INDIAN STATISTICAL INSTITUTE

FIFTYSIXTH ANNUAL REPORT
April 1987—March 1988

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0. INTRODUCTION[1]

The financial problems which had plagued the Institute throughout 1986-87 were solved to some extent in the current year. This was possible because the Government took a realistic and sympathetic view of the Institute's essential requirements and was guided by this in the approval and prompt release of grants. This did not mean the Institute could take up all the projects that had been found interesting. Indeed it was still necessary to be very careful in the choice of projects, and cautious in all matters of expenditure. But the financial crisis that had seemed inevitable earlier was averted.

The following paragraphs contain a brief description of the major events, achievements and prospects. Details will be available in the subsequent chapters.

For some time a Review Committee appointed by the Academic Council had been examining the Institute's B.Stat and M.Stat programmes. The current B.Stat programme has been functioning since 1978 when it underwent a major revision from the original Mahalanobis-Haldane plan. The current M.Stat programme was introduced in 1981. After a very thorough study, the Review Committee has submitted a comprehensive report containing several major recommendations to make these programmes more unified and relevant for our times and our country. The recommendations, which have been accepted by the Academic Council, will be placed before the Council for final decision[2]. In this connection it may be mentioned that the stipends of the B.Stat and M.Stat students, which had been stagnating for quite sometime, will be substantially enhanced from the next financial year. During the year under review a total of about 4000 candidates appeared for admission tests. Of them about 270 candidates were selected for admission to the various courses of the Institute.

The International Statistical Education Centre (ISEC) is operated jointly by the International Statistical Institute and the Indian Statistical Institute under the auspices of the UNESCO and the Government of India. During the year under review, the centre had conducted its regular course of the 41st term with 26 trainees from 13 different countries in South and South-East Asia, the Middle East, the Far East and Africa. Recently a number of new special courses have been started. Two trainees from Maldives and one from India attended a two month course in Advanced Data Processing. A course in Statistical Quality Control and Operations Research was given to ISEC trainees at the Bangalore Centre for the first time.

Professor S. K. Mitra was the President of the Statistics Section of the Indian Science Congress Association which met in Pune from 23 December 1987 to 15 January,

[1] Based on the Annual Review presented by the Director at the twentysecond convocation of the Institute held on 14 January, 1988.

[2] The Council subsequently accepted the recommendations on 5 April, 1988.

1988 celebrating its Platinum Jubilee. This was a fitting recognition of a distinguished scientist in the Institute. To celebrate its Platinum Jubilee, the Indian Science Congress Association organised two Platinum Jubilee lectures in each subject. It is gratifying to note that these lectures in statistics were delivered by National Professor C. R. Rao who remains closely associated with the Institute and Professor S. R. S. Varadhan, a distinguished probabilist and a former student of the Institute.

The Institute hosted in Bangalore the Silver Jubilee Conference of the Indian Econometric Society, with which the Institute has very close links. Shri Ramkrishna Hegde, Chief Minister of Karnataka, inaugurated the conference. The conference was organised by the Institute's Economic Analysis Unit in Bangalore under the leadership of Professor N. S. Iyengar and Professor P. R. Brahmananda. It may be recalled that Professor C. R. Rao and Professor P. C. Mahalanobis, along with others, were instrumental in setting up this society and the first Indian Econometric Conference was held in the Institute in Calcutta.

The Third Series of Mahalanobis Memorial Lectures on Modelling and Asymptotic theory was delivered by Sir David Cox, FRS, of Imperial College of Science and Technology, London.

During the year, the Institute held a Summer School on Statistics which was attended by participants from all over India.

In the area of publication, the Institute has undertaken to bring out Professor Rao's selected works in several volumes. Work for the first volume has began. In this connection it may be mentioned that Professor J. K. Ghosh recently edited a selection of Professor D. Basu's seminal papers on the problems of foundations of statistical inference which has been accepted for publication by Springer-Verlag. The proceedings of the International Conference on Multivariate Analysis has been brought out. The Institute's journal $Sankhy\bar{a}$ brought out its fiftieth volume, to be completed by December, 1988.

A lovely result was discovered this year by Mr. B. Rajeev and Professor B.V. Rao. There is a famous theorem due to Paul Lévy that if $\{X_t\}$ as well as $\{X_t^2\}$ is a martingale and $\{X_t\}$ is continuous then $\{X_t\}$ must be the Brownian motion. Professor K. R. Parthasarathy had asked if the same result is true if $\{X_t\}$ and $\{X_t^2 - t\}$ are replaced by a pair of Hermite polynomials and one requires that these polynomials be martingales. Rajeev and Rao show the answer is essentially yes.

As announced last year, a Nodal Centre for a Fifth Generation Knowledge-Based Computer Systems (FGCS/KBCS) in the fields of Pattern Recognition, Computer Vision, Image Processing and Artificial Intelligence has been established in the Institute, all financial support coming from the Department of Electronics. Professor D. Dutta Majumder is the co-ordinator for this Centre. Steps were taken to make this unit fully functional and involve the Institute's statisticians, mathematicians and economists in these projects so that they work on problems of common interest within the broad framework of agreement between the Institute and the Department of Electronics.

The Institute has undertaken the task of developing a microcomputer-based software package for pre-tabulation editing and validation of NSSO survey data. To

make the package user-friendly, particularly for the convenience of subject-matter specialists who design the validation checks for data, it was decided that facilities should be provided in the package so that the validation checks may be specified in an English-like natural language. A suitable language has been designed for this purpose and extensive testing on the suitability of the language for specifying the validation checks used by NSSO is now completed. The software for translating the specifications written in this language has been developed. The final phase of the work involving software for actual validation of individual schedules is under progress and expected to be completed shortly.

The ONGC project for modelling discovery of oil and optimising investment is nearly complete. An important problem on which some discussion is going on between our statisticians and economists, and the specialists in the Reserve Bank of India is that of estimating the volume of demand of currencies of different denominations. In an exciting new project the Geological Studies Unit tries to establish a new hypothesis about the sudden extinction of the dinosaurs.

Construction of the last three floors of the Library Building in Calcutta was completed. Construction of the Senior Students' Hostel has been progressing smoothly according to schedule. The new office building and staff quarters at Hyderabad have been completed and started functioning. Work on an additional floor of the guest house at Delhi has been progressing satisfactorily. The hostel building at the new campus of Bangalore Centre has been completed and has started functioning well. The SQC Unit has also been shifted to the new campus. The need for a new guest house and some more staff quarters at Calcutta for staff of all categories has been felt by the Institute since long. The Government has been requested to provide funds for these items of construction, which is yet to be approved.

1. TEACHING AND TRAINING

Degree and Training Courses

During the period under review, 6760 candidates applied for admission and were called for written selection tests for the following courses of the Institute : B.Stat. (Hons.), M.Stat. (M-stream and S-stream), M.Tech., One-year Post-Graduate Diploma in SQC and OR, Two-year Part Time Post-Graduate Diploma in SQC and OR (Bombay and Madras), Research Fellowships in Statistics, Mathematics, Economics, Theoretical Physics, Physics and Geology, One Year Evening Course in Statistical Methods and Applications and the course on Operation of Automatic Data Processing Equipment. Admission tests were conducted at 12 Centres all over the country. A total of 3799 candidates appeared for admission tests. Five foreign applicants who applied directly for admission to our courses were given admission tests conducted through the Indian High Commission or Embassies of France, Sri Lanka and Bahrain. In all 520 candidates were called for interviews and 271 candidates offered admission to various courses during the academic session 1987-88.

The annual examinations for the B.Stat. and M.Stat. courses were held in May/ June 1987. The 1987-88 academic session commenced on 6 July, 1987.

Eightyeight candidates received their degrees and diplomas at the Twenty-second Convocation of the Institute held on 14 January, 1988. One hundred candidates who passed the various regular courses of varying duration (one-year or less) received the certificates during the year. Four candidates of the Institute were awarded the Ph.D. degree of the Indian Statistical Institute.

Three trainees in Engineering from Banaras Hindu University and two trainees from Jadavpur University received six-week practical training in the Electronics and Communication Sciences Unit and the Electronics Unit respectively.

One Egyptian scholar had been undergoing advanced training in Statistics and Mathematics at the Institute, under the Indo-ARE Cultural Exchange Programme of the Government of India. One candidate from Sri Lanka admitted in the First Year of the 2-year M.Stat. degree course during the period. One Soviet Scholar has been pursuing a research programme at the Institute under the Indo-Soviet Cultural Exchange Programme of the Government of India.

The number of candidates admitted to the different degree, diploma and training courses during 1986-87 and 1987-88 and the results of the examination, held during the period are given in the following page :

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NUMBER OF STUDENTS ADMITTED AND PASSED IN DIFFERENT COURSES

APRIL, 1987—MARCH, 1988

Courses	Number of Students			
	Enrolled in 1986-87	As on November 1986	Number passed in annual examination in 1987	Enrolled in 1987-88
	(1)	(2)	(3)	(4)
1. *Courses leading to a Degree in Statistics*				
1.1 Bachelor of Statistics with Honours B. Stat. (Hons.)				
1st year	32	14	12	25
2nd year	17	17	16	12
3rd year	12	12	12	16
1.2 Master of Statistics (M. Stat)				
1st year (M-stream)	18	14	7	17
2nd year (S-stream)	28	28	15	44
1.3 Junior and Senior Research Fellows, Visiting Fellows*	80	80	—	95
2. Specialised Courses in Applied Statistics leading to Diplomas				
2.1 Statistical Quality Control and Operations Research (One-year)	16	16	7	10
3. Courses in Statistics for Persons in Employment (jointly with C.S.O.)				
3.1 Junior Certificate Course in Statistics	12	12	12	9
3.2 Indian Statistical Service Probationers' Training Courses	18	18	18	16
4. *Evening Course*				
4.1 Statistical Methods and Applications Calcutta	37	37	9	35
4.2 Two year Post-Graduate Diploma in Statistical Quality Control and Operations Research (Bombay and Madras)				
Bombay —1st year	7	7	2	5
2nd year	—	—	—	3
Madras —1st year	6	6	4	7
2nd year	10	10	7	5
4.3 Six-months Evening Course in Statistical Quality Control (Bangalore and Hyderabad)				
Bangalore —July-December 1986	25	25	14	—
January-June 1987	13	13	—	—
July-December 1987	20	20	—	—
Hyderabad—July-December 1986	18	18	3	—
January-June 1987	10	10	—	—
5. *Computer Courses*				
5.1 M. Tech. in Computer Science —1st year	16	16	14	21
2nd year	8	8	8	14
5.2 M. Tech. by Dissertation	—	—	1	—
5.3 Intensive Course on Programming and Applications	28	28	28	28
5.4 Course on Operation of Automatic Data Processing Equipment —1st year	14	14	10	13
2nd year	10	10	—	14
6. Associateship in Documentation and Information Science —1st year	8	8	5	6
2nd year	5	5	19**	8
Grand Total	468	446	223	403***

*In the following areas : Statistics, Mathematics, Economics, Theoretical Physics, Communication Sciences, Anthropometry and Human Genetics, Computer Science, Embryology, Geology, Biometry, Chemistry, Physics, Leaf Protein and 2 CSIR Fellowships in Theoretical Physics. The figure includes 16 Research Fellows and Associates at Delhi Centre and 4 at Bangalore Centre.

**Including number passed in 1987, but belonging to previous years' batches.

***This figure includes 101 who joined 1st year of the Courses during the session 1987-88.

INDIAN STATISTICAL INSTITUTE

International Statistical Education Centre (ISEC), Calcutta

A brief report on activities of the International Statistical Education Centre during the year 1987-88 is presented below :

It may be recalled that the Centre was opened in 1950, and is operated jointly by the International Statistical Institute and the Indian Statistical Institute, under the auspices of the UNESCO and the Government of India. The Centre functions under a joint Board of Directors. The Directors represent International Statistical Institute, Indian Statistical Institute and the Government of India. Professor P. C. Mahalanobis was the Chairman of the Board of Directors since its inception in 1950 until his death in 1972. Since then National Professor C. R. Rao has been the Chairman of the Board.

The Centre provides training in Theoretical and Applied Statistics at various level to selected participants from the countries in the Middle-East, South and South-East Asia, the Far East and the Commonwealth countries in Africa, sponsored by respective Governments. The major training programme of the Centre is a 10-month Regular Course. In addition, Special Courses of varying duration are also organised. Facilities exist for research work and advanced study by senior statisticians from abroad. Since inception, the Centre has provided training to 1085 trainees from 52 countries.

Three trainees of the 40th Term and one trainee from an earlier Term attended Spiecal Courses of two to three months duration. One of them in Demography and three in Advanced Data Processing ; one of them enjoyed SCAAP fellowship, two Colombo Plan fellowship and the other was supported by her Spensor.

A total of 50 candidates from 24 different countries were nominated by respective Governments for admission to the 41st Term of the Regular Course of this Centre. Of these 50 candidates, 35 were offered admission and 26 participants from 13 countries joined. Twenty trainees were supported by fellowships awarded by the Government of India under the Technical Cooperation Scheme of the Colombo Plan, Special Commonwealth African Assistance Plan, and Indian Technical and Economic Co-operation scheme. Of the remaining 6, two enjoyed fellowship by the Commonwealth Fund for Technical Cooperation, Commonwealth Secretariat, London. 4 received support from respective employers and Governments.

Fiftyfive teachers of Calcutta, Bangalore and Delhi Centres of the Indian Statistical Institute and 36 Officers of the Government of India participated in teaching the Regular Course during the year. In addition Visiting Professor Dr. Y. Fujino from Japan taught at the Centre. It should be specially mentioned that out of 26 trainees, 9 trainees went to Bangalore Centre of ISI to undergo specialization in SQC and OR and 3 trainees to Delhi Centre to undergo specialization in Economic Planning.

All the Special Course trainees completed their training programme successfully. All the 26 Regular Course trainees have been recommended for the award of Statistical Training Diploma.

Members of the Board of Directors continue to show their interest in ISEC Teaching programme. Professor J. K. Ghosh, Director of the Indian Statistical Institute lent his constant guidance and maintained active interest in smooth functioning of the Centre.

Professional Examinations in Statistics

During the period under report, the Statistical Assistantship Certificate, Junior Diploma in Statistics and Senior Diploma in Statistics Examinations were held at Bangalore, Bombay, Calcutta, Delhi, Hyderabad, Lucknow and Madras Centres during April 1987 and October 1987 terms respectively.

The total number of candidates who registered, appeared for examination and their results for April 1987 and October 1987 terms are given below :

Examination	Number of candidates					
	Registered		Appeared		Passed*	
	April	October	April	October	April	October
1. Statistical Assistantship Certificate	28	38	19	21	5	2
2. Junior Diploma in Statistics	26	31	10	17	2	7
3. Senior Diploma in Statistics	14	9	10	8	4	2

*Passed in one or more papers only—not necessarily completed the examination.

The total number of candidates who have qualified for the award of the Certificates and Diplomas in the Professional Examinations in Statistics including the results of October 1987 term are 479 and 243 respectively.

2. RESEARCH WORK

A brief account of the progress of research in different divisions and units of the Institute is given below :

Theoretical Statistics and Mathematics

Calcutta

The Division has the major part of the responsibility of teaching theoretical statistics and mathematics in the B.Stat., M.Stat., and other courses of the Institute. The Division also conducts a course, lasting 12-18 months, at an advanced level for research scholars enrolled for the Ph.D. degree of the Institute.

Nature and description of work done during the current year :

1. *Probability Theory and Stochastic Processes :* Various relations between sojourn times and crossings of martingales were obtained. The study of the associated local times is in progress. Levy's characterization of Brownian motion was extended using Hermite polynomials. A detailed analysis of Markovian motions of a particle with velocities either zero or one, with the restriction that in any compact time interval there are only finitely many velocity changes, was undertaken.

The use of Chernoff-type inequalities in the characterisation of uniform distributions was discussed.

2. *Inference :* A simple formula for the power difference in the one parameter case for the third order comparison of tests was given. The problems of bounded risk estimation of the sample mean and efficient estimation in presence of many nuisance parameters were studied in detail. Rao's test was further considered and a second order maximum property was obtained. For circular data, correlation and regression were discussed. A stochastic representation of the logarithm of P-value was obtained.

3. *Design and Analysis of Experiments :* Kronecker factorial designs and optimal weighing designs were further considered. Universal optimality criteria of main effect deletion designs were obtained and partially-efficient, balanced designs were studied further. Geometric construction of variance balanced designs was given.

4. *Multivariate Analysis :* The problem of pattern recognition when training samples are subject to error was considered. Characterisation of joint distribution of random variates, sum of whose squares is a chi-square, was obtained. An elementary proof of multidimensional Polya's theorem was given. A new condition called "uniform integrability in the Cesaro sense" was introduced and used to obtain several generalisations of Khinchin's WLLN.

5. *Sample Surveys :* The problem of estimation of Lorenz ratio for a finite population was discussed. Domain estimation as well as small area estimation were considered during the period under review. Utilisation of auxiliary information in transformation of data, double sampling and for comparison of sampling strategies was further discussed. Certain properties of the sample mean over distinct units in SRSWR were obtained. The use of multiple auxiliary information for general sampling design was also considered.

6. *Combinatorics, Group Theory and Graph Theory :* Even order miquelian inversive planes were characterised and intersection pattern of classical ovoids in symplectic space determined.

Totally supercompact graphs were studied as also the extreme points of the convex set generated by potentially P-graphic and forcibly P-graphic degree sequences for various invariant properties P of graphs and digraphs. The study of reciprocity in stratified social networks continued.

7. *Descriptive Set Theory :* The relation between the Borel hierarchies of the countable product of Polish spaces (equipped with the product of discrete topologies

and also with the product of the copies of the Polish topology)was completely established. Interest in complexity theory led to several seminars in the division and these are likely to continue.

8. *Analysis, Geometry and Topology :* Research was carried out in Harmonic Analysis in Euclidean spaces and on Ergodic Transformations. In Banach Space Theory, stability properties of spaces with Mazur's intersection property were examined and it is proposed to continue this investigation. Work on the theory dispersion culminated in the publication of two papers on the dispersion of a contaminant in oscillatory flows. In algebraic and differential topology, some work was done on four dimensional topological bordism and the classification of locally stable sections of some fibre bundles satisfying certain differential inequalities.

Bangalore

The faculty of this Unit took part in the teaching of the following M.Stat. courses : Statistical Inference, Applied Stochastic Processes, Probability, Analysis, Numerical Analysis, Sample Surveys, Statistical Methods.

Research was carried out in the following areas : Probability theory—Large deviations theory, Urn models, Semi-stable measures and processes, Diffusion processes. Statistics—Sample Surveys, Large sample theory, Bayesian inference, Reliability theory. Mathematics—Functional analysis, Geometry of Banach spaces, Operator algebras, Operator Theory, Harmonic analysis, Differential geometric methods in mathematical physics.

Delhi

The broad areas of research in which the faculty members of the unit have worked are : Probability Theory and Stochastic Processes, Quantum Probability, Functional Analysis, Linear Algebra and its applications, Mathematical Statistics, Game Theory.

An examination of the list of publications, given later, will show the specific topics in which significant results were obtained but in brief summary these are : characteristic functions, functional equations in probability theory, limit theorems in finitely additive probabilities, quantum stochastic calculus, spectral theory of Schrodinger operators, applications of geometric, topological and functional-analytic methods to perturbations of eigen values, matrix inequalities, order statistics for non-identical variables, partial order induced by generalized inverses of matrices, existence of stationary equilibrium strategies in certain stochastic games.

From the work on Quantum Stochastic Calculus, special mention is made on the following : (a) Using cohomological ideas a whole class of association algebras has been constructed with the help of functions of brownian motion. This answers several questions raised by P. A. Meyer in his Strasbourg seminars. Furthermore 'his leads to the construction of a family of quantum fields constituting a bridge between boson and fermion fields ; (b) realisation of arbitrary correlation functions for quantum spin observables has been achieved, (c) from a philosophical point of view the idea of a Bernoulli trial in quantum probability has been clarified and (d) a remarkable class

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of classical martingales has been constructed through quantum stochastic calculus with inspiration derived from a recent lecture by P. A. Meyer.

Applied Statistics, Surveys and Computing

The Applied Statistics, Surveys and Computing Division consists of two units : The Computer Science Unit and Biometry Research Unit. Research activities in the Division include both theoretical investigation of methodology and application of existing methods to the solution of practical real-life problems. The scope of the Divisional research work is broadly in the areas of applied statistics,computer escience and biometry. In addition the Computer Science Unit has the responsibility of management of Institute's in-house Computer system.

(A) Research activities in Computer Science Unit

Sample survey : Studies on optimal strategies and randomized response technique have been continued. Results have been obtained regarding the problem of taking simple random samples of varying sample sizes in a number of replicates showing how efficiency may be gained in choosing the replicates without replacement but efficiency is lost relative to a comparable single sample drawn according to simple random sampling without replacement if replicates are taken with replacement. A simple condition connecting the sample size, size measures and the sampling interval has been reported in case of circular systematic sampling with varying probabilities. The condition is important in noting limitations on sample sizes when a sampling interval is pre-assigned.

Certain required modifications of available procedures have been identified when quantitative randomised responses are obtained as linear functions of true values with random co-efficients. A super-population model has been identified yielding the expected exact mean square error of the ratio estimator for SRSWOR less than that based on Midzuno Scheme.

The problems of estimation of variance in multistage sampling have been studied. The optimal strategies for estimation of population total in two-stage stratified sampling have been found under different super-population models. An optimal estimator of finite population variance under a class of super-population models has also been developed. Some minimax properties of an otherwise optimal strategy for estimation of finite population total under a class of transformation models have also been investigated.

In the area of life testing, estimation and testing procedures based on a single order statistic have been found as effective competitors for those based on comparable censored data. Asymptotic distribution and power of an ANOVA test based on two-sided censored data from several weibull populations with a common shape have been studied, a characterization of the weibull distributions having been obtained. Two procedures have been investigated to test the equality of two exponentials with a known common co-efficient of variation.

Empirical studies in sample survey have confirmed through a number of socially significant projects like TV Viewership Survey, Survival History of Cancer Patients, Domestic Tourist Survey in Orissa.

Design of Experiments and Combinatorics : The major trust of research in Design of Experiments has been in the study of optimality in construction of designs. The important work includes study of optimality in the presence of two-factor interactions among nuisance factors and study on a class of row-column designs proved to be optimal with regard to a wide class of optimality criteria. A method of construction for Steiners—2 designs has been developed which gives rise to a large number of new designs. One design among them is of special importance as this belongs to a series (called unitals) all the existing members of which are constructed by a different method and those methods cannot be used for constructing this one.

In combinatorics, studies were undertaken on error-correcting code over a binary alphabet, in particular, the classification of 1-error correcting perfect codes. A class of single-error-correcting, non-linear, perfect binary codes was constructed. The question of determining the class of single-error-correcting perfect codes has been open for several decades.

Multivariate Analysis, Reliability, Inference : Studies in the following areas have resulted in important findings : Optimal tests and efficient estimation in mixture families ; improved estimation of the parameters in the intra class multivariate normal model with results proving the inadmissibility of the usual estimators ; inadmissibility of usual estimators with a distribution having a linear combination of two independent chi-square variables with applications to MINQUE es imator of the intraclass correlation co-efficient.

A new iterative algorithm called Q—procedure has been developed to solve the likelihood equation, arising in the analysis of covariance structures (ACOVS). The procedure helps in obtaining the m.l. estimates of the k parameters of the population variance covariance matrix without inverting Σ. It does not also require the second-order derivatives of the maximizing function. Some algebraic aspects and a few points of superiority of Q —procedure over Anderson's (1973) procedure have been demonstrated in the light of their invariance property. A computer programme in Fortran has also been written to implement the proposed algorithm. The algorithm seems to have the advantage of rapid convergence and of robustness against bad starting values. Published data from the field of psychometry and biometry have been analyzed using the programme to test various structural hypotheses on the pattern of Σ.

Two new measures of goodness-of-fit have been proposed which are useful for testing and fitting a certain structural model on the population covariance matrix Σ that prescribes equality or lack of any relations between the elements of Σ. Certain distinctive features of these proposed indices have been derived algebraically and the efficiency of the proposed measures have been demonstrated vis-a-vis a few measures of goodness of fit which are currently available for analysis of covariance structures (ACOVS). For all covariance matrices with linear structures, a necessary and sufficient condition has been established for the OLSE to the equivalent to GLSE. and MLE.

A new two-stage test of significance has been developed for testing the H_0 that the population dispersion matrix Σ is a symmetric positive definite Toeplitz covariance matrix. The usefulness of the proposed test in analyzing different types of longitudinal or time-series data in which the disturbance terms are expected to generate a Laurent type of autocorrelation matrix has been demonstrated with real-life data.

Psychometry : Using the techniques of analysis of covariance structures, a simple procedure has been developed for testing the independence, if any, between item-content and acquiescence (agreeing response tendency) in self-administered questionnaires and/or personality inventories. The superiority of this procedure over the existing methods has been demonstrated with published data based on MMPI Hysteria and paranoid scales.

The invariance of the scale values and the test-retest reliability of a unidimensional measure of altitudes toward air pollution have been examined. The investigation demonstrates the advantages of the proposed attitudinal measure in studying certain psychological aspects of air pollution.

Econometrics : A general index of growth has been obtained from a set of axioms which can be used to construct a growth index for signle-valued time series data. Unbiased estimates of Lorentz ratio and unbiased estimates for its variance have been obtained for a finite population. Estimates of parameters in a domain were obtained with and without auxiliary information. It was used to find an unbiased estimate of poverty index.

Biostatistics : *Anthropmetry, Human Genetics* : Research is continuing on statistical tests for detecting non-random segregation of alleles from parents to offspring in the context of detection of linkage between a disease locus and marker locus. Work is going on to find the effects of such variables as education, occupation, smoking and dietary habits on blood pressure.

It is acknowledged that research in this area is undertaken in collaboration with the Institute's Biological Sciences Division.

Pattern Recognition and Image Processing : Investigations have been continuing in the area of pattern recognition with imperfect teachers. Some new and more realistic models for supervisor imperfection have been tried out ; methods of estimation of parameters including the EM algorithm have been worked out and efficiencies of such supervision are being compared. These developments have applications in practical problems of pattern recognition in the area of medical diagnosis and remote sensing. The EM algorithm has been used to estimate the gene frequencies for the OAB blood group system. This method is a simpler alternative to maximum likelihood estimation by scoring method given in text books. This idea is applicable to a variety of problems in genetics.

In the area of image processing, some algorithms for image segmentation have been developed. Some of these algorithms are based on psycho-visual phenomenon and some on a new definition of entropy which does not possess some undesirable properties of Shanon's entropy.

Parallel Processing, Fault-tolerant Computing : Design of an adaptable pipeline based on transputers has been proposed. An important work in Fault-tolerant computing is the design of a fault-tolerant pipeline processor in which operation continues uninterrupted even when a segment of the pipeline fails. Some new findings have been obtained which may be utilized for acceleration of system diagnosis algorithms.

Software Design and Development : The applied statisticians and the software specialists of the Division have successfully collaborated in developing a software package for editing NSSO survey data. The package is designed so that specification of the edit requirements may be made in an English-like language requiring no knowledge of computer programming. The package is now being tested with live NSSO data.

The division is also engaged in developing a microcomputer-based statistical package which should meet the data analysis requirements of biologists, hydrologists and environmental scientists.

(B) Research Activities of Biometry Research Unit

Analysis of Biochemical results on the onset of diabetes from etiological point of view indicate some geographical variation of immunoglobin (M) particles of serum of diabetic people located with oral anti-diabetic drugs for a short period. This may raise serious doubts about the long-standing hypothesis that natural immunity is an almost stable and invariant character.

Studies on the dietary influence on the synthesis cholesterol in human body have revealed that the pure carbohydrate food does not produce hyper-cholesterolemia whereas butter or any food that contains saturated fatty acids of animal origin is hyper-cholesterolemic.

A study is in progress on the role of biological, immunological and genetic variables in malaria. Another study has been undertaken to investigate the different sub-units of genetic markers in tissues of Indian freshwater carps.

(C) Teaching and Training

Members of this Division participated in teaching B.Stat. (Hons.), M.Stat., M. Tech. in Computer Science, Operation of Automatic Data Processing Equipments, Intensive Course on Programming and Application of Electronic Computer, Junior Certificate Course in Statistics (for Government Officers) ISS and ISEC Courses.

In addition, members supervised students of other Universities placed at the Institute for practical training.

(D) Projects

The Division mainly executes various projects at the request of Government/ Semi-Government Organizations. During the year under review, following projects were executed and were in various stages of completion.

1. Externally funded projects :

(i) *A Pilot Study of Social Attitudes Towards Air Pollution in Proper Calcutta* (A Project sponsored by the Department of Environment, Ministry of Environment and Forests, Government of India, New Delhi) : The data obtained from 1,724 respondents through personal interviews have been partially analysed. Interim reports are being prepared on the basis of this statistical analysis. The analysis reveals that about 80 per cent of the adults in Calcutta proper seem to have heard about air pollution.

For the majority of people in Calcutta, newspapers appear to be the most popular medium of communication about air pollution. Radio and TV seem to be the second and third effective media of mass communication. About one-third of the respondents reported that they heard about air pollution in recent years (within the past 2 years).

When asked as to how they felt in general about the quality of air in their respective localities, almost 58 per cent of the respondents expressed no complaints. Interestingly about 80 per cent of the respondents from the illiterate stratum of the population felt dissatisfied with the quality of air in their localities. However, more than 75 per cent of the replied in negative when asked if any of the members of their families were ever affected by air pollution. About 60 per cent of the respondents from the illiterate stratum of the population expressed their concern or worry about air pollution in their locality. In the case of literate and educated strata, the concern about air pollution was expressed by about 75 per cent of the respondents. About 40 per cent of the total respondents believed that Calcutta's atmosphere produces cancer.

About 90 per cent of the respondents thought it essential to employ antipollution abatement measures in their localities. However, when asked if they would like to participate in anti-pollution campaign for Calcutta as a whole, about 30 per cent expressed their unwillingness. A substantially high percentage of respondents said that they were not at all hopeful about their own efficiency in abating air pollution in in their localities. This pessimistic note was expressed more often by females than males. About 33 per cent of the respondents felt that the Government departments should take initiative in employing air pollution abatement programme in Calcutta.

Further analysis of data by stratum and NSS blocks is in progress. The association between concern about air pollution in Calcutta and a number of socio-economic characteristics is also being studied.

(ii) *Study on per acre yield of FFDA/Non FFDA water areas* (sponsored by the Directorate of Fisheries, Government of West Bengal) : As the list of beneficiaries of the Bankura District was not supplied to us in proper time and because of the natural calamity (i.e., flood) last year it has not been possible to start our main field work though a preliminary report has already been sent to the Department of Fisheries based on a pilot survey carried at the North 24-Parganas District. Several discussions have been made to finalise the questionnaire of the survey. Field work is expected to start in the month of May, 1988.

(iii) *A Study on Discovery Cost, Production Cost and optimization of ONGC Activities* (Collaborative research project sponsored by ONGC) : The simulation model developed for predicting the discovery of oil along with its associated costs is being tested with the real life data collection from the Cambay basin.

The theoretical exercises on the optimization model incorporating the discrete nature of discoveries and the associated uncertainties involved are more or less complete. Programmes are being developed and will be tested on the data collected from ONGC in this connection.

(iv) *A pilot study on the determination of survival, growth and reproduction rates of major Indian carps with particular reference to Hatchery, bundh-bred and riverine*

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sources (sponsored by the Directorate of Fisheries, Government of West Bengal) : Indian major carp seeds collected from three sources, namely, Hatchery, Bundh and river were subjected to laboratory investigation as far as their growth and survivability is concerned. Along with physical parameters e.g., weight, length and age, biochemical parameters related to growth, such as, total proteins content, inorganic phosphate, amylase and phosphotase activity were also measured. It was observed that bundh-bred *Catla Catla* seeds are more susceptible to adverse pond ecosystem than the other species. Bundh-bred *Labeo rohita* species developed more quickly than their hatchery counterparts.

An interim report has been submitted to the sponsors.

2. *Internally funded projects* :

(i) *Survey on a Socio-economic classification of medical, engineering and post-graduate students, Calcutta,* 1986 : The report is being written. A stratified sample of 877 students of the final years of various university departments, medical and engineering colleges in Calcutta and Sibpore has been surveyed. SRSWOR's were taken from 13 strata composed of students of various corners cutting across the affiliating bodies. Only theoretical innovation consists in trying qualitative and quantitative techniques for randomized references on confidential issues. The investigation is considered practically useful as follow-up of the school survey held during 1.4.85—31.3.86. Findings will appear in the forthcoming report under preparation.

(ii) *TV Viewership Survey in Calcutta* : Only innovative features so far have been the (1) use of Rao-Hartley Cochran technique of choosing samples of "distinct" units with varying probabilities by formation of groups of pairs of units of which one is to be chosen, (2) keeping the other as a stand-bye in case of a non-response, and (3) forming independent pairs of sub-samples of equal average effective sizes. Deciding to sample one available member out of 4 age-sex groups chosen per household, the household size-members were taken as numbers of categories (1-4) of members available per household, a practical purpose was served in increasing the sample of TV Viewers with reduced costs.

Choosing 11 localities in Calcutta 1274 households have been listed and a sample of 637 out of them is selected. So far 390 households have been completely canvassed, 103 have been partially canvassed and the rest is proposed to be completed by 30.6.88. The analysis and tabulation are expected to be completed by 31.3.89 and the report is expected to be out latest by 1.11.89.

(iii) *A survey of cancer patients in and around Calcutta* 1987-88 : The survey was undertaken during the period. The field work of collection of data from the patients started in February 1988. The survey is expected to throw light on the problems of data collection in an area where so far little data seem to be available in an organised manner. The survey should also bring out estimates of some socio-medical parameters, e.g. association of incidence of cancer with addictivity, survival rates since incidence of the disease, effect of social environments, occupations etc. on the incidence rate, etc. Listing of patients suffering from some specific types of cancer are registered with the Calcutta Medical College Hospital, R. C. Kar Hospital, NRS Hospital, S. S. K. M. Hospital, Chittaranjan Hospital and C. C. W. H., Thakurpukur during the year 1987,

84, 85 were done and about 350 patients suffering from oral cancer were surveyed during the period. The survey will continue during 1988-98.

(iv) *Studies on the impact of common oral antidiadetic drugs at the immunoglobulin and heptaglobin levels of maturity-onset diabetic people and their role in the long term control of the disease :* The study was mainly pursued with the hypothesis that 'stress factors' as a result of rapid industrialization and also day-to-day modern life play a vital role in proliferating the catabolic disease, diabetes mellitus. Data were collected from urban and rural areas of Calcutta, from industrial areas of Jamshedpur and from the tribal people of Giridih. Laboratory investigation on the measurement of the specific biochemical parameters and been indertaken and statistical analysis of the chemical results are being performed. The results, so far obtained, suggest that short term treatment by Chlorpropamide produces some proliferation of Immunoglobulin (M) which are not antibody precursors. The study may have some far reaching implications so far as the diagnosis and treatment of the disease is concerned.

(v) *Block Plan Development :* Data processing have been completed. Draft report is under preparation. The full draft report is expected to be available by the end of May 1988

(vi) *Attitudes of Scientists and Professional towards Environmental Pollution :* The data obtained from about 100 scientists are being analyzed. The project is continuing during 1988-89. New data will be collected from scientists working in Indian Association for the Cultivation of Science and Jadavpur University.

(E) In-house Computer System :

The in-house facility consists of EC-1033, ORG-80, ORG-20 (Graphics) and a z-based microprocessor Zenith (ORIEN 8000).

In addition to providing regular computer services for project and training activities, the following major jobs were undertaken on the EC-1033 and other computer systems during the period April 1987 to March 1988 : (i) An investigation into the personality make-up, Intelligence and Study Habits of High and Low Achievers; (ii) Analysis of Light-Trap Catch of Rice Green Leaf hoppelus; (iii) Study on Sex Perference based on Calcutta Fertility Survey, 1970; (iv) A Pilot Study of Attitudes of Scientists and Professionals towards Environmental Pollution in Calcutta proper; (v) Design of software for NSSO Data Processing; (vi) The estimation of statistical data homogeniety in sample survey of socio-economic processes; (vii) Processing of NSSO Survey data; (viii) A Survey of Cancer Patients in and around Calcutta, 1987-88; (ix) Simulation Techniques; (x) Study on Sex Preference based on Calcutta Fertility Survey, 1970; (xi) Fertility Models; (xii) Development of Algorithm for Shape Analysis; (xiii) Development of Algorithm and Software System for Shape Analysis and Pattern Recognition; (xiv) Development of Algorithm and Software System for Shape Analysis and Pattern Recognition; (xv) People of India; (xlv) Some problems on Convective Diffusion with or without reaction; (xvii) Lipid Peroxidation in Mammalian Uterus; (xviii) An approach to estimation of the effects of Non-Tariff Barrier to Trade; Some Economic Implications to Indo-US Trade Structure; (xix) Determinants of Rural Development : A Case Study of Bagdah Development

Block—24-Parganas, West Bengal ; (xx) Analysis of Income Distribution, Poverty and Growth ; (xxi) Studies in Agriculture, Growth and Planning ; and (xxii) A Study of Indian Agricultural exports with particular reference to Jute and Tea over the period 1967/68 to 1982/83.

Physical and Earth Sciences

CHEMISTRY

Research Activities

1. *Study of Soil Rhizosphere :* Plant roots being the habitate for the development of symbiotic and non-symbiotic micro-organisms the soil rhizosphere permeated by them is the zone of vivorous activity. This attributes to the rhizosphere properties and composition different from those in the bulk soil. A comparative investigation was undertaken to understand the biochemical and microbiological path ways of humus formation through measurement of physico-chemical parameters at root-zones and away. Significant difference in humus composition and soil physical properties have been observed.

2. *Colloid chemical behaviour of days and related minerals :* Adsorption and desorption of organic and inorganic ions on fine-grained rocks, feldspars, quartz and clays have been measured to understand the growth of surface area and exchange capacity during the soil-development. Relative flocculation-sedimentation characteristics of organo-mineral substances has been employed to develop a possible method of isolating individual mineral from their complex mixtures in soils.

ELECTRONICS

A. *Digital Systems Research :*

1. *Parallel Architecture and Parallel Algorithms :* Efficient parallel realization of different numeric, non-numeric and graph theoretical algorithms were carried out. Suitable parallel architectures and their VLSI implementation for efficient running of these algorithms were also under study. Some problems like Binary multiplication, Sorting, Diameter evaluation in symmetric graphs have already been implemented.

2. *Network architecture :* Different network architectures have been proposed with some inherent properties like low diameter, extensibility, fault tolerance. The routing schemes for these networks under fault-free and fault conditions have also been derived. The cost-performance measure for evaluating network architecture have also been carried out.

3. *Some studies on Interconnection networks :* Different properties of Multi-Stage Interconnection Networks (MINS) have been extensively studied. The problem of partitioning a given permutation into a minimum number of subsets such that the transmission in each subset can be routed in a single pass without conflict have been solved. From the analysis of conflict graphs an optimal graph coloring algirthm have been derived to find out the optimal number of passes for a set of permutations. This has been tried on Baseline network which could suitably be modified for other MINS.

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A fault tolerant design of a baseline network, the analysis of conflict graphs in presence of faults and the algorithm to find out the optimal number of passes for such a fault-tolerant baseline network are currently under progress.

4. *Modified Benes network and its routing* : Benes network has all possible permutation capability but due to some redundant switching elements the routing scheme is not straight-forward like other MINS. A modified Benes network has been proposed and a simplified routing scheme for this network has been obtained.

5. *Testing and fault tolerance of interconnection networks* : The versatality of MINS have led to widespread use of these networks in multiple processor and communication systems. As a result, testing of the MINS is becoming a topic of increasing interest and research. Fault tolerant design schemes for a class of MINS implemented with 2×2 switching elements have been obtained. These schemes tolerate only control element faults. But the novelty of the scheme is that they do not use any multiplexers or any special type of elements but only some additional stages of switching elements and they cover a large number of multiple faults as well.

6. *System diagnosis* : Work is in progress to develop an efficient algorithm for diagnosing faulty units in a multiproccessing environment. Graph theoretic modeling has been adopted and several interesting results have been obtained.

7. *Delay fault analysis* : The detection of delay faults is an important area of concern to any VLSI designer. The effects of logic partitioning on the behaviour of delay faults and how circuits can be designed with guaranteed performance have been investigated.

8. *VLSI layout design* : In hierarchical design of VLSI chips, a floorplan is often obtained as a rectangular dual of a given graph depicting topological neighbourhood among functional modules. The area and shape constraints for each module are also given. Since it is advantageous to generate sliceable floorplans, an investigation of the graph-theoretic conditions under which a given graph has sliceable dual has been done and a method to construct it has been developed. A polynomial-time algorithm has been developed for transforming a given nonsliceable floorplan to a sliceable one, with changes in aspect ratios of minimal number of modules.

B. *Theoretical physics*

During the period, the main areas of research undertaken were as follows :

Particle Physics :

1. *Geometrical and topological properties of particles* : The role of holomorphic quantum mechanics and twister geometry have been investigated to study the topological properties of hadrons.

2. *Stochastic field theory and thermo field dynamics* : Quantum Field Theory at finite temperature has been investigated from the point of view of stochastic field and thermofield dynamics. Also Renormalization group at finite temperature and

critical phenomena have been investigated. A stochastic field theoretic approach towards Kadanoff-Wilson formalism are being studied.

3. *Stochastic field theory and supersymmetry :* A formalism for stochastic quantization in Minkowski space has been developed and the relevance of supersymmetry and supercharge in stochastic field theory has been studied.

4. *Quantum gravity and supergravity :* The role of complex manifold has been investigated to study quantum gravity and supergravity. The relevance of stochastic geometry in quantum gravity and supergravity has been investigated.

5. *String model and Ising system :* The equivalence of Polyakov fermionic string with 3-dimensional Ising System has been studied. The topological features of non-Abelian bosonisation of massive Thirring fermion and its relationship with nonlinear σ-model have been investigated.

6. *Quantum field theory and anomalies :* Abelian and non-Abelian chiral anomalies have been investigated from the point of view of Quantum Geometry. Geometrical and topological aspects of non-Abelian field theory have been studied and their relevance with quantum geometry have been formulated.

7. *Quantum fluid and superfluidity :* The topological properties of He^3 and He^4 are being studied from the point of view of vortex lines as classical relatives of fermions.

8. *Quantum field theory and quantum mechanics :* In quantum field theory supersymmetry breaking at finite temperature using thermo field dynamics approach was studied. Same approach is now being extended to string theory. A most general ansatz was given for the exact solutions of the non-polynomial potential $x^2 + \lambda z^2/ (1 + gx^2)$ using the underlying supersymmetry. Group theoretic approach has been applied to find out the eigenvalue of screened Coulomb potential. A method has been developed to use the techniques of the shifted 1/N expansion in the case of relativistic potential. So far relativistic potential has not been treated by this method by any previous authors.

9. *Theory of measurement in stochastic mechanics :* An attempt has been made to construct a consistent theory of measurement so that a measurement can be performed without the collapse of state vector. This is in conformity with the recent results of Neutron Interferometer by Rauch et al. The influence of gravitational noise on the interference pattern is still under investigation.

10. *Stochastic geometry and the cosmological problems :* The Einstein-equation has been studied on the fluctuating conformal metric space. The cosmological constant has been shown to be of fluctuating origin. The particle creation mechanism and the cosmological vacuum instability problem are still under investigations.

11. *Space-time metric fluctuation and the ultrahigh energy cosmic rays :* The acceleration and origin of ultrahigh energy cosmic ray particles are being investigated within the framework of space-time metric fluctuation.

Plasma Physics :

12.   Double layer problems for both magnetised and non magnetised plasma was being studied using the pseudo potential method. This method has been saccessfully applied to find out ion-acoustic solitary wave solutions in plasma with multiple ions.

C. *Fluid Mechanics*

1. *Study of two-phase flow in a Hydrocyclone :* Hydrocyclones are extensively used as seperators of suspended solid particles in a liquid. The mechanism of separation is a very complicated phenomenon.   The study of the two-phase flow in a hydrocyclone was continued during this period.   The analysis of the boundary layer was done by the Pohlhoausen Method.

2. *Effect of a strong vertical vortex on a sandy bed :* Experiments were conducted to study the effect of a strong vertical forced vortex on a sandy bed.   The forced vortex was generated by rotating a hollow circular perforated cylinder at high speed in water contained in a reservoir with a bed of sand.   This study was undertaken primarily to investigate whether a strong stationary vortex could be responsible for the vertical cylindrical structures found in sedimentary rocks.   The experiments have yielded interesting results supporting the view that the vertical vortices could be responsible for these structures.

3. *Study of the influence of stable density stratification :* The study of the influence of stable density stratification is of considerable interest in a geophysical fluid dynamics.   A model based on the principle of a generalised eddy-viscosity is developed to describe the spectral characteristics of turbulent velocity and temperature fields associated with a stably stratified shearing current.   The predicted spectra of turbulent kinetic energy and temperature variance, shear stress spectrum and the heat-flux spectrum confirm many observed characteristics of atmospheric environment.

4. *Hydrodynamic stability :* The heat transfer and stability for the following two different types of problems have been studied : (i) Flow and heat transfer in a visco-elastic fluid over a stretching sheet. (ii) Stability of thin layer of visco-elastic fluid on a rotating disk.

Both the problems have their important industrial application viz., (i) has application in the extrusion of a polymar sheet from a die, this sheet is sometimes stretched. The properties of the final product depend on the rate of cooling and (ii) is used in the process of spin coating the product materials. The most important part of this process is to maintain the uniformity of the coating throughout the surface. This is possible if one can avoid the instability of the flow field. Results : for (i), an exact analytical solution of the nonlinear equation governing the self similar flow has been obtained.   The analysis of this flow reveals that (a) the skin friction decreases with increase in the elastic parameter R_1 and the temperature increases with the increase in R_1 for fixed Prandtl number σ.   For (ii), it is found that the elastic parameter M of the fluid destabilizes the flow whereas the cross-viscous parameter N has a stabilizing influence on the flow.

5. Blood flow in cardiovascular system : Blood flow sometimes is disturbed by the presence of unnatural growth on the inner surface of an artery in the cardio-vascular system and as a consequence arterial diseases result. From the physiological point of view the study of the effect of this abnormal growth on the flow characteristics is absolutely necessary. A model has been developed in which fluid is flowing through a tube having consine-shaped constrictions. The flow rate, resistive impedance wall shear stress and phase lag have been studied.

D. *Project work*

A project was undertaken and also completed in the current year to supply a set of electronic instruments to the Institute for Speech Rehabilitation, Government of Tripura, Agartala. These instruments were supplied to aid in speech rehabilitation of deaf and dumb children. This work was a sequel to an earlier project of the Unit undertaken during 1971-72 when similar instruments were also supplied for the same purpose. The objective of the current project was to modernize those equipments with the recent IC technology and improve upon certain features.

ELECTRONICS AND COMMUNICATION SCIENCES

Activities of the Unit include (i) investigation for the methodology and algorithms development of the various problems in the application area of computer and communication sciences (ii) teaching some of the coursees in M.Tech (Computer Science) and M.Stat programme of the Institute and carrying out esxternal project work.

During the period April 1987 to March 1988 research work was directed in the following areas.

1. *Development of Methodologies for Image Analysis, Shape Analysis, Image Understanding, Pattern Recognition and Computer Vision Technology :*

(a) *Studies on image segmentation :* Algorithms have been developed for automatic image segmentation. For this, homogeneity measure and contrast measure were defined on the basis of co-occurrence matrix of the image. The measure of contrast involves the concept of logarithmic response (adaptibility with background intensity) of the human visual system (HVS). The work includes also a merging algorithm in order to remove the undesirable thresholds. Studies also were made on the effectiveness of the algorithm.

Modified schemes for segmenting the noisy image was also studied. The results of the investigation were published in different journals.

(b) *Human visual system for image analysis and vision :* Threshold selection criteria using human visual response and gray level co-occurrence matrix for edge detection in an image were found out.

New definitions of image entropy, such as global, qth order ($q > 1$), local entropy and conditional entropy have been given. These are used to partition object from background in any kind of images. Superiority of these algorithms over the existing ones has been demonstrated for a wide range of images.

(c) *Fuzzy techniques in pattern recognition and image processing* : Algorithms for feature ordering, clustering and image quantitative measures have been developed using the concept of fuzzy measures. These measures are then optimised for taking decision when the patterns are ill-defined, unreliable and incomplete. Fuzzy transforms are also defined for colour image enhancement and segmentation. Fuzzy geometry of image subsets have been used in extracting both fuzzy and non-fuzzy segments of image. Dispersion measure is used in extracting skeleton of images.

(d) *Fuzzy operators :* The work on need fuzzy operators for union, intersection and inclusion has been done. Unlike the existing ones, these operators take the sense of membership function into consideration. These operators are also found to be generalised in the sense that the existing operators can be formulated from the purposed framework. Bounds for membership functions to be used in real life problems have been defined based on fuzzy correlation.

(e) *Coding :* A new coding scheme has been developed for two-tone image contours. The basic idea behind this is to extract some knots on the contour. The arcs between the knows are then coded using variable length code words. The decoding is based on computer-graphics techniques. It has been shown that the compressibility is high and the visual difference between the original image and the decoded image is not objectionally sensitive. Recently an approximate coding technique based on Bezier triangle parameter has been reported. Algorithms for exact reconstruction of binary/gray tone image are in progress.

(f) *Cluster analysis* : The literature of cluster analysis is essentially concentrated on the development of algorithms but it lacks the abstract data structure through which algorithms can be judged. Works were therefore directed to find out a solution of such problems. Detailed studies were made to provide such a set up in R^2 and it was later on used to estimate classes. For this three different classes namely compact regions, bounded line classes and bounded mixture classes were considered. For each of them an estimation procedure was provided on the basis of minimal spanning tree. It was shown that some procedure bolds for all of them. The entire work was reported in a thesis.

(g) *Machine learning* : Some properties of a self-supervised restricted updating learning algorithm in the PR context, was studied, with a view to improving their performance. Properties examined include stochastic convergence and mean squared error. Assuming a simple probability model which takes into account the probabilities of mislabelling of training samples, this algorithm was compared with the standard algorithm, and conditions were found under which the former performs better.

(h) *Studies on shape analysis* : Algorithms for some geometric operations on 3-D objects/images are developed which are useful for 3-D shape matching. These operations include propagation, shrinking and rotation. The propagation and shrinking algorithms can propagate or shrink the input image by arbitrary factors. The rotation algorithm involves not only the angles that are multiples of 45 or 90 degrees, but any arbitrary angles for 3-D rotation. The algorithms proposed for these operations also preserve the shape of the input image.

For the purpose of shape discrimination in 3-dimensions, a shape distance for 3-dimensional objects is proposed on the basis of volume mismatch. This shape

distance involves certain characteristic planes of 3-dimensional objects and in the analog domain satisfies all the metric properties. This approach is used to construct some degrees of symmetry of 3-dimensional objects with respect to symmetry around a plane, around an axis and around a point. Computational techniques for the shape distance and the degrees of symmetry are also developed.

2. *Studies in Statistical Pattern Recognition Methodology :*

(i) *Mahalanobis distance-based feature evaluation criteria :* Studies have been made regarding the Mahalanobis distance-based new feature evaluation criteri . They have some desirable theoretical properties which suggest their suitability as feature evaluation criteria. Further studies on their theoretical properties are under investigation. Successful applications of these criteria for evaluation of features in handwritten character recognition have been accepted for publication in journal.

(ii) *Texture analysis of images : statistical pattern recognition approach :* Review studies have been made regarding the existing texture analysis procedures for image classification. From these studies it was apparent that statistical pattern recognition techniques could play an important role in texture discrimination. It is proposed that, subject to availability of suitable texture data, the Mahalanobis distance-based feature evaluation criteria and some other statistical techniques are to be investigated in the context of texture analysis.

3. *Speech Recognition and Processing :*

(a) *Spectrographic analysis of Bengali vowels :* Acoustic phonetic features for non-nasal Bengali vowels for 5 male and 5 female informants have been analysed and documented. Spectrographic studies of 350 multisyllabic words confirm the existence of seven standard Bengali vowels with an additional compromise vowel. The coefficient of variations of formant frequencies for different vowels are also included. The findings have been reported in journal.

(i) *Development of expert system for isolated word recognition :* A speech re cognition system using association of experts has been proposed and tested on Bengali speech sound. The three expert systems are operating in tandem. The primitive expert, the acoustic expert and the lexical expert are dedicated to respectively the extraction of acoustic phonetic parameters, classification of phonenemes and analysis of various matching status of the input string with the lexicon. The results have been reported in journal.

(ii) *Development of Lexical data base on Bengali language :* A lexical module containing 20,000 Bengali words has been completed. Analysis on this module is still incomplete.

3. *Digital Communication, Signal Processing and Biomedical Engineering :*

(a) *Studies of the Fading characteristics of UHF/VHF signals :* Multistation recordings of VHF signal at 189 MHz band are going on simultaneously in different centres for studying the fading characteristics of VHF and microwave signals. The propagation characteristics of these signals during the atmospheric disturbance and

in the presence of atmospheric irregulatiries have been investigated and reported. Further investigations for calculating propagation parameters for VHF signal and microwave signals are going on.

(b) *Indepth study of the atmospheric behaviour with 1 km. range :* A sound radar system has been installed at the top of Geology building to monitor continuously the atmospheric behaviours within 1 km range. The atmospheric characteristics such as thermal plunes and nocturnal inversion have been investigated thoroughly in this region of the city. The atmospheric turbulences that are created due to thunderstorms/ nor-westers are noted and the occurrences of eluvated layer characteristics in this coastal stations are reported in journal. These atmospheric boundary layer data are correlated with the VHF and microwave signal characteristics in predicting the propagation characteristics in this region.

(c) *Instrumentation work for communication and biomedical signals :* In order to deal with the vast amount of propagation data and biomedical signals (ECG) micro-processor based instrumentation works are in progress. The on line digitization of these signals and storing of these digitized data in the microcomputer memory for further processing have been planned and these works are going on. Also some suitable algorithms for processing of these data have been done.

4. Studies on Cybernetics and System Theory

Research on application of fuzzy set theoretic approach in Management Science and other socio-economic systems was continued. A work on Fuzzy linguistic approach for decoupling of a large multivariate system in the refercnce of power plant operation had been under consideration. The Department of Electronics, Government of India appointed a task-force to study the feasibility of Artificial Intelligence for Thermal Power Plant under the Chairmanship of Prof. D. Dutta Majumder.

5. External Collaborative Projects :

(a) The project on '*Application for Pattern Recognition and Image Processing Techniques to Geological Mapping and Mineral Detection*' funded by Electronics Commission is in progress.

The interpretation of geological data has been usually done on the basis of spectral signature. 'Spectral signature' means single feature or a pattern of features whose shapes, locations, and relative intensities : re complete characteristic of a parti-cular material. For mapping, in general, two geologic themes are treated : lithologic classification and structural analysis. Lithologic classification studies are in progress.

LANDSAT MSS provides multispectral digital image data for the Earth's surface in four different bands, each image considered represents the spectral distribution of energy coming from the Earth in one wavelength range in the electro-magnetic spectrum. Other sources of spatially distributed data are also often required for regions of interest. For example, true geological mapping requires LANDSAT images be registered with geographical maps. One approach to do this is to select some common ground control points on both LANDSAT image and geographical map, and finally to establish a transformation which will transform image co-ordinates

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to map co-ordinates or vice-versa. For this purpose appropriate Toposheets (or Degree sheets) have been procured from Survey of India. Secondly, to establish relation between ground information (i.e., material content of the Earth's surface at a particular region) and reflective intensity recorded for corresponding pixel of LANDSAT image in a band geophysical and geochemical data may be required. Or, sometimes a certain portion of LANDSAT image may be used as a training sample if detail geological survey over that area has been done.

Identification of features in remote sensing imagery is effective for global assessment of geometric characteristics and general appraisal of ground cover type. It is, however, impracticable to apply at the pixel level unless only a handful of pixel is of interest. Computer interpretation of remote sensing image data is referred to as quantitative analysis because of its ability to identify pixel based upon their numerical properties and owing to its ability for counting pixels for area estimates. The procedures for quantitative analysis are classification based.

(b) The temporary laboratory set-up for the research project entitled '*System and Algorithm Development for Pattern Recognition and Shape Analysis of Objects of Defence Interest*' under Defence Grant in Aid scheme has been complete and the work is in progress.

(c) The joint project on '*Statistical Studies on the Tropospheric Propagation for VHF/UHF and Microwave Link*' funded by the Department of Science and Technology (DST) is going on. Another multisodar project which is an extension of the on-going project is under consideration of DST.

(d) The collaborative research project between ISI and Sangeet Research Academy (SRA) on '*Hindusthani Raga and Indian Stringed Instruments*' was continued during the year.

(e) *Fifth Generation Computer System/Knowledge Based Computer Systems* (*FGCS/KBCS*) *Research* (jointly funded by the Department of Electronics, Government of India and UNDP) : Electronics and Communication Sciences Unit is a nodal agency (National Nodal Center) with Prof. D. Dutta Majumder as co-ordinator cum Project Director in the fields of pattern recognition, artificial intelligence, image processing and computer vision for Fifth Generation Computer Systems Programme of the Government of India.

The FGCS / KBCS research work started last year in the Unit. Research personnel for this were recruited, the site for the laboratories are complete. The installation of the computer systems is about to start. Meanwhile the work has started in the following areas :

(i) *Modelling of 3-dimensional objects from the 2-D images* : A PC based small system has been designed which takes 2-D line of a block world (consisting of simple geometric primitives e.g. cube. cone, cylinder, sphere etc.) on input and tries to find the spatial relationship among the 3-D entities. The system applies logic programming for pattern matching. A quantitative measure is attached for matching those partially occluded figures which are incompletely described at the input. The design system

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has provided some insight regarding the representation of 3-D vision knowledge and partial matching. It was found that logical representation in the form of Horn-clauses is well suited for representing geometric relationship among different entities. But a more compact and efficient representation scheme is required for implementing a complex structure.

(*ii*) *Development of* 3-*D Solid Modelling Software* : The development work for 3-D solid modelling software is in progress. It will be used to model the solid and generate different perspective views to build-up the knowledge base. From the different computer generated perspective views the characteristic views will be extracted and will be used to uniquely represent a solid in the knowledge base. ·

GEOLOGICAL STUDIES

Research Activities

The following research activities were undertaken during the year : Tectono-stratigraphic studies of the Delhi Supergroup, Rajasthan; Tectonics, stratigraphy, sedimentation and depositional environment of the Proterozoic rocks of Pranhita-Godavari Valley ; Gondwana Geology and Palaeontology of the North-Western Pranhita-Godavari Valley; Studies on Late Cretaceous dinosaur fauna from the Lametas in Maharashtra ; Ultrastructure and SEM studies on dinosaur egg shells from Central India ; Evaluation and description of Late Cretaceous fish faunas; Fossil amphibians of the Satpura Gondwana basin; Stratigraphy, fossil and geological relationship of the Lameta beds, Jabalpur ; An empirical statistical study of preferred orientation of line in 3-dimensionsional space—applications in geology ; Experimental study on the developme of large scale vertical scour-holes through action of stationary vortex.

The Delhi Supergroup of Central Rajasthan has been interpreted as shallow-water ensialic deposits. Proterozoic rocks of the Somanpalli area, Pranhita-Godavari Valley, have demonstrated after intensive mapping, considerable shortening across the basinal strike through deformation. A unique aeolian sequence, made up dominantly of adhesion structures has been recognised in the Proterozoic Pakhal rocks of the Godavari area. A revised stratigraphy of the Gondwana rocks of the northern Pranhita-Godavari Valley has been worked out.

Teaching and training

Apart from teaching Geology in the B.Stat. (Hons.) course, several members participated in the teaching programmes of other universities and institutions, e.g., M.Sc. course in Geology, Calcutta University ; B.Sc. (Hons.) and M.Sc. in Applied Geology, Jadavpur University. There were Research Fellows working for Ph.D. degree.

PHYSICS

Research Activities

The research activities of the Physics Unit have on problems of 'Bioengineering and Medical Physics' and during the period 1987-88, the Unit worked mainly on :

(i) Thermal properties of skin e.g. the cutaneous thermal sensory threshold (TST) determination and its applications in detecting leprosy at an early stage and quantifying the sensory loss incurred therefrom, studies on the responses of skin to thermal challenges—heat and cold challenge—to plaque type psoriasis of hand and hand eczema, use of TST's as an 'ageing index' of skin and the determination of state of hydration of stratum corneum.

(ii) Electrical properties of the stratum corneum of the skin such as the determination of skin impedance conductance using 3.5 MHz A.C. and the shifts in these parameters due to sorption of water by the stratum corneum to evaluate its boundary function. Iontophoretic application of drugs in corn, hyperkeratoses and such other skin conditions.

(iii) Age-related changes in the sebum level of skin by determining the casual level of sebum photometrically. pH-mapping of skin and the development of a hypothesis on the site-variations of the 'acid mantle' of skin based on the activities of the sebaceous and sweat glands' distribution and also the distribution of bacterial flora on the skin surface.

Project work

On-going projects : The only on-going project of the Physics Unit is entitled *'Thermal and Electrical Properties of Skin'* which is a logical extensoin of the previous completed project 'Mechanical Properties of Skin'.

The project aims at, among others, quantitative measurement of cutaneous thermal sensory thresholds, its loss in certain pathological cases and also recovery on appropriate treatment, age-related changes in threshold values and its use as 'aging index' for skin, studying the phenomenon of heat transport in skin and subcutaneous tissue, determining the skin surface pH-normal and pathological, evaluation of state of hydration of skin surface *in vivo* (normal and pathological) by measuring the electrical impedance of skin. electrical studies of sorption and desorption of stratum corneum and thereby evaluationg the barrier function of skin.

Progress of the project: An electronic device has been developed to assess quantitatively the cutaneous thermal sensory thresholds (TST) and has been (and is being) usefully utilised in early detection of leprosy and in measuring the amount of sensory loss restored on medication by follow-up. Age-related changes in TST has been utilised as an 'ageing index' of skin.

Skin surface pH in normal population has been measured and data analysed statistically. A complete pH-mapping of skin has been made in the prepubertal age group and is being extended to other age groups. The changes in pH with sites (in the prepubertal age group) is being explained on the basis of the distribution of sweat gland, sebaceous gland and the normal flora on the skin. Study on the buffering action of skin is being continued using commercial soaps and detergents.

Skin surface hydration state *in vivo* has been evaluated in xerotic skin of ichthyosis vulgaris patients and an objective assessment of the application of a topical agent (coteril) has been made. Sorption and desorption studies are under way.

Photometric measurements of sebum level of skin of both normal and pathological subjects have also been made and the higher level of sebum in acne patients has been quantitatively assessed. The effect of drug on the sebum level of acne patients has just been taken up.

Teaching activities

The Physics Unit was engaged during the year 1987-88 in giving one full semester course to the Second Year B.Stat. Honours students. The course contents included, as in last year, Thermodynamics, Statistical Mechanics, Relativistic mechanics and some selected topics of Atomic and Nuclear Physics.

FLUME PROJECT

The renovative work of the Hydraulic Flume has been completed. The intake and outflow pipes and the honeycomb are readusted by trial and error methods to obtain wave free surface and logarithmic velocity profiles. A new set of honeycomb structures for flow stabilization have been constructed.

Biological Sciences

ANTHROPOMETRY AND HUMAN GENETICS

Research Activities

1. *Health status and labour productivity* : The results of the study on tea labourers show, unlike in other studies, that productivity is not related to the labourers health or skill.

2. *Psychological stress and health of mother and child :* The results obtained so far show, unlike expectation, that the anxiety level of working women is not higher than that of non-working ones.

3. *Sociocultural characteristics and community health status of the Lepchas of Darjeeling district, West Bengal* : The results show that (i) different sociocultural factors (religion, rural-urban habitat and developmental status) effect different health traits, i.e., all of them do not affect all health traits ; (ii) the rural developed group is worse-off, healthwise, compared to both urban and rural less-developed ones ; and (c) the Lepchas of the study area are aware, in spite of their very limited information base, of the slow population growth rate compared to neighbouring populations. A Ph.D. thesis on the data collected so far has been submitted.

4. *Human Biology of Indian Populations* : A comprehensive and critical review of the biomedical characteristics of Indian populations, and their exogenous and endogenous determinants, is being prepared in the form of a book, on invitation from the Oxford University Press, Oxford.

5. *Nature and extent of Planter Dermatoglyphic variation among some endogamous groups of West Bengal* : Dermatoglyphic prints of 1800 individuals (both sex) of Brahmin, Mahishys, Pod, (Schedule caste) and Muslim families from Howrah district were collected (100 families for each group).

Prints of 40 families (200 individuals) of Santal tribe of Purulia district were taken and further field work in the tribe is in progress. Adult anthropometric measurements (total 24 variables) in the same population groups have also been done.

6. *Study of Physical growth of the Bengali children* : The present study for 26 anthropometric characters of the contemporary Bengali boys aged 7.0 to 16.0 years in the city of Calcutta have been studied. The results provided cross sectional adolescent growth of 14 anthropometric characters of the children between 12.0 and 13.0 years, 2 characters between 13.0 to 14.0 and 2 other characters between 14.0 and 15.0 years. Subcutaneous skinfold thicknesses showed prepubertal increase as well as pubertal loss of fat, the maximum being quite interestingly in correspondence with mean ages of peak height velocity. The data collected so far could be utilized as a reference population data. A Ph.D. thesis has been submitted on the adolescent growth of the Bengali boys.

7. *Bio-statistical study on vitiligo* : *a skin disease* : Data on 298 pedigrees, each collected through an affected proband, have been analyzed to study familial aggregation and genetics of Vitiligo. A genetical model is found to provide a good fit to family data on Vitiligo. Collection of further data is in progress.

8. *Genetic Epidemiology of Blood Pressure* : 56 families of Marawari community residing in Calcutta, covering about 600 individuals were surveyed for Blood Pressure, Physiometry, Anthropometry and Socio-demographic information. Further survey including blood chemistry is in progress.

9. *Genetic Survey of some endogamous groups of Eastern India* : About 1000 individuals from S endogamous groups from Bihar (Brahmin, Muslim, Bhuia, Chammar, Santal) and West Bengal (Poliya, Deshi, Tiyor) have been studied for about 15 blood markers, including Haemoglobin type, as well as Haematology, Anthropometry, immunoglobin level and clinical examinations. This also includes the study of Thalassaemia in Malda District amongst Poliya and Deshi in collaboration with the Department of Haematology, School of Tropical Medicine, Calcutta. In this survey a very high frequency of HbE gene was detected in the populations (Poliya, Deshi, Tiyor). The analysis of the results is in progress.

10. *Effects of microenvironmental factors on health in rural populations* : Anthropometric data were collected on about 550 children (approximately 300 of them were measured about 10 years ago).

11. *Impact of altitude on Human populations* : Reanalyses of data collected earlier have been done and a comprehensive report has been published.

AGRICULTURAL SCIENCE

Research activities

1. *Crop improvement* : 11 high yielding paddy varieties along with *Subarna*, a local aman, raised in ISI experimental station at Giridih were put on adaptive trials with the objective of selecting out the promising ones on the basis of selection criteria like

harvest index and biological yield. The data suggests *Subarna* to be well suited in terms of higher biological yield at low fertilizer input and hence acceptable to marginal farmers. A field trial with *Subarna* has also been separately carried out to find out the agronomic optimums for maximum yield. Data are being processed.

2. *Intercopping*: Three field trials, one in Kharif and two in rabi seasons, were undertaken to find out the yield potential of maize, mustard and wheat respectively in combinations with other legumes. Maize in combinations with groundnut and Soyabean seems to be promising. Effects of legumes on soil fertility through soil analysis and their effects on succeeding crop wheat have also been carried out. Data analysis is in progress. In the winter season intercropping of mustard and wheat with three legumes, gram, pea and lentil have been carried out. Harvesting has recently been completed and data analysis is being done.

3. *Crop introduction* : Preliminary field trials with different crops suggest the potential of different crops under rainfed farming in lateritic soils without any input with fertilizer and irrigation. Potential crops noted are grain amaranth : a protein rich C_4 type pseudocereal; winged bean : a legume fodder cum grain crop and ricebean— a leguminous fodder.

4. *Exploratory work on palmae* : Development process of endosperm and embryos of different palms were being studied and at present anatomical and chemical investigations are undertaken.

5. *Problems of laevo and dextrorotatory situation in nature* : During the period under study a few legume crops including winged bean were being investigated to note the effect or rotatory movement in yield.

6. *Oil palm and Coconut adaptability* : With the objective of examining the adaptability in saline and lateritic tracts trials on these two crops have been initiated in Manmathanagar (Sundarban) and Giridih (Bihar plateau) farms. Mortality rate of coconut seems to be high in Giridih although oil palm has established well in both the regions.

BIOCHEMISTRY

A brief account of the progress of research is given below :

1. *Distribution of intestinal parasites in West Bengal* : This has been noticed in previous studies that economic and cultural variations causes variation in the nature and prevalence of intestinal parasitic infestation. Five villages in the sandy constal zone have been covered in this study. The data is under analysis. Analysis of Birpara data (collected earlier) has also been completed.

2. *Genetic epidemiology of blood pressure* : To study the relative influence of the determinants of hypertension, blood pressure reading in a rural affluent population is being carried out. So far 56 families have been completed, covering about 600 individuals. They have been examined with social and demographic informations. Complete family pedigrees were drawn for all the families.

Standardisation of various biochemical tests for blood biochemistry have been completed. Estimation of different biochemical parameters in blood/serum with special reference to lipid metabolism is in progress.

EMBRYOLOGY

Main Topics of Research

1. *Biochemical Embryology* : Development of the embryo from the egg has been the long-term subject of research in this Unit. Limnaea (mollusc) has been the most utilized system. Recently the mediterrenian squid has been studied in the course of two short visits to France and the availability of local squids at Digha has been studied on a year round basis.

2. *Pheromones of tigers* : A markedly multidisciplinary subject is being studied in a project funded by DOEN, Government of India.

3. *Mathematical and Stochastic Modelling of Embryonic Growth, Differentiation and Morphogenesis* : Mathematical studies of growth, differentiation and morphogenesis during embryogenesis based on mathematical and stochastic models constructed earlier have been continued. Multiple-loop biochemical control network of the epigenetic system has been studied. The mechanism of the formation of the first layers of differentiation during embryonic development, viz., ectoderm, mesoderm and endoderm has been mathematically established. Formation of an ordered structure far from the thermodynamic equilibrium has been exhibited by stochastic modelling of the epigenetic system.

ENTOMOLOGY

Seasonal distributies and relative abundance of the Yellow Fever Mosquito (Aedes aegyptii L.) in two suburban localities—Baranagar and Dum Dum : Collection of yellow fever mosquitoes (both larvae and adults) were made from different sites in Dum Dum. They are most abundant during monsoon and tend to be the dominating species of that season. During monsoon and autumn large larval population could be found in bathing cisterns. Even if these cisterns are cleaned with lime or bleaching powder they appear within a week. They are fairly available from May to middle of November. During winter these mosquitees seem to disappear although the larvae could be collected from certain spots only. Larval sites include sanitary porcelain equipments and coconut shells. Their abundance in relation to other species of mosquitoes is not clearly understood.

LEAF PROTEIN

Research activities

1. *Screening and agronomic studies of various plant species including* fodder crops, weeds (water and terresterial weeds) and tree leaves : For large scale production, commercial trial of five promising aquatic weeds namely—*Azolla Pinuata, Lemna Minor, Pistia stratiotes, Lemnanthenum cristatum* and *Alternenthera philoxeroids* were

undertaken. Bulk quantities of leaf protein prepared were freeze dried and stored in air-tight containers in a cold room. The Nitrogen content of the leaf proteins were— Azolla (6.25%), Lemna (6.13%), Pistia (8.18%), Limnanthenum (8.67%) and Alternenthera (7.17%) as required amounts of dry leaf protein samples of all five plants could not be prepared, only three plants i.e. Lemna, Pistia and Alternenthera were used for in-vivo studies using weanling rats.

For the work on three leaf samples of 30 different tree species have been screened. Of these, 12 species, on the basis of nitrogen content protein nitrogen extractability percentage of N content in the Leaf Proteins, are found promising. These are : (1) *Ailanthus excelsa*, (2) *Albzzia procera*, (3) *Dalbergia latifolia*, (4) *Gliricidia masculata*, (5) *Serbania grandiflora*, (6) *Samanea saman*, (7) *Trema orientalis*, (8) *Peltopherum sp.*, (9) *Mrianga oleifear*, (10) *Toona cillata*, (11) *Tecoma sp.* and (12) Red siris.

The protein nitrogen extractability of these above mentioned species varied from 10.0% to 40.62%. Ailanthus excelsa gives best protein nitrogen extractibility percentage (40.62%).

The nitrogen content of Leaf Protein concentrate of these above mentioned species varied from 6.0% to 9.95%. The Leaf Protein concentrate from Samanea saman gives best nitrogen percentage (9.95%).

The Chemical composition (crude protein, total ash, insoluble ash, crude fat) and in vitro digestibility of the Leaf Protein of the above mentioned tree species are being analysed.

An experiment, taking cowpea (*Vigna sinensis*) variety phalguni with P at 30, 60 and 90 kgs/ha keeping N and K fixed at 30 kgs/ha was laid in the fields on 2.4.87. The crop was harvested at 40, 50, 60, 70, 80 and 90 days for LP extraction work. Highest vegetative yield of 140/q/ha at 80 days was recorded. Detailed analysis of the samples and data are under study.

2. *Microbiological aspects of Leaf Protein Research* : To study the micro-biological load of deproteinized leaf juice samples, the extract was dispensed into 500 ml conical flask, each with 200 ml samples with 1.5 % agar, sterilized in an autoclave at 10 lbs pressure per sq inch for 10 minutes. Molten agar media were plated (25 ml media on each plate and was allowed to solidify), plates were then exposed to one to three hours. The pH was 6.0 before sterilization. To isolate the fungal colonies 0.5% sodium propionate and crystalline benzyl penicillin (conc. 500 units/ml) was dissolved separately and added to suppress bacterial growth.

To obtain the actinomycetal colonies, in addition to sodium propionate and benzyl penicillin grivin (greseofulvin 625 mg/ml) was added to suppress the growth of bacteria as well as fungi.

During the incubation period the plates were examined and the colonies were counted, subcultured for proper identification.

Fungal isolates from different DLJ Media.

Phoma	*nebulso*	*Aspergillus*	*flavus*
Rhizopus	*Oryzae*	A. *tamarii*	
Gliocladium	*roseum*	A. *fumigatus*	
Trichoderma	*pseudokoningii*		
Leura	*eureka*		
Alternarea	*alternata*		

Chemical composition of fungal biomass : Biomass obtained from different fermentation studies was analysed for ash, nitrogen, crude protein, carbohydrate and lipid content. *Chemical composition of biomass obtained from different fungi* are ash : 10—18% ; Protein 19—28% ; Carbohydrate 26—33% ; and Lipid 8—15%.

Studies on digestibility, protein efficiency ratio and net protein utilizatoin (NPU) and nitrogen balance of the harvested biomass are in progress.

Biodegradation of fibrous residues of leaf protein production plant by thermophilic microorganisms : Cellulose degrading strains were isolated from fibrous residues of leaf protein production plant mixed with diluted soil samples collected from different localities of West Bengal.

The strains identified as *sporobichum* sp., *Humicola* sp, *Trichoderma* sp. Fibre samples were inoculated with these strains separately and incubated at 50°C for 30, 60 and 90 days. After treatment the volume was reduced to one third of its original volume. The nitrogen, phosphorus and potassium contents increased appreciably after incubation.

Cultivation of some Indian Tropical Mushrooms (*edible*) *in leaf protein by -products* : Analysis of various fibre samples (fibres from aquatic weed, tree leaves) are in progress. Fibre samples contain 2.75—3.5% nitrogen and 16—30% carbohydrate. Estimation of cellulose, hemicellulose, pectin, legnin are in progress. After this study mushroom cultivation study will be initiated. Work proposed to be done in 1989-90. (i) Utilization of hemicellulosic fractions of the agroresidues by mushroom, (ii) Cultivation of some Indian tropical edible mushrooms in leaf protein by products.

Effect of shaking and incubation period on growth and lipase production by streptomycin sp. L_4 : A streptomyces sp. L_4 producing exocellular lipase was isolated from soil in our laboratory. The organism was grown in flasks in a liquid medium containing g/L peptone 7.5 ; soluble starch, 10.0, NaCl, 3.0 and $MgSo_4$, $7H_2O$ 1.0 The flasks were incubated for 1, 2, 3, 4, 5, 6, 7 days respectively at 28°C. Maximum yield of enzyme was noted in the medium on 3rd day of incubation. Shake and still cultures of the organism in broth showed more yield of the enzyme in shake flask fermentation than that in still culture.

Effect of urea, potash fertilisers and rhizobial inoculation on growth and nodulation winged bean : Winged bean (KPS 31) was grown in pots. Four sets of experiments were performed. Rhizobial population per gram of soil was determined. Rhizobial inoculation with potash fertiliser showed best results.

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3. *Biochemical and Nutritional studies of different Leaf Protein Concentrates and other fractions from water weeds, byproduct leaves-tree leaves, etc. In-vivo studies on 3 water weeds* :

In this study the protein efficiency ratio (P.E.R.) method of evaluating protein quality was used. Weanling albino rats averaging 52 g body weight were randomly divided into eight groups (four males and four females) and assigned to experimental diets in individual cages. Six experimental diets containing 10% protein were used— Pistia leaf protein, Alternenthera leaf protein, wheat flour, wheat flour + pistia, wheat flour + Alternenthera wheat flour + Lemna and a reference diet of casein all diets were fed *ad-libitum* for a period of four weeks.

The daily food intake of individual rats were recorded. Body weight changes were recorded weekly. Fecal matter of individual rats was collected during the last week of the experimental study. At the end of the study, the rats were sacrificed and the liver was removed. Blood samples were also collected. The results of this experiment are being analysed.

Besides the *in-vivo* experiment, studies on calorific values and valuable wineral contents of the promising five LPC have been also analysed.

Keeping in view the prevelant severe drought conditions and consequent acute shortage of fodder in many regions of the country some work was initiated on the most productive and menacing water weed-water—hyacinth. With the combination of heat, maceration and pressing at 2.5 kg/cm^2 a product has been achieved which on the basis of chemical analysis seem to be promising. The D.M. has been raised to 25-30% and reduced K and oxalate content reduced by more than 50%. For acceptance and digestibility trials Animal Nutrition and Husbandary Deptt. of B.C.K.V.V. has agreed to conduct the experiments.

4. *Conditions to achieve maximum yields of tops and roots in sugarbeet crop* : *complete utilization of all the parts and working of economic aspects in comparison to the conventional practice and a pilot plant to produce ethanol, pectic, leaf protein and animal feed* : Thorough analysis, statistical and otherwise, on the data obtained on the 1986-87 experiment and write up there-off are under way. However the preliminary observations and findings of the experiment are : (a) Four doses of fertilizer Nitrogen i.e., N_{60}, N_{100}, N_{140}, N_{180} and two cultivation practices namely earthing up and non-earthing were tried. (b) Harvests were made at 80, 100, 120 and 140 days after sowing. (c) Highest shoot yield was 41.11 t/ha in 100 days with 180 kg/ha with earthing up practice. (d) Highest root yield was 35.18 t/ha at 140 days with N_{100} and earthing up. While, highest sugar yield of 6.44 t/ha (18.3% sucrose) with the same fertilizer and age was achieved. (e) Total N extractability of 70% was observed at 80 days, and highest extracted protein yield of 583 kg/ha with N_{100} and non-earthing practice was reco rded. This yield of LP which is 7.3 kg/ha/day is perhaps the highest achieved in any root crop so far.

Experiments on solid phase fermentation were carried out many times to ascertain, 1. Quantities of ethanol, pectin and oxalic acid obtainable, 2. Efficiency of conversion of beet sugar to ethanol and exact condutions under which highest efficiency is achieved.

ECONOMIC RESEARCH

The Economic Research Unit continued to be engaged in research work covering different areas of theoretical and applied economics and econometrics and in teaching and training at various levels.

Research Activities;

The research activities of the Unit during the period under review covered fields like economic theory, national and regional economic planning, issues in development economics, level of living and poverty in India, besides methodological studies in econometrics.

1. *Economic Theory* : Research work has been going on over the past several years on the history of economic thought and on various areas in economic theory. Investigations have continued on social choice theory and game theory, covering topics like measures of industrial concentration, welfare economics etc. Attempts have been made to characterise the 'number equivalent' form of the Shannon-Theil inverse index of industrial concentration. Generalized Gini social evaluation functions have been formulated, yielding the result that a rank preserving transfer of income from a rich person to a poor person increases social welfare with greater weight being attached to transfers lower down the scale. Another work considers quasi-orderings of income profiles when the social evaluation function is equity conscious and satisfies an efficiency condition which is inequality preserving. Apart from these topics, studies have also been made on regional inequality and economic development, the problem of foreign borrowing in a developing economy.

2. *Economic Planning* ; Analytical studies in the area of regional planning have continued in connection with Ph.D. dissertation. One study is related to the empirical identification and evaluation of the regional variations in the pattern and growth of agricultural activities in India during the period 1960-61 to 1980-81. Another study is related to a regional analysis of human resources in India.

Two studies on planning models have been completed. One is the regional model for agriculture developed with a view to estimating the yield and production of six crops and also allocating total input endowments, irrigation and fertilizer among these crops. The second one is a planning model for an expansion of railway network. The model has been developed to select a programme with the minimum cost from among a few such alternative expansion programmes.

3. *Economic Development* ; A study attempts to analyse the grouping of countries according to the socio economic and other characteristics, using cluster analysis methodology. The study considers important indicators of development reflecting almost all dimensions of development and group the countries according to their levels of development. Another study observes that in many third world countries including India tertiary sector has been growing faster than the GDP of these countries. The study thus seeks to examine the behaviour of service sector in these countries. A third study examines the marketing network of paddy and rice as prevalent in some parts of Bankura district of West Bengal.

4. *Income and Level of Living*: Various aspects of income and level of living have been examined in a number of studies. On the basis of a sample survey a study attempts to assess the level of income and its differential among workers in small enterprises in Calcutta. A second study seeks to analyse the intertemporal variations between state differentials in rural consumer prices. Attempts have also been made to study the intra and interoccupational variation in income and level of living in some parts of West Bengal. Another study examines the areal distribution of poverty in rural India during 1973-74.

5. *Methodological Studies in Econometrics*: A considerable amount of research has been carried out on various topics in econometrics, e.g.(i) problems relating to multicollinearity in misspecified models, (ii) estimating Box-Cox models with non-spherical disturbances. (iii) Bayesian estimation and comparison of expenditure model with additive or multiplicative heteroscedasticity, etc.

Project Work:

The members of the Unit have undertaken a number of projects. These projects are described below in brief.

(a) *Intra and Inter Occupational Differentials in Income and Level of Living*: Work on unequal distribution of income, expenditure, wealth etc. that has been done in the country mostly treat the population as an undifferentiated mass, distinguishing only between the urban and rural sectors. There is however a great deal of economic inequality between occupation groups as well as within such groups, and this is the subject matter of the present study. For this purpose some important occupation groups have been selected viz, unskilled labourers, skilled industrial workers, office assistants/typists, office managers, administrative officers and executives, and teachers. Before taking up a fullfledged project, a pilot enquiry was taken up. Sample design has been prepared and enquiry schedule has been finalized on the basis of the experiences obtained from the pilot enquiry. Field work has been started.

(b) *Regional Model for Agriculture*: The project 'Regional Model for Agriculture' sponsored by the Planning Commission, Government of India has been completed. The study relates to agricultural performance over time in different regions of three states, Andhra Pradesh, Karnataka and Haryana, growth of acreage, production and yield, and stability and variability of yield of different crops. A model for estimating yield response functions of six food crops simultaneously together with optimum allocation of total input endowments, irrigation and fertiliser among these crops has been developed and worked out for each region. The model is expected to provide rational estimates of yield and production of these crops, that can be considered for realistic agricultural development planning.

(c) *A Study on the Steel Industry in India*: The work relating to the disaggregation of the 'Steel Sector' in the 89 X 89 input-output (I-C) table constructed by the Planning Commission has continued, mainly based on the secondary data obtained from SAIL, MECON and NCAER. The first phase of the work related to the domestic resource cost (DRC) estimation of the steel produucts is almost over. The preliminary result suggests that among the various steel products lowest D.R.C. is for 'Bars and Rods'. Obtaining the ranks of major steel products in terms of D.R.C. may help to

determine the appropriate choice of the product-mix for steel when there is no restriction to purchase some of the steel products from the international market.

(d) *Linguistic Analysis of the Complete Works of Rabindranath Tagore Based on Complete Statistical Counts :* The project has been taken up in collaboration with the Institute for Study of Languages and Cultures of Asia and Africa (ILCAA), Tokyo. ILCAA began to transcribe Tagore's works on magnetic tapes and to supply word counts and the other results to the ISI groups for further linguistic and statistical analysis. Three poetical works, Gitanjali, Sandhya Sangeet and Prabhat Sangit, have been taken up. Almost of the work on Gitanjali have been completed.

(e) *Discovery Cost Modelling for Hydrocarbon :* The Unit is actively involved in the ISI-ONGC collaborative project on the Discovery Cost Modelling for Hydrocarbon. The project is interdisciplinary. The purpose of the project is to develop a model for the estimation of discovery cost and an optimisation model for the allocation of resources between exploration and exploitation of hydrocarbon in India. A theoretical model on the estimation of discovery cost has been developed and tested empirically. The work for the other part of the project, viz., development of an optimisation model for the allocation of resources between exploration and exploitation has been taken up.

Teaching and Training Activities :

Members of the scientific staff shouldered the responsibilities of teaching economics, economic statistics and econometrics in the degree and research courses in economics and other courses conducted at ISI, Calcutta. Several faculty members participated in the teaching programme of other universities. There were in addition a number of research fellows working for the Ph.D. Degree under the supervision of faculty members.

PLANNING (DELHI)

Research Activities :

The members of the Unit continued research in a number of fields in both applied as well as theoretical economics, regional planning, women and development studies, analysis of social movements. Research in applied economics included diverse topics such as planning, problems in estimation of poverty, estimates of labour force and unemployment, foreign trade and economic development, health and family planning, amongst others. Work was continued on the development and application of macro-economic models for analysing policy instruments such as dual pricing and quantity rationing. Research in economic theory revolved around game theory and its applications, economic inequality, undernutrition and unemployment, growth theory.

Project Work :

Various members of the Unit have been working on a number of projects. Topics covered include : (i) A study on provision of basic social services in rural areas of Haryana, (ii) Conflict, structure and change, (iii) Autonomy-seeking movements in Punjab and Darjeeling, (iv) Steel pricing for Modernisation and Growth,

(v) Resource Inventory for Planning, (vi) Perspective Plan Model for Economic Development of Assam, (vii) Family Planning awareness, attitudes and practices among Members of Parliament and (viii) Family Planning among workers of Hindustan Latex Limited.

ECONOMIC ANALYSIS (BANGALORE)

The Economic Analysis Unit at Bangalore carried on theoretical and empirical reasearch in a number of broad areas during the year 1987-88. Particular mention may be made about studies on Income distribution, Poverty and Inequality, Levels of Living, Demand Analysis, Macroeconomic Analysis, Macroeconometric Modelling. A number of papers on problems in the above areas have been prepared and published in different journals.

LINGUISTICS

During the period April 1987 — March 1988, the Linguistic Research Unit continued its programme of research in the areas of Fundamental and Applied Linguistics. There are three main headings under which the Unit's research projects may be grouped, namely :

I. Studies on the phonetic structures of major Indian languages and application of the results in the areas of : (a) Speech Pathology ; (b) Second Language Acquisition and (c) Cultivation of Mother-tongue.

II. Studies on acquisition of language and bi-lingualism and

III. Application of statistics in linguistic problems

I. *Fundamental Research :* A survey of the articulatory and acoustic structures of the Oriya language is in progress. Data on the frequency of occurrence of Oriya phonemes has been collected and statistical processing of the same will be carried out. Research on the Suprasegmentals of Oriya will also be carried out. Fundamental research on the Suprasegmentals of Bengali, Hindi and Telugu is in progress.

Applied Research : Studies are in progress on : (a) Development of articulation of speech sounds during the period of language acquisition in the pre-school age child. (b) Measurement of threshold of bilingualism.

Studies are continuing on the academic achievement of hearing impaired children attending general schools with normal hearing children.

Studies are in progress on the comparative intonation patterns of Indo-Aryan and Dravidian languages as well as between languages within the broad Indo-European group. Studies on pitch and intensity are being carried out, utilising the Visi-Pitch.

POPULATION STUDIES

Research Activities :

1. *Some determinants of Child Mortality and the Latter's Impact on Fertility :* The quality scrutiny of data and the field checking of filled in schedules are continuing.

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The transfer of data from schedules to computer-types has partly been done so far. Only about ⅓rd of the data from the first survey schedules could be taped during the last 14-month period beginning from the September, 1986. The follow-up survey among the selected women is taken up.

2. *Education Development Survey in Rural Areas around Patna :* This survey has been taken up to study the educational development and other socio-demographic aspects of the rural population around Patna.

Education and literacy status changes between father and son were studied over different time periods using birth cohort approach to population belonging to different socio-economic groups. It was revealed that upper caste and other Hindus possessed higher education and literacy mobilities than that of Scheduled Caste Hindus and Muslims. Scheduled Caste Hindus showed a slight trend of development. And downward trend of education and literacy of daughters over their educated mothers was observed for the Muslims in the study area. Higher net upward education and literacy mobilities were found among population of the study area, especially among upper caste and other Hindus in comparison with the population in rural areas of districts around and away from Calcutta.

3. *A Study of Educational Wastage (Stagnation and Drop-out)* at *Primary and Middle School Levels :* The objectives of the study are : (a) to estimate the expected student life—a problem of methodological interest, (b) to find out educational wastage differential by various demographic, socio-economic and other related factors, and (c) to identify and evaluate various factors as determinants of educational was'age.

The sample survey employed for the study consist of three schedules—one for school, one for teachers and another for students' household. The field work of rural area has been completed but only 10% of the Schedules are being verified. Processing and analysis of collected data are in progress. The second phase of the work i.e. the urban area survey will be started very soon. Sampling and other preliminary jobs are completed and the three types of Schedules are being sent to press for printing.

4. *Pre-Census Atlas :* Recently some maps have been sent to the Office of the Registrar General, India, Map Division, to get approval and sanction for publication from the Ministry of Home Affairs. The title of the maps are : (1) District Gorakhpur, Land Utilisation Pattern, 1814, (2) Gorakhpur, Administrative Division, 1814, (3) Gorakhpur, Population and Occupation, 1814, (4) India : Population Density, 1812, (5) India : Political Divisions 1820 and (6) India : Political Division, 1823. The map 'Extent of Harappa Culture' has just been completed and work is going on to draw the map of undivided Bengal 1810, based on Rennel's Map.

5. *Economic Changes in Rural India :*

(a) *A Study of 200 Villages in Bengal,* 1850-1981 : Data were collected from Central Record Room of Directorate of Land Records and Surveys of more than 3,000 villages of the Districts of 24-Parganas, Nadia, Murshidabad, Malda and Birbhum, Bankura, Purulia, West Dinajpur and Darjeeling for 1846-1850 on a ten percent sample basis. Among these villages, 1080 villages have been identified on a current list

contained in the respective District Census Handbook. On a thorough scrutiny it has become possible to find out the Jurisdiction list number of the villages. A systematic sample of 200 villages has been drawn with due weight to proportion of villages in each district. Tabulation work is in progress.

Supplementary data representing records of rights at mauza level have already been collected on a selective basis from Settlement Halka Office.

Data for these 200 villages have been tabulated districtwise showing area, population with religions and broad occupational classifications.

Records of right for some of the villages have been collected and tabulation programme worked out. Collection of data for each of these villages from the census report with that of revenue is being attempted. Time series of population relating data from earlier records and those of census reports are being prepared.

(b) *Trends of socio-economic changes in 4 districts of India—Burdwan, Broach, Gorakhpur and Bellary,* 1801-1981 : A draft report is under preparation. There is some data gap and efforts will be made to fill this gap from archival sources. Some important documents have been collected from the Maharashtra Archives and attempts are being made to use them in the report.

6. *Sampling bias and confidence interval for some fertility measures under cluster sampling scheme :* The bias of the demographic rates, TFR., GRR, NRR under cluster sampling scheme has been investigated. Attempt has been made to estimate the sampling bias and provide corrected estimators for the above rates. Estimators for MSE of these rates has been proposed so that they can be used to give confidence interval for the above estimators.

7. *Impact of type of medical attention at birth on maternal and child mortality :* The objective of this study is to assess the impact of type of medical attention at birth on maternal and child mortality. It was found that around 80 percent deliveries are taking place at home till now—18 percent by trained professionals, 45 percent by untrained professionals and 17 percent by relatives/friends. Infant mortality rate is directly associated with the delivery attended by untrained persons (including relatives/friends) and this is true for both rural (coefficient of correlation = 0.53 at 5% level of significance) and urban (coefficients of correlation = 0.55 at 5% level of significance) areas. The study points out crucial deficiency in data for planners and programmers for MCH services and proposes (a) establishment of a standardised MCH Information system, (b) continuous epidemiological studies to study various factors that inter act with pre-natal infant and maternal behaviour for planning and development of preventive measures to reduce MCH problems and (c) decentralisation of information system.

Project work :

Child Mortality and Environmental Differentials in a Newly Industrialised Indian City —Durgapur in West Bengal (A collaborative project with the School of Oriental and African Studies, London) : The object is to obtain information on child and

infant mortality differentials and other basic socio-economic data among working class families living in two contrasting areas.

It is intended to examine the hypothesis that there is a need for public sector interventions in the field of health planning and health related infrastructure to ensure that the whole population is adequately serviced in the new town localities. The main survey work has been completed.

Teaching and Training Activities :

In addition to participating in ISI & ISEC's teaching and training programmes the following teaching and training programmes were also organised. (1) Vital Statistics and Demography and Demographic Surveys for students of the Diploma in Health Statistics jointly with All India Institute of Hygiene and Public Health (April 1987 and January, 1988). (2) Specialisation in Vital Statistics and Demography for participants of the Junior Certificate Course in Statistics (June 1987). (3) Dissertation for students of M.A. Economics, Kalyani University. (Specialisation : Population, April—June, 1987). (4) Orientation Course in Demography for a Commonwealth Fellow from Uganda (Mr. M. N. Orach) : About 4 months from January, 1988. (5) Training in Health Information System to two WHO Fellows from Bangladesh during March 14-18, 1988. (6) Training in Health Services Research to one WHO Fellow from India during April 18-29, 1988.

PSYCHOMETRY

Research Activities :

1. *Development of a non-verbal intelligence test for hearing impaired children :* The test is already standardised and ready for use. Only the norms are to be developed for different age groups. Data from three metropolitan cities viz., Calcutta, Delhi and Madras have been collected and it is going on in Bombay. As soon as that is over the norms will be ready.

2. *Consequences of socio-economic deprivation on academic achievement :* Pilot study is over. Two reports are ready on the basis of the data so far collected. Data from thirtysix schools situated in rural and urban areas of nine districts of West Bengal have been collected.

3. *Predictive validity of the forced choice scale of managerial skill :* The test has already been developed. For the purpose of predictive validity, data are being collected from managers of different organisations and also ratings from their supervisors and colleagues. So far data are being collected from Calcutta, Delhi, Bombay and Visakhapatnam.

4. *Intelligence and personality pattern in some social groups of West Bengal based on some dermatoglyphic and anthropometric variables :* The objective of the study is to find out whether intelligence and personality pattern varies with the variation in the dermatoglyphic and anthropometric variables. Data from different families belonging to different social groups, for example, different castes and tribes residing in

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different parts of West Bengal will be collected through some psychological tests. Data collection from some of the families have just been started.

5. *Assessment of minimum learning in primary education :* During this period 'tailored tests' were prepared for Bengali and Mathematics for Class II and III pupils and were administered upon 1567 Class II and 1569 Class III students reading in 57 primary schools of the Hooghly district. Besides the achievement tests, data were also collected on socio-economic status of guardians (guardian/parent schedule) and relative information on the concerned schools (school schedule).

Some special tests were also administered to the pupils (approx. 260 in number for each class) of a selected group of 26 schools to assess their intelligence, span of memory, etc. Their reading ability were also recorded.

Besides data collection, scrutiny and evaluation of data collected during the year 1986-87 have also been completed. Analysis of the same is on progress and the report is expected to be published.

Service project :

A selection test was undertaken in June 1987 for admission of students to the B.Lib. (Sc.) course for the Calcutta University.

SOCIOLOGY

The Sociological Research Unit has been formally recognised by the Indian Council of Social Science Research, New Delhi as a Regional Centre of 'Guidance and Consultancy Services'. The ICSSR has also requested a project proposal on 'Data Repository on Socio-Historical Data on Eastern India'.

Research was carried out during the period under report on the following projects :

1. *Potentialities and Constraints of Development : A Social-Economical Approach :* The primary objective of this study is to explore the scopes and barriers to development of symbiotic relationship between societal groups and their natural resources in a specific economical zone. The area under study is Similipal forest range in the district of Mayurbhanj, Orissa.

The field survey has been completed. A preliminary report on some aspects of the study is available in the Unit. Final report writing is in progress.

2. *Social Ecology of Sundarban :* The objective of the study is to identify the possibilities and potentialities of development and survival a network relationship within and between the societal groups and their natural resources.

A preliminary report on some aspects of the study is available in the Unit. Final report writing is in progress.

3. *Ageing of population in India :* (i) Health and medicare survey of the elderly persons (ii) Opinion about the elderly person (iii) Country monograph on

the demographic and socio-economic aspects of population ageing (a collaborative study sponsored by the CICRED, Paris). (iv) Human ageing (Dementia) and (v) Socioeconomic survey of the elderly persons of Giridih (Bihar) town.

The aim of the studies mentioned here is to find out the nature of impact of ageing population on society, and that of society on ageing, and the conditions of life or elderly persons under varying demographic, social and economic circumstances.

Preparation of a country monograph is in progress.

4. *Problem of Afforestation (jointly with Economic Research Unit)* : Surveys in West Bengal and Bihar villages were completed earlier. A preliminary report has been prepared.

5. *Factors Disintegration Non-Formal Networks of Help and Cooperation in Rural Society : An Exploration into Villagers' Perception* : This project is a part of an all India one covering 8 states coordinated by Department of Sociology (Delhi University) and Department of Anthropology (McGill University, Canada). The International Development Research Centre, Ottawa (Canada) is also collaborating in the study.

The final report is under preparation which will discuss the usefulness of ponds as sources of irrigation, specially in upland areas. A paper has been accepted for publication in a book.

6. *The Peasant Movements during the Early Phase of Colonial Rule in Bengal* : Objective of the project is to study the variations in the context of peasant risings which challenged the colonial rule from the middle of the 18th century onwards with special reference to the Hindu-Muslim relations, which have played an important role in Indian society.

Collection of data from the State Archives and records preserved in the District Collectorates of West Bengal is continuing. Two research papers have been prepared and published and one research paper has been presented in a seminar on the basis of the collected data so far.

7. *Value System and Social Change* : The study seeks to identify sociocultural and political value patterns among various societal groups in two sample villages in Purulia to find out how and to what extent these affect the programmes of rural development.

A preliminary report based on first phase of work has been prepared and circulated. A paper based on the study has been presented at the Anthropological Conference in Calcutta. Another paper is ready for publication. Detailed analysis of the entire data is under progress for preparing the final report.

8. *Child Labour : An exploratory Enquiry in Giridih, Bihar* : Usually young workers below 14 years of age are known as child Labour in India. Percentage of such workers (vide Census of India 1971) to total workers is nearly 6%, which covers

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nearly 8% of total children population. In Bihar percentage of child workers to total workers, and to total children are 6% and 4% respectively.

Data collection work have been almost completed. Few tables have been prepared to examine the nature and type of information received.

9. *New Pattern of Leadership and Social Action* : *An Exploratory Enquiry* : The objective of the enquiry is to study the process and background of the new generation of leaders emerging in the villages along with the recent socio-political changes in the State. The findings from this study shall also focus on whether this "new" generation appears to be qualitatively different from the traditional pattern of "local leadership" in the villages being monopolised by elite cliques with vested interests and whether, in this sense, the pattern of distribution of power in rural society seems to be changing in West Bengal.

A paper was presented in the annual meeting of the Association for Asian Studies at the University of California, Berkeley, USA. The final report is under preparation.

10. *The Study of Registry Marriage and the Impact of Legislation in West Bengal* :

The objective is to study the roles play by the marriage legislation in changing the character of marriage institution in West Bengal. The study attempts to identify the groups involved and explore the social, economic, cultural and psychological forces behind their social action with an emphasis on their pre- and post-marital adjustment.

Detailed information have been collected through field survey in and around Calcutta. These are being processed and tabulated for detailed analysis. One paper has been revised and submitted for publication.

11. *A Study of Educational Wastage (Stagnation and Drop-out) at Primary and Middle School Levels (in collaboration with Population Studies Unit)* : The objective of the study is to (a) attempt an estimation of expected 'life' of a student—a problem of methodological interest ; (b) find out educational wastage differential by various demographic, socio-economic and other related factors ; and (c) try to identify and evaluate various factors as determinants of educational wastage. The study will be confined in the 24-Parganas District of West Bengal.

The field work has been completed for the rural phase. Scrutiny and tabulation work is in progress. Major part of collection of school data for the urban schools is complete.

12. *Reciprocity in weighted digraph (in collaboration with Statistics-Mathemetics Division)* : A work has been completed on the measurement of "reciprocity" in multi-digraph using international trade statistics on export and import of various commodities from and to different countries and regions. This work is expected to provide quantitative measures to indicate the levels of balance or equilibrium in a network of flow of "goods" or "values" or any such thing. The final report is under preparation.

Statistical Quality Control and Operations Research

1. *General*

Statistical Quality Control and Operations Research Division was set up by the Government of India in 1952 under the technical guidance of the Indian Statistical Institute. The Division continued with its objectives of promoting applications of Statistical Quality Control (SQC) and Operations Research (OR) methods, training and education of executives, inspectors, trainees, operators, consultative services to industrial establishments and research in SQC and OR and allied methods. The activities of the Division are organised through comprehensive programme under the broad classification of (i) promotion, (ii) training, (iii) plant services and (iv) research.

1.2   Promotional activities were continued in public and private sectors. Inplant training of technologists, trainers, inspectors and operatives etc. including the training programme in local languages and services continued to have support from a number of public and private sector organisations. The units of Bharat Heavy Electricals Ltd., - Hyderabad, Hardwar, Bhopal and Jhansi etc., Hyderabad and Calcutta units of Hindustan Cables Ltd. and Metallurgical and Engineering consultant (MECON (I) Ltd.) at Calcutta, Ranchi, Bokaro, Durgapur, Rourkela and Bhilai continued as servicing plants of the Division besides a number of other plants both in public and private sectors. Several organisations were added to the list of servicing plants during the period.

1.3   The Division undertook new project assignments during the period apart from rendering consultative services to factories already on its roll. The Division has so far produced about 1075 specialists and over 850 research papers, techincal literatures, manuals etc.

1.4   The Division continued liason with various academic and technical in stitutions, productivity councils, societies and several other national and international bodies by way of its academic, technical and promotional activities.

2. *Service*

2.1   During the period under review 16 plants joined the SQC service scheme. 67 technical reports were sent to factories and 5 factories discontinued. A total of 83 factories are taking consultative services as in March 1988.

2.2   Special studies involving applications of SQC and OR methods were taken up in the selected areas : control of worm thread runout of table fan rotor shaft, design stability of table fan, optimal inspection procedure at paper plant, farmer's adoption behaviour, estimation of MTBF for system of relays, quality circle implementation, control of quality in building engineering, process capability of bush bore and spigot diameter of ceiling fan, sampling procedure for jelly and polythene granules, control of bottom thickness of cans at extrusion, conductivity and elongation of cables, water penetration test duration, control of quality of cocoa etc., study of mould wear problem, HFP compressor prewelding rejection due to wrong gaskets, control of rejection of water coolers due to less drop, RAC compressor due to auxiliary terminal clip drop, investigating causes of motor burn out, control of post-dehydration breakage of rubber stoppers in the compressor assembly, evaluation of variation in the copper wire,

acceptance sampling procedures for PIJF cables for electrical parameters, wooden drums circum battens, acceptance sampling procedure for water proof cotton tape, control of rejection due to lead segregation ; evolving optimum raw material mix, process capability of machines and statistically establishing optimal measuring internal and optimal calibration for bottom and wall thickness of 37mm. shells, control of variation at annealing of aluminium coils, performance of clutch assembly in 100 cc scooters.

3. *Education and training*

3.1 Inplant training programme at various factories continued. A series of training programmes for senior executives of Bharat Heavy Electricals Ltd. continued on regular basis besides regular inplant programme for executives etc. at various level. One-year special programme for executives at fairly advanced level blended with practical applications continued for eighth and ninth batches of trainees at Madras. A newly designed course on quality circle for 300 consulting engineers of Metallurgical and Engineering Consultant (MECON (I)) Ltd. was conducted at Calcutta, Ranchi, Durgapur, Bokaro and Bhilai besides follow up project guidance. Several short term specially designed training programmes were also conducted at different units of the Division for select group of executives etc. from organisations in India and abroad.

3.2 Faculty members of the Division participated in the teaching of academic courses of the Institute such as M.Stat. degree courses at Calcutta, and Delhi, SQC-OR Diploma and M.Tech. courses at Calcutta, part-time SQC-OR courses at Bangalore, Bombay, Hyderabad and Madras, ISEC course at Calcutta and Bangalore and Evening course at Calcutta.

3.3 During the period under review 3517 managers and technologists were trained in various inplant, general and other courses, 123 trainees underwent professional training in SQC and OR at a Post-graduate level and in part-time course in Calcutta, Bombay, Delhi, Madras and Bangalore.

4. *Research*

4.1 During the period under review 11 papers were published, 36 submitted for publication, and presented at conferences, seminars etc., 29 manuals and technical reports, etc. prepared by the specialists of the Division. Some of the areas in which applied and theoretical research work is carried out include multivariate analysis of economic data, single sampling multivariate plan, weight variation tests in pharmaecopia, group testing plan for bulk materials, linear complementarity problem, three-decision acceptance sampling plans, fuzzy and non fuzzy goal programming application in acceptance sampling by attributes, continuous sampling inspection, desirability function, applied stochastic processes, inventory control, geological prospecting, committee problem of a single game.

5. *Promotional activities*

5.1 The specialists from the Division delivered 155 lectures, talks etc. to various institutions and organisations. The Division also arranged 32 seminars and the specialists from various units attended 29 seminars.

5.2 Introductory visits were paid to 51 factories. 10 surveys and pilot projects were carried out and 21 reports sent.

CENTRAL LIBRARY

With the addition of 1,164 books and 400 journals to the stock, the total collection of the Library rose to 1,87,022. The main activities of the centrale Library were as follows :

Acquisition : The Acquisition Unit accessioned 1,164 books during the period under report, out of which 712 were purchased and 422 were received as gift. 30 titles were received on exchange basis. It also acquired 21 titles for the Circulating Library.

Periodicals : The Periodicals Unit received 1,659 periodicals out of which 375 were received as gift, 652 against subscription, and 617 on exchange arrangement with national and international organizations. The Unit also acquired 43 back volumes of journals. It accessioned 1067 journals and completed the technical processing of 400 journals.

Circulation and Stock Maintenance : The Unit issued 44,655 books and journals to the users on loan and on reference. The total membership of the Library was 4101 which includes 389 new members and the total number of membership withdrawn was 155. The total memberships includes ISI staff, general member, research scholars, project assistants, B.Stat. and M. Stat. students, ISEC trainees etc. as well as outside students and institute members. 455 readers were given special permission to use the library for a short period. 34 books and journals were borrowed from other libraries and 5 books and journals were loaned to other Libraries under the inter-library loan arrangement.

Reports and Records : The Unit accessioned 504 titles and processed 684 titles. 934 titles were issued to borrowers during the period.

Translation : The Translation Unit translated the following : (i) From Russian to English and (ii) From French to English. The Unit also checked the transliteration and translation of the titles of 150 books. Shri Sunit Bose is giving regular Russian lectures to the B.Stat. students.

Documentation : The Unit rendered documentation services to the researchers of the Institute and provided documentation list on Optimal Allocation, Sequential Allocation, Scientific Communication, Bibliometrics, Bandits, Bandit problems, Design of Experiments, Sequential Analysis, Sequential Designs, Sequential Experiments. The Unit has also undertaken the work in the arens : Bank of Sample Dispersion Matrix, Asymptotic Properties of Maximal Correlation Coefficient, Asymptotic properties of Multiple Correlation Coefficient, Testing of Equality Means, Measuring of Internal Dependence and Dequality of Maximal Correlation Coefficient in Sub-Sub-sample.

Special Materials : The Unit accessioned and prepared 590 catalogues of photographs and transliterated and processed 207 Russian books.

Technical Processing : The Unit classified 695 and catalogued 1229 new books.

Reprography and Photography Services : The Reprography and Photography Unit provided 3,35,166 xerox prints for the users during the period under report.

686 frames of photographs of different natures, 1764 prints of photographic enlargements, 2596 prints of photo copies of documents, 686 frames of microfilming from drawing books, charts, journals etc., 145 frames of lecture slides and 1,88,450 off-set prints were made during the period under report.

Circulating Library : The Workers' Circulating Library acquired 21 new titles bringing the total collection to 33,556. It issued 28,351 books to the members.

BANGALORE CENTRE LIBRARY

1. *Additions* :
During the period, 518 books were added to the Library ; 14 books were received on gratis. The library received 42 books from the British Council ODM scheme through DRTC. During the year a total of 463 volumes of journals were bound, 4 journal titles were cancelled and 26 new titles were subscribed. About 56 back volumes of journals were purchased.

2. *Stock Position* :
The total stock position as on 31 March, 1988 : books 10,174 ; books on gratis 593 ; bound volumes of periodicals 3,359 ; number of current periodicals titles 2 32 ; number of current periodicals titles (gratis) 20.

3. *Technical work* :
About 550 books were classified and catalogued during the year. Nearly 2750 catalogue cards were filed.

4. *Circulation* :
A total of about 7100 books and 2200 periodicals (including bound volumes) were circulated by the library during this period. The in-house use of books and periodicals was around 14,000. About 180 inter-library loan transactions were registered.

5. *Services* :
During the year, ISI Bangalore Centre Library provided the following services :
(i)   Circulation service, (ii) Inter-library loan service, (iii) Reference service,
(iv) Monthly addition list of books, (v) Fortnightly list of current periodicals,
(vi) On demand bibliography compilation, (vii) Reprographic service.

DELHI CENTRE LIBRARY

During the period April 1, 1987 to March 31, 1988, the Delhi Centre library was busy performing following activities :

1. *Acquisition* : 189 new books were purchased and added to the stock. Besides 103 publications received on gratis from varied agencies have also been added to the stock thus bringing the total to 26,500. 535 sets of loose issue of journals after getting duly bound have also been added to the stock. More than 110 reprints/technical reports in printed form and 45 in microform have also been received and added to the stock.

2. *Periodicals* : Two hundred and eightytwo titles of periodicals, both Indian as well as foreign have been received in the library during the period. Out of it 268 have been received against subscription and 14 on Exchange and complimentary basis. All the subscribed titles have been renewed for the next year. Five new titles of journals have been added from 1988.

3. *Membership and Circulation* : During the period 230 persons enjoyed the library membership with 60 as temporary members availing the reading room facilities only, whereas 148 as permanent members availed the lending facilities. 22 Visiting Professors were also given all the lending facilities. Approximately 12470 publications were circulated during the period among the members.

Under the Inter-Library Loan programme about 96 publications were lent out to the neighbouring institutes and about 115 publications were borrowed from other libraries for use by ISI, Delhi Centre Library members.

4. *Reprographic Services* : Requests for providing photocopies of more than 44,417 pages were received during the period and complied with. Xeroxing facilities have also been provided to outside research scholars on nominal rates for taking photocopies of the articles available in library resources.

5. *Documentation Services* : An annual issue of 'List of Additions' listing the new books added to the stock during the period January to December 1987 has been brought out.

6. *Other activities* : Like every year this year too four library trainees with remuneration were appointed for the duration of three to four months. At the end of the training period each trainee was given an experience certificate.

One of the major achievements of the Delhi Centre library is getting a computer PC installed in the library. Efforts are on way to automate routines in the book acquisition, periodicals and circulation sections. Issual of reminders to users for over·due publications have already been automated.

DOCUMENTATION RESEARCH AND TRAINING CENTRE (DRTC) BANGALORE

The activities of DRTC have been organised into : (1) Research programme ; (2) Advisory service programme ; (3) Extension programme ; (4) Publication programme ; (5) Training programme ; (6) Employment information programme ; (7) Continuing education programme and (8) Faculty Development programme.

The following is the report of activities of DRTC during the period under report.

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Training in Documentation and Information Science :

Course leading to ADIS : Under the training programme, DRTC conducts a course of 24 month duration leading to the award "Associateship in Documentation and Information Science" (ADIS). The award is recognised by the Government of India as equivalent to a Master's degree in Information Science. Not more than 10 students are admitted in each academic session. The admission is based o n merit as determined by an All India Admission Test and Interview. In July, 1987. a batch of 8 students appreared for the final examination after completing their formal residential part of the course. They are now engaged in their respective research projects. They are to submit their respective project reports on or before 31 August, 1988.

The new session for 1987-89 was started on 1st September 1987. In all, 6 candidates were selected for admission to the course. All the candidates joined the course ; and were undergoing training during the period of the report.

Short-Term Course in Computer Applications to Library Work and Services : Under the sponsorship of the National Information System for Science and Technology (NISSAT, Department of Scientific and Industrial Research, New Delhi), DRTC is conducting a 6-week course on Library Automation. The third course was held during 15 June—24 July 1987. A batch of twelve students were selected for the third course. All of them have completed the course. The fourth course was started on 18th January, 1988. It continued upto 25th February, 1988. A batch of eight students were selected for the fourth course. All of them have completed the course.

Study Tour of ADIS Students (1987-88) : The programme of educational tour for the students belonging to 1987-89 session was fixed up for the period 19-29 February 1988. The students visited (1) INSDOC, New Delhi ; (2) National Informatics Centre, New Delhi ; (3) DESIDOC, New Delhi ; (4) Delhi University (Both the Library and the Department of Library Science) ; (5) British Council Regional Library, New Delhi ; (6) Indian Bureau of Standards, New Delhi and (7) American Centre Library, New Delhi under the guidance of Prof. M. A. Gopinath for the purpose of observational studies. After the completion of the study tour, each student submitted a report of their respective observational studies.

3. *Research Activities :* The main areas of research in which the different members of the DRTC Faculty have been engaged in during the period of report are furnished below :

(a) Application of the Postulate-based Permuted Subject Indexing (POPSI) to text indexing for information retrieval ; (b) Demonstration of the methodology of designing a classaurus based on the General Theory of Subject Indexing Language using Agricultural Sciences and Technology as the 'Base' for demonstration ; (c) Revision of the Schedules of Basic Subjects and Common Isolates in the Colon Classification of Dr. S. R. Ranganathan ; (d) Characteristics features of the different varieties of sources of information and communication media ; (e) Design and development of Depth Classification Schedules in the field of Health Sciences ; (f) Planning and Management of Information Systems and services ; (g) Information Analysis and Consolidation ; (h) Designing an Environmental Information System including the development of a Vocabulary Control Device on Environmental Sciences ; (i)

Bibliometrics : Development of measures for evaluating use of library and information services ; (j) Library Automation : Guidelines for developing software for Library House-keeping operations ; (k) Development of a system for on-line generation and maintenance of an alphabetic classaurus ; (l) Computer-generation of Index Entries in different formats from a single input prepared according to the General Theory of Subject Indexing Language.

4. *Project Work* :

1. *Demonstration of the Methodology of Designing a classaurus based on the General Theory of Subject Indexing Language using Agricultural Sciences and Technology as the 'Base'* : Considerable exprience has been gained about the methodology of designing the specific variety of Vocabulary Control Device designated as 'Classaurus'. The aim of the project has been to consolidate these experiences in order to develop a systematic methodology of designing a classaurus. For the purpose of demonstrating the methodology, the Base Agricultural Sciences and Technology has been chosen. The formal project work has been started with the preparation of a selective bibliography of pertinent documents. The preparation of bibliography is completed. The collection of source entries to be used for subject analysis is in progress.

2. *Development of Performance Standards for Library and Information Work and Service* : The objectives are : (1) to study the existing standards for library and information work in India and other countries, (2) to identify and discuss the impact of technology on library and information work and science, (3) to examine critically the applicability of Ranganathan's staff formula (used as a Standard) to computer based information systems and (4) to evolve performance standards to suit new requirements.

The formal project work has been started with the compilation of an annotated bibliography to be used for this project. The next step consists of the preparation of a State of the Art Report on the subject concerned. The work is in progress.

3. SYMPOSIA, SEMINARS, LECTURES AND CONFERENCES

Among different conferences, symposia, seminars, workshops and lectures organised by the Institute mention may be made of the following :

3.1 *Symposia, Conferences, Workshops etc.*

A Workshop on Genetics of Blood Pressure was organised by the Anthropometry and Human Genetics Unit in July, 1987. A number of Medical persons, Anthropologists, and Statisticians participated in the discussion.

A Seminar on Fundamentals of Articulatory and Acoustic Phonetics and their relevance to speech pathology was organised by Linguistic Research Unit in April 1987.

A Seminar on Quality Circles was organised by SQC Unit, Bangalore in April 1987. About 20 participants attended the seminar.

A Seminar on Taguchi Techniques for Textile Quality Improvement was conducted by the SQC Unit, Bangalore in April 1987. About 20 participants attended the seminar.

A Summer School on Statistics and Probability was organised by Stat-Math Division during 11 May—30 May 1987. About 20 participants and 10 teachers attended the School.

Professor S. K. Mitra presided over the Statistics Section of the Platinum Jubilee Session of the Indian Science Congress, Pune January 7—12, 1988. He delivered his Presidential Address "On the methods of overlapping maps in Survey Sampling".

To mark the event of the Platinum Jubilee Celebration of the Indian Science Congress Association two platinum jubilee lectures were arranged along with three symposia on Frontiers of Statistics. Professor C. R. Rao, University of Pittsburgh, USA and Professor S. R. S. Varadhan of Courant Institute of Mathematical Sciences gave the two Platinum Jubilee Lectures entitled : (a) Prospects of the L_1 norms in Statistical Theory and Practice ; (b) Large deviations and its many applications. Professor Sir David Cox, FRS of Queen's College, London gave a special lecture "Statistical Models of Rain". Professors S. R. Adke, R. R. Bahadur, B. R. Bhat, S. Dasgupta, J. K. Ghosh, R. L. Karandikar, A. C. Mukhopadhyay, K. R. Parthasarathy, Prem Narayan, P. S. Puri and B. V. Rao were the invited speakers for the Frontiers of Statistics Symposia.

In addition, the other symposia were :

(i) "Linear Models and their applications" : Speakers : Professor S. K. Chatterjee, Professor B. K. Kale, Professor C. G. Khatri and Professor Bimal K. Sinha.

(ii) "Statistics and OR in Planning and Evaluation" : Speakers : Professor S. P. Mukherjee, Professor K. S. Parikh, Professor K. C. Seal and Professor Padam Singh.

(iii) "Validation of NSS Data" : Speakers : Professor B. S. Minhas, Professor S. N. Roy, Professor S. D. Tendulkar, and Professor A. Vaidyanathan.

A Three Day Workshop on 'Microwave and Millimeterwave Propagation Problems in Atmospheric Boundary Layer's was held at ISI in collaboration with C.U., N.P.L., DST, DOE and CSIR from 23rd—25th February 1988. The workshop was attended by leading research organizations all over India and was inaugurated by Dr. A. P. Mitra, Director General of CSIR. The workshop was attended by participants both from users organizations such as TRC, Railways and P & T and Universities all over India. The exchange of views regarding the problems faced by different users and research organizations on the above problem were discussed. The three day workshop was addressed mainly by leading experts in the field and different research groups explained their activities in the workshop. Two panel discussions—one on 'Teaching Curriculum on Atmospheric sciences' and 'Microwave and Millimeterwave Propagation data in System Planning and Design' were held and the recommendations of the panel discussions were forwarded to respective Government departments for necessary actions.

The Economic Analysis Unit organised the Twenty-fifth (Silver Jubilee) Annual Indian Econometric Conference in Bangalore during January 4-6, 1988 at which four papers were presented by the Unit's research staff. There was wide newspaper coverage on this conference ; Special supplement and reports were issued in the Economic Times (Bangalore), The Hindu and The Indian Express.

The Economic Analysis Unit hosted the final meeting of the Curriculum Development Centre in Economics set up by the University Grants Commission, for recommending a restructuring of under-and post-graduate courses in economics in Indian universities. The Committee, in its Report, particularly commended the contribution of the Indian Statistical Institute in the development of Quantitative Economics.

The Economic Analysis Unit organised special lectures on Bayesian Inference as a preamble to the International Workshop on Bayesian Analysis in Statistics and Econometrics to be held in Bangalore during December 1987.

The Third I.S.I. Conference on Economic Theory and Related Mathematical Methods, held between February 1-4, 1988 was organised by the Planning Unit. Selected papers from the three conferences held so far will be published in a volume.

Two Session of the Conference of Association for Modelling and Simulation Enterprise held in New Delhi, 1987 was organised by the Planning Unit.

A Two-Day Seminar on Fundamentals of Articulatory and Acoustic Phonetics and their relevance to Speech Pathology" conducted by Dr. Alokananda Mitter and Guest Scientist Dr. K. Nagama Reddy, Department of Linguistics, Osmania University, Hyderabad, Andhra Pradesh during 8-9 April 1987.

A Staff Development Programme on Taguchi methods and their applications was conducted at Hyderabad during 18-19 April 1987 for the staff members of the SQC & OR Division. 20 participants attended the programme.

A Staff Development Programme on Fuzzy Statistics, Mathematical Modelling and allied topics was conducted at SQC-OR (T & P) Unit, Calcutta during 14-18 December 1987 for the staff members of the Division. 25 participants attended the programme.

The DRTC Silver Jubilee Seminar was held at ISI Bangalore Centre during the period 16-20 December 1987. The seminar was specially organised on the occasion of the completion of 25 years of DRTC's existence. The theme of the seminar was 'Information Personnel Development'. The different facets that formed part of the theme were as follows : (1) Emerging information society and its features and impact on society ; (2) Knowledge and skills needed for various types of services in library and information centre ; (3) Information technology, its implications to library and information personnel development ; (4) Information industry ; (5) Evaluation and measurement of information activities ; (6) Sectorwise impact on information personnel development and (7) Professional education in library and information science since 1960s. On different facets of the theme 21 papers were selected for presentation in the proceedings. These papers constituted the seminar volume. It was published

prior to the seminar and was made available to all the participants. About 100 participants from different parts of India attended the Silver Jubilee Seminar.

3.2 *Lectures and Seminars*

The following seminars/lectures were arranged during the period :

Stat-Math (Delhi)

Dr. T. Parthasarathy, ISI Delhi (3.11.87) : "Matrix Games".

Dr. Andrezej Wieczored, Polish Academy of Science (9.11.87) : "An open problem on fixed point theory".

Dr. R. Bhatia, ISI Delhi (10.11.87) : "The Clarkson-McGarthy Inequalities".

Dr. Surjit S. Bhalla (25.11.87) : "Evaluation of ability through nonrepeatable experiments—A case study of test cricket".

Dr. David Lane, University of Minnesota (3.12.87–4.12.87) : (i) "Generalized Urn Processes and their Applications to Economics", (ii) "Foundations of Statistics : Coherence and Conglomerability".

Dr. Ram Shanmugam, ISI Bangalore (9.12.87) : "A discussion on the intervention effect".

Dr. V. S. Sunder, ISI Bangalore (10.12.87) : "Braid groups and knot invariants".

Dr. T. Ando, Hokkaido University, Japan (15.12.87) : "Some cyclic inequalities in matrix theory".

Dr. J. J. Seidel, Eindhoven Tech. University, Netherlands (29.12.87 & 31.12.87) : (i) "Integral Lattices", (ii) "Graphs and Spectra".

Dr. Charles E. Michelli, IBM Thomas J. Watson Research Centre (1.1.88) : "Admissible slopes for monotone interpolatoins".

Dr. Pelant Jan, Mathematical Institution, Czecholovak Academy of Science, (5.1.88) : "Uniformly continuous selections".

Dr. J. L. Verdier, (25.1.88) : "Elliptic Solitons".

Dr. L. De Haan, Erasmus Universiteit, Rotterdam (9.2.88) : "A. S. Continuity of stable moving average processes with index 1".

Dr. Kuldeep Kumar, IIM, Lucknow (10.2.88) : "Identification of nonlinear and non-Gaussian time series models".

Dr. Van Dulst, (12.2.88) : "Banach Spaces".

Dr. R. R. Bahadur, University of Chicago, (17.2.88 & 24.2.88) : (i) "Large deviations and Inference", (ii) Asymptotically efficient estimation".

Dr. Akhilesh Pandey, School of Physical Sciences, Jawharlal Nehru University, Delhi (19.2.88 & 18.3.88) : "Random Matrices".

Dr. Joseph Horowitz, University of Massachusetts, Amherst (23.2.88) : "A uniform law of large numbers and empirical central limit theorem for limits of finite population ".

Applied Statistics, Surveys and Computing

Mr. Anup K. De (5.8.87) : "Computer Construction of some Group Divisible Designs".

Mr. S. K. Bhandari (7.9.88) : "A Conjecture of Karlin (1974) of Finite Population Sampling Theory and its Aftermath".

Mr. B. Seal (5.10.87) : On inadmissibility of sample intraclass correlation coefficient".

Mr. T. Samanta (2.11.87) : "Asymptotic efficiency of estimators and limits of experiments".

Dr. S. Bandyopadhyay (3.2.88) : "Survey with incomplete frame".

Dr. Anup Dewanjee, Department of Health and Welfare, Government of Canada and National Institute of Health, USA (8.4.87) : "Test for Trend in Binomial Proportions Using Historical Control Information".

Dr. Ryszard Jarzecki, Institute of Fundamental Technological Research, Warsaw, Poland (24.4.87) : "Macroeconomy and Energy Modelling for Poland".

Dr. K. Vijayan, University of Western Australia, Nedlands (27.5.87) : "Estimating Functions in Sampling".

Professor Subir Bandyopadhyay (17.6.87) : "Prolog and Expert System".

Professor Suddhendu Biswas, Department of Mathematical Statistics, Faculty of Mathematics, University of Delhi (19.6.87 & 22.6.87) : "On the Estimation of the Residual Survival Time Following the Failure of First Organ in a Bilateral Parallel Paired System".

Professor S. K. Dey, Department of Mathematics, University of Eastern Illinois, USA (10.7.87 & 27.7.87) : (i) Stability Analysis in Numerical Methods", (ii) "D-Matrix and its Applications to Nonlinear Models".

Dr. Ratan K. Guha, Department of Computer Science, University of Central Florida, Orlando, USA (31.7.87) : "Software Specification and Design Using Petri Nets and Abstract Petri Nets".

Professor W. Lassmann, Martin Luther University, Halle-Wiltenberg Centre of Economic Science, German Democratic Republic (14.10.87) : "Operations Research and its Application as a Tool for Planning and Management".

Professor Ivanka Seykova, Sofia University, Bulgaria (16.10.87) : "Some Problems on the Statistical Survey".

Professor S. Biswas, Delhi University (27.10.87 & 3.11.87) : "Some Problems on Competing Risk Theory".

Professor G. K. Bhattacharya, Stat-Math Division, Bangalore (23.11.87) : "Accelerated Life Testing an overview and some recent advances".

Professor Jack Van Lint, Technological University, Eindhoven, Netherlands (1.2.88) : "Error Correcting Codes".

Dr. T. K. Askarov, Institute of National Economy, USSR (22.3.88) : "Application of cluster Analysis for Defining Geological Regions : A Multistage Approach".

Professor D. V. Gokhale, Department of Statistics, University of California at Riverside, U.S.A. (11.3.88) : "Some Topics on Statistical Inference".

Embryology

Sri A. K. Saha, SRF (March 1987) : "Mathematical Models of the Epigenetic System"

Sm. Anuradha Chakraborty, SRF (September 1987) : "Pheromones of Tigers".

Economic Research

Dr. Surekha Rao, ISI, Calcutta (1.4.87) : "A Bayesian and a Non-Bayesian Test of Causality".

Dr. Tamal Datta Chaudhury, University of Calcutta (8.4.87) : "On Distribution of the Gains from productivity change in a Lewis Type World".

Shri Chiranjib Neogi, ISI, Calcutta (15.4.87) : "Business Concentration and Structural Change in Post-independent India : An empirical enquiry".

Dr. Neela Mukherjee, ICSSR and ISI Calcutta (29.4.87) : "International Economic Crises and Balance of Payments Policy Responses of four South-Asian Countries — India, Pakistan, Sri Lanka and Bangladesh"

Dr. Arun Kumar Sengupta, ISI, Calcutta (6.5.87 & 17.6.87) : (i) Some Evidence on Factor Content of Indian Trade and (ii) On Joint Stability of Input-Output Production and Allocation Coefficients.

Dr. Amita Mazumder, ISI, Calcutta (20.5.87) : "A Generalized Functional Form for Size Distribution of Income".

Dr. Dipankar Dasgupta, ISI, Calcutta (3.6.87) : "Procurement Price, Market Price, Employment and Effective Demand".

Dr. Abhirum Sarkar, ISI, Calcutta (10.6.87) : "A Simple Model of Regional Development".

Dr. Sudipto Dasgupta, University of Southern California (24.6.87) : "Procurement Auctions".

Dr. Sanjit Bose, ISI, Calcutta (29.7.87) : "The Service Form of Production".

Dr. Sanjoy Banerjee, York University (12.8.87) : "Foreign Exchange Constraint, Terms of Trade and Inflation".

Dr. Asoke Rudra, Viswabharati University and ISI (26.8.87) : "Some Problems in the Marxian Theory of Capitalist Development".

Dr. S. K. Chakraborty, World Bank (12.10.87) : "Macro-economic Policy Model for Kenya".

Dr. Ramprosad Sengupta, Jawaharlal Nehru University and Planning Commission, Govt. of India (24.11.87) : "Some aspects of energy modelling for India".

Dr. Dilip Mookherjee, Stanford University (9.12.87) : "A Competitive Efficiency Wage Model with Keynesian Features".

Dr. Nityananda Sarkar, ISI, Calcutta (23.12.87) : "Comparison among some estimates in misspecified Linear Models with multicollinearity".

Dr. Subhas Ray, University of Connecticut (19.1.88) : "Elasticities of substitution : An exposition and extension".

Dr. Surajit Sinha, Mc Master University (20.1.88) : "Technological innovation and the Schumpterian hypothesis : some additional evidence".

Mr. Gray McMohan, Laurentian University (9.3.88) : "Tariff policy, income distribution and long run structural adjustments in a duel economy".

Dr. Soumyen Sikdar, Presidency College, Calcutta (16.3.88) : "A model of corruption".

Dr. D. K. Bhattacharya, University of Leicester, England (17.3.88) : "On the estimation of the 'hidden economy' in the U. K. and it consequences on model building".

Economic Analysis (Bangalore)

Dr. S. Siva Kumar, University of Madras (27.5.87) : "Poverty and Income Distribution in Tamil Nadu : A Historical Perspective from 18th Century to 1960's.

Dr. P. R. Brahmananda, ICSSR National Fellow and Honorary Visiting Professor (3.6.87 & 11.3.88) : (i) "Gunnar Myrdal, Nobel Prize Winner and Economist", and (ii) "Union Budget 1988-89 and the Emerging Fiscal Crisis".

Dr. Gary McMahon, Visiting Professor, ISI (24.11.87) : "Applications of Long-run Tariff Policy to Income Distribution".

Dr. N. S. S. Narayana, ISI, Bangalore Centre (24.2.88, 16.3.88 and 23.3.88) : "Applied Time Series Analysis". (Course of three lectures).

Linguistics

Dr. Alokananda Mitter, ISI, Calcutta (8.4.87 — 9.4.87) : (i) "Articulatory Evaluation of Speech Sounds" and (ii) "The Role of Acoustic Phonetics in the Speech Habilitation of the Hearing Impaired".

Population Studies

On a Generalised Age Dependent Model For the Estimation of Mean Survival Time in the presence of two competing Risks, on 16 June, 1987.

On a probability model for classifying the unknown causes of Death due to Two competing Risks Assignable causes, on 18th June, 1987. There were 16 participants.

Mathematics of Stable Population, on 25 June, 1987. There were 18 participants.

Effects of son preference on fertility in Bangladesh. There were 14 participants.

Stochastic Models on Population and Related Topics, 5 lectures on 16th, 23rd and 30th October and 6th and 13th November, 1987.

Psychometry

Professor John E. Hunter, State University of Michigan, U.S.A. (16.12.87) : "Intelligence (cognitive ability), Experience, Job knowledge and Job performance".

Sociology

Dr. Bidyut chakraborty, State University of Iowa, U.S.A. (22.3.88) : "National democratic ideology and the 1928 Jamshedpur Strike".

DRTC (Bangalore)

A Seminar on "Information Service Products for public sector undertaking" was held on 29-30 April, 1987. The seminar was offered by Shri B. S. Ramananda, Deputy General Manager (Technical Information), HMT Ltd., Bangalore. About 25 participants attended the seminar.

A Seminar on "Information Support System for technology Transfer" was held on 4 May, 1987. The seminar was offered by Prof. A. Neelameghan. About 30 participants attended the Seminar.

A Seminar on "Industrial Information Systems and Services" was held on 5 May 1987. The Seminar was offered by Prof. A. Neelameghan. About 30 participants attendend the seminar.

A Seminar on "Expanding Scope of Information Science" was held on 26 May, 1987. The seminar was offered by Prof. T. N. Rajan, Scientist, INSDOC, New Delhi. About 25 participants attended the Seminar.

A Seminar on "Current Trends in Information Systems Design" was held on 12 August, 1987. Mr. M. N. Seetharaman of National Aeronautical Laboratory, Mr. N. V. Sathayanarayan of Informatics Pvt. Ltd. and Mr. M. S. Sridhar of ISRO offered the Seminar. Prof. G. Bhattacharyya presided over. About 60 participants attended the seminar. The seminar was organised to celebrate Dr. S. R. Ranganathan's Birthday.

A Seminar on "Information Retrieval System Models" was held on 23-24 September, 1987. Dr. S. E. Robertson, City University, London, led the Seminar. This was part of the Sarada Ranganathan Lectures of 1987. More than 100 participants attended the Seminar.

A Seminar on "Public Enterprises Information System" was held on 27 September, 1987. The seminar was led by N. K. Gopalakrishnan, Institute of Public Enterprises, Hyderabad. The Seminar was held to celebrate Prof. S. R. Ranganathan's Death Anniversary. This seminar is held every year and is known by the name "Five Laws Lecture". About 80 participants attended the seminar.

A Seminar on "Integrated Information System for Health Sciences" was held on 29 September, 1987. The seminar was led by Prof. A. Neelameghan. About 30 participants attended the seminar.

A Seminar on the "Nature of College Library Services in Australia" was held on 19 November, 1987. Mr. Marvyn Joseph, Librarian, Leederville College of Tafe, Western Australia, led the seminar. About 25 participants attended the seminar.

A Seminar on "Foundations of Bibliometrics" was held on 21-23 December 1987 and 7-8 January, 1988. On all the days the seminar was offered by Dr. Leo Egghe a visiting Professor to DRTC from Lihurg Universitair Centrum, Belgium. On an average, about 35 participants attended the seminar on each day.

A Seminar on "Developments with Micro-CDS/ISIS : Its new features and applications" was held on 16 February, 1988. Prof. A. Neelameghan, Honorary Professor, DRTC offered the seminar. About 40 participants attended the seminar.

A Seminar on "Bibliographic citations in Technical papers : Process and Analysis" was held on 23 March, 1988. The seminar was led by Shri Arun Kumar Chakraborty, a student of 1987-89 batch. About 20 participants attended the seminar.

A Seminar on "Information Economics" was held on 30 March, 1988. The seminar was led by Ms. A. Srikantaluxmy, a student of 1987-89 Batch. About 20 participants attended the seminar.

A Seminar on "Information User Education : Its purpose, procedure and perspective" was held on 8 April, 1988. The Seminar was led by Ms. Karuna Gupta, a student of 1987-89 Batch. About 25 participants attended the seminar.

A Seminar on "Current Trends on Information Sources and Communication Media" was held on 15 April, 1988. The seminar was led by Vinayak M. Bankapur, a student of 1987-89 Batch. About 25 participants attended the seminar.

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A Seminar on "Expert Systems in Library and Information Systems", was held on 22 April, 1988. The seminar was led by Shri R. Krishnamurthy, a student of 1987-89 Batch. About 20 participants attended the seminar.

A Seminar on "Construction and Maintenance of Thesaurus by using CDS/ISIS" was held on 27 April, 1988. The seminar was followed by a demonstration. Prof. A. Neelameghan, Honorary Professor, DRTC, offered the seminar. About 20 participants attended the seminar.

A Seminar on "Copy Right and its Implications to Library Sciences" was held on 29 April, 1988. The seminar was led by Shri K. Mohan, a student of 1987-89 Batch. About 20 participants the seminar.

4. PUBLICATIONS

The following publications were brought out during April 1987—March 1988 :

(i) Sankhya : The Indian Journal of Statistics, the official organ of the Indian Statistical Institute.

Series A : Vol. 49, Parts 2 & 3

Series A : Vol. 50, Part 1

Series B : Vol. 49, Parts 1, 2, & 3.

(ii) Twentyfive technical reports from the Statistics-Mathematics Group have been issued during the period.

5. SCIENTIFIC PAPERS AND PUBLICATIONS[1]

SCIENTIFIC PAPERS PUBLISHED

Theoretical Statistics and Mathematics

Calcutta

1. Bagchi, B. (with Sastry, N.S.N.) (1987) : Even order inversive planes, generalised quadrangles and codes. *Geom. Dedicata*, 22, 137-147.

2. Chandra, T. K. (with Samanta, T.) (1988) : On the second order local comparison between perturbed maximum likelihood estimators and Rao's statistic as test statistics. *Jour. Mult. Analysis*.

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[1] Joint papers of scientists belonging to different units are shown in the list of publications of one unit only.

3. Datta, Basudev (with Nag, S.) (1987) : Zero-sets of quaternionic and octonionic analytic functions with central coefficients. *Bull. London Math. Soc.*, 19, 329-336.

4. Ghosh, J. K. (1988) : The sorting hypothesis and new mathematical models for changes in size distribution of Sand Grains. *Indian J. Geol.*, 60(1), 1-10.

5. ———(with Sathe, Y. S.) (1987) : Convergence of Bhattacharya bounds—revisited. *Sankhyā* 48(1), 37-42.

6. Maiti, P. (1988) : Some results on T_f-class of linear estimators. *JISAS*, Vol. XL(1).

7. Mukherjee, R. (1987) : On zero cells in log-linear models. *Sankhyā* (B) 49, 97-102.

8. ——— (1987) : On fourth order rotatable designs. *Comm. Statist. Theory and Methods*, 16, 1697-1702.

9. ——— (with Kageyama, S.) (1987) : Search for CD designs with small values of characteristics. *J. Jap. Statist. Soc.*, 17, 1-10.

10. ——— (with Jimbo, M. and Kageyama, S.) (1987) : On cyclic semi-regular group-divisible designs. *Osaka J. Math.*, 24, 395-407.

11. ——— (with Sen, M.) (1987) : Optimal repeated measurements designs under interaction. *J. Statist. Plan. Inf.*, 17, 81-91.

12. ——— (with Chandra, T. K.) (1987) : Comparison between the locally most powerful unbiased and Rao's tests. *Jour. Mult. Analysis.*, 22, 94-105.

13. ——— (with Khatri, C. G.) (1987) : Characterization of normality within the class of elliptical contoured distributions. *Statistics and Probability Lett.*, 5, 17-190.

14. ——— (with Khatri, C. G.) (1987) : Characterization of bijective and bimeasurable transformations for bivariate normal variates. *Sankhyā* (A) 49, 405-411.

15. ——— (with Huda, S.) (1987) : Minimax second-order designs for the difference between estimated responses in extrapolation region. *Statist. Prob. Lett.*, 6, 43-45.

16. ——— (with Bose, M.) (1987) : Factorial designs for quality-quantity interaction. *Calcutta Statist. Ass. Bull.*, 36, 39-49.

17. ——— (with Rao, T. J. and Vijayan, K.) (1987) : Regression type estimators using multiple auxiliary information. *Aust. J. Statist.*, 29, 244-254.

18. ——— (with Huda, S.) (1988) : Optimal design for the estimation of variance components. *Biometrika*, 75, 75-80.

19. ————(with Saha, G. M. and Kegeyama, S.) (1988) : Bounds on the number of constraints for balanced arrays of strength t. *J. Statist. Plan. Inf.*, 18, 255-265.

20. Rao, T. J. (1987):   On certain unbiased product estimators. *Comm. Statist. Theory Meth.*, 16, 12, 3631-3640.

21. ———— (with Amahia, G. N. and Choubey, Y. P.) (1988) :   Efficiency of a new estimator in PPS sampling for multiple characteristics, *J. Statist. Plan. Inf.*

22. Sarma, Y. R. (1987) : Asymptotic properties of Rao's test for testing hypotheses in discrete parameter stochastic processes. *Ann. Inst. Statist. Math.*, 39, 491-511.

23. Sinha, B. K. (with Rao, B. V.) (1988) : On a further characterization of Dirichlet distributions. *Jour. Mult. Analysis.*

24. Tripathi, T. P. (1987) : A class of estimators for population mean using multi-variate auxiliary information under general sampling designs. *Aligarh J. Statist.*, 7, 49-62.

25. ———— (with Ige, A. F.) (1987) : On double sampling for stratification and use of auxiliary information. *Jour. Ind. Soc. Agri. Statist.*, XXXIX, 2, 191-201.

Bangalore

1. Bhaskara, K. H. (with Viswanath, K.) (1988) :   Calculus on Poisson Manifolds. *Bull. London Math. Soc.*, 20, 68-72.

2. Padmawar, V. R. (1988) : On the completeness of certain classes of two-state sampling strategies. *Metreka*, 35,

3. Ramamurthy, K. (1988) : On Weak limits of sami-stable laws. *Sankhyā* (A), 50, 52-58.

4. Ramasubramanian, S. (with Bhattacharya, R. N.) (1988) : On the Central Limit theorem for diffusions with almost periodic coefficients. *Sankhyā* (A), 50, 9-25.

5. Rao, T. S. S. R. K. (with Harmand, P.) (1988) : An intersection property of balls and relations with M. ideals. *Math. Zeitschift*, 197, 277-290.

6. Sunder, V. S. (1987) : A Model for A F algebras and a representation of the Jones Projections. *Jour. Operator Theory*, 18, 289-30

Delhi

1. Bapat. R. B. (1987) : Majorization and singular values. *Linear and Multilinear Algebra*, 21, 211-214.

2. ——— (1988) : Discrete multivariate distributions and generalized log-concavity, *Sankhyā*, 50, 98-110.

3. ——— (with Kwong, M. K.) (1987) : A generalisation of $A.A^{-1} \geqslant I$. *Linear Algebra Applic.*, 93, 107-112.

4. Bhatia, R. (with Halbrook, J. A. R.) (1987) : Unitary invariance and spectral variation. *Linear Algebra Applic.*, 95, 43-68.

5. ——— (1987) : Some inequalities for norm ideals. *Comm. Math. Phys.*, 111, 33-39.

6. ——— (with Ando, T.) (1987) : Eigenvalue inequalities associated with the Cartesian decomposition. *Linear and Multilinear Algebra*, 22, 133-147.

7. Karandikar, R. (1988) : A general principle of limit theorems in finitely additive probabilities : The dependent case. *Jour. Mult. Analysis*, 24, 189-206.

8. ——— (1987) : On the Feynman-Kac formula and its application to filtering theory. *Appl. Math. and Optimization*, 10, 263-276.

9. Mitra, S. K. (1987) : On group inverses and the sharp order. *Linear Algebra Applic.*, 92, 17-37.

10. ——— (with Krishnamoorthy, K.) (1987) : Optimal integration of two or three PPS surveys with common sample size $n > 1$. *Sankhyā*, 49(3), 283-306.

11. Parthasarathy, K. R. (with Sinha, K. B.) (1987) : Stop times in Fock space stochastic calculus. *Prob. Theory and Related Fields*, 75, 317-349.

12. ——— (with Accardi, L.) (1988) : A martingale characterisation of cononical commutation and anticommutation relations. *J. Funct. Analysis*, 77, 1, 211-231.

13. Ramachandran, B. (1987) : On the equation $f(x) = \int f(X+y) \; d\;\mu(y)$. *Sankhya*, Ser. A, 49, 195-198.

14. ——— (1988) : On the equation $f(x) = \int f(x+y) \, d(y)$ for x 0. *Sankhya*, Ser. A, 50, 44-51.

15. ——— (with Seshadri, V.) (1988) : On a property of strongly reproductive exponential families on R. *Statist. Prob. Lett.*, 6, 171-174.

16. Sinha, K. B. (1987) : Wigner-WeissKopf atom and quantum Stochastic dilations. *Proc. Ind. Acad. Sci.*, (*Chemical Sciences*), 99, 3-9.

17. ——— (1987) : Mathematical theory of scattering in quantum mechanics— A review. *Current Sci.*

18. ——— (with Amrein, A. O. and Cibils, M.) (1987) : Configuration space properties of S-matrix and time delay in scattering. *Ann. Inst. Henri Poincare*, 47, 367-382.

INDIAN STATISTICAL INSTITUTE

Applied Statistics, Surveys and Computing

1. Arnab, Raghunath (with Okafor, F. C.) (1987) : Some strategies of two-stage sampling for estimating population ratios over two occasions. *Aust. J. Statist.*, 128-132.

2. Bagchi, Sunanda (1987) : On the E-optimality of certain Asymmetrical Designs under Mixed effects Model. *Metrika*, 34, 95-105.

3. ——— (1987) : On the optimalities of MBGDD's under mixed effects model. *Communications in Statistics*, 16(12), 3565-3576.

4. Basu, Anirban (1987) : Parallel Processing System's : A Nomenclature Based on their characteristics. IEE Proceedings, Part E, 134, 3, 143-147.

5. Basu, T. K. (with Ganguly, S., Sarkar, S., Banerjee, S. K., Banerjee, R. N. and Das, S.) (1987) : Effects of Chlorpropamide at the protein and Immunoglobulin levels of maturity-onset diabetic people. *Annals. Nat. Academy of Medical Sci.*, 23, 19-23.

6. Chaudhuri, Arijit (1987) : Ramdomized response surveys of finite populations : a unified approach with quautitative data. *J. Statist. Plan. Inf.*, 15. 157-165.

7. ——— (with Adhikary, Arun Kumar) (1987) : On certain alternative IPNS schemes. *J. Ind. Soc. Agric. Statist.*, 39(2), 121-126.

8. ——— (with Adhikary, Arun Kumar) (1987) : Circular Systematic Sampling with varying probabilities. *Calcutta Statist. Assn. Bull.*, 36, 193-195.

9. ——— (with Chandra, N. K.) (1987) : Inference about the scale-parameter of n logistic distribution using a single order statistic. *IAPQR Transactions*, 12(1), 51-57.

10. ——— (with Mukherji, Rahul) (1987) : Randomized response Techniques : a review. *Statistical Neerlandica*, 41(1), 27-44.

11. Gupta, Sanjib (1987) : Functional significance of dietary factors in the occurence of Ischaemic Heart Disease. *Ind. J. Phys.*, 31(5).

12. Krishanan, T. (1987) : Some comments on the statistical analysis in genetic significance of the relationship between finger ridge count and its variability : Indian data. *Homo*, 38, 266-268.

13. ——— (with Nandy, S.) (1987) : Discriminant analysis with a stochastic supervisor. *Patt. Recog.*, 25, 379-384.

14. Mukherjee, B. N. (with Yanai, H.) (1987) : A Generalized Method of Image Analysis from an Intercorrelation Matrix which may be Singular. *Psychometrika*, 52, 555-564.

64

15. Pal, Nikhil Ranjan (with Pal, S. K.) (1987) : Segmentation using contrast Homogeneity measures. *Patt. Recog. Lett.* 239-354.

16. ——— (with Pal, S. K.) (1987) : Segmentation based on measures of Contrast, Homogeneity, and Region size, *IEEE Trans. Syst., Man and Cybernetics*, SMC-17(5), 857-868.

17. Sengupta, Ashis (1987) : Tests for standardized generalized variances of multivariate normal populations of possibly different dimensions. *J. Multivariate Analysis*, 23, 209-219.

18. ——— (1988) : On Loss of Power Under Additional Information. *Scandinavian J. Statist.*

Physical and Earth Sciences

Electronics

A. *Digital Systems*

1. Bhattacharya, B. S. (with Seth, S. C.) (1987) : On the reconvergent structure of combinational circuits with applications to compact testing. *Proc. IEEE 17th International Symposium on Fault-tolerant Computer Systems*, Pittsburg, U.S.A., pp. 264-269.

2. ——— (with Deogun, J. S.) (1987) : An Unified approach to via minimization with movable terminal in VLSI routing. *Proc. 2nd IEEE International Conference on Computers and Applications, Beijing*, China, pp. 863-869.

3. Dutta Gupta, J. (with Ghosh, S. and Sinha, B. P.) (1987) : An incrementally extensible network architecture with low diameter and fault tolerance. *Proc. IEEE INFOCOM*, Sanfrancisco, U.S A., p.). 599-607.

D. *Theoretical Physics*

1. Bandyopadhyay, P. (with Basu, Banasri) (1988) : Equivalence of three dimensional Ising system and Polyakov Fermionic string. *Europhysics Lett.*

2. ——— (with Ghosh, P.) (1987) : Stochastic field theory at finite temperature supersymmetry and Witten index. *Annals Phys.*, 179(1).

3. Bhattacharyya, S. (1987) : Extensive air showers, high energy behaviour of ... some comments. *Astrophysics and Space Science* (U.K.), 136., 177.

4. ——— (1987) : Radiation from Cygnus X-3 and the related muon puzzle.........
Nuovo Cimento, 10C, 201.

5. ——— (1987) : On the problematic rising ratio of Cosmic Ray Positions.
Nuovo Cimento, 10C(6).

9

6. ——— (1988) : On some remarkable differences between PP collisions at ISR energies and $P\overline{P}$ at collider energies. *J. Phys. G.*, 14(1), 9.

7. ——— (1987) : On the behaviour of a dependence of the ratio of nucleon-nucleon and nucleon-nucleus collisions. *Proc. 20th International Cosmic\Ray Conference, Moscow*, 5, 17

8. Roy, B. (with Roychoudhury, R. K.) (1987) : The shifted 1/N expansion and the energy eigenvalues of the Hulthen potential for $1. \neq 0$. *J. Phys. A.* (U.K.), 20, 3051.

9. Roy, P. (with Roychoudhury, R. K.) (1987) : New exact solutions of the non-polynomial oscillator $V(x) = x^2 + \lambda x^2 / (1 + gx^2)$ and supersymmetry. *Phys. Letts.* A 22, 122, 275.

10. ——— (with Roychoudhury, R. K.) (1987) : New integral solutions of the non-polynomial oscillator $V(x) = x^2 + \lambda x^2 / (1 + gx^2)$ where $\lambda = 2g (2 - 3g)$. *J. Phys. A.* 20, L 1245.

11. ——— (with Roychoudhury, R. K.) (1987) : On exact solutions of the double anharmonic oscillator. *J. Phys. A.* (U.K.), 20, 6597.

12. Roy, S. (with Asanov, G. S. and Ponomarenko, S. P.) (1988) : Finslerian multi-dimensionality, gauge fields and the stochastic space-time. *Forst. der Physik*, 9.

13. Roychoudhury, R. K. (1987) : Modified impulse approximation and Photo-Nucleon energy loss term : HE—4.1—4p. *Proc. 20th International Cosmic Ray Conference*, Moscow.

14. ——— (with Roy, P.) (1987) : Antiproton spectrum : supersymmetry and super string dark matter vs. intergalactic production, OG 6.1—4p. *Proc. 20th International Cosmic Ray Conference*, Moscow.

15. ——— (with Bhattacharyya, Sikha) (1987) : Ion-acoustic solitary waves in relativistic plasmas. *Physics of Fluids* (USA), 30, 2582.

16. ——— (with Roy, S.) (1987) : Stochastic geometry and the perturbation of energy levels of hydrogen atom . *Phys. Lett.* A. 123., 149.

17. ——— (with Varshni, Y. P.) (1987) : Shifted 1/N expansion and scalar potential in the Dirac equation. *J. Phys. A.* 20, L 1083,

C. *Fluid Mechanics*

1. Haldar, K. (1987) : Oscillatory flow of blood in a stenosed artery. *Bull. Math. Biol.* 49(3), 279-287.

2. Mazumdar, H. P. (with Chakraborty, A. K.) (1988) : Some remarks on the spectra of stably stratfied turbulent shear flow. *Int. Comm. Heat Mass Transfer*, 15(1), 103-112.

3. ——— (with Chakraborty, A. K.) (1988) :   On the spectra of thermally stratified turbulent flow with no shear. *Ind. J. Pure Appl. Math.*, 19(3), 305-311.

Electronics and Communication Sciences

1. Chaudhuri, B. B. (1987) : Hierarchical decomposition techniques in Pattern Classification. *Proc. Int. Symp. on Clinical Cytology and Histometry.* Schloss Elman, W. Germany, Academic Press, London, 112-114.

2. Dutta, A. K. (with Ray, A. and Ganguli, N. R.) (1987) :   An Expert System for Key Syllable Based Isolated Word Recognition. *Patt. Recog. Lett.*, 6.

3. Ganguli, N. R. (with Dutta, A. K. and Mukherjee, B.) (1988) : Acoustic Phonetics of Non-Nasal Standard Bengali Vowels—A Spectrographic Study. *JIETE*, 34(1).

4. Murthy, C. A. (with Pal, S. K. and Dutta Majumder, D.) (1987) :   Representation of Fuzzy Operations Using Ordinary Sets. *IEEE Trans. Syst. Man and Cyberns.*, SMC-17(5), 840-847.

5. Pal, S. K. (1987) : Image Enhancement and Quantitative Index Using Fuzzy Sets. *Int. J. Syst. Sci.*, 18(9), 1783-1797.

6. ——— (with Pal, N. R.) (1987) : Segmentation Based on Measures of Contrast, Homogeneity and Region Size. *IEEE Trans. Syst. Man and Cyberns.*, SMC-17(5), 857-868.

7. ——— (with Rosenfeld, A.) (1988) : Image Enhancement and Thresholding by Optimation of Fuzzy Compactness. *Patt. Recog. Lett.*, 7(2), 77-86.

8. ——— (with Pal, N. R.) (1987) : Segmentation Using Contrast and Homogeneity Measures, *Patt. Recog. Lett.*, 5(4), 293-304.

9. ——— (with Pathak, A. and Basu, C.) (1988) : Dynamic Guard Zone for Self Supervised Learning. *Patt. Recog. Lett.*, 7(3), 135-144.

10. Pathank, A. (with Pal, S. K.) (1987) : A Self Supervised Vowel Recognition. *Patt. Recog.*, 20(2), 237-244.

11. ——— (with Pal, S. K.) (1987) : Learning with Mislabelled Training Sample Using Stochastic Approximation. *IEEE Trans. Syst. Man and Cyberns*, SMC-17(6), 1072-1077.

12. Ray, S. (1988) :   A Heuristic Noise Reduction Algorithm Applied to Handwritten Numeric Characters. *Patt. Recog. Lett.* 7, 9-12.

13. Ray, Kumar S, (1987) :   Application of Fuzzy Logic Controller to a Block—Decoupled Nonlinear Steam Generating Unit (210 MW). *Control Theory and Advanced Technology*, 3(4), Mita Press, Japan.

Geology

1. Chatterjee, S. (with Jain, S. L., Kutty, T. S. and Roy Chowdhury, T.) (1987) : Mesozoic Gondwana vertebrates of the Pranhita-Godavari Valley — a review. *Geol. Surv. Ind. Sp. Pub. No.* 11, 1, 195-212.

2. Chaudhuri, A. K. (with Chakraborty, T.) (1987) : A field guide for Proterozoic sedimentaries around Ramgundam, Pranhita-Godavari Valley, Andhra Pradesh. *Sp. Pub. Geol. Min. Met. Soc.* India, 35 pp.

3. ——— (with Sarkar, S. and Chanda, S. K.) (1987) : Proterozoic coastal sabkha halite pans : an example from the Pranhita-Godavari Valley, South India. *Precambrian Res.*, 137, 305-321.

4. Jain, S. L. (with Vianey-Liaud, M. and Sahni, A.) (1987) : Dinosaur egg shells (Saurischia) from the Late Cretaceous Inter Trappean and Lameta Formation (Deccan, India). *J. Vert. Palaeont.*, 7(4), 408-424.

5. Rudra, D. K. (with Maulik, P. K.) (1987) : Stromatolites from Jurassic freshwater limestones, India. *Mesozoic Res.*, 1, 15-23.

6. Saha, D. (1987) : SPIN8—a FORTRAN 77 program for automated rotation of poles. *Computers and Geosciences*, 13, 235-254.

7. Sarkar, S. (1987) : Petrology of caliche derived peloidal calcirudite/calcarenite in Late Triassic Maleri Formation of the Pranhita-Godavari Valley, South India. *Sed. Geology*, 55, 263-282.

Physics

1. Bhattacharya, Manisha (with Gupta, A. B.) (1988) : Sebum level in normal male and female (Indian). *XVI Nat. Conf.* IADVL abstract, 26.

2. Gupta, A. B. (1987) : A device for quantifying cutaneous thermal sensation. *Bioengineering and the Skin*, 3, 11-24.

3. ——— (with Mukherjee, Soma) (1987) : Age-related changes in thermal sensory thresholds of skin. *Bioeng. Skin abstract* (International Meeting in Israel), 23.

4. ——— (with Tripathi, T. P. and Halder, B.) (1987) : Surface pH of normal skin. *Ind. J. Dermatology. Venereology and Leprology*, 53, 19-21.

5. Mukherjee, Soma (1988) : Iontophoretic treatment of corn by sodium salicylate. *XVI Nat. Conf.* IADVL abstract, 1.

BIOLOGICAL SCIENCES

Anthropometry and Human Genetics

1. Basu, A. (1987) :   Human biology in India : Its possible role in a Third World society under rapid transformation. *Colloquium Anthropologicum* (Zagreb), 11, 233-250.

2. ——— (with Mukhopadhyay, S., Majumder, P. P., Roy. S. K., Mukhopadhy, B., Bharati, P. and Gupta, R.) (1987) :   Food practices in contrasting populations : An anthropological study of the Sherpas, Lepchas, Oraons and Mahishyas of West Bengal. *Social Sci. Inf.* (Paris), 26, 847-868.

3. Gupt , R. (1987) :   Book Revies on *The Bronze Age Harappans* by P. C. Dutt . *J. Ind. Anthrop. Soc.* (Calcutta), 22, 98-99.

4. ——— (with Basu, A.) (1987) :   A genetic study among the Lepchas of Darjeeling area of eastern India. *Hum. Hered.* (New York), 37, 113-121.

5. ——— (with Basu, A., Pawson, I. G., Bharati, P., Mukhopadhyay, B., Mukhopadhyay, S., Roy, S. K., Majumder P. P., Bhattacharya, K. K., Bhattacharya, S. K. and Das, S. K.) (1987) :   Altitude and Human biology : A comparative study of Himalayan Andean and Ethiopian data. *J. Ind. Anthrop. Soc.* (Calcutta), 22, 101-180.

6. Karmakar, B. (with Malhotra, K. C.)(1987) :   Types and combinations of Axial Triradii among the 20 Dhangar castes of Maharashtra, India. *Int. J. Anthrop.*, 2(2), 171-181.

7. Malhotra, K. C. (1987) :   Total fluctuating asymmetry variance in digital ridge counts in man. *Collegium Anthropologicum*, 11(2), 339-346.

8. ——— (with Gilligan, S. B., Boreki, I. B., Mathew, S., Vijayakumar, M. and Rao, D. C.) (1987) :   A family study of dermatoglyphic traits in India : Segregation analysis of accessory palmar triradii and the atd angle. *Am. J. Phys. Anthrop.*, 74(1), 117-124.

9. ——— (with Vijayakumar, M.) (1987) :   Greening Urban Centers. *Sci. Age.*, 12-15.

10. ——— (with Vijaykumar, M., Borecki, I. B., Mathew, S., Poosha, D. V. R. and Rao, D. C.) (1987) :   Resolution of genetic and uterine environmental effects in a family study of new dermatoglyphic measure : sole pattern ridge counts. *Am. J. Phys. Anthrop.*, 47(1), 103-108.

11. ———(with Vijayakumar, S. M., Borecki, I. B., Malhotra, S., Poosha, D. V. R. and Rao, D. C.) (1987) :   A family study of dermatoglyphic trait in India. Resolution of genetic and environmental effects for manus, pes and total pattern ridge counts in man. *J. Genetics*, 66(2), 93-100.

12. Mukherjee, B. N. (with Byard, P. J., Bhattacharya, S. K. and Rao, D. C.) (1988) : Blood pressure in a rural West Bengal fishing community : An Epidemiologic Profile. *Human Biol.* (USA), 60(1), 69-79.

13. ―――― (with Chakrabarty, R., Walter, H., Sauber, P., Malhotra, K. C., Banerjee, S. and Ray, M.) (1987): Immunoglobulin (Gm and Km) allotype in Nine endogamous groups of West Bengal, India. *Annals Human Biol.*, (London), 14(2), 155-157.

14. ―――― (with Vijaykumar M., Malhotra, K. C., Walter, H., Gilbert, K., and Lindenberg, P. Dannewitz, Angela and Reddy, A. P.) (1987) : Genetic studies ámong the Siddis of Karnatak, India : A migrant population from Africa. *Zeitschrift. Morphologie Anthropologie*, 77(2), 97-121.

15. ―――― (with Walter, H., Chakraborty, R., Sauber, P., Banerjee, S., and Roy, M.) (1987) : Population Genetic study in Ten endogamous groups of West Bengal, India. *Anthrop. Anzingar*, (W. Germany), 45(3), 239-254.

16. ―――― (with Walter, H., Matsumoto, Hideo, Miyazaki, Tokiko, Malhotra, K. C., Das, B. M., Gilbert, Klaus and Lindenberg, Peter) (1987) : Distribution of Gm and Km allotypes among Ten populations of Assam, India. *Am. J. Phys. Anthrop.* 73, 439-445.

17. Pakrasi, K. B. (with Dasgupta, P. and Dasgupta, I.) (1987) : Arm circumference and fatfold at triceps in Bengali boys of Calcutta. *Ind. J. Phys. Anthrop Human Genetics*, 13, 2.

18. ―――― (with Dasgupta, P. and Dasgupta, I.) (1987) : Growth height, weight and skinfolds of the Bengali girls : a cross-sectional study. *J. Ind. Anthrop. Soc.*, 22(1), 25-37.

19. ―――― (with Dasgupta, P., Dasgupta, I. and Majumder, P. P.) (1988) : Growth in height, weight and skinfold thickness of Bengali boys of Calcutta, India. *Anthropolegisecher Anzieger*, 46(1), 1-6.

20. Reddy, B. M. (with Malhotra, K. C.) (1987) : Genetic significance of the relationship between absolute total finger ridge count and its variability. *Int. J. Anthrop.*, 2(2), 141-149.

Agricultural Science

1. Bagchi, D. K. (with Banerjee, A. and Bhattacharya, B.) (1987) : Growth and yield of grain *amaranth* in lateritic region of Bihar. *Sci. & Cult.* 53, 11, 338-340.

2. ―――― (with Banerjee, A. and Bhattacharya, B.) (1987) : Effect of N, B and Mo on root and extracted leaf protein yield of radish. *Indian J. Agric. Sci.*, 58(3), 222-224.

3. De, S. K. (with Ghosh, S. S. and Davis, T. A.) (1987) : Germination of *Nypa fruticans* and establishment of the seedlings under non-swampy conditions. *J. Palm and Cycad Soc. Aust.* 17, 1-7.

4. Ghosh, M. (with Johri, B. M.) (1987) : Cell inclusion in vegetative organs of young palms. *Proc. Ind. Nat. Sci. Academy*, B53(2), 193-196.

5. Ghosh, S. S. (with Davis, T. A.) (1987) : Morphology of juvenile palms of four species of *Phoenix*. *Date Palm Journal*, 5(1), 19-35.

Biochemistry

1. Bhattacharya, S. K. (with Gupta, R. and Das, S. K.) (1984) : Altitude and haematology among the Sherpas and Lepchas of Eastern Himalaya. *Anthropobiologia*, (Lisbon), 3(1-2), 3-10. (Published in 1987).

2. ———— (with Saha, N., Mukhopadhyay, B., Gupta, R. and Basu, A.) (1987) : The distribution of transferrin, Group specific component and phosphoglutase—1 subtypes among the Lepchas of Darjeeling, Eastern India (1987). *Japanese J. Hum. Genet.*, 32, 311-318.

Embryology

1. Brahmachary, R. L. (1987) : Reversible Inhibition of Mitosis in Limnaea Embryos Induced by Glycerol, A Cryoptectant. *Proc. Int. Cryogenic Conf.*, Calcutta.

2. Tapaswi, P. K. (with Roychoudhury, R. K. and Prasad, T.) (1987) : A Stochastic Model of Gene Activation and RNS Synthesis during Embryogenesis. *Sankhyā* 49, B. 1., 51-67.

Leaf Protein

1. Chakraborti, S. (with Chanda, S. and Matai, S.) (1987) : Effect of some oils, fats and bile salts on growth and Lipase production by streptomyces sp. L_4. *J. Food Sci. Technol.*, 24, 135-136.

2. ———— (with Bagchi, D. K., Chanda, S. and Matai, S.) (1987) : Effect of rhizobial inoculation on growth and nodulation in winged been. *Indian J. Agric. Sci.*, 57(ii), 852-584.

3. Chanda, S. (with Matai, S. and Chakraborti, S.) (1987) : Deproteinized Leaf Juices as Medium for Growth of Rhizobium. *Indian J. Expt. Biol.*, 25, 573-575.

4. Matai, S. (1986) : Project proposal to assess, technical and economic feasibility of Leaf Protein Production system—II. *Plan of action. Proc. First Convention of Green Vegetation, Leaf Protein Research*, (eds.) N. Singh, J. Dijkstra, J., Venkataraman, L. V. 27-29 Nov. at Varanasi, 133-136.

5. ———· (with Bhattacharya, M. and Bagchi, D. K.) (1986) : Utilization of Sugarbeet (*Beta vulgaris*) crop ; Effect of some Agronomic practices on yields. *Proc. First Convention of Green Vegetation, Leaf Protein Research*, (eds.) N. Singh, J. Dijkstra, Venkataraman, L. V., 27-29 Nov. at Varanasi, 147-152.

SOCIAL SCIENCES

Economic Research

1. Chakravarty, S. R. (with Weymark, J. A.) (1987): Axiomatisations of the Entropy Numbers Equivalent Index of Industrial Concentration. *Measurement in Economics, Physica Verlag*, (New York).

2. Chattopadhyay, K. (1987): Some Economic Aspects of Tourist Traffic — A case study of Amarnath. *Annals of Tourism Research*, 14(2).

3. Chattopadhyay, M. (with Bhattacharya, N. and Rudra, A) (1987): Changes in Living in Rural West Bengal : Private Consumption. *Econ. Pol. Wkly.*, 22(28), 1149-1150.

4. ——— (with Bhattacharya, N. and Rudra, A,) (1987): Changes in Level of Living in Rural West Bengal : Social Consumption. *Econ. Pol. Wkly.*, 22(33), 1410-1413.

5. ——— (with Bhattacharya, N. and Rudra, A.) (1987): Changes in Level of Living in Rural West Bengal : Housing Condition. *Econ. Pol. Wkly.*, 22 (36-37), 1559-1560.

6. ——— (with Bhattacharya, N. and Rudra, A.) (1987): Changes in Level of Living in Rural West Bengal : Consumer Durables, Clothing and Footwear. *Econ. Pol. Wkly.*, 22(44), 1871-1873.

7. ——— (with Bhattacharya, N. and Rudra, A.) (1987): Changes in Level of Living in Rural West Bengal. Perceptions of the people. *Econ. Pol. Wkly.*, 22(48)

8. Coondoo, D. (with Majumdar, A.) (1987): A system of demand equations based on price independent generalized linearity. *Int. Econ. Rev.*, 28.

9. Majumdar, Krishna (1987) : Interstate variations in the Human Resources and Economic Development. *Arthashastra*, 6(2), 19-23.

10. Sarkar, A. (1988) : Supply Constraints, Government Subsidies and Industrial Employment. *J. Dev. Econ.*, 29.

11. Sarkar, N. (with Mukherjee, R.) (1987) : Dependence of the Small Scale Manufacturing Enterprises on the Organised Sector—Some Evidence. *Artha Vijnana*, XXIX(3), 286-296.

Planning (Delhi)

1. Bhat, L. S. (1987) : Agricultural and Socio-economic development—A Regional perspective. *Quart. Bull. Indian Assn. of Social Science Inst.*, 6(3), 48-55.

2. Dutta, B. (1987) : Fuzzy Preference and Social Choice. *Mathematical Social Sciences*, 13, 215-229.

3. ——— (1988) : Covering Sets and a New condorcet choice correspondence. *J. Econ. Therory*, 44, 63-80.

4. Jain, L. R. (1987) : A Note on Iyengar's Method of Estimating Engle Elasticities from Grouped Data. *Sankhyā*, B., 49.

5. Minhas, B. S. (1987) : The Planning Process and Annual Budgets : Some Reflections on Recent Indian Experience. *Indian Econ. Rev.*, 22, 115-149.

6. ——— (with Jain, L. R., Kansal, S. M. and Saluja, M. R.) (1987) : On the Choice of Appropriate Consumer Price Indices and Data Sets for Estimating the Incidence of Poverty in India. *Indian Econ. Rev.*, 22, 19-50.

7. Mukherjee, P. N. (1987) : Study of Social Conflicts: Case of Naxalbari Peasant Movements. *Econ. Pol. Wkly.*

8. ——— (1987) : Rural Poverty and Agrarian Reforms. *Indian Jour. Agric. Econ.*, 42.

9. Ray, D. (1987) : Nonpaternalistic intergenerational altruism. *J. Econ. Theory.*

10. Saradamoni, K. (1987) : Labour, Land and Rice Production : Women's Involvement in Three Indian States. *Econ. Pol. Wkly.*, WS2-WS6.

11. ——— (1987) : Women in a Male-Dominated Unjust World. *Mainstream.*

12. ——— (1988) : Efficency of Central Law for Farm Labour. *Mainstream.*

Economic Analysis (Bangalore)

1. Brahmananda, P. R. (1987) : A New Classical Model for the Indian Economy. *Ind. Econ. Jour.*

2. ——— (1987) : Gunnar Myrdal. *Indian J. Social Sci.*, 1(1).

3. ——— (1988) : A Second Great World Depression 1987 : A Monograph. *Mangalore University Teachers Association.*

4. Iyengar, N. S. (1988) : Macro-econometric comparisons between the U.S. and India. (Abstract) in Iyengar, N. S. (ed.) : Programme and Abstracts of Papers. *The Indian Econometric Society Silver Jubilee Conference, Bangalore.*

5. ——— (with Mallika Gopalakrishna) (1988) : About poverty Line—An alternative approach (Abstract) in Iyengar, N. S. (ed.) : Programme and Abstracts of Papers. *The Indian Econometric Society Silver Jubilee Conference, Bangalore.*

10

6. ——— (with Vani, B. P.) (1988) : Estimates of Household Demand for Selected Commodities : Rural/Urban India—1990, 2000 and 2010 A.D. (Abstract). *In* Iyengar, N.S.(ed.) : Programme and Abstracts of Papers. *The Indian Econometric Society Silver Jubilee Conference, Bangalore.*

7. Narayana, N. S. S. (with Parikh, K. S. and Srinivasan, T. N.) (1987) : Indian Agricultural Policy—An Applied General Equilibrium Model. *J. Policy Modelling*, 9 (4).

8. ——— (with Parikh, K. S. and Srinivasan, T. N.) (1987) : Estimation of Yield Functions for Major Cereals in India. *J. Quant. Econ.* 3(2).

9. ——— (with Parikh, K. S. and Srinivasan, T. N.) (1987) : Policies and Impacts—Analysis with a General Equilibrium Model for India. Discussion Paper No. 3, *Indira Gandhi Inst. Dev. Res.*, Bombay.

10. Shailoja Raghuprasad (with Iyengar, N. S.) (1988) : Estimates of Household Demand for Selected Commodities : Rural/Urban India—1990, 2000 and 2010 A.D. (Abstract) *In* Iyengar, N.S.(ed.) : Programme and Abstracts of papers. *The Indian Econometric Society Silver Jubilee Econometric Conference.*

11. Suryanarayana, M. H. (with Pradhan, B. K.) : Structural Change in Orissa's economy : A Partial analysis in Orissan Perspective (ed. Basudev Sahoo), *Ravenshaw College*, Cuttack.

12. ——— (1988) : All-India Consumption inequality—An Intra-sectoral and inter-sectoral decompositon. *Sankhyā*, Sr. B., 50(1).

Population Studies

1 Bairagi, R. (1987) : A comparison of five anthropometric indices for identifying factors of malnutrition. *American Jour. of Epidemiology*, 126(2),258-267.

2. ——— (with Chowdhury, M. K., Kim, Y. J., Curlin, G. T. and Gray, R. H.) (1987) : The association between malnutrition and diarrhoea in rural Bangladesh. *Int. Jour. of Epidemiology*, 16(3), 477-481.

3. Deb, Roy, R., et.al. (1987) : Data base of a quantitative socio-economic history of India, 1800-1830. *Proc. Indian Historical Records Commission*, 49th Session, 37-46.

4. ——— (1987) : Glimpses of land records of Bengal, 1750-1800. *Proc. Indian Historical Records Commission*, 49th Session, 73-82.

5. Guha Roy, S. (1987) : Developing model schedules of female proportions single for India. *Genus*, XLII(3-4), 181-196.

6. ——— (1987) : Parameterizing Indian fertility experience by Gompertz function. *Demography India*, 16(1), 136-143.

7. Malaker, C. R. (1987) : On recent developments of marriage models and their applications to Indian nuptiality, *Genus*, XLIII (1-2), 93-102.

Psychometry

1. Chatterji, S. (1987) : Role of Psychometric tests in increasing efficiency of Personnel Selection. Proceedings of the Seminar on Personnel Selection & Appraisal System. Department of Humanities and Social Sciences. *Indian Inst. Technol., Madras.*

2. ——— (with Mukherjee, M.) (1987) : Family size, General Aptitude and Achievement. *Jour. Educ. Psychol.*, 34, 193-201.

3. ——— (with Mukherjee, M.) (1988) : Agreement between self ratings, Examiner's and 16 PF. *Jour. Psychometry*, 1, 1-7.

4. ——— (with Mukherjee, M. and Ghosh, Anjali) (1988) : Relationship between measures of personality traits. *Productivity*, XXVIII(4), 375-382.

5. ——— (with Mukherjee, M. and Gupta, Rumki) (1987) : Assessment of Intelligence level of Hearing Impaired children. *Indian J. Applied Psychol.*, 13, 31-37.

6. Ghosh, A. (1987) : A comparative study between a group of managers and non-managers with respect to some cognitive and non-cognitive aspects. *Proc. Indian Academy of Applied Psychol.*, Hyderabad.

7. Mukherjee, M. (1987) : Measurement of Personality Traits under Selection Situation. Proceedings of the Seminar on Personnel Selection and Appraisal System. Department of Humanities and Social Sciences. *Indian Inst. Technol.*, Madras.

Sociology

1. Bandyopadhyay, Suraj (with Rao, A. R.) (1987) : Measures of reciprocity in a social network, *Sankhyā* 49, A. 2, 141-188.

2. Biswas, S. K. (1987) : What future awaits the aged of north-east India ? North East India 2000 AD—edited by B. Dutta Ray, 239-257.

3. Dasgupta, Atis (1987) : Early trends of anti-colonial peasants resistance of Bengal. *Social Scientist*, 20-32.

Statistical Quality Control and Operations Research

1. Chaudhury, S. K. (with Sengupta Sukalyan) (1987) : A type of group test in plan for bulk materials in packaged unit, *Calcutta Statist. Assn. Bull.* 36, 197-202.

2. Handa, S. S. (1987) : Estimation of MTBF for system of relays under testing conditions. *OR Journal.*

3. Majumder, A. (1987) : Acceptance criterion for Bayesian multi attribute sampling plans. *Proc. ICQC* L987, Tokyo, Japan. 563-566.

4. Majumder, S. K. (with Banerjee, K. K.) (1987) : Study on improving the functional performance of a selected model of ceiling fan. *Proc. Int. Conf. on Quality Control* at Tokyo, Japan. 519.

5. Mukherjee, S. P. (1987) : Optimum ordering interval for time varying decay rate in inventory. *OPSEARCH.* 24, 19-24.

6. ———— (1987) : Control of incidence of defect categories in case of defect interface. *Proc. Int. Conf. Quality Control.* Tokyo, Japan. 747-748.

7. Pandey, R. J. (1987) : A note on determination of Bayesian three decision plans using Thyregod's method. *Sankhyā*, B. 49, 2, 148-152.

8. Ramamurthy, K. G. (1988) : A review of an optimization problem. *OPSEARCH.* 25, 29-48.

9. ———— (1988) : A new algorithm to find the smallest committee containing a given set of players, *OPSEARCH.* 25, 49-56.

10. ———— (with Mohan, S. R.) (1987) : On the linear complementarity problem with a reflexive inverse of singular matrix. *OPSEARCH.* 24, 133-142.

11. Seth, A. (1987) : Wastage reduction in wood cutting. *OPSEARCH.* 24, 94-105.

LIBRARY, DOCUMENTATION AND INFORMATION SCIENCES

DRTC (Bangalore)

1. Gopinath, M. A. (1987) : Design of Concept Codes in Information Retrieval. *Lib. Sci.*, 24, 226-234.

2. ———— (1987) : Symbiosis of thesaurus and classification. *Lib. Sci.*, 24, 211-225,

Delhi Centre Library

1. Arora, Aruna (1987) : Sources of Statistical information in India. *I. L. A. Bull.*, XXIII, 1-2.

BOOKS PUBLISHED

Theoretical Statistics and Mathematics

Bangalore

1. Bhaskara, K. H. and Viswanath, K. : Poisson Algebras and Poisson Manifolds. *In* Pitman Research Notes in Mathematics Series, No.174. Published by Longman Scientific & Technical. Essex and New York, 1987.

Delhi

1. Balasubramanian, K. : Basic programming for school students. (Mimeographed). Indian Society of Management and Economics, Madras, 1987.

2. Bhatia, R. : Perturbation Bounds for Matrix Eigenvalues. Vol. 162. *In* Pitman Research Notes in Mathematics No. 162, Longman Scientific and Technical Essex and New York, 1987.

Applied Statistics, Surveys and Computing

1. Chaudhuri, Arijit and Mukherjee, Rahul : Randomized Response : Theory and Techniques. Marcel Dekker, Inc. N. Y., U.S.A. (1987).

2. Chaudhuri, Arijit and Vos, J. W. E. : Unified theory and strategies of Survey Sampling. North-Holland, Amsterdam, The Netherlands (1988).

PHYSICAL AND EARTH SCIENCES

Physics

1. Gupta, A. B. : Properties of Matter. Book Home, 32, College Row, Calcutta, (1988).

SOCIAL SCIENCES

Economic Research

1. Roy, Biswanath : Paschimbanger Samajik Oh Arthanaitik Samiksha. (in Press).

Planning (Delhi)

1. Bhat, L. S. : Integrated Area Development—Case Study of North Kanara District. Concept Publishing Company, New Delhi.

2. Mukherjee, P. N. (Ed.) : International Symposium on Social Movement and Social Change.

3. Saradamoni. K . : Women and Rice Cultivation. (in Press).

Economic Analysis (Bangalore)

1. Iyengar, N. S. (Ed.) : The Indian Econometric Society Silver Jubilee Conference, January 4-6, 1988. *Programme and Abstracts of Papers.* Bangalore, 1988.

2. Iyengar, N. S. (Ed.) : The Indian Econometric Society 1960-1987 : A Profile. Indian Econometric Society, January, 1988, Bangalore.