties—There were fresh developments in the fifties and sixties which were to give the Institute its special character. In 1950, the Institute undertook the responsibility of technical direction and tabulation of the National Sample Survey data, which meant considerable expansion in the staff of the Institute at both technical and non-technical levels. A new division of Statistical Quality Control was started in 1953 to provide consultation service to industry and this meant the establishment of a number of branches of the Institute in different parts of India. The Institute's planning units in Calcutta and Delhi were expanded in 1954 to undertake studies in economic planning on behalf of the Government of India. A few years earlier, two research units, one for Sociology and another for Demography, started functioning. The fifties also saw the establishment of an Electronics Division and Workshop for the development of computers.

The Institute was declared as an Institute of national importance and empowered to award degrees by an Act of Parliament in 1959. The Institute immediately introduced undergraduate and post-graduate programmes leading to B.Stat., M.Stat., and Ph.D. degrees. The Institute continued to attract brilliant students. Some of them, D. Basu, G. P. Patil, T. N. Srinivasan, V. S. Varadharajan, K. R. Parthasarathy, R. Ranga Rao, S. R. Vardhan, and D. K. Roychoudhury have achieved international recognition.

Earlier a research unit in Biometry was started with a few workers, which considerably expanded when Prof. and Mrs. J.B.S. Haldane joined the staff of the Institute and branched off into a number of independent units, anthropometry, botany, agriculture, human genetics, embryology and biochemistry. About the same time,

Psychometry (under the leadership of Dr. Edwin Harper) and Linguistic research units were established. At the suggestion of Professor Haldane, Dr. Pamela Robinson of the London University was invited to start a geological research unit. With the introduction of the B. Stat. course, the departments of physics and chemistry were opened. Two research units, one for immuno-chemistry and another for leaf protein work, were established recently.

Thus the I.S.I. as it exists today, is a many-faceted organization. It functions as a university in its educational programmes and degree-awarding activity, as a corporation in undertaking large-scale projects, as a firm of consultants for industry to improve productivity and as a meeting place of scientists, economists and literary figures from all parts of the world.

Visitors are often intrigued to find such diverse and unrelated activities in the I.S.I., some of which may appear to be far removed from statistics, and also a Geological Museum with a rich collection of palaeontological material including dinosaur fossils. But to Prof. Mahalanobis, such diversification was a necessity. Though Statistics has its origin in gambling and demography, it grew in importance as a principal tool in scientific investigations, and statistical methodology has today been applied to the study of many problems.

Mahalanobis Distance

The first opportunity to use statistical methods came to Mahalanobis when N, Annadale (then Director of Zoological Survey of India) asked him, during a chance. meeting at the Nagpur session of the Indian Science Congress in 1920, to analyse the anthropometric measurements taken on Anglo-Indians (of mixed British and Indian parentage) in Calcutta. This study led to Mahalanobis's first scientific paper published in 1922 in the records of the Indian Museum under the title 'Anthropological observations on the Anglo-Indians of Calcutta.' This was a remarkable contribution. Among other things, it established Mahalanobis's skill in applying statistical methods for extracting information from given data and drawing inferences. This study was followed by a number of other investigations, based on anthropometric measurements, which led to the formulation of the statistic, known in statistical literature as '*Mahalanobis Distance*' and widely used in problems of taxonomical classification.

Mahalanobis was not satisfied with just providing a tool for cluster analysis based on a specified set of measurements. His logical mind had led him to raise fundamental issues connected with the application of the D^2 statistic. He argued that inferences drawn on affinities between populations might depend on particular measurements chosen for study, in which case the conclusion would not have the desired practical significance. The configuration may change, and even the order relations between distancees may be disturbed, if one set of measurements is replaced by another. Mahalanobis was, therefore, led to lay down an important axiom for the validity of cluster analysis called dimensional convergence of D^2.

Mahalanobis also pleaded for the standardization of anthropometric measurements so that data obtained by different investigators are comparable. In a paper

published in 1928 in '*Biometrika*,' he examined the anthropometric data available from different sources and showed how a comparative study was not possible because of differences in the definitions of measurements in different investigations. He also emphasized the need for scrutiny of field records and devised systematic methods for detecting recording errors and making adjustments.

Mahalanobis's early work on statistical analysis of anthropometric data and the theoretical problems it raised opened up a rich field of research in multivariate analysis to which several of his colleagues at the Institute have made valuable contributions.

In addition to his duties as Professor of Physics at the Presidency College, Mahalanobis also worked as a Meteorologist in Calcutta, in charge of the Eastern Region, from 1922 to 1926. During this period, he carried out a number of statistical studies on meteorological data, some of which were published in 1937.

Early Examples of Operations Research

In 1922, a disastrous flood occurred in North Bengal. An Expert Committee of engineers appointed by the Government was about to recommend the construction of expensive retarding basins to hold up the flood waters, when the question was referred to Mahalanobis for examination. A statistical study of rainfall and floods extending over a period of 50 years showed that the proposed retarding basins would be of no value in controlling floods in North Bengal. The real need was improvement of rapid drainage and not holding up the flood water. Specific remedies were recommended, many of which were implemented and proved effective.

A similar question of flood control in Orissa was referred to Mahalanobis, after a severe flood in the river '*Brahmini*' in 1926. An Expert Committee of engineers were of the opinion that the bed of the'*Brahmini*' had risen, and they recommended increasing the height of river embankments by several feet. The statistical study covering a period of about sixty years showed that no change had occurred in the river bed, and the construction of dams for holding up of excessive flood water in the upper reaches of the river would provide an effective control. Mahalanobis also pointed out that dams could be used for the generation of electric power needed for the economic development of the region. He also gave the first calculations for a multipurpose (flood control, irrigation and power) scheme for the '*Mahanadi System*' in Orissa, which formed the basis of the Hirakud Hydroelectric Project inaugurated about thirty years later in 1957.

In retrospect, one finds that Mahalanobis's early work on river floods is in the nature of operations research (O.R.) introduced as a separate discipline after the Second World War. Another example of such an approach is the study he made, in a note submitted to the Government of Bengal in 1937, on the Hooghly-Howrah Flushing and Irrigation Scheme. He had estimated the expected increase in the yield of paddy by the introduction of an irrigation scheme by which high floods in the Damodar river were intended to be used to supplement the rainfall. This report

was of some help in developing in later years the Damodar Valley Multipurpose Hydroelectric Project.

Education Tests

Mahalanobis developed an interest in the construction and performance of educational tests in his early days of statistical research. Group tests in the medium of the Bengali language were constructed and used in the Institute. Studies were also made of the correlation between intelligence or aptitude tests and success in school-leaving certificate and other examinations, and of standardization of tests.

The Institute has now a separate division for the development of educational and vocational tests. It offers a regular service to educational institutions for the admission of students and to industrial establishment for the recruitment of skilled personnel.

Errors in Field Experimentation

In 1925, Mahalanobis had occasion to study the probable errors of results of agricultural experiments in which six varieties of paddy had been sown in a systematic manner in ten replicated blocks. In this study, the variation in soil heterogeneity was sought to be eliminated by fitting non-linear graduating curves (a method which was used independently by J. Neyman several years later). Mahalanobis was not aware of experiments introduced a few years earlier by R.A. Fisher, and suggested that each strip or plot should be divided into a number of sub-plots with a view to securing replicated observations for the computation of error. This paper placed him in touch with R. A. Fisher, and Mahalanobis immediately began to study seriously Fisherian methods of field experimentation. During a visit to England in 1926, he met Fisher, and a close personal relationship was established which was strengthened by Fisher's frequent visits to the Indian Statistical Institute The two had common views on the foundations and methodological aspects of statistics, and also on the role of statistics as a new technology. Fisher's death in 1962 removed a very close friend of Mahalanobis.

Large-Scale Sample Surveys

Large-scale sample survey techniques as practised today owe much to the pioneering work of Mahalanobis in the forties and fifties. He recognised the need for sample surveys in collecting information, especially in the developing countries, where official statistical systems are poor and 'data are treated as an integral part of the administrative system regulated by the principle of authority.' A sample survey, properly conducted, would provide a wealth of data, useful for planning and policy purposes, 'expeditiously, economically and with a reasonable degree of accuracy,' and at the same time 'ensuring objectivity of data.'

The methodology of large-scale sample surveys was developed during 1937-44 in connection with the numerous surveys planned and executed by the Institute. Some

were on consumer expenditure, tea-drinking habits, public opinion and public preference, acreage under a crop, incidence of plant deseases' rupee census and so on. The basic results on large-scale sample surveys were published in 1944 in the *'Philosophical Transactions of the Royal Society'* and also presented at a Meeting of the Royal Statistical Society, London.

Mahalanobis made three notable contributions to sample survey techniques, namely, pilot surveys, concept of optimum survey design, and interpenetrating network of samples.

The concept of pilot surveys as developed by Mahalanobis was the forerunner of sequential analysis developed ten years later by the late Abraham Wald. A pilot survey serves many purposes. It provides basic information on operational costs and the variability of characters, which are two important factors in designing an optimum survey. It gives an opportunity to test the suitability of certain schedules or questionnaires to be used in the survey. A pilot survey can also be used to construct a suitable 'frame' for sampling of units.

From the beginning, Mahalanobis was very clear about the principles involved in drawing up a good sample design. A method proposed in this connection by Mahalanobis sparked off a controversy in India, some supporting small-sized cuts and others advocating larger ones. The controversy still exists although it has been repeatedly demonstrated that small circular cuts are more economical, operationally more convenient, and free from bias when the procedure is properly standardized.

Besides the variance function, the optimization problem involves the knowledge of cost function for field operations as well as for statistical analysis.

One of the greatest achievements of Mahalanobis is the establishment of the National Sample Survey (N.S.S.) in 1950. It is a continuing exercise employing a large number of field investigators spread over the entire country for collection of information on socio-economic and demographic aspects of the population, periodically, on a sampling basis. During the last twenty-two years the N.S.S. has provided valuable information needed by the government in the formulation of the five-year economic plans and for taking policy decisions from time to time. The N.S.S. is recognized as an integral part of the official statistical system in India for the collection of data. But it took years to convince the government and the users of the data that sample surveys, when properly organized, can provide reasonably accurate estimates of a wide variety of economic variables expeditiously and at low cost, and periodically at desired points of time. The task proved to be extremely difficult especially because there was no parallel anywhere in the world in the use of a continuing sample survey covering an entire country for collecting official statistics.

Mahalanobis was concerned more with the practical aspects of sample surveys, rather than with mathematical research on survey sampling. As Chairman of the United Nations Sub-Commission on Sampling (1947-51), he advocated the use of sample survey methods in less developed countries for the collection of socio-economic and demographic data and laid down specifications for conducting large-scale sample surveys.

Fractile Graphical Analysis

It is said that a scientist's best work is done when he is young; as he grows older he can only elaborate on his earlier ideas. But Mahalanobis was an exception. Throughout his long years of research he had been continually providing new ideas and new tools for statistical analysis. During the last ten years of his life he developed a semi-non-parametric method for comparison of two samples, which he called fractile graphical analysis. This method was first developed for comparison of socio-economic conditions of a group of people at different points of time or of two groups of people at two different places. Applications have been found in other fields such as demography, psychology, biometry, etc.

Contributions to Perspective Planning

Mahalanobis's acquaintance with economics was neither systematic nor complete. The economics he learnt was connected with the problems he had to solve, and these came intermingled with problems in other fields. In his studies on rainfall and floods in the Damodar valley and Hirakud project areas conducted in 1931, he mentioned the need for regional planning and made some suggestions. He had even given a plan for development of roads.

Mahalanobis initiated a number of family budget surveys in rural and urban areas during the forties. He also undertook a number of studies on consumer preferences. He even tried his hand on rupees census, estimating the life of a rupee coin. A survey of the after-effects of the great Bengal famine in 1943 made him acutely aware of the poverty of the country.

In 1949, Mahalanobis became the Chairman of the Indian National Income Committee, when he began to think about the macro-economic problems of India. There were gaps in information of computing national income. To fill this, he established the National Sample Survey (N.S.S.) in 1950, and also organized a statistical unit devoted to the study of national income. When Mahalanobis was called upon to help in the planning work of the Government, he took up the study of planning models. He realized that the models suitable for advanced countries might not be applicable for underdeveloped countries. Setting himself the twin objectives of doubling the national income and reducing unemployment considerably over a period of twenty years, he produced what are now known as Mahalanobis two- and four-sector models for economic development.

Mahalanobis's association with the Planning Commission and his involvement in the formulation of the Second Five Year Plan brought him into contact with problems of wider national and international importance. He wrote extensively on subjects like (*i*) priority of basic industries, (*ii*) role of scientific research, technical man-power and education in economic development, (*iii*) industrialization of poorer countries and world peace and (*iv*) labour problems, unemployment and demographic problems.

Mahalanobis considered scientific advance as a prerequisite of sustained economic development. Economic progress entails technological change that could be

brought about only by engineers and technologists. Sustained technological research could only prosper in an atmosphere in which science in general is flourishing.

In his writings on scientific research, technical manpower education, etc., one could discover beginnings of a theory of economic growth. While the role of innovations in economic development has been stressed by Schumpeter and others, Mahalanobis emphasized the connection between scientific advance and technological innovations and the role of decision making at the appropriate time.

Mahalanobis discussed labour problems in India with particular reference to unemployment. The notion of unemployment had to be different in India in view of the existence of a large body of self-employed persons. *'As they do not have jobs, they cannot lose jobs, and cannot, therefore, be unemployed in the sense of industrial countries'*. On the other hand, manpower is grossly under-utilized in the country, and this applies to both self-employed and workers and employers. In addition, Mahalanobis thought that the conditions of living had not improved materially for the working class in comparison with the Prewar Period and labour productivity probably remained stagnant over the time. The solution according to him has to be simultaneous improvement in productivity, efficiency and remuneration.

In this context, Mahalanobis's idea of Labour Reserve Service (L.R.S.) run by government assumes considerable importance. When a particular worker is thrown out of a job, the enterprise should make a payment of L.R.S. Under the circumstances, a person will be thrown out only when the anticipated benefit is more than the payment to be made. All such workers will be maintained by the L.R.S., financed by the government and payments received from enterprises. The workers in L.R.S. will receive training and be engaged in productive work, the average wage in L.R.S. being slightly lower than the industrial wage. With industrial expansion, the enterprise will provide employment to members of L.R.S. at nominal wage rates, the L.R.S. thus serving as a buffer against unemployment. Since enterprises will be able to fire a worker on grounds of economy and efficiency, it will be possible for them to attain high productivity. On the other hand, the workers will find a regime free from any apprehension of unemployment.

Honours and Awards

Mahalanobis received numerous awards from academic societies all over the world for his contributions to statistics and economic planning. He was elected Fellow of the Royal Society of London (1945), Fellow of the Econometric Society, U.S.A. (1951), of the Pakistan Statistical Association (1952), Honorary Fellow of the Royal Statistical Society, U.K. (1954), of King's College, Cambridge (1959), Honorary President of the International Statistical Institute (1957), Foreign Member of the U.S.S.R. Academy of Sciences (1958), Fellow of the American Statistical Association (1961), and Fellow Member of the World Academy of Arts and Science (1963). He received the '*Weldon Medal*' from Oxford University (1944), '*Gold Medal of the Czechoslovak Academy of Sciences* (1963)' on his seventieth birthday, the *'Sir Deviprasad Sarvadhikari Gold Medal* (1957)', *'Durgaprasad*

Khaitan Gold Medal (1961)' and the *'Srinivasa Ramanujan Gold Medal* (1968)', all for contributions to science.

He was a Founder Fellow of the Indian National Science Academy (1935), and its President (1957-58). He was President of the Indian Science Congress in 1950. He received Honorary Doctorates from Calcutta (1956), Delhi (1964), Stockholm and Sofia Universities.

He received one of the highest civilian awards, *'Padmavibhushan',* from the Government of India in 1968 for his contributions to science and services to the country.

Life with a Mission

The seventy-nine years of the Professor's life were full of activity. His contributions were massive, on the academic side, as the builder of the Indian Statistical Institute, Founder and Editor of *Sankhya,* organizer of the Indian Statistical Systems, pioneer in the applications of statistical techniques to practical problems, promoter of the statistical quality control movement for improvement of industrial products, and as the architect of the Indian Second Five Year Plan.

Statistical science was a virgin field and practically unknown in India before the twenties. Developing statistics was like exploring a new territory. It needed a pioneer like Mahalanobis, with his indomitable courage and tenacity to fight all opposition, clear all obstacles and throw open wide pastures of new knowledge for the advancement of science and society.

With the passing away of Professor Mahalanobis, India has lost an outstanding personality, the like of whom is born perhaps once in several generations.

C. R. Rao

BIBLIOGRAPHY

1919. A new coefficient of correlation with applications to some biological and sociological data. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Bombay*), *Sec.* **6**, and *Proc. Asiat. Soc. Beng.*, New Series, **15,** (4); cxxiii.

1920. On the stability of anthropometric constants for Bengal caste data. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Nagpur*), *Sec. Phys. & Maths.*, **7**, and *Proc. Asiat. Soc., Beng.*, New Series **16,** lv-lvi.

— Statistical notes on anthropometric sub-group constants for Bengal caste data. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Nagpur*), *Sec. Phys. & Maths.*, **7**, and *Proc. Asiat. Soc. Beng.*, **16** lvi.

— (With Mukherji, Sasanka Sekhar). On the new compensated ballistic method for magnetic measurements, with a preliminary note on the magnetic behaviour of nickel in the form of powder under different physical stimuli. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Nagpur*) *Sec. Phys. & Maths.*, **7**, and *Proc. Asiat. Soc. Beng.*, New Series, **16,** lv.

1921. Note on the criterion that two samples are samples of the same population. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Calcutta*), *Sec. Phys. & Maths.*, **8**; *Proc. Asiat. Soc. Beng.*, New Series, **17,** cxvii-cxviii.

— The statistical constants of an Anglo-Indian sample: Part II: Head length and head breadth. (*Abstr.*) *Proc. Indian Sci. Congr.* (Calcutta), **8**; *Proc. Asiat. Soc. Beng.*, New Series, **17,** ccxlvii-ccxlviii.

1922. Anthropological observations on the Anglo-Indians of Calcutta. Part I: Analysis of meal stature. *Rec. Indian Mus* , **23,** 1-96.

— On the correction of a coefficient of correlation for observational errors. (*Abstr.*). *Proc.*

Sci. Congr. (*Madras*), *Sec. Phys. & Maths.*, **9**; and *J. Proc. Asiat. Soc. Beng.*, New Series **XVIII**, (6); 54.

— On the probable error of the component frequency constants of a dissected frequency curve. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Madras*), *Sec. Phys. & Maths.*, **9**, *J. Proc. Asiat. Soc. Beng.*, New Series **XVIII**, (6); 54.

— On the probable error of constants obtained by linear interpolation. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Madras*), *Sec. Phys. & Maths.*, **9**, 54; *J. Proc. Asiat. Soc. Beng.*, New Series, **XVIII** (6), 54.

— On upper air correlations. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Madras*), *Sec. Phys. & Maths.*, **9**, *J. Proc. Asiat. Soc. Beng.*, New Series, **XVIII** (6) 53-54.

1923. Correlation of upper air variab'es. *Nature*, **112**, 323-324.

— On errors of observation and upper air relationship. *Mem. India Met. Dept.*, **24**, 11-19.

— On the seat of activity in the upper air. *Mem. India Met. Dept.*, **24**, 1-9.

— Statistical note on the significant character of local variation in the proportion of dextral and sinistral shells in samples of the Buliminus Dextro Sinister from the salt range, Punjab. *Rec. Indian Mus.*, **25**, 399-403.

— On the probable error of interpolation for parabolic curves. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Lucknow*), *Sec. Phys. & Maths.*, **10**, 77.

— Statistical analysis of five independent samples of *carıdina nilotica var gracilipes*. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Lucknow*), *Sec. Phys. & Maths.*, **10**, 82.

1924. New method of computing the rate of standard clocks. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Bangalore*), *Sec. Maths. & Phys.*, **11**, 65.

— Statistical studies in meteorology. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Bangalore*), *Sec. Maths & Phys.*, **11**, 48-47.

1925. Analysis of race-mixture in Bengal. Presidential Address Anthropological Section, *Indian Sci. Congr.* (Edited); *J. Proc. Asiat. Soc. Bengal*, **23**, 301-33; Published separately, 1928.

— Probable error of field experiments agriculture. *Agric. J. India*, **28**, 96-116.

1926. Anthropometric survey of India. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Bombay*), *Sec. Anthropology*, **13**, 320.

— Appendicitis, rainfall and bowel complaints by Capt. S. K Ray, Part II: Scope of the enquiry. *Cal. med. J.*, **21** (4), 151-187, Discussion 213.

— Correlation and variation of normal rainfall for July, August and September in North Bengal. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Bombay*) *Sec. Maths. & Phys.*, **13**, 68.

— Local variations of specimens of *cardina nilotica var gracilipes* (*Abstr.*) *Proc. Indian Sci. Congr.* (*Bombay*), *Zoology Section*, **13**, 190.

1927. Report on rainfall and flood in North Bengal during the period 1870-1922. (In 2 volumes with 29 tables and 28 maps) submitted to the Government of Bengal, 1-90. *Indian Sci. Congr.* (*Bombay*), *Section Maths. & Phys.* (*Abstr.*) [Title: Rainfall in relation to floods in North Bengal], **14**, 67 pp.

1928. On the need for standardization in measurements on the living. *Biomet.*, **20**, A, 1-31., (*Abstr.*) *Proc. Indian Sci. Congr.* (*Calcutta*), *Anthropology Sec.*, **15**, 325.

— Statistical study of the Chinese head. *Man in India*, **8**, 107-122. *Proc. Indian Sci. Congr.* (*Calcutta*). *Sec. Anthropology*, (*Abstr.*) [Title: "A first study of Chinese head", **15**, 325.

1930. On tests and measures of group divergence, Part I: Theoretical formulae. *J. & Proc. Asiat. Soc. Beng.*, New Series, **26**, 541-588.

— Statistical study of certain anthropometric measurements from Sweden. *Biomet.*, **22**, 94-108. (*Abstr.*) *Proc. Indian Sci. Congr* (*Allahabad*), *Sec. Anthropology*, **17**, 396.

— Anthropological observations on the Anglo-Indians of Calcutta. Part II: Analysis of Anglo-Indian head length. *Rec. Indian Mus.*, **21**, 97-149, (*Abstr.*) *Proc. Indian Sci. Congr.* (*Nagpur*), *Sec. Anthropology*, **18**, 411.

1931. Application of statistics to agriculture. *Proc. Indian Sci. Congr.* (*Nagpur*), *Sec. Agriculture*, General discussion, **18**, 446-447.

— On the normalizaton of statistical variates. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Nagpur*), *Sec. Maths. & Phys.*, **18**, 91-92. [See also 140].

— Revision of Risley's anthropometric data relating to the tribes and castes of Bengal. (Title with slight alteration) (*Abstr.*) *Proc. Indian Sci. Congr.* (*Nagpur*), **18**, 1931, 411. *Sankhya*, **1**, 1933, 76-105.

— Statistical study of the level of the rivers of Orissa and the rainfall in the catchment areas during the period 1868-1928. Submitted to the Government of Bihar and Orissa.

— Studies in group tests of intelligence: (1) The reliability and age-normals of scores in, Form (A). (*Abstr.*) *Proc. Indian Sci. Congr.* (*Nagpur*), *Sec. Psychology*, **18**, 437.

— (With Chakravarti, N.). Statistical report on river floods in Orissa during the period 1868-1928. (In 20 chapters with 47 tables and 27 maps), submitted to the Government of Bihar and Orissa.

1932. Auxiliary tables for Fisher's *Z*-test in analysis of variance.(Statistical notes for agricultural workers, no. 3). *Indian J. agric. Sci.*, **2**, 679-693.

— Revision of Risley's anthropometric data relating to the Chittagong hill tribes (*Abstr.*).

Proc. Indian Sci. Congr. (*Bangalore*), *Anthropology Sec.*, **19,** 424; *Sankhya*, **1,** 1934, 267-276.

— Rice and potato experiments at Sriniketan. (Agricultural Department of the Visva-Bharati) 1931. (Statistical notes for agricultural workers No. 4). *Indian J. agric. Sci.*, **2,** 694-703. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Patna*), *Sec. Agriculture*, **20,** 1933, 48.

— A statistical analysis of the height of the Brahmani River at Jenapore. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Bangalore*), *Sec. Maths. & Phys.*, **19,** 123.

— Statistical note on certain rice breeding experiments in the Central Provinces. *Indian J. agric. Sci.*, **2,** 157-169. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Bangalore*), *Sec. Agricultural Statistical Methods*, **19,** 88.

— Statistical note on the method of comparing mean values based on small samples. *Indian J. agric. Sci.*, **2,** 28-41. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Bangalore*), *Sec. Agricultural Statistical Methods*, **19,** 88.

— (With Bose, S.S.) A first study of sampling experiments on the effect of systematic arrangements in field trials. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Bangalore*), *Sec. Agricultural Statistical Methods*, **19,** 88.

— (With Bose, S.S.). Note on the variation of the percentage infection of Wilt disease in the cotton (Statistical notes for agricultural workers, No 5). *Indian J. agric. Sci.*, **2,** 704-709. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Patna*), *Sec. Agriculture Statistics*, **20,** 48.

1933. A comparison of different statistical measures of intelligence based on a group test in Bengal (*Abstr.*) *Proc. Indian Sci. Congr.* (*Patna*), *Sec. Psychology*, **20,** 439.

— Editorial. *Sankhyā*, **1,** 1-4.

— Effects of fertilizers on the variabilty of the yield and rate of shedding of buds and flowers and bolls in the cotton plant in Surat. (Statistical notes for agricultural workers, No. 6). *Indian J. agric. Sci.*, **3,** 131-138. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Patna*), *Sec. Agriculture Statistics*, **20,** 46.

— A new photographic apparatus for recording profiles of living persons. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Patna*), *Sec. Anthropology*, **20,** 413.

— Notes on field technique. Submitted to Department of Agriculture. Government of Bombay.

— On the need of randomization of plots in field trials. (Statistical notes for agricultural workers, No. 13) *Indian J.agric. Sci.* **3,** 549-551. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Patna*), *Sec. Agriculture Statistics*, **20,** 48.

— The reliability of a group test of intelligence in Bengali. (with five figures). (Studies in educational test, No. 1). *Sankhyā*, **1,** 25-49.

— A study of the correlation between the height of Brahmani at Jenapore and the rainfall in the catchment area. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Patna*), *Sec. Maths. & Phys.*, **20,** 123.

— Tables for the application of Neyman and Pearson's *L*-tests for judging the significance of observed divergence in mean values and variabilities of *K* samples. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Patna*), *Sec. Maths. & Phys.*, **20,** 123.

— Tables for comparing standard deviation of small samples. (*Abstr.*) *Proc. Indian Sci.. Congr.* (*Patna*), *Sec. Maths. & Phys.*, **20,** 122

— Tables for *L*-tests. *Sankhyā*, **1,** 109-122. Published as pamphlet. Calcutta, Statistical Laboratory, 14 pp.

— Use of the method of paired differences for estimating the significance of field trials. (Statistical notes for agricultural workers, No. 11). *Indian J. agric. Sci.*, **3,** 349-352. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Patna*), *Sec. Agriculture Statistics*, **20,** 41.

— Use of random sampling numbers in agricultural experiments. (Statistical notes for agricultural workers, No. 14). *Indian J. agric. Sci.*, **3,** 1108-1115.

— (With Basak, K. C.). A study of the intensity of floods in the Mahanadi for the period 1868-1929. *(Abstr.) Proc. Indian Sci. Congr. (Patna), Sec. Maths. & Phys.*, **20,** 124.

— (With Bose, S.S.). Analysis of a manurial experiment on wheat conducted at Sakrand, Sind. (Statistical notes for agricultual workers, No 10. *Indian J. agric. Sci.*, **1,** 345-348.

— (With Bose, S.S.). Analysis of verictal tests with wheat conducted at Sakrand, Sind, 1931-32. (Statistical notes for agricutural workers, No. 12). *Indian agric. Sci.*, **3,** 544-548. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Patna*), *Sec. Agriculture Statistcs*, **28,** 47.

— (With Bose, S.S). Certain varietal studies on the cot on plant in Surat. (Statistical notes for agricultural workers, No. 9) *Indian J. agric. Sci.*, **3,** 339-344.

— (With Bose, S. S.). Effect of different doses of nitrogen on the rate of shedding of buds, flowers and bolls in the cotton plant in Surat, (Statistical notes for agricultural workers,. No 8). *Indian J. agric. Sci.*, **1,** 147-154. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Patna*), *Sec. Agriculture Statisics*, **28,** 47.

— (With Bose, S. S.). Effect of the time of application of fertilizers on the yield and the rate of shedding of buds, flowers and bolls in the cotton plant in Surat. (Statistical notes for agricultural workers, No. 7). *Indian J. agric. Sci.*, **3,** 139-146. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Patna*), *Sec. Agriculture Statistics* **28,** 47.

— (With Bose, S. S.). A study of the intensity of floods in the Brahmini for the period 1868-1929. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Patna*), *Sec. Maths. & Phys.*, **20,** 124.

— (WITH CHAKRAVARTI, NISTARAN). A study of the precipitation and the percentage run-off in the Mahanadi. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Patna*), *Sec. Maths. & Phys.*, **28,** 124.
— (WITH DAS, KEDARNATH). A preliminary note on the rates of maternal deaths and still-births in Calcutta. *Sankhyā,* **1,** 215-230.
— (WITH NAG, A. C.). A study of the areal distribution of rainfall during rain storms in the Mahanadi catchment. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Patna*), *Sec. Maths. & Phys.*, **28,** 123.
— (WITH RAY, P. R.). A study of the correlation of the height of Mahanadi at Sambalpur and at Naraj. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Patna*), *Sec. Maths. & Phys.*, **20,** 124.
— (and SEN, R. N.). A study of the seasonal fluctuations in the height of the Orissa rivers. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Patna*), *Sec. Maths. & Phys.*, **20,** 124.

1934. Age variation of scores in a group test of intelligence in Bengali. (with eight figures). (Studies in educational tests, No. 2). *Sankhyā,* **1,** 231-244.
— A statistical analysis of rotational experiments with cotton, groundnut, and juar in Berar, with notes on designs of rotational experiments. (Statistical notes for agricultural workers, No. 15). *Indian J. agric. Sci.*, **4,** 361-385. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Bombay*), *Sec. Agricultural Statistics,* **21,** 69.
— [Note by Editor appended to] "Tables for testing the significance of linear regression in the case of time-series and other single-value samples by Bose, S. S." *Sankhyā,* **1,** 284.
— [Note by Editor appended to] "Thirty-eight years of rice yields in lower Birbhum, Bengal by Hashim Amir Ali, assisted by Tara Krishna Bose," *Sankhyā,* **1,** 387-389.
— On the statistical divergence between certain species of phytophthora. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Bombay*), *Sec. Maths. & Phys.*, **21,** 151.
— A preliminary note on intervarietal correlation in the rice plant in Bengal. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Bombay*), *Sec. Agricultural Statistics.* **21,** 70.
— A preliminary study of the intelligence quotient of Bengali school children. (With ten figures.) (Studies in educational tests, No. 4.), *Sankhyā,* **1,** 407-426.
— (WITH BOSE, S. S.). Effect of different types of soil-covers on the moisture economy of irrigated plantations of *Dalbergia sissoo* in Lahore Division. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Bombay*), *Sec. Agricultural Statistics,* **21,** 70.
— (WITH BOSE, S. S.). Statistical note on the effect of pests on the yield of sugarcane and the quality of cane-juice. *Sankhyā,* **1,** 399-496. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Bombay*), *Sec. Agricultural Statistics,* **21,** 71.
— (WITH BOSE, S.S. *et al.*). Tables for random samples from a normal population. *Sankhyā,* **1,** 289-328. Pamphlet, Calcutta Statistical Laboratory, pp. 40.
— (WITH CHAKRAVARTI, K. N.). Analysis of marks in the school leaving certificate examination in the United Provinces, India, 1919 (with ten figures). (Studies in educational tests, No. 3). *Sankhyā,* **1,** 245-266.
— (WITH CHAKRAVORTTI, S. C., *and* BANERJEE, E. A. R.). Influence of shape and size of plots on the accuracy of field experiments with rice, Chinsurah, Bengal. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Bombay*), *Sec. Agricultural Statistics,* **21,** 71.
— (WITH DAS, KEDARNATH *and* NAG, ANIL CHANDRA). A preliminary note on the rates of maternal deaths and still-births in Calcutta. *Sankhyā,* **1,** 215-230.
— (WITH NAG, A. C.). A preliminary study of the maternal death-rate and the proportion of still-births in Bengal for the period 1848-1901. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Bombay*), *Sec. Medical and Veterinary Research,* **21,** 380.

1935. Analysis of racial likeness in Bengal castes. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Calcutta*) *Sec. Anthropology.*, **22,** 335.
— Application of statistical method in industry. *Sci. Cult.*, **1,** 73-78.
— [An Editorial correction to] "On the distribution of the ratio variances of two samples drawn from a given normal bivariate correlated population, by Bose, S. S." *Sankhyā,* **2,** 72.
— Further studies of the Bengali profile. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Indore*), *Sec., Anthropology,* **22,** 337.
— On the validity of a group test of intelligence in Bengal [*i*]. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Calcutta*), *Sec. Psychology,* **22,** 446.
— A statistical note on certain haematological studies of fifty new-born. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Calcutta*), *Sec. Med. & Vet. Res.*, **22,** 411.
— Study of consumer preference tn Calcutta. Submitted to D. J. Keymer & Co.
— (WITH BANERJEE, K. C., *and* RAY, P. R.). Studies in tiller-formation. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Calcutta*), *Sec. Agricultural Statistics,* **22,** 347.
— (WITH BOSE, R. C.). On the generalised statistical distance between samples from two normal populations. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Indore*), *Sec. Maths. & Phys.*, **22,** 80.
— (WITH BOSE, S. S.). Extension of *X*-table (corresponding to Fisher's *Z*-table) for testing the significance of two observed variances. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Indore*), *Sec. Maths. & Phys.*, **22,** 79.
— (WITH BOSE, S. S.). A note on the application of multiple correlation for estimating the

individual digestibilities of a mixed feed. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Calcutta*), *Sec. Agricultural Statistics*, **22,** 348.

— (WITH BOSE, S. S.). On estimating individual yields in the case of mixed-up yields of two or more plots in agricultural experiments. *Sci. Cult.*, **1,** 205; [Slightly altered title ". . . . plots in field experiments"]. *Sankhyā*, **4,** 1938, 103-111.

— (WITH BOSE, S. S., *and* CHAKRAVARTI, S. C.). A complex cultural experiment with rice. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Calcutta*), *Sec. Agricultural Statistics* **22,** 347. [altered title] "Complex experiment on rice at the Chinsurah farm, Bengal, 1933-34" (Statistical notes for agricultural workers, No. 16). *Indian J. agric. Sci.*, **6,** 34-51.)

— (WITH BOSE, S. S., *and* HARRISON, C. J.). Effect of manurial dressings, weather conditions and manufacturing processes on the quality of tea at Tocklai experimental station, Assam. *Sankhyā*, **2,** 33-42.

— (WITH BOSE, S. S., *and* MENON, T. V. G.). A statistical study under permanent manurials in Pusa. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Calcutta*), *Sec. Agricultural Statistics*, **22,** 348.

— (WITH BOSE, S. S., *and* RAY CHOUDHURI, S.). A bivariate sampling experiment. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Calcutta*), *Sec. Maths. & Phys.*, **22,** 80.

— (WITH DAS, P. C., *and* RAY CHOUDHURY, N. K.). A statistical analysis of hospital records of some delivery cases in Calcutta. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Calcutta*), *Sec. Med. Vet. Res.* **22,** 410.

— (WITH MENON, T. V. G., *and* BOSE, S. S.). A statistical study of soil deterioration in the permanent manurial experiments in Pusa. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Calcutta*), *Sec. Agricultural Statistics*, **22,** 348.

— (WITH NANDI, G. C. ***et al.***). Relation between heights and weights of Bengali women. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Calcutta*), *Sec. Med. Vet. Res.*, **22,** 410.

— (WITH RAY, K. C.). A statistical method of testing the genuineness of a sample of ghee. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Calcutta*), *Sec. Med. Vet. Res.*, **22,** 410.

1936. Appendix 1. Editorial note on the fundamental formulae [to]: "The yield of Andropogon Sorghum in relation to circumference of head, length of head and height of plant by Venkataramanen, S. N." *Sankhyā*, **2,** 263-272.

— Editorial note on the margin of error in the calculation of the cost of cultivation and profit Appended to 'Marketing of rice at Bolpur, by Satya Priya Bose.' *Sankhyā*, **2,** 121-124.

— Karl Pearson, 1857-1936. (Lecture delivered at Satistical Laboratory, Calcutta, 27.11.1936. *Sankhyā*, **2,** 303-378.

— New theory of ancient Indian chronology. *Sankhyā*, **2,** 309-320.

— (ROY, S.). School marks and intelligence test scores. *Sankhyā*, **2,** 397-402.

— Note on the statistical and biometric writings of Karl Pearson (with references). *Sankhyā*, **2,** 411-422.

— Note on cotton prices in relation to quality and yield. *Sankhyā*, **2,** 135-142.

— Note on the use of indices in anthropometric work. *Sci. Cult.*, **1,** 477. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Indore*), *Sec. Anthropology*, **23,** 392.

— On the generalised distance in statistics. *Proc. natn. Inst. Sci. India*, **11** (1), 49-55.

— On the generalized measure of divergence between statistical groups. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Indore*), *Sec. Maths. & Phys.*, **23,** 108.

— Sir Rajendra Nath Mookerjee: First President of the Indian Statistical Institute 1931-1936. *Sankhyā*, **2,** 237-240.

— (WITH ACHARYA, D. P.). A statistical study of marks in the annual and test examinations in relation to university results in I.A. and I.Sc. examinations in Bengal. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Indore*), *Sec. Psychology*, **23,** 536.

— (WITH BANERJEE, K. C., ***and*** BOSE, S. S.). The influence of the date of planting and the number of seedlings per hole on tillering in rice at Bankura. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Indore*), *Sec. Agriculture*, **23,** 437.

— (WITH BOSE, RAJ CHANDRA ***and*** RAY, S. N.). On the evaluation of the probability integral of the D^2 statistic. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Indore*), *Sec. Maths. Phys.*, **23,** 107.

— (WITH BOSE, S. S.). On the estimate of missing yields in a splitplot type of arrangement. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Indore*), *Sec. Agriculture*, **23,** 426.

— (WITH BOSE, S. S.). On the estimate of mixed up yields in an agricultural field experiment. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Indore*), *Sec. Agriculture*, **23,** 426.

— (WITH BOSE, S. S.). A situation experiment with rice. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Indore*), *Sec. Agriculture*, **23,** 437.

— (WITH BOSE, S. S., ***and*** BANERJEE, K. C.). Studies in tiller variation. (Statistical notes for agricultural workers, No. 20). *Indian J. agric. Sci.*, **6,** 1122-1133.

— (WITH BOSE, S. S., ***and*** CHAKRAVARTI, S. C.). Effect of different methods of harvest on the estimated error of field experiments on rice. (Statistical notes for agricultural workers, No. 21). *Agric. Live-stk. India*, **6,** 814-825.

— (WITH BOSE, S.S., *and* GANGULY, P. M.). Frequency distribution of plot yields and optimum size of plots in a uniformity trial with rice in Assam. (Statistical notes for agricultural workers, No. 19). *Indian J. agric. Sci.*, **6,** 1107-1121.

— (WITH BOSE, S. S., *and* KULKARNI, R. K.). On the influence of shape and size of plots on the effective precision of field experiments with juar (Andropogon Sorghum). (Statistical notes for agricultural workers, No. 17). *Indian J. agric. Sci.*, **6,** 460-474.
— (WITH BOSE, S. S., *and* SENGUPTA, S. C.). Statistical analysis of a manurial experiment on Napier grass (*Pennisetum perpureum*) by the method of covariance. (Statistical notes for agricultural workers, No. 18) *Agric. Live-stk. India,* **6,** 183-194.
— (WITH CHAKRAVERTI, S. C., *and* BOSE, S. S.). A complex cultural experiment with rice at Chinsurah, Bengal, for the year 1934-35. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Indore*), *Sec. Agriculture,* **23,** 436.
— (WITH GUHA ROY, K. K.). Statistical methods and their applications to agronomy—a bibliography. *Misc. Bul.,* No. **9,** Coun. Agric. Res. India, 120p.
— (WITH GUPTA, J. C.). A preliminary note on measurements of blood pressure. (*Abstr. Proc. Indian Sci. Congr.* (*Indore*), *Sec. Med. Vet. Res.*, **23,** 485.
— (WITH ROY, S.). Schools marks and intelligence test scores. *Sankhyā,* **2,** 377-402.
— (WITH SEN, J. C.). A comparative study of measures of intelligence. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Indore*), *Sec. Psychology,* **21,** 536.
1937. Need of a sample survey of the growth of population in India, *Sankhyā,* **3,** 58.
— A note on forecasting value of intelligence test. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Hyderabad*), *Sec. Psychology*, **24,** 448.
— Variation of rainfall with lunar periods in Calcutta for the month of July (*Abstr.*). *Proc. Indian Sci. Congr.* (*Indore*), *Sec. Maths. & Phys.*, **23,** 72. (altered title) "Note on the influence of lunar phase on the rainfall in the month of July in Calcutta, 1878-1924." *Sankhyā,* **3,** 233-238.
— On the accuracy of profile measurements with a photographic profiloscope. *Sankhyā,* **5,** 65-72. [Slightly altered title]: "Studies with the photographic profiloscope." (*Abstr.*) *Proc. Indian Sci. Congr.* (*Indore*), *Sec. Anthropology*, **23,** 391.
— Rectangular co-ordinates in sampling distributions: Appendix (Note). *Sankhyā,* **3,** 35.
— Review of the application of the statistical theory to agricultural field experiments in India. *Proc. Second Meeting Crops and Soils, Wing, Board of Agriculture and Animal Husbandry, Lahore,* 6 December, Govt. of India, 1-15 [1]. Revised paper, *Indian J. agric. Sci.*, **10,** 192-212.
— Statistical note on the Hooghly-Howrah flushing and irrigation scheme. Submitted to the Government of Bengal, Irrigation Department, 1937, 1-44.
— (WITH BOSE, R. C., *and* ROY, S. N.). The use of intrinsic rectangular coordinates in the theory of distribution. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Hyderabad*), *Sec. Maths. & Phys.*, **24-99.**
— (WITH BOSE, R. C., *and* ROY, S. N.). Normalization of statistical variates and the use of, rectangular co-ordinates in the theory of sampling distributions. *Sankhyā,* **3,** 1-34. Appendix by P. C. Mahalanobis, 35-40.
— (WITH ACHARYA, D. P.). Note on the correlation between results in the college and university examinations. *Sankhyā,* **8,** 239-244.
— (WITH BOSE, S. S.). On an exact test of association between the occurrence of thunderstorm and an abnormal ionisation. *Sankhyā,* **3,** 249-252. [Slightly altered title: "On a method of testing the association between thunderstorm and upper air ionisation." (*Abstr.*) *Proc. Indian Sci. Congr.* (*Hyderabad*), *Sec. Maths. & Phys.*, **24,** 99.
— (WITH DATTA, B. N.). Note on the foot and stature correlation of certain Bengali castes and tribes. *Sankhyā,* **3,** 245-248.
1938. First session of the Indian Statistical Conference, Calcutta, 1938. *Sankhyā,* **4,** 1-4.
— Note on grid sampling. *Sci. Cult.*, **4,** 300.
— On the distribution of Fisher's taxonomic coefficient. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Calcutta*), *Sec. Maths. & Phys.*, **52,** III; 31.
— On an improved model of the profiloscope. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Calcutta*), *Sec. Anthropology*, **25,** 206.
— Professor Ronald Aylmer Fisher. *Sankhyā,* **4,** 265-272. *Biomet.* (with few minor editorial amendments), **20,** 238-251.
— Report on the sample census of jute in 1938. (Submitted to Indian Central Jute Committee.)
— Statistical report on the experimental crop census, 1937 (Submitted to Indian Central Jute Committee).
— (WITH BANERJEE, K. C., *and* PAL, J. R.). Study on tillers of rice plant bearing on their duration on life, and performance and death. *Sankhyā,* **4,** 149, (*Abstr.*) *Proc. Indian Sci. Congr.* (*Calcutta*), *Sec. Agriculture,* **25,** Pt. III; 220.
— (WITH BOSE, S. S.). Test of significance of treatment means with mixed-up yields in field experiments. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Calcutta*), *Sec. Agriculture,* **25,** pt. III, Sec IX, 219.
— (WITH CHAKRAVARTY, S. C., *and* BOSE, S. S.). Complex cultural experiment of rice. (*Abstr.*) *Sankhyā,* **4,** 149.
— (WITH HEDAYATULLAH, S., *and* ROY, K. P.). Complex experiment of winter rice at Dacca.

[1936-37] *Sankhyā*, **4**, 149-150. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Calcutta*), *Sec. Agric.* **25**, pt. III, Sec IX, 220.

1939. Enquiry into the prevalence of drinking tea among middle class Indian families in Calcutta, 1939. Submitted to the Tea Market Expansion Board, 1939. *Sankhyā*, **6**, 1943, 283-312.

— *First Report on the Crop Census of* 1938. Indian Central Jute Committee, 1939, 1-110.

— A note on grid sampling. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Lahore*), *Sec. Maths. & Phys.*, **26**, Pt. III, Sec. I, 7.

— Progress report of the jute census scheme for 1939. Submitted to the Indian Central Jute Committee, 1939.

— Review of the application of statistical theory to agricultural field experiments in India. *Proc. Second Mtg. Crops Soils Wing Agric. India.*, 200-215.

— Subhendu Sekhar Bose, 1906-1932. *Sankhya*, **4**, 313-336.

— The technique of random sample survey. (*Abstr.*) *Proc. Indian Sci. Congr.* (Lahore), *Sec. Theoretical statistics*, **26**, Pt. IV Sec. II, 14-16.

— (WITH BOSE, S. S., *and* KHANNA, K. L.). Note on the optimum shape and size of plots for sugarcane experiments in Bihar. (Statistical notes for agricultural workers, No. 24). *Indian J. Agric. Sci.*, **9**, 807-816.

— (WITH CHAKRAVARTI, S. C., *and* BOSE, S. S.). Complex cultural experiment on rice. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Calcutta*), *Sec. Agriculture*, **25**, III, 220.

— (WITH NAIR, K. R., *and* CHAKRAVARTI, S. C.). A 10 x 10 quasifactorial experiment at Chinsurah with 100 strains of rice. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Lahore*), *Sec. Agriculture*, **26**, Pt. III, Sec. IX, 199.

1940. Application of statistical methods in physical anthropometry, (appears as part of "Discussions on the application of statistical methods in anthropometry"). *Proceedings of the Second Indian Statistical Conference*, Lahore. *Sankhyā*, **4**, 594-598. Altered title "Application.....anthropological research." (*Abstr.*) *Proc. Indian Sci. Congr.* (Lahore), **26**, Part IV, Sec VIII, 23.

— Anthropological observation on the Anglo-Indians of Calcutta, Part III, Statistical analysis of measurements of seven characters. *Rec. Indian Mus.*, **23**, 151-187.

— Characteristic features of rain storms and river floods in Orissa. *Sankhyā*, **4**, 601-602.

— Discussion on planning of experiments. *Sankhyā*, **4**, 530-531.

— Errors of observation in physical measurements. *Sci. Cult.*, **5**, 443-445.

— Note on the expenditure on tea among working class families in Howrah and Kankinara. Submitted to the Tea Market Expansion Board.

— Preliminary report on the sample census of the area under jute. Submitted to the Indian Central Jute Committee.

— Rain storms and river floods in Orissa (with a map). *Sankhyā*, **5**, 1-20.

— (Report on the) sample census of the area under jute in Bengal in 1940. Submitted to the Indian Central Jute Committee, 1941. Proc. 2nd Indian Statistical Conference [with minor alterations and omission of some of the detailed tables] *Sankhyā*, **29B**, 1967, 81-182. Published in book form by Statist Publ. Soc. 1968, ii, 102p.

— *Report on the Sample Census of Jute in* 1939. Submitted to the Indian Central Jute Committee, 1940, 1-146.

— Statistical note on crop-cutting experiments on paddy in Mymensingh. Submitted to the Government of Bengal, 1940.

— Statistical report on crop-cutting experiments on jute 1940. Submitted to the Indian Central Jute Committee, 1940.

— (WITH NAIR, K. R.). Simplified method of analysis of quasifactorial experiments in square lattice with a preliminary note on joint analysis of yield of paddy and straw. (Statistical notes for agricultural workers, No. 25). *Indian J. agric. Sci.*, **10**, 663-685.

— (WITH SEN, SATYABRATA). Fertility rates based on a sample survey. *Sankhyā*, **4**, 601.

1941. General report on the sample census of the area under jute in Bengal, 1941, Submitted to the Indian Central Jute Committee, 1941, pp. 43.

— Note on random fields. *Sci. Cult.*, **7**, 54.

— On non-normal fields. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Banaras*), *Maths. & Statist.*, **28**, Section I, Pt. III, 12.

— On the sample survey of Jute in Bengal. Indian Central Jute Committee, Calcutta, 1938-1941.

— Preliminary statistical report on the regional survey of Borer pests of sugarcane. December 1940 March 1941. Submitted to the Imperial Council of Agricultural Research, June 1941.

— Report on programme preference and broadcast reactions, Calcutta, April-May 1941. Submitted to the Department of Information, Government of India, July, 1941.

— Report on the sampling technique for forecasting the bark-yield of Cinchona plants: Experiment series B, 1940-41. Submitted to the Superintendent, Cinchona Culture in Bengal, Mungpoo, October 1941.

— Statistical note on nutritional investigations in college hostels in Calcutta. *Sankhyā*, **5**, 439-448.
— Statistical report on crop-cutting experiments on jute in Bengal, 1940. Submitted to the Indian Central Jute Committee, June 1941.
— Statistical report on the rupee census—Mathematical Appendix. (Revised). *Rep. Currency and Finance*, 1940-41, Reserve Bank of India, 49-55.
— Statistical report on a sample survey of the prevalence of drinking tea in Nagpur City in 1940. Submitted to the Tea Market Expansion Board, March 1941.
— Statistical survey of public opinion. *Mod. Rev.*, **69**, 393-397.
— (With Bose, C.). Correlation between anthropometric characters in some Bengal castes and tribes. *Sankhyā*, **5**, 249-269.
— (With Nair, K. R.). Statistical analysis of experiments on different Limen values for lifted weights. *Sankhyā*, **5**, 285-294.
1942. Family budget enquiries of labourers, Jagaddal. Scheme for Labour Family Budget Enquiry and Preparation of cost of Living Index of Industrial Workers. Submitted to the Board of Economic Enquiry, Bengal, January 1942.
— Note on the life of a rupee note, July 1940-June 1941. Reserve Bank of India, 1942.
— Preliminary report on Burdwan-Hooghly-Howrah crop-cutting survey. Submitted to the Government of Bengal, Irrigation Department, 1942.
Preliminary report on the crop-cutting experiment on jute, 1942. Submitted to the Government of Bengal, 1942.
— Preliminary report on the sample census of the area under aus paddy in Bengal. 1942. Submitted to the Government of Bengal, 1942.
— Preliminary report on the sample census of the area under jute in Bengal, 1942. Submitted to the Government of Bengal, 1942.
— Report on the precision of family budget enquiry at Jagaddal, August 1942. Submitted to the Board of Economic Enquiry, Bengal, 1942.
— Report on the sample survey of the jute and aus paddy crops.
— Sample survey of public opinion. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Baroda*), *Maths. & Statist.*, **29**, Pt. III, Sec. I, 15, *Sankhyā*, **6**, 1943, 251.
— Sample surveys. Presidential Address, Section of Mathematics and Statistics, Indian Science Congress, Boaroda, 1942. (*Abstr.*) *Proc. Indian Sci. Congr.*, **29**, Part II, 25-46. *Sci. Cult.*, **7**, No. 10 (Supplement); 1942 April, 1-2.
— Statistical definition of standard yield of crops. *Sankhyā*, **6**, 97-98.
— (With Bose, C.). On devising an efficient sampling technique for forecasting the mean value of a variable. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Baroda*), *Maths. & Statist.*, **29**, Pt. III Sec. I, 14. *Sankhyā*, **6**, 251-252.
— (With Gupta, K.). Enquiry into the family budgets of labourers in Bengal. (*Abstr.*) *Proc. Indian. Sci. Congr.* (*Baroda*), *Maths & Statist.*, **29**, Part III, Sec. I, 15, *Sankhyā*, **6**, 1943, 252.
— (With Mathew, N. T.). On the rupee census problem. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Baroda*), *Maths & Statist.*, **29**, Pt. III, Sec. I, 14-15.
1943. Enquiry into the prevalence of drinking tea among middle-class Indian families in Calcutta, 1939. (Studies in Sample Surveys). *Sankhyā*, **6**, 283-312.
— Final report on the sample census of the area under jute and aus paddy in Bengal 1943-Sample surveys for estimating the acreage and yield of jute in Bengal 1937-43. Submitted to the Government of Bengal. 1-51, (37 Tables).
— Preliminary report on the sample census of the area under aman paddy in Bengal 1943. Submitted to the Government of Bengal.
— Report on the regional survey of Borer pests on sugarcane. December 1940—March 1941. Submitted to the Imperial Council of Agricultural Research 1-284.
— (With Ghosh, B. N.). Statistical analysis of data relating to incidence of pests and diseases on different varieties of sugarcane *Proc. Indian statist. Conf.*, Calcutta, 1943. (*Abstr.*) *Sankhyā*, **4**, 349.
1944. [Editorial Note] to "The stability of the income distribution by Harro Bernardelli.", *Sankhyā*, **6**, 362.
— Multi-stage sampling. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Delhi*), *Maths. & Statist.*, **31**, Pt. III, Sec. I, 3-4.
— On large-scale sample surveys. *Phil. Trans. R. Soc., London*, Series B, **231**, 329-451.
— Organisation of statistics in the post-war period. *Proc. natn. Inst. Sci. India*, **10**, 69-78.
— Preliminary report on crop-cutting experiments on aus paddy, 1942. Submitted to Govt. of Bengal.
— Report on Bengal crop survey 1943-44. Pt. I-Jute and aus paddy 1943. Pt. 2-Aman paddy. 1943-44. 46p.
1945. Bengal crop survey 1944-1945: Progressive reports on bhadoi (monsoon) crops. Submitted on 8 and 20 October and 4 November 1944; on aghani (winter) crops on 11 November 1, 8, and 25 December 1944; 2 and 22 January, 2 and 9 February and 21 March 1945; and on robi (spring) crops on 19 and 23 March 1945.

— Bengal crop survey 1944-1945: Progressive reports. Submitted to the Govt. of Bengal on jute and aus paddy crops on 31 August, 16 September and 14 October 1944 and on aman paddy crop on 19 December 1944 and 16 and 24 January and 1, 8, 14 and 23 February 1945.
— Note on the mortality in Bengal in 1943. Submitted to the Famine Inquiry Commission in February 1945.
— Note on the number of destitutes in Bengal in 1943. Submitted to Government of Bengal on 28 May 1945.
— Report on the Bihar crop survey, Rabi season, 1943-44. Submitted to Bihar Govt. *Sankhyā*, **7**, 29-106.
1946. Bengal famine: the background and basic facts. (Paper read at East-Asia Association at the Royal Society 25 July 1945). *Asiat. Rev.*, October 1946, 7p.
— A direct method of estimating total production of crops. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Bangalore*), *Statist*, **33**, Part III, Sec. II, 17.
— Distribution of the Muslims in population of India. *Sankhyā*, **7**, 429-434.
— Problems of current demographic data in India. [In] "Papers presented by special guests of the Population Association of America. Oct. 25-26, 1946." New York (mimeo).
— Recent experiments in statistical sampling in the Indian Statistical Institute (with discussion). *J. R. statist. Soc.*, Series A, **109**, 325-378. *Sankhyā*, **20**, 1958, 329-397. *Experiments in Statistical Sampling in the Indian Statistical Institute*, Asia Publishing House and Statistical Publishing Society. 1961, 9, 70p.
— Sample surveys of crop yields in India. *Sankhya*, **7**, 269-280.
— Traffic census on new Howrah bridge. Submitted to the Government of India, 1946.
— Use of small-size plots in sample surveys for crop yields. *Nature*, **158**, 798-799.
— (WITH MAJUMDAR, D. N., *and* RAO, C.R.). Biometric analysis of anthropological measurements on castes and tribes of the United Provinces. (*Abstr.*) *Proc. Indian Sci. Congr.* (*Bangalore*), *Anthropology & Archaeology*, **33**, Part III, Sec. 8, 138.
— (WITH MUKHERJI, R. K., *and* GHOSE, A.). Sample survey of after-effects of the Bengal famine of 1943. *Sankhyā*, **7**, 337-400. '*Famine and Rehabilitation in Bengal*'. Calcutta Statistical Publishing Society, 1946. 1-63p.
1947. Enquiry into the economics of agricultural labour and rural indebtedness. Submitted to the Government of India, 1947.
— Enquiry into the economics and statistics of road developments. Reports of the traffic and economic surveys conducted at Sherghati, Jehanabad, Bariarpur, Mohania and Toposi. Submitted to the Government of India, 1947.
— On the combination of data from tests conducted at different laboratories. Summary of lecture reported by Tucker, J. (Jr.). *ASTM Bull.*, **144**, 64-66.
1948. Report on tour of Canada, U.S.A. and U.K. October 15 to December 15, 1946. *Sankhyā*, **8**, 403-410.
— Walter A. Shewhart and statistical quality control in India. *Sankhyā*, **9**, 51-60.
1949. Historical note on the D^2 statistic, Appendix 1. Anthropological Survey of United Provinces, 1941: a statistical study. *Sankhyā*, **9**, 237-239.
— Statistical tools in resource appraisal and utilization. UN, 1-14p. *Proc. UN Scientific Conference on the conversion and utilization of resources.* 17 Aug.-6 Sept. 1949, Lake Success, New York. Vol. 1, (Plenary Meetings), 196-200p.
— United Nations. Economic and Social Council. Sub-commission on statistical sampling. Report to the statistical commission on the second session of the sub-commission on statistical sampling (held from 30 August to 11 September 1948) [Chairman: P.C. Mahalanobis] *Sankhyā*, **9**, 377-398.
— (WITH MAJUMDAR, D.N., *and* RAO, C.R.). Anthropometric survey of the United Provinces, 1941: a statistical study. *Sankhyā*, **9**, 90-324.
1950. Age tables based on the *Y*-samples. Submitted to the Government of India, 1950.
— Cost and accuracy of results in sampling and complete enumeration. *Bull. int. Statist. Inst.*, **32** (2), 210-213.
— Survey of economic condition of agricultural labour (1946-47). Submitted to the Government of West Bengal, 1950.
— Survey of rural indebtedness. Final Report: Rural Indebtedness Enquiry, 1946-47. Submitted to the Government of West Bengal, 1950.
— Syllabus for an advanced (Professional) course in Statistical Sampling. *Sankhyā*, **10**, 152-154. [Part of Appendix 'A' of Unesco. Subcommission on statistical sampling. Report on the 3rd session. *Sankhyā*, **10**, 129-158]
— Why Statistics? General Presidential Address, Indian Science Congress, Thirtyseventh Session, Poona. (2 January 1950). *Proc. Indian Sci. Congr.* (*Poona*), **37**, Pt. II, 1-32., *Sankhyā*, **10**, 195-228.
1951. In memoriam. Abraham Wald. *Sankhyā*, **12**, 1-2.
— India. Finance (Ministry of—) Economic Affairs (Dept. of—) National Income Committee. Chairman: P. C. Mahalanobis. First report—1951. 102p.

— Professional training in statistics. *Bull. int. statist. Inst.*, **33** (5), 335-342.
— Means of livelihood and industries tables based on the *Y*-sample. Submitted to the Government of India, 1951.
— Role of mathematical statistics in secondary education. *Bull. int. statist. Inst.*, **33** (5), 323-334.
— (WITH SENGUPTA, J. M.). On the size of sample cuts in crop-cutting experiments in the Indian Statistical Institute, 1939-1950. Appendices A & B. *Bull. int. statist. Inst.*, **33**(3), 359-404.
1952. National income, investment and national development. Lecture delivered at the National Institute of Sciences of India, New Delhi, 4 October 1952. *Talks on Planning*. Asia Publishing House and Statistical Publishing Society, 1961, 9-12p.
— Some aspects of the design of sample surveys. *Sankhyā*, **12**, 1-7.
— Statistical methods in national development. The Thirteenth *Jagadish Chandra Bose Memorial Lecture*, Bose Institute, Calcutta, 30 November, 1951. *Sci. Cult.*, **17**, 497-504.
— National Sample Survey: General Report No. 1 on the first round, October 1950-March 1951. Submitted to the Government of India, 1952. *Sankhyā*, **13**, 47-214.
1953. Some observations on the process of growth of national income, *Sankhyā*, **12**, 307-312.
— (WITH S. B. SEN). On some aspects of the Indian national sample survey. *Bull. int. Statist. Inst.*, **34** (2), 5-14. (Spanish translation: Sobre algunos aspectos de la encuesta nacional de la India por muestras. *Estadistica*, **55**, 260).
1954. Foundations of statistics. *Dialectica*, **8**, 95-111. *Sankhyā*, **18**, 1957, 183-194.
— India. Finance (Ministry of—). Economic Affairs (Department of—). National Income Committee. Final report. [Chairman: P. C. Mahalanobis.], 1954, 173p.
— Report on survey of saver's preference in Delhi State. Submitted to the Ministry of Finance, Government of India, 1954.
— Studies relating to planning for national development. Address delivered on the occasion of inauguration by Prime Minister Jawharlal Nehru of the *Studies relating to Planning for National Development*, at the Indian Statistical Institute, Calcutta, 3 November, 1954. *Talks on Planning*, Asia Publishing House and Statistical Publishing Society, 1961, 13-18.
1955. Approach to planning in India. Based on a talk broadcast from All India Radio, 11 September, 1955. *Talks on Planning*, Asia Publishing House and Statistical Publishing Society, 1961, 47-54.
— Approach of operational research to planning in India. *Sankhyā*, **16**, 3-62, *An Approach of Operational Research to Planning in India*, Asia Publishing House and Statistical Publishing Society, 1963, vi, 168p.
— Draft plan-flame for the Second Five-Year Plan 1956-1961. *Sci. Cult.*, **20**, 619-632.
— Draft plan-frame for Second Five Year Plan. 1956/57-1960/61: recommendations for the formulation of the Second Five Year Plan. Submitted to the Government of India 17 March, 1955. *Sankhyā*, **16**, 63-90. Published as "recommendations for the..... plan" [in] *Talks on Planning*, Asia Publishing House and Statistical Publishing Society, 1961. 19-46p.
1956. Agricultural statistics in relation to planning. Address delivered at the Ninth Annual Meeting of the Indian Society of Agricultural Statistics, 7 January, 1956. *J. Indian Soc. agric. Statist.*, **8**, 5-13.
— The Geological, Mining and Metallurgical Society of India, Calcutta. Address delivered at the Thirty Second Annual General meeting of, 28 September 1956. *Q. J. geol. min. metall. Soc. India*, **28**, 87-88.
— Statistics must have purpose. Presidential address, *Pakistan Statistical Conference*, Lahore, February, 1956.
1957. Some impressions of a visit to China, 17 June-11 July 1957. 35p. [typed].
— Statistics, a survey. (University teaching of social science, No. 7). Prepared and edited on behalf of the International Statistical Institute, The Hague, Paris. UNESCO, 1957. 209p.
1958. *Enfoque de la planeacion en la India. Trim. Econ.*, **25**, 654-663.
— Industrialization of underdeveloped countries—a means to peace. Paper presented at the Third Pugwash Conference at Kitzbuhel-Vienna, Sept. 1958. *Bull. atom. Scient.*, **15** (1), 1959, 12-17, 46. *Sankhya*, **22**, 1960, 173-180; *Talks on Planning*. Asia Publishing House and Statistical Publishing Society, 1961. 125-136 (with appendix).
— Industrializatsiya—klyuch kukrepleniyu nezavisimosti. (Industrialization—a key to the consolidation of independence), *Sovremennyi Vostok* (Contemporary East), No. **12**, 15-18.
— Method of fractile graphical analysis with some surmises of results. *Trans. Bose Res. Inst.*, **22**, 223-230.
— Relaxation of tensions through industrialization of the underdeveloped countries (Mimeograph) Kitzbuhel-Vienna Conference of Scientists, Sept. 1958.
— Science and national planning. Anniversary address delivered at the National Institute of Science of India, Madras, 5 January, 1958. *Sankhya*, **20**, 69-106. *Talks on Planning*.

Asia Publishing House and Statistical Publishing Society, 55-92. *Sci. Cult.*, **23,** 396-410.
— Some observations on the 1960 world census of agriculture. *Bull. int. statist. Inst.*, **36** (4), 214-221, (Spanish translation: "Algunas observaciones sobre el censo agropecnario mundial de 1960", *Estadistica*, March 1960, 11-31).
1959. *Heralding a new epoch.* [in] *A Study of Nehru*: (Ed. Rafiq Zakaria) 1959, 309-320. *Talks on Planning*, Asia Publishing House and Statistical Publishing Society, 1961, 1-8p.
— Izuchenie problem industrializatii slaborazvitikh stran. (Study of the problems of industrialization in the underdeveloped countries). *Sovremennyi Vostok* (Contemporary East), No. **9.** English translation in *Talks on Planning*, Asia Publishing House and Statistical Publishing Society, 1961, 137-142p.
— Need of scientific and technical man-power for economic development. Based on a talk broadcast from All India Radio, 23 September 1959. *Talks on Planning*. Asia Publishing House and Statistical Publishing Society, 1961, 143-146.
— Next steps in planning. Anniversary address, delivered at the National Institute of Sciences of India, New Delhi, 20 January 1959. *Sankhya*, **22,** 1960, 143-172; *Talks on Planning*. Asia Publishing House and Statistical Publishing Society, 1961, 1-8.
— Problems of economic development in India and other underdeveloped countries in relation to world affairs. *Bulletin of the International House of Japan*, **3,** 10-15.
— Review of recent developments in the organisation of science in India. Presented at the 6th General Assembly and Scientific symposium held under the auspices of the World Federation of Scientific Workers, Warsaw, 1959. *Vijnan Karmee*, **11,** 13-27.
— Unemployment and underemployment. Address delivered as the Sectional Chairman of the Second All India Labour Economics Conference, Agra, January 1959, *Indian J. Labour Econ.*, **2,** 39-45. *Talks on Planning*. Asia Publishing House and Statistical Publishing Society, 1961, 147-152. Also *TP*-1961.
— (With Das Gupta, A.). The use of sample surveys in demographic studies in India. *UN World Population Conference, Rome*, 1954. E/Conf. 13/418, **VI**, 363-384.
1960. Economic development of Afro-Asian countries. (Prepared for Bandung Conference, April 1955). Appendix to 'Industrialization of underdeveloped countries—a means to peace' by P.C. Mahalanobis. *Sankhya*, **22,** 181-182.
— Incentives and scientific and technical personnel. *Dainik Samachar*, 1960.
— Labour problems in a mixed economy. Presidential address delivered at the Third All India Labour Economics Conference, Madras, 2 January 1960. *Indian J. Labour Econ.*, **3,** 1-8. *Talks on Planning*. Asia Publishing House and Statistical Publishing Society, 1961, 153-159.
— Method of fractile graphical analysis. *Econometrica*, **28,** 325-351. *Sankhya*, 23-A, 41-64.
— Note on problems of scientific personnel. Draft recommendations placed before the Scientific Personnel Committee, 24 March, 1960. *Sci. Cult.*, **27,** 40-128.
— On the use of the fractile graphical method for analysis of economic data. (*Abstr*). *Proc. Indian Sci. Congr.* (*Bombay*), *Sec. Statistics*, **47,** Pt. III, Sec. II, 23].
— Perspective planning Address delivered at the Third Session of the SEANZA Central Banking Course in Bombay.
— Scientific workers in the UK, USA, and USSR. *Sci. Cult.*, **26,** 101-110.
— (With Lahiri, D. B.). Analysis of errors in censuses and surveys with special reference to experience in India. *Bull. int. Statist. Inst.*, **38** (2), 1960, 409-433. *Sankhya*, **23A,** 1961, 325-358.
— Preliminary note on the consumption of cereals in India. (With 4 appendices). *Bull. int. Statist. Inst.*, **39**(4), 53-76. *Sankhya*, **25B,** 1963, 217-236.
— (With Mukherjee, M.). Operational research models used for planning in India. Presented at the Second Operational Research International Congress, September, 1960.
1961. Role of science in economic and national development. Lecture delivered at the University of Sofia, 4 December, 1961. *Indian J. Public Admn.*, **8,** 153-160.
— Statistics for economic development. *J. O. R. Soc. Japan*, **3,** 97-112. *Sankhya*, **27B,** 1965, 179-188.
— '*Talks on Planning*' (collected addresses and broadcasts on various aspects of planning in India). Asia Planning House and Statistical Publishing Society. (Studies relating to Planning for National Development, No. 6). (Indian Statistical Series No. 14) iv, 159p.
1962. Scientific base on economic development. Presented at the Conference for *International Cooperation and Partnership*, Salzburg-Vienna, 1-7 July, 1962. *Sankhya*, **25B,** 1963, 55-56.
1963. First convocation of the Indian Statistical Institute—Section II Review of the Director by P. C. Mahalanobis. *Sci. Cult.*, **28,** 92-97.
— Introducing volume twenty-five. *Sankhya*, **25A,** 1-4 and **25B,** 1-4. Corrigenda 427.
— Need of a standard terminology for classification of different types of research. *Sci. Cult.*, **29,** 224-225.
— A preliminary note on the consumption of cereals in India. *Bull. int. Statist. Inst.*, **39**(4), 53-76. *Sankhya*, **25B,** 217-236.

— Recent developments in the organization of science in India. *Sankhya*, **25B,** 67-84. Corrigenda 426.
— Social transformation for national development. *Sankhya*, **25B**, 49-57. Corrigenda 426.
— Some personal memories of R.A. Fisher. *Sankhya*. **25A,** 1-4. *Biomet.*, **20,** 1964, 368-371.
— (WITH SOM, R. K., *and* MUKHERJEE, H.). Analysis of variance of demographic variables. (Note by the Editor, P. C. Mahalanobis). *Sankhya*, **24B,** 21-22.
— Problems of internal transformation. Presented at the Conference for International Co-operation and Partnership, Salzburg-Vienna, July, 1962.
— Statistical tools and techniques in perspective planning in India. *Bull. int. statist. Inst.*, **40**(1), 152-169, *Sankhya*, **26B** 29-44.
1964. India, Planning Commission. Report of the committee on distribution of income and levels of living. Chairman: P. C. Mahalanobis, Part I: Distribution of Income and Wealth and concentration of economic power, 1964. 107p.
— Objects of science education in underdeveloped countries. (The Commonwealth Conference on the teaching of science in schools, Colombo, December 1963). *Sankhya*, **26B,** 253-256. [slightly altered title] "The aims of science teaching in schools-science education in underdeveloped countries" in Commonwealth Education committee: Schoolscience teaching-report of an expert conference held at the University of Ceylon, Paradeniya. Appendix II (ii), 28-31.
— Perspective planning in India: statistical tools. *Coexistence*, 1964, May, 60-73.
— Priorities in science in underdeveloped countries. (The *Twelfth Pugwash Conference*, Udaipur, January 27-February 1) 181-193, *Sankhya*, **26B,** 45-52.
1965. Some concepts of sample surveys in demographic investigations. Presented at the U.N. World Population Conference, Belgrade, August-September, 1965. Vol. **III,** 246-250. [Reprinted with changes] *Sankhya*, **28B,** 1966, 199-204.
— Statistics as a key technology. *Am. Statist.*, **19**(2), 43-46.
— Use of capital output ratio in planning in developing countries. Proc. 35th Session, International Statistical Institute, Belgrade, September 1965. *Bull. int. statist. Inst.*, **41**(1), 87-95. *Sankhya*, **29B,** 249-256.
1966. Extensions of fractile graphical analysis to higher dimensional data. RTS Technical Report No. 7/66, February 1966, 1-13. (mimeographed). *Essays in Probability and Statistics* (S. N. Roy Memorial Volume). Calcutta, Statistical Publishing Society, 1969. 397-406p.
— Objectives of science and technology. Presented before the Symposium on Collaboration between the Countries of Africa and Asia for the Promotion and Utilization of Science and Technology, New Delhi, April-May, 1966. *Seminar*, **82,** 38-43.
— Some concepts of sample surveys in demographic investigations. *Sankhya*, **28B,** 199-204.
1967. Quality control for economic growth. *Sankhya*, **29B,** 191-200. (Inaugural address. 4th All India Conference on Statistical Quality Control, Madras. 7-9 December 1967). *Tech. Report* No. 41/69.
— Royal Society Conference on Commonwealth Scientists. *Sci. Cult.*, **33,** 149-153.
1969. The Asian Drama: an Indian review. *Sankhya*, **31B,** 435-458. Shorter Review in *Scient. Am.*, **221**(1), 1969 July, 128-134. Longer version *Econ. Pol. Weekly*, **4**(28)/30); Special Number, July 1969; 1119-1132. July 1969.
— Basic problems of design of sample surveys. International Conference on Computer Science organized by the Institute of Statistical Studies and Research, Cairo University, December 1969.
— Extensions of fractile graphical analysis. *Proc. int. Conf. Quality Control*, Tokyo, *ICQC*, 1969, 515-518.
— (WITH BHATTACHARYYA, D. P.). Growth of population of India and Pakistan: 1800-1961. General Congress, 1969, International Union for Scientific Study of Population, London. Tech. Report No. Demo/6/69.
— India. Planning Commission. Report of the Committee on distribution of income and levels of living. [Chairman: P. C. Mahalanobis.] Part II: Changes in levels of living. 1969. 114p.
— (WITH BOSE, R. C. *et al.*). (Eds.). Essays in probability and statistics. Calcutta Statistical Publishing Society, 1969.
1970. Social change, science and economic growth. One Asia Assembly on New Directions for Asia organised by Press Foundation of Asia, Manila, Philippines, April, 1970.
— (WITH LAHIRI, D. B. *et al.*). Technical aspects of design, National Sample Survey. RTS publications: mimeograph series. 226p.
1971. Some observations on recent developments in sample surveys. Proc. 38th Session (Washington). *Bull. int. statist. Inst.*, **44** (1), 247-261. Discussion 262-268.