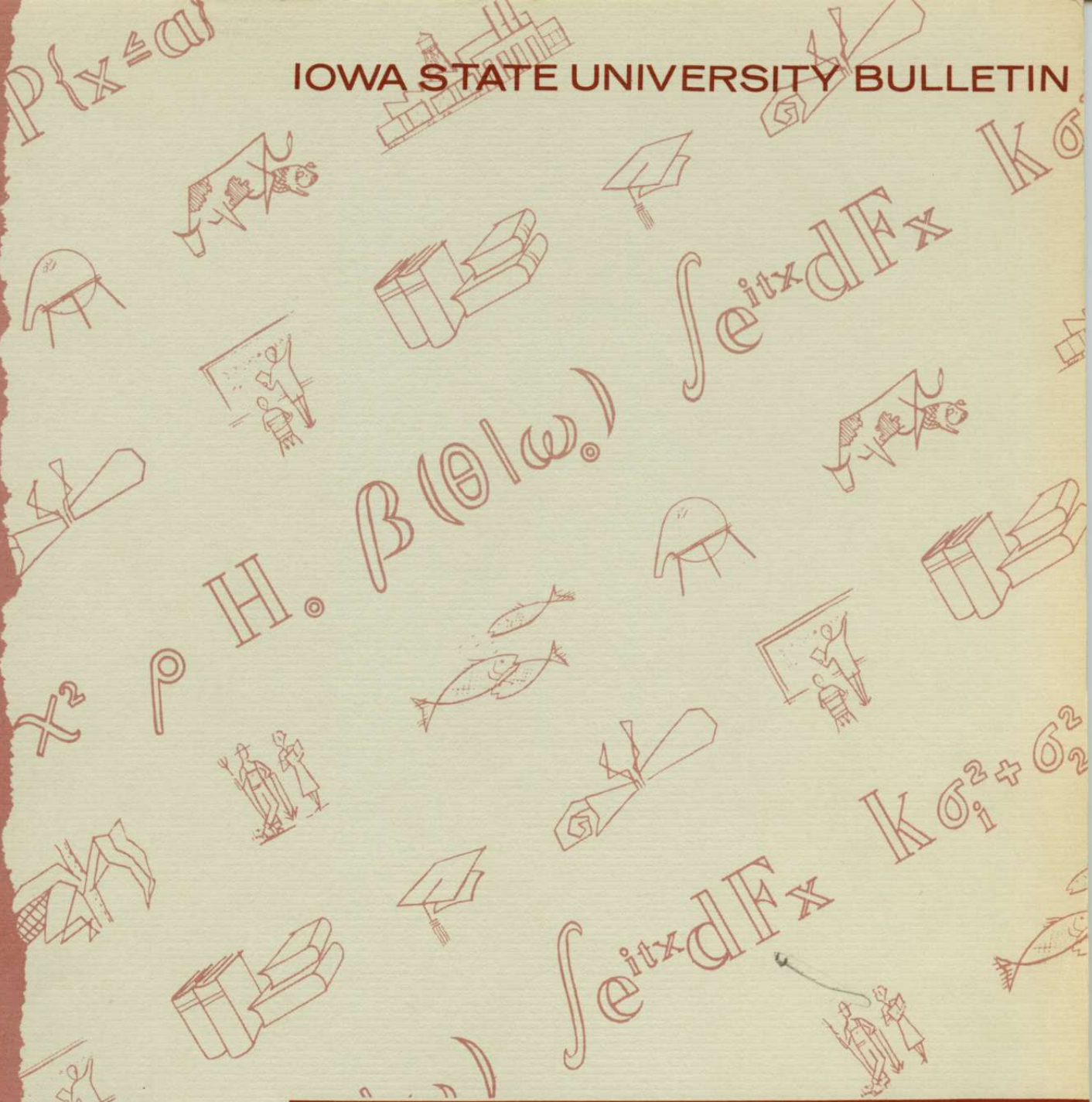
The Statistical Laboratory Established 1933 Iowa State University

IOWA STATE UNIVERSITY BULLETIN



ANNUAL REPORT

July 1, 1961 to June 30, 1962

President James H. Hilton
Iowa State University of
Science and Technology
Ames, Iowa

Dear President Hilton:

This is the Annual Report of the Statistical Laboratory staff at Iowa State for the period July 1, 1961 through June 30, 1962. It reports on the research, consulting, teaching and operational work of members of the university statistical center as complementary activities of the center's five components: the Statistical Laboratory, established as a research and service institute under the President's Office; the teaching Department of Statistics of the College of Sciences and Humanities; the statistics department of the Agricultural and Home Economics Experiment Station; and the statistics participant unit of the Industrial Science Research Institute; together with the research field office of the Statistical Standards Division, Statistical Reporting Service, United States Department of Agriculture, which is located in the Statistical Laboratory. Inasmuch as the statistical endeavors of individuals are carried on through institutions and departments of Iowa State University, this constitutes an annual report from those organizations.

Respectfully submitted on behalf of
the Statistical Laboratory staff,

T. A. Bancroft

Director, Statistical Laboratory and
Head, Department of Statistics; head
statistics department, Agricultural and
Home Economics Experiment Station

THE STATISTICAL LABORATORY

Iowa State University

ANNUAL REPORT 1961-1962

IOWA STATE UNIVERSITY BULLETIN
Ames, Iowa

Vol. LXI December 28, 1962 No. 28

Published weekly by the Iowa State University of Science and Technology, Ames, Iowa. Entered as second-class matter at the Post Office at Ames, Iowa, under the Act of August 24, 1912.

ORGANIZATION CHART

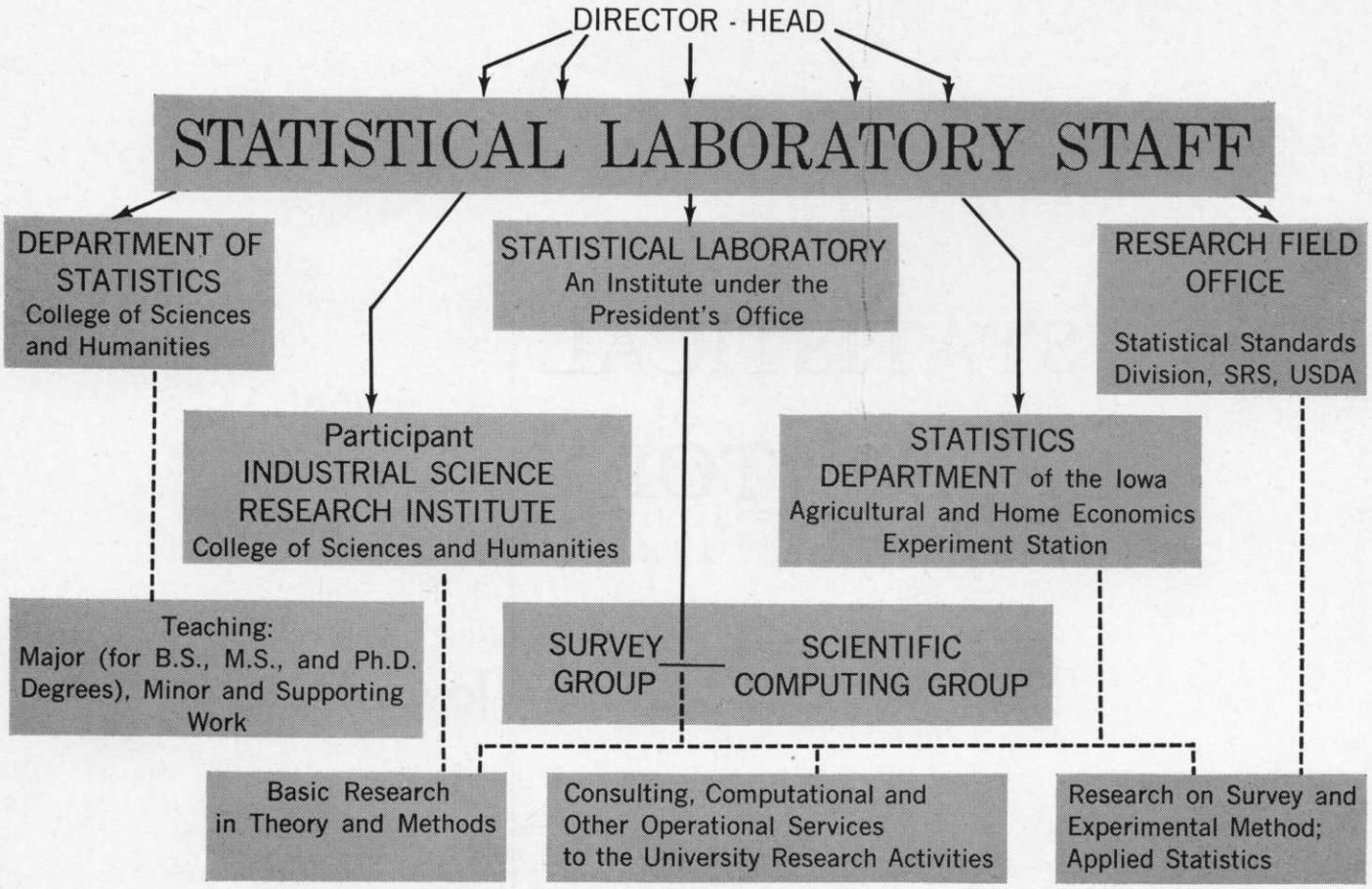
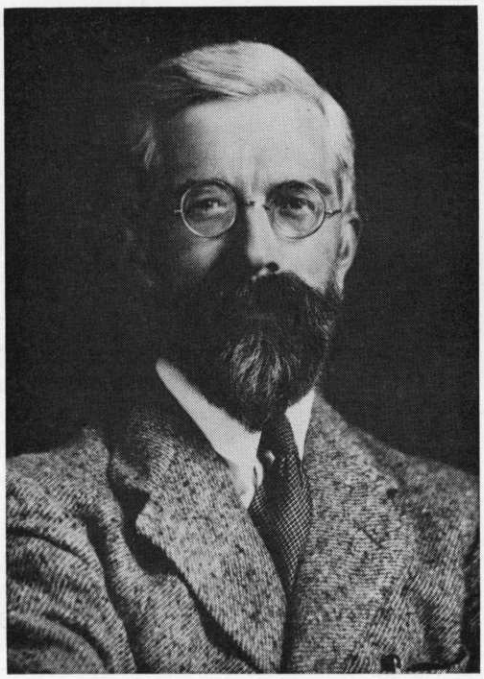


TABLE OF CONTENTS



SIR RONALD AYLMER FISHER
M.A., Sc.D., F.R.S.

We take sad notice of the death of Sir Ronald Fisher in Adelaide, Australia, on July 29, 1962.

This British statistician has been called "not only the greatest figure in the history of statistics, but one of the greatest figures in the history of scientific method generally." (Wallis and Roberts, 1956) And again, "Although hundreds of scholars have contributed to the science of statistics, this one man must be credited with at least half of the essential and important developments as the theory now stands." (Mood, 1950) The impact of Sir Ronald's many original contributions to the development of statistics as a science is well known, and the applications of his theories have made possible the acquisition of new knowledge in many areas.

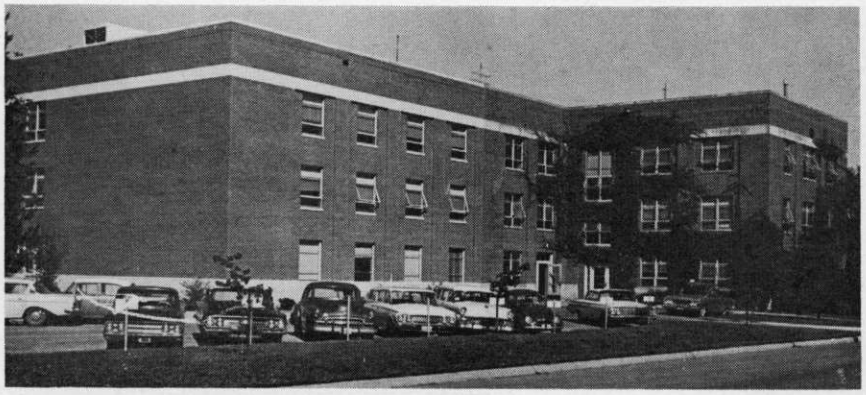
In 1931 and 1936 he was visiting professor for the summer sessions at Iowa State University. He visited the university on two other occasions, in 1952 and in 1957. His distinguished lectures and intensely stimulating mind supplied a major spur to the development of the research, consulting and teaching programs of the Statistical Laboratory and later of the Department of Statistics at Iowa State.

Professor George W. Snedecor was among the first in America to recognize the importance of Sir Ronald's work in the application of statistics to biological and agricultural research and to see that his work was brought to the attention of research workers in these and other fields.

Iowa State University has the honor of having been the first American university to honor Sir Ronald Fisher by awarding him the honorary degree of Doctor of Science on July 23, 1936.

On behalf of the staff of the
Statistical Laboratory and the
Department of Statistics of
Iowa State University
T. A. Bancroft, Director and Head

The Statistical Laboratory



The addition to the Service Building almost doubles the space available to the Statistical Laboratory and the Department of Statistics for offices, research, operational and computing laboratories.

The following quotation is taken from the Statistical Laboratory Annual Report for 1950-51.

> In 1924 twenty members of the faculty of Iowa State College met on Saturday afternoons to study multiple regression and other statistical methods under Henry A. Wallace, then assistant editor of **Wallace's Farmer,** and Charles F. Searle, state agricultural statistician. Especially interested in these early conferences were R. A. Pearson, president of the college, S. W. Beyer, Science Division dean, E. R. Smith, head of the department of mathematics, and George W. Snedecor of the same department.
>
> The bulletin "Correlation and machine calculation" by Wallace and Snedecor was published in 1925 as a result of these conferences, and distributed widely both in this country and abroad. This pamphlet had now become practically a collector's item.
>
> The demand for statistical help increased, until in 1927 the college set up a Mathematics Statistical Service with Professor Snedecor in charge. Calculating and punched card tabulating equipment were installed. . . . The development of use and study of statistics at Iowa State has, from the beginning, been a cooperative enterprise . . . (and) the importance of cooperation between experimenter and statistician was formally recognized with the appointment of Snedecor as Statistician of the Agricultural Experiment Station . . . The Statistical Laboratory was organized as an institute of the college in 1933 under Snedecor. (It was the first statistical center of its kind in the United States.)
>
> Research fields of the Laboratory were expanded under a number of cooperative agreements set up with governmental agencies—first, in 1938, with the Bureau of Agricultural Economics, USDA, and subsequently with the Weather Bureau, Bureau of the Census and Office of Naval Research.
>
> In 1947 a separate Department of Statistics was formed within the Division of Science. The Ph. D. in statistics is now granted instead of the Ph.D. in mathematical statistics formerly given by the Department of Mathematics . . . The Statistical Laboratory now includes (1) a department of the Agricultural Experiment Station, (2) a unit which participates in the work of the college Industrial Science Research Institute, (3) a research field office of the Bureau of Agricultural Economics, US DA, (4) a unit for basic research and general consultation sponsored by the President's office and (5) an all-college service unit.

T. A. Bancroft became professor and head of the Department of Statistics, Director of the Statistical Laboratory and Head of the Department of Statistics of the Iowa Agricultural Experiment Station in 1950.

In the following decade numerous contracts were made with governmental agencies making possible greatly expanded research activities in the Statistical Laboratory. Some of the larger contracts were with the Bureau of Human Nutrition and Home Economics, the Union Stock Yards-Agricultural Experiment Station, the Atomic Energy Commission, Wright Air Development, Camp Dietrick, Air Force-Office of Scientific Research, Office of Ordnance Research, National Institutes of Health, National Aeronautical and Space Administration, Army Research Organization, and the National Science Foundation. Since 1950 nearly one million dollars has been made available by these agencies for research which has been carried on by the staff and graduate students in the Department of Statistics.

In 1956-57 construction of the Cyclone, Iowa State's high-speed computer, was begun, and an IBM 650 was installed in the Statistical Laboratory on a rental basis.

The 25th anniversary of the Statistical Laboratory and the 100th anniversary of Iowa State were celebrated in 1958. In the centennial celebrations the establishment of the Laboratory and the acquisition of high-speed computers were both cited as major landmarks in the history of the institution, which was now to be known as Iowa State University.

The Survey Group operational staff in new surroundings—the large, light offices where operational and research work is carried on for many departments of the university and for some federal agencies and other institutions a nd commercial groups.

In the current year 1961-62, the problems of housing the rapidly expanding activities of the Statistical Laboratory and the Department of Statistics have been greatly alleviated. In October the Laboratory expanded to occupy additional quarters in its new building, a three-story addition to the south of the Service Building. Staff who are now housed in the new addition were formerly working in substandard temporary quonsets, barracks and temporary building "N". The first floor of the addition contains the IBM computing area, which on April 1, 1962, became, for administrative purposes, a part of the university computing center.

George Zyskind, Oscar Kempthorne and Dewey L. Harris with their stock-in-trade—paper and pencils with which they record the results of their research in Experimental Design and Genetic Statistics.

On the second floor are the headquarters of the Survey Group: the large rooms on the east are used for operational work, design and selection of samples, coding of questionnaires and interview data, and data processing; and across the corridor are four modern offices for the professional workers in survey, sampling and computing. The third floor has five offices for the teaching staff and researchers and two laboratories, one of which is also used as a seminar room.

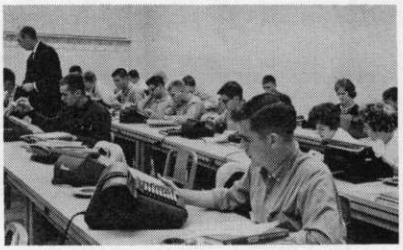
The administrative offices, offices for five staff members, and the library and conference room remain in the northeast half of the old building.

During February and March, 1962, the northwest corner of the first floor of the old building, where the computing group formerly had its space, was expanded, modernized and renovated for the Experimental Design-Genetic Statistics Group. This was made possible by a Graduate Research Laboratories Development Grant from the National Science Foundation and matching funds from the State of Iowa. The area now consists of one single office and two double offices for research professors, a general office for the secretary for the group, and two large offices for associates and graduate assistants. The renovation of this area was made necessary by the expansion of the research activities of this group through federal grants and contracts.

Added space makes possible further growth of the activities of the statistical center, a growth which has been tremendous over the past decade. However, the energies of the staff are still, as in the beginning, given with almost equal emphasis to research, consulting, service and teaching. The Laboratory has continued to have both permanent and temporary support of the Agricultural and Home Economics Experiment Station as well as research contracts in 1961-62 with the National Aeronautical Space Administration, Wright Air Systems Development, Office of Ordnance Research, Army Research Office, a research training grant from National Institutes of Health for research in biostatistics, and nine National Science Foundation grants for research projects in various areas.

The Laboratory is a research and service institute. It is concerned with conducting research in statistical theory and methodology and with promoting and fostering the use of sound statistical methods in the researches of the university. The staff cooperates closely with research workers in all the colleges on the campus. Staff and facilities are maintained for statistical consulting aid, numerical analysis and programming, sample survey operations, and statistical design and analysis of surveys and experiments. Similar research cooperation, consulting aid and services are extended to off-campus groups, other colleges and universities, or civic groups, when such activities are of mutual benefit or otherwise in the public interest.

Finally the Department of Statistics offers a full schedule of approximately fifty courses for graduate and undergraduate students. Twenty eight hundred and fifty-four students, many of whom were graduate students from other departments of the university, were enrolled in these courses in 1961-62. Graduate majors in statistics numbered fifty-four, twenty of whom were from foreign countries, and there were approximately 24 undergraduate statistics majors. The laboratory conducts a weekly seminar in statistics and cooperates in sponsoring interdisciplinary seminars in quantitative genetics and computer science.



One of two student laboratories which are furnished with 65 calculating machines for computing statistical problems. This is a class in Principles of Statistics for undergraduates. Students enroll from many departments on the campus.

Personnel

Under the administrative direction of

James H. Hilton, D.Sc. .....President

J. J. L. Hinrichsen, Ph.D. .....Acting Dean, College of Sciences and Humanities; Acting Director, Industrial Science Research Institute (ISRI) (until April 1, 1962)

Chalmer J. Roy, Ph.D. .....Dean, College of Sciences and Humanities; Director, Industrial Science Research Institute (ISRI) (after April 1, 1962)

Floyd Andre, Ph.D. .....Dean, College of Agriculture; Director, Iowa Agricultural and Home Economics Experiment Station (AHEES)

Theodore A. Bancroft, Ph.D. .....Director, Statistical Laboratory; Head, Department of Statistics; Head, statistics department, Iowa Agricultural and Home Economics Experiment Station

The Statistical Laboratory is one of several independent research institutes on the campus of Iowa State University. The five components of the center have a single director and share personnel. In fiscal terms this means that a staff member's salary may be provided from several sources—e. g., the Department of Statistics, the Statistical Laboratory budget set up by the President's Office, a statistical project of the Iowa Agricultural and Home Economics Experiment Station, or a research contract arranged by the Statistical Laboratory and the Industrial Science Research Institute. The Laboratory also has a number of research grants and contracts with federal agencies which provide funds for research for both staff and graduate students at all levels.

The members of the statistical center, including its affiliated fellows and graduate students, are listed below.

THE STATISTICAL LABORATORY STAFF FOR THE YEAR 1961-1962

Professors:

T. A. Bancroft
Herman O. Hartley
Oscar Kempthorne
Norman V. Strand
Gerhard Tintner (Joint appointment with the Department of Economics & Sociology and Mathematics)
H. C. Fryer (Visiting professor, June 1 - August 31, 1961)
Rex L. Hurst (Visiting professor, June 1 - July 15, 1961)

Professor Emeritus:

George W. Snedecor (in absentia)

Associate Professors:

Robert J. Buehler
C. Philip Cox
Herbert T. David (Joint appointment with the Engineering Experiment Station)
David V. Huntsberger
Leroy Wolins (Joint appointment with the Department of Psychology)

Assistant Professors:

Foster B. Cady
Wayne A. Fuller
Dewey L. Harris
Donald K. Hotchkiss
Campbell C. Mosier (Head of University Data Processing Service until March 30, 1962); Operations Manager, Computer Center since April 1, 1962)
J. N. K. Rao
Dale O. Richards (Joint appointment with Department of Industrial Engineering)
George Zyskind

Post Doctoral Associate:

B. V. Shah

Instructors and Associates:

Russell Altenberger (resigned August 31, 1961)
Harold Baker
E. J. Carney (since March 1. Formerly graduate assistant)
Mary Clem (until April 1, 1962)
John Gill
William J. Hemmerle
Edwin J. Hughes (since December 1, 1961. Formerly graduate assistant)
Howard W. Jespersen
Lawrence Prince (Resigned March 1, 1961)
Harold Rosenberg (since December 1, 1961. Formerly graduate assistant)
Florence Tetreault

Graduate Assistants:

Ross Adams (January 1, 1962 - April 1, 1962. Formerly graduate student)
Rodney Basson (since March 1, 1962)
George Byrne (Teaching, Department of Mathematics, Spring 1962)
Robert Cochran
Charles Cress
Eugene Dayhoff
Thomas Doerfler
Alan Feddersen
Francis Giesbrecht
John Graham
Klaus Hinkelmann
Ronald Hocking
James Kosmiski
Marvin Lentner
Allen Lipis
Frederick Loo
Donald Mallory
Philip Mills
Brenda Morrison
Fred Ramsey
Larry Ringer (until October, 1961)
Carl Schach
Chang-sheng Shih
Kenneth Simons
LaFarr Stuart
Gary Sutter
Bert Webster

National Institutes of Health Trainees:

Ross Adams (since April 1, 1961. Formerly graduate assistant)
Eugene Cohen
Betty Eberle (Supported by Western Reserve University NIH Grant)
Carol Bates Edwards
Darrol Heggen (in absentia)
Paul Leaverton
Ilbok Lee
Howard Marsh (Supported by Western Reserve University NIH Grant)
James Zweifel

Graduate Students:

Edward J. Carney (Joint Industrial Engineering—Statistics)
Donald R. Jensen (Joint Agronomy—Statistics)
William D. Lawing
Dale O. Richards (Joint Industrial Engineering—Statistics)

General Electric Fellow:

Dale Grosvenor

Iowa State University Research Foundation Fellow:

Lee H. Smith

Fellows:

Charles E. Caudill	USDA
Carlos Cavallini	ICA-Argentina
Emilio Ellena	ICA-Argentina (until November 1961)
Ahmed El Mawaziny	UAR-Egypt
Jose Gutierrez	FAO-Philippines
Rodolfo Mengido	ICA-Argentina
Esmat Nouri	UAR-Egypt
Phrensi Svasti-Salee	FAO-Thailand
Fred Thorpe	USDA
Mauritz van Aarde	Union of South Africa (Graduate Assistant May 1, 1961)

National Science Foundation Undergraduate Research Participants:

Leon Burmeister
Robert Croft
Arthur Warrick

Student Assistants (Undergraduates):

James Heard
Gregory Sampson
James Veale
Donbe Whiting

General Office Staff:

Administrative Assistant: Margaret G. Kirwin
Margaret Willey, bookkeeper (until April 1, 1962)
Mabel M. Peterson, accountant
Eleanor F. Bolton, technical writer (since December 1, 1961)
Jauvanta Walker, technical writer (until May 1962)
Secretarial Staff:
Audrey Graham, Experimental Design
Susan Kosmiski, Teaching
Anne Leicht, Survey Unit
Glenda Sampson, General Office
Sandra Partlow, Summer Institute

Survey Group:

Survey Supervisor, Helen Ayres
Clerical Supervisor, Marjorie Mason
Clerks: Lucile White
Mabel Matthews
Marie Osterman
Evelyn Howe
Alice Eldridge
Hazel Cook (Interviewer)
Jeanne Wagaman
Ava Klopf

Numerous field interviewers are temporarily employed by the Survey Unit during the time various sampling projects are carried on.

Computing Services (until April 1, 1962):

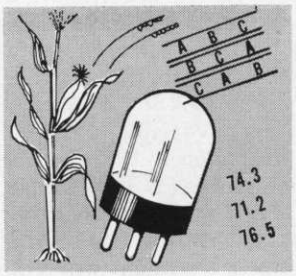
IBM 650 Computing Section:
Supervisor, Mary Clem, Associate
Howard Jespersen, Associate
Bertha Eastman, assistant supervisor
3 machine operators
6 key punch operators

Cyclone:

Supervisor of Programming, William Hemmerle, Associate
Natalie Skola, secretary
Graduate assistants:
George Byrne
Lawrence Prince
La Farr Stuart

Undergraduate technicians
June Fisher
Robert Croft
Arthur Warrick

Consulting and Joint Research



The members of the staff of the Statistical Laboratory through their consulting activities come into contact with research work being carried on in agriculture, the sciences, engineering, home economics and veterinary medicine at Iowa State University. The Statistical Laboratory budget, provided by the President's Office, supports consultation in mathematical statistics and computational methodology, as well as general statistical consultation in areas where no other specific funds have been provided for advisory work. Recent problems are exemplified in the material which follows.

In General Statistical Methodology

H. O. Hartley consulted on a wide variety of statistical problems in his work with graduate students and staff and with outside groups. He worked with an industrial engineer concerned with the expected waiting and service times for a fleet of trucks carrying bulk material to a paver. Data showed that the service times followed an Erlang distribution for about 30 degrees of freedom, and the distance between the arrivals followed an Erlang distribution for about 4 degrees of freedom. As an approximation, a constant service-time was assumed, and following a method described by Saty, a graph was prepared for the above expectations.

Hartley consulted with a research scientist from the Department of Veterinary Medicine on analysis of data concerned with the consistency and reproducibility of blood tests for bucellosis. An analysis of variance by laboratory and blood sample was carried out with the help of variate transformations.

Several agricultural economists were assisted in their statistical problems by Hartley. One was concerned with the relationship between the volume of corn stored by elevators and bin sites, and the total profit of elevators in relation to their total volume capacity and their practices. A mixed linear relationship and Cobb-Douglas type of regression was used. Another agricultural economist was concerned with the aggregation of supply functions estimated from the results of linear programming applied to a sample of representative farms. The solution to the problem was presented by Hartley at a Farm Foundation NCR-4 Workshop in Chicago, "Samples and Methods for Aggregation of Supply Functions." Hartley also consulted with another agricultural economist who was concerned with adjusting multiple regression estimates in a production study for a priori information on the effect of some of the input variables.

In conjunction with estimating parameters of the rainfall distribution, Hartley consulted with a climatologist on the statistical treatment of no-rain days in the distribution of daily rainfalls. He assisted in a vocational education study of the significance of the IQ in predicting students' grades. He assisted an agronomist in the analysis of the moisture content of the surface soil and with large-scale records on moisture content of the soil. He consulted with an agricultural engineer simulating on the hi-speed computer the operations involving the use of a single tractor on a farm.

A farm machinery company representative was assisted in the problem of applying computers to inventory control. At the request of the Engineering Extension Service, Hartley and Dale Grosvenor planned a course on application of linear programming and simulation in operational research for the Maytag Company in Newton, Iowa. They surveyed the problems arising at Maytag from the point of view of their suitability for the application of these techniques.

A proposed new cancer morbidity survey for the State of Iowa and the possibility of establishing a human population center for the State were the subjects of consultation of T. A. Bancroft, N. V. Strand and Wayne Fuller with Mr. William Hanzel of the National Cancer Institute, Washington D. C., and members of the medical staff of the State University of Iowa.

T. A. Bancroft consulted with the staff of the Agronomy Department as a member of the Committee on Iowa Corn Yield Tests to evaluate the 1961 corn yield for the state.

Bancroft also consulted with Dr. T. A. Brindley of the Department of Entomology and Zoology in directing the work of Donald Sisson on his Ph.D. thesis on "Combining Biological Data from European Corn Borer Experiments over Locations and Years." The data utilized were taken from a North Central states regional project, NC-20, on the ecology of the European corn borer carried out during the years 1953-57 inclusive. The three locations involved were Ankeny, Iowa, Waseca, Minnesota, and Wooster, Ohio. The experimental design for any one year and any one location was a split-split plot. Procedures were developed for combining split-split plot experiments over years and locations.

Bancroft consulted with F. F. Dicke and George Pescho of the Department of Entomology and W. A. Russell of the Department of Agronomy on the design and analysis of entomological experiments.

A group of statisticians and mathematicians from Columbia, Missouri, visited the Statistical Laboratory to study the organization of the Laboratory with the idea of setting up some similar organization in the University of Missouri College of Commerce. They consulted with Bancroft on reorganizing work in statistics and computing at the University of Missouri.

An interdisciplinary committee made up of Robert Clyde of WOI, Dr. Donald Boles of the Department of History and Government, William Hemmerle, J. N. K. Rao and T. A. Bancroft of Statistics considered the feasibility of predicting the outcome of the November elections from early returns to be obtained the night of the elections. A design for the prediction was drafted and the procedure was set up.

D. V. Huntsberger consulted with staff and graduate students on statistical problems in a number of areas, of which the following are examples. With a chemical engineer he was concerned with heat transfer between two liquids and with extraction efficiency, together with the processing of data. He made an analysis of data for the Department of Dairy and Food Industry concerning bacterial counts in definite stages in the processing of powdered skim milk. With a member of the Entomology-Zoology Department, he examined the effectiveness of different methods of trapping mice in the field, different kinds of traps, spacing and arangements. He assisted in the analysis of stream characteristics affecting the spawning of salmon in Alaska for Wildlife Fisheries; and for a geologist he advised on how to locate drill holes for locating and sampling various geologic formations in Alaska.

In Engineering

Herbert T. David, because of the quality and extent of his on-campus consulting with the Engineering Experiment Station, held a joint appointment in Statistics and Engineering in 1961-62. His consulting has been done in various areas.

David worked with a Ph.D. candidate in Agricultural Engineering in connection with the design and analysis of several experiments dealing with the effect of drainage on yield. A publication dealing with this research, "Response of Corn Yields in a Planosol Soil to Surface Drainage, Cropping System and Variable Fertilizer Treatments," was published in October 1961 by the Agricultural Experiment Station, Research Bulletin No. 499. (See Publications, page 30.) David also consulted on two other studies made by agricultural engineering graduate students: one was in connection with the analysis of several experiments dealing with soil friction; the other was in connection with a project for the theoretical study of vibrating conveying.

For a graduate degree candidate in Industrial Engineering, David consulted on a thesis dealing with the study of a road surfacing operation.

He consulted on five master's degree theses in Sanitary Engineering, one dealing with the effects of freezing on waste, one with the retention time in filter tanks, and three with bacterial respiration.

With members of the Soils Engineering Group in Civil Engineering, David has prepared several papers and publications. He co-authored a paper which was given at the American Society for Testing Materials in the summer on 1961, "A Nomographic Procedure for the Detection of Outlying Observations in a Series of Triplicate Soil Strength Observations." This paper was published under the title, "Detecting Outliers in Soil-Additive Strength Tests," in **Materials Research and Standards** 1: 12, December 1961. (See Publications, page 30.) A paper of which David was co-author was presented at the Iowa Academy of Sciences, and was later published in the Proceedings of the IAS, entitled "The Relationship between the CBR and UCS tests for Soil Cement." David was co-author of a paper, "Strength-Maturity Relations of Soil-Cement Mixtures," which was presented at the annual meeting of the Iowa Highway Research Board in January 1962.

David consulted on five master's degree theses with students in Soils Engineering. Their subjects were as follows:

1. The predictions of soil cement strength
2. The correlation of field and laboratory tests for a length of experimental highway
3. The effect of curing time on the density and strength of lime-soil and cement-soil mixtures
4. A machine for the simulation of pumping action on highways
5. Manufacturing differences of calcitic limes

In Chemical Engineering, David consulted with several degree candidates working in the area of compression-permeability testing. Two problems concerned the effect of cell geometry on specific resistance and porosity, and the assessment of the error components, such as replication, material, packing and measurement, involved in the determination of this effect. A third problem concerned the design of a Monte Carlo simulation of flow through a filter. David also consulted with another degree candidate on an experiment concerning the effect on the yield of a certain reaction of the length of exposure to two different reducing agents.

David assisted a graduate student in geology with the development of probabilistic methods of Buffon-needle type for the evaluation of surface-to-volume ratios in geological lattices.

Dale O. Richards and Edward J. Carney hold joint appointments in the Department of Industrial Engineering and the Statistical Laboratory. They have consulted with staff members and students in Industrial Engineering and others on statistical problems, as well as instructing classes in Statistical Quality Control.

Mr. Frank Boyer and Mr. R. D. Zimmer of Collins Radio Company, Cedar Rapids, Iowa, consulted with T. A. Bancroft, H. T. David, Dale O. Richards and E. J. Carney on the statistical aspects of the Apollo Project. Collins had a subcontract on the telecommunications Guidance System for the Apollo Project from North American Aircraft Corporation.

The Engineering Extension Service and the Department of Industrial Engineering, with the cooperation of the Statistical Laboratory, held the second annual conference for an off-campus group on "Statistical Tools of Quality Control" on May 16-17, 1962. Dale Richards and E. J. Carney were co-chairmen of the event. Dr. Acheson J. Duncan, professor of statistics in the Department of Industrial Engineering at Johns Hopkins University was the featured off-campus course instructor. He spoke on "Fundamental Concepts of Quality Control." Several members of the Statistical Laboratory staff spoke to the group: H. T. David, "Making Uncertain Decisions"; E. J. Carney and Dale Richards, "Common Tools of Quality Control"; T. A. Bancroft, "Statistical Activities at Iowa State"; D. V. Huntsberger, "Estimation and Tests of Hypotheses (Normal Distribution and t Distribution"; E. J. Carney, "Estimation and Tests of Hypotheses (Chi-square and F Distribution)"; Dale O. Richards, "Quick Approximate Methods"; Oscar Kempthorne, "Planning Technological Investigations"; and H. O. Hartley, "Introduction to Evolutionary Processes." H. T. David also served as moderator of a "Questions and Answers" panel. The success of this joint effort of the Engineering Extension Service and the Industrial Engineering Department with the Statistical Laboratory has prompted the Extension Service to make plans for a third conference to be held in May 1963.

Dale Richards, who is a member of the Iowa State University Operations Analysis Standby Unit of the United States Air Force, attended the 1961 World-Wide Operations Analysis Technical Conference, which was sponsored by the Air Force at Ent Air Force Base, Colorado Springs, Colorado, on October 12-13, 1961. Richards also attended the 8th National Symposium on Reliability and Quality Control held in Washington, D. C., on January 9-11, 1962. This symposium was sponsored by the American Society for Quality Control, the Institute of Radio Engineers and the American Manufacturers of Electronic Equipment. At the invitation of the Electronic Division of the American Society for Quality Control, Richards attended, as an observer, a training course in reliability given by that organization. The five-day course was conducted during the week of February 5, 1962, and was held at the Air Force Ballistic Systems Division at Englewood, California.

In Social and Behavioral Sciences

Leroy Wolins consulted with a high percentage of the students doing research in the social and behavioral sciences. He helped with various aspects of psychological testing, with problems of the formulation and design of investigations, and with the analysis of results. The researches of these students were largely investigations rather than formal experiments. Following are a number of examples of Wolins' consulting activities during the 1961-62 period.

A Home Economics Education-Food and Nutrition student for her doctoral dissertation explored the relationships between various intellectual, attitudinal, personality, psychophysical and physiological measures and the eating habits of girls between twelve and fourteen years of age. One of the conclusions drawn from this study is that younger girls, who are menstruating and of lower socio-economic level, tend to have more family conflicts and poorer diets than girls characterized by other combinations of age, menarche and socio-economic level.

A master's thesis in psychology investigated some of the implications of the work of S. S. Stevens in psycho-

physics with respect to psychological stimuli (such as test questions or attitude statements) on a five-point scale according to their certainty about the correctness or appropriateness of the stimuli. If, for example, the stimuli were true-false questions, the subject would indicate whether the statement is true or false and then on the five-point scale indicate how certain he is about his response. Since the subject can be right or wrong and has the option of not responding, an eleven-point scale results. This scale is transformed to normal deviation via normalized ranks (eleven ranks). The metric thus derived tends to result in such properties as additivity and homogeneous error variances. Also the intercorrelations among the transformed responses to stimuli of a given type tend to be homogeneous.

A doctoral dissertation in sociology explored the relationship between preconceived social status and group membership. In a small community 45 people were selected who were mutually acquainted. These 45 people were also selected so that there were 15 members from each of the three churches in the community. Each of the 45 people rated the remaining 44 people on social status. Three composite ratings were derived for each ratee, one from each source. Conventional analysis of variance procedures were utilized. It was inferred that members of different churches differed with respect to rated social status and, more important, people who belong to the high social status church tend to perceive the community as being more homogeneous in regard to social status than members of low social status churches.

In the field of Child Development two simple studies were made. One was to investigate the effect of pupils' reaction to their teacher's attitude toward their performance of psychomotor tasks. One group was highly praised for its work, another was berated, a third was ignored. The results showed no difference in the degree of skill of performance resulting from the different treatments. In the other study, the student wanted to find out if there were similarities or differences in psychological measures between members of sixth grade classes regarding their selection or rejection of each other. No differences were measureable.

Wolins advised and consulted with approximately 30 to 40 students in the behavioral sciences during each quarter of the 1961-62 academic year.

The Iowa Agricultural and Home Economics Experiment Station

This experiment station provides financial support to permit certain members of the Statistical Laboratory to consult on statistical problems in the biological and agricultural sciences. Foster Cady and Donald K. Hotchkiss, under Agricultural Experiment Station Project 101, consulted with a large number of research workers and faculty members on designs, techniques, and analyses of investigations in the areas of soils, field crops, animal nutrition and management, botany, entomology, horticulture, forestry, food technology, and zoology. Hotchkiss also did extensive work with students and staff members in Home Economics in areas of human nutrition and in household equipment. Oscar Kempthorne and Dewey L. Harris assisted in problems involving genetics. N. V. Strand and Wayne Fuller performed statistical consulting services for sampling investigations under the Agricultural Experiment Station Project 113. The examples which follow are representative of the consulting activities in these areas.

Statistical services in the plant sciences

Project 101 continued to provide statistical consulting services in the plant sciences, primarily in agronomy, botany, horticulture and forestry. Foster Cady, with assistance from Chang-Sheng Shih, worked in these areas.

Several weed control experiments involving corn were designed to measure the competition of yellow foxtail (simulated by soybeans) for water, light and nitrogen fertility. Water levels were provided by irrigation, light levels by tall and dwarf corn, and nitrogen levels by nodulating and non-nodulating soybeans. Physical mechanics of the experiment resulted in a split plot design with subunits in strips. The analysis was modified to consider that four replications were used in an area which encompassed two replications of past fertility treatments.

A number of multiple regression problems were handled in various areas. These problems usually involved choice of the appropriate model, procedure of eliminating variables and interpretation. Specific examples were (1) developing prediction equations from which estimates of surface run-off volumes for individual storm events and growing season could be made from measurable climatic data, soil variables and cropping conditions and (2) equations studying the relationship between yield and soil fertility and climatic variables.

Assistance in revising the corn yield test districts was continued. The possibility of using the variety by location component of variance as a criterion for examining the present district structure of Iowa for hybrid corn testing was investigated and found useful. In another study in combining experiments, assistance was given in analyzing a group of tillage experiments conducted at different locations over a period of years where the treatments were not always the same and heterogeneous errors were present. Use of Basilio Rojas' doctoral thesis (Iowa State U. Library, 1958) was made. Aid was given in the design of a regional study on forage quality as related to variety and cutting frequency at various latitudes in the midwest. Analyses of variance were set up for yield and protein content over space and time.

The analysis of a soil microbiology experiment designed to measure nitrogen release where the treatments, consisting of year-after residue application, are confounded with year effect. In cooperation with H. T. David and an agronomy staff member, an investigation was made on the use of certain combinations of a regular 5 x 5 factorial instead of a Box response surface design. Assistance was given concerning a planned set of treatment comparisons in an experiment involving the effect of ridging and mulches on increasing soil temperature.

Other activities included planning a tomato fertility experiment; investigation of factors affecting the specific gravity of pine; analysis of an experiment comparing the precision of three chlorophyll measuring instruments; a study of the structure of a split plot design and breakdown of variety by spray interaction in an oat rust experiment; optimum plot size in sorghum experimenta-

tion; design of a dwarfed apple experiment studying the effects of spacing, variety and stock; consideration of the design alternatives in a study of factors influencing the establishment of a seeding; and discussion of the interpretation of a covariance analysis when the treatments and the independent variable are related.

Statistical services in the animal sciences

Hotchkiss and Charles Cress, graduate assistant, carried on extensive work with the Agricultural Experiment Station in the animal sciences. Besides consultation, joint research with members of other departments in the Experiment Station was continued.

In a study in Dairy Industry two incubation temperatures and two incubation periods were used to establish optimum growth conditions for cold-tolerant bacteria present in milk samples. A straight-forward analysis was possible on the temperature variable; however, a test of differences was necessary to evaluate the incubation period data, due to a correlation between plate counts. Logarithmic transformation of the bacterial counts was accomplished to normalize the data.

Assistance was given the Dairy Science Department in analysis of bloat data collected during the past two years. These calculations involved adjustment for disproportionate numbers of animals and for non-homogeneous variance found among the treatment groups.

Assistance was given to workers in the Animal Science Department in the analysis of data from a factorial experiment where growth rate was evaluated as it was affected by various levels of selected enzymes. A continuation of the study was designed to evaluate the optimum combination of proteinase and cellulase enzymes for maximum early growth.

Hotchkiss developed a design and the resulting analysis of a balanced incomplete block arrangement of four storage treatments as they affect some selected nitrogen fractions of turkey meat. This help was given researchers in the Poultry Science Department.

Working with the Department of Zoology, Hotchkiss prepared procedures for analysis of data involving several physiological responses among reproducing mice colonies as affected by feeding of food additives (Tween emulsifiers). The greatly disproportionate subclass numbers dictated the use of the "Method of Unweighted Means" to evaluate the data.

C. P. Cox has consulted with university staff members on various biological research projects. He consulted with R. M. Melampy, professor of Animal Science, on the design possibilities for experiments investigating the relation between hormone implantations and activity on the rat and on the statistical analysis of results. He worked with L. W. Schierman, associate in Poultry Science, on the analysis of results on the survival times of skin grafts on chickens.

Statistical services in Food Technology and Home Economics

Hotchkiss, Kempthorne, Harris and others have consulted with researchers in Food Technology and Home Economics.

A study was conducted by researchers in human nutrition to evaluate the influence that different mechanical strains have upon hamburger meat insofar as organoleptic qualities and physical alternations were concerned. The entire array of treatments could not be evaluated by the panel at one sitting and thus an incomplete block design was utilized. Assistance was given by Hotchkiss in the analysis and interpretation of these data.

Kempthorne and Harris advised on the planning and analysis of studies on relationships among meat and carcass qualities, the effects of cooking on constituents of meat, and the analysis of meat tenderness data.

Another study was conducted in the area of food technology to evaluate the taste threshold of members of a taste panel and their sensitivity to varying degrees of taste. Being given varying concentrations of a pure substance, they were asked to determine the point where sweetness and sourness could be detected, and then to arrange samples according to varying degrees of concentration. Using a complex substance, they demonstrated their ability to detect varying concentrations of honey in candy. The relationship among these tests were evaluated statistically by Hotchkiss and Cress, using a regression approach and a likelihood ratio test.

Harris consulted on transformations for the analysis of taste panel data for milk products.

In preparation for a study to evaluate the role that washing machine conditions play in causing wrinkles in fabrics, the Household Equipment Department called upon the Statistics Department to assist in developing a suitable mechanized measuring procedure to replace the visual scoring normally used with a trained panel. An electric eye measurement of reflectivity showed very high correlation with the panel scoring and is to be used in a subsequent study. Hotchkiss consulted on this project.

Statistical services in genetics

The Genetic Statistics Group has consulted with personnel in the departments of genetics, animal science, poultry science, agronomy, entomology, and horticulture on statistical aspects of various projects involving genetics and breeding.

O. Kempthorne and Dewey L. Harris spent considerable time with members of the corn breeding group in various design and analysis aspects of the data of their experiments. Francis Giesbrecht analyzed some corn data which had been obtained from a partial diallel cross involving fifty lines. Kempthorne assisted with the design and analysis of an experiment on the diurnal variation in the chlorophyll content of soybean leaves. Harris consulted with a graduate student in horticulture on the analysis of data from a tomato breeding program involving the concept of introgressive hybridization. A set of meaningful orthogonal comparisons were devised for analysis of variance of the three traits of interest. An agronomy student doing research on orchard grass was assisted with the various aspects of the analysis of data from the development and testing of "synthetic" varieties.

Harris worked with a Ph.D. candidate in poultry science on the estimation of the egg production of birds of three genotypes when the classification of the birds into genotypes was partly on the basis of a progeny test. Due to inaccuracies in the progeny test, the number of birds of each genotype for each level of production had

to be estimated by equating the observed results to their expected values as functions of the true classifications.

The estimation of "heritability values" for swine data, where only litter means were observed, was discussed with a graduate student in animal breeding. Harris also discussed with an animal science staff member the procedure of analyzing derivation from herdmate averages, a procedure which is used in the analysis of dairy data.

A design for a study into the effectiveness of selection for resistance to AFB infection in honey bees was developed with an entomology student.

Members of the Survey Group consider a sampling plan for a project in the field of economics. Left to right: Harold Baker, Wayne A. Fuller, H. O. Hartley and N. V. Strand.

Statistical services for sampling investigations

Project 113, Statistical Services for Sampling Investigations, under Norman V. Strand and Wayne A. Fuller, is a consulting project with the Iowa Agricultural and Home Economics Experiment Station. Statistical services were provided within the areas of sociology, economics, home economics, poultry science, agricultural engineering and other areas. These services have consisted of designing surveys and/or experiments, outlining appropriate analyses of data collected, supervising required computations and assisting in the interpretation of results.

Fuller consulted with the Department of Economics on estimation of production functions for crop response to fertilization. He consulted with a member of the Agricultural Engineering staff on a study of gully growth, giving aid in designing a function and suggesting estimation procedures, and on a long-term study of gullies, an experiment for which several watersheds will be observed and studied. He worked with members of the Sociology Department on a further analysis of data obtained in the bench mark survey. Specifically, an attempt was made to determine the influence of the number of visits of the extension personnel on certain measurable variables. Fuller also worked with members of the Forestry Department on an experimental survey to test the relative merits of different procedures for determining the stand and basal area of sumac on three plots near the Ledges. Five variable plot procedures were shown to be biased; one fixed plot was not. Among the Home Economics studies were two analyses of experiments on floor care; and analysis of a survey of children's preference for clothing materials; and an analysis of factors influencing farm people's choice in new housing.

Strand consulted with the Home Economics Experiment Station on a study being proposed for the used clothing market. The problem considered was how to measure the kinds and amounts of used clothing sold or otherwise transferred. Another project of the Home Economics Experiment Station concerned the diet and other characteristics of families having children under five years of age. Strand consulted on how to relate food buying practices to such factors as nutritional needs, food expenditures and family goals. He also consulted with members of the Poultry Science Department on the relative preferences of consumers for frozen and unfrozen chickens.

For the Department of Economics and Sociology, a sample was designed to be used in determining characteristics of agricultural land tenure systems in the North Central Region of the United States. Another study made in cooperation with the Department of Economics and Sociology and the State University of Iowa Agricultural Law Center involved the attitudes of Iowa families toward land tenure. (See page 14.) The object of the study was to find the means by which land transfers are made and to attempt to associate attitudes of farmers with land tenure problems. The objective of a third study for the Department of Economics and Sociology was to analyze prospects for industrial development for a small area within the state to find the relation of community institutions to industrial development, and to learn what adjustment of local resources is being made to changing economic conditions.

The Survey Group

The Survey Group with its associated workers and interviewers provides direct technical and operational services to the rest of the university on all aspects of sampling, surveys and census-type studies. Research in survey methods, teaching and consulting services are combined with the operational work through the financing of the Statistics Department, Statistical Laboratory, the Iowa Agricultural and Home Economics Experiment Station, and the Industrial Science Research Institute. Professional staff members of the Survey Group for 1961-62 were H. O. Hartley, Norman V. Strand, Wayne A. Fuller, Leroy Wolins, J. N. K. Rao and Harold Baker, and a group of graduate assistants, Robert Cochran, Frederick Loo, Philip Mills, Carl Schach and Kenneth Simons. Supervisors of field interviewers and clerical personnel were Helen Ayres, Marjorie Mason, and Lucile White.

Within the year, three International Cooperation Administration fellows, two Food and Agricultural Organization fellows and two United States Department of Agriculture in-service trainees took courses in the department and worked with the Survey Group personnel in a special training program involving agricultural statistics.

Data obtained through the Survey Group's applied research and operational services have been the basis for publications and theses in other departments on the campus, as well as in statistics. Data collected for a study of consumer preferences and consumption of meat

products (the Marshalltown Study) were used in a Ph.D. thesis in Economics, ("Product Acceptability in Relation to the Demand for Meat," by Yien-I Tu, Iowa State U. Library, July 1961.) Another student in Economics wrote his Ph.D. thesis on a marketing study in which the Survey Group participated. ("Reducing Short Term Price Variability in Slaughter Hogs," by William E. Goble, Iowa State University Library, November 1961.) The Survey Group, with the assistance of Leroy Wolins and Helen Ayres, worked out the statistical design and did the data processing of a study for a Home Economics student for her doctoral thesis. ("Freedom in Making Personal Decisions as Perceived by Puerto Rican Ninth-Grade Girls," by Maria Lacot, Iowa State University Library, May 1962.)

The Survey Group participated in a number of studies during the year which were administered jointly by the Statistical Laboratory and the Iowa Agricultural and Home Economics Experiment Station. Some projects which have been fully reported in previous annual reports were completed; others were only initiated, work to be continued. Progress on seven studies is reported here.

(1) The Business Impact Project, supported by the Iowa College-Community Research Center, the Department of Economics at Iowa State University, and the State University of Iowa, had as its purpose the measurement of the impact of the purchases of open-country residents of the businesses in towns and cities in which purchases were made. It is part of a research program being carried on to measure the responses Iowa business has made and is making to agricultural change. The Survey Group, under the direction of N. V. Strand, was responsible for selecting the statistical design which was used in this survey, for drawing the sample and for making estimates of the relevant quantities and attributes and their variances. This study supplies data regarding farm and farm household expenditures and sales and investigates patterns of expenditures and marketing. Two questionnaires were used. The housewife was interviewed to obtain detailed reports of expenditures for household items, food, clothing, etc; the farm operator was interviewed to obtain similar reports of farm expenditures and receipts. About 500 farm men and women were interviewed, as well as approximately 115 non-farm women. The Survey Group aided in the design of the questionnaires, trained the interviewers, supervised their field work, coded the data, and had the data punched on IBM cards. Certain aspects of the analysis were done at the State University of Iowa. Wilbur Maki of the Department of Economics, Iowa State University, will do analysis pertaining to farms.

(2) One of the main tasks of the Survey Group this year has been the work on a contract with the USDC, Bureau of the Census, a study of Response Errors for Agricultural Data Collected by Mail. Wayne A. Fuller has directed this project which is described in Current Research, page 26. The Census Bureau selected from the June 1961 Enumerative Survey of the Department of Agriculture a sample of approximately 1500 farms located in five different small areas of the United States. The regions constituted parts of Indiana, Texas, Tennessee, Kansas, North Carolina, South Carolina, Arkansas and Missouri. The operators in each area were divided into four groups, and one of four different questionnaires was mailed to the operators in each group. The questionnaires were of two general types: an abbreviated version of the 1959 agriculture census questionnaire (Form A-1); and a modification of the A-1 which contained certain reminders and probing questions. These two general types were divided into two subtypes. One subtype supplied to the respondent the information reported in the 1959 census; the other did not. The purpose of the survey was to evaluate the relative merits of the questionnaires and specifically to see if availability of data from the 1959 census reduced response errors on the part of farmers filling out the questionnaire; and to identify those types of persons and operators which are often associated with misreporting. The ultimate purpose is to design a better mail questionnaire.

The Survey Group (1) provided professional assistance in planning the experimental design and procedures to be used and took full responsibility for drafting the questionnaires and instruction manuals needed; (2) assisted in reviewing the returned mail questionnaires; (3) conducted field interviews with 647 of the 1500 operators who were sent mail questionnaires; and (4) recruited, trained and supervised the field enumerators. Helen Ayres supervised the interviewers.

Following data collection, mail questionnaires and the personally enumerated questionnaires were compared to identify differences between the initial mail response and the values obtained in the field by more precise methods. The methods are being compared by computing the estimated response bias and mean square errors for each type of questionnaire. Individual cases are being subjected to critical analysis to identify the kinds of errors which occur in determining total net acreage and the characteristics of farms where these errors occur.

(3) D. R. Kaldor of the Department of Economics and Norman V. Strand are co-leaders of a study for the Agricultural Adjustment Center called the Farming Opportunities Project. The purpose of this study was to find out how new farmers meet and solve their problems.

Helen Ayres, N. V. Strand and Marjorie Mason consider a coding scheme for a project being done by the Survey Group.

The Survey Group designed the survey, constructed the questionnaires to be used in the field, and was responsible for processing data for the project—constructing codes, punching the IBM cards, tabulating the data and

computing the results. The sample used in the survey consisted of 600 area segments of expected size twelve farms each. The sample was allocated to each county in the state of Iowa in proportion to its 1959 Census number of farms. One hundred and ninety-nine farmers who started farming in 1959 and 1960 were interviewed on Phase 1 of the project; and approximately 7000 short interviews were obtained in the 600 area segments on Phase 2 of the project. The objectives of this study were (Phase 1) to learn the levels and sources of the assets of new farmers and how they got their start; and (Phase 2) to make an estimate of the number of farm operators who die, retire or otherwise give up farming in any given year. Also information was obtained regarding the size and quality of the farms given up by this group of new farmers.

(4) In the winter of 1962 the Survey Group worked with the Agricultural Adjustment Center on a study concerning the realization of occupational plans made by senior high school boys who lived on farms in 1959. This was a follow-up on a survey made in 1959 on career plans the boys had made while they were in high school. Under the direction of the Department of Economics, the follow-up study was made to determine whether or not their plans had materialized and their expectations had been met. Mail questionnaires were sent to these boys. About 70% were returned. Coding of the data was done, and analysis of the data is in progress. A subsample of the 30% of the boys who had not responded by mail was drawn and personal interviews were made with this subgroup. Hartley consulted on this project. The survey encompassed only rural high school boys with an agricultural home background. Subsequently estimates were acquired which included the small number of agriculture seniors at metropolitan high schools, and hence a special technique had to be developed to estimate the small contributions from such high schools. The non-metropolitan data were used to estimate a relation between the response and the percentage of agriculture senior boys in the school enrollment; this relation was then used to obtain estimates for the metropolitan schools using the percentage of agriculture seniors in their enrollment.

(5) The Department of Economics and Sociology of Iowa State University in cooperation with the Economic Research Service, USDA, conducted a Feed Grain Study in six midwestern states. The Survey Group performed certain phases of the work in Iowa. The objectives of this study were (1) to find characteristics of Iowa farms and farmers who participated in, or did not participate in, the 1961 Feed Grain Program; and (2) to get the farmers' opinions and possible reactions to suggested changes in, or alternatives to, this program in regard to price support levels and production controls. In January and February 1962 interviews were conducted in twelve counties, six of which were in south central Iowa and six in north central Iowa. Data was coded, punched and tabulated. Dean McKee of the USDA and Norman K. Whittlesey of the Iowa State Department of Economics were in charge of content aspects of the survey.

(6) "Attitudes and Values Associated with Agricultural Land Tenure" is the title of a study in which the Survey Group is collaborating with the State University of Iowa. It is a part of the program of research of the north central states regional tenure committee of the Land-Grant colleges. Marshall Harris and Harold Mark of the Agricultural Law Center, SUI, wrote the questionnaire and will prepare reports on the study. The Survey Group drew the sample, trained the interviewers, supervised the field work, and will perform the data processing phases of the project.

(7) The tabulation phase of the Statistical Laboratory's work for the Soil Conservation Service, USDA, was continued under the direction of Norman V. Strand, with the assistance of Marjorie Mason of the operations staff. This included coding for IBM and punching of soil and other measurements as made by SCS field personnel. Tabulations made from punch cards included acreages in the several land uses by land capability units; land use by soil, slope and erosion; land use by slope and erosion; and land use by soil. This was done by county, by land resource area, and by states for California, Colorado, Idaho, Michigan, Missouri, Nebraska, North Dakota, Puerto Rico, South Carolina, Wisconsin and Wyoming.

Special tabulations were made for parts of the Great Plains and Inter-mountain regions. These tabulations were land use by land capability class and subclass for each of the states in the regions: Colorado, Montana, Nebraska, North Dakota, South Dakota and Wyoming.

Work is progressing on an irrigation study utilizing Conservation Needs Inventory data for North Carolina. Coding of Mississippi Conservation Needs Inventory data was begun.

Microfilming soil and water conservation study sample maps for each county (about 2700) was completed. Also completed were the IBM listings showing state, county, sampling unit number and acreages in each sample unit for about 2400 counties.

The Survey Group made two studies administered through the Statistical Laboratory.

Under the supervision of N. V. Strand, the Survey Group undertook for the third time a School Census for the Ames Community School District. The main objectives of the study were to enumerate, as of June 1, 1962, all children up to 21 years of age who reside in the district, to identify those with any of five types of physical or mental handicaps, as well as all blind adults 21 years of age or over. The census identified 8364 households and 9538 persons under twenty-one in the district.

The second project administered through the Statistical Laboratory was an extensive study of the Iowa Park System. Strand and Fuller consulted with the Iowa Conservation Commission in planning and executing this 21-week study which started May 6 and will continue through September 1962. The purpose of the study is to collect the following information: characteristics of persons who use the Iowa state parks, e. g., the proportion of people in each age and sex group, how far they come, how long they stay, where they learned about the park visited, which facilities they made use of, which activities are most popular with park visitors, what they like and dislike about their state parks, and what suggestions they have for improvements. The

survey was designed and the questionnaires were constructed by the Survey Group. Twenty thousand questionnaires were distributed, based on a sample drawn from park users during certain periods each week in the various parks in the sample. Campers who stayed overnight and visitors whose stay was less than one day are two of the main groupings of the respondents. State Conservation Commission representatives distributed the questionnaires at park exits and gave the occupants of the car passing through the gate a letter explaining the study. The questionnaires were to be filled out and returned to the Statistical Laboratory Survey Group. Following the survey, tabulations will be made by the Statistical Laboratory staff.

The Scientific Computing Group

The Statistical Laboratory has since the beginning provided computational services to any department or research group on the campus, to graduate students, to governmental agencies, and to off-campus research organizations. On April 1, 1962, this service was transferred from the Statistical Laboratory to become a part of the University Computation Center. At that time William Hemmerle, with H. O. Hartley acting as scientific consultant, was appointed to head the Statistical Laboratory Numerical Analysis-Programming Group, which will continue to provide assistance, as in the past, in numerical analysis, programming and statistical analysis to users of the computing services.

During the first nine months of 1961-62 the computing services were operated as part of the Statistical Laboratory. Among the principal users of the computing services are the various governmental agencies on the campus: the Iowa Agricultural and Home Economics Experiment Station, the Atomic Energy Commission, the Agricultural Adjustment Center and the United States Department of Agriculture-Agricultural Research Service. The departments of economics, sociology, agronomy, psychology, dairy science, animal science, genetics and chemistry were the largest users from the various colleges on campus. Computational services were also provided for studies in nuclear, civil, agricultural and industrial engineering, largely through the Engineering Experiment Station; for projects for the departments of home economics education and research, child development and home management; and for research projects in chemistry, bacteriology, forestry, geology, plant pathology, poultry science, entomology and wildlife conservation, and vocational education, all under the IAHEES. The Department of Statistics and the Statistical Laboratory researchers have, of course, used the computing services for many of their projects.

H. O. Hartley directed the two operational computing services, one in conjunction with the IBM 650 and the other in conjunction with the University's high-speed computer, the Cyclone. Members of the IBM 650 section this year were Mary Clem, Dale Grosvenor, Howard Jespersen, James Kosmiski, Fred Ramsey, Harold Rosenberg, Bert Webster, and Russell Altenberger (July 1 - August 31, 1961). Those who worked on the Cyclone section were William Hemmerle, George Byrne, Edward Carney, June Fisher, Lawrence Prince (until March 1) and LaFarr Stuart.

The IBM 650, under the supervision of Mary Clem, has been in operation since 1957 and was available for use 24 hours a day 7 days a week. Qualified staff and graduate students throughout the university were given access to the IBM 650, and research workers from many departments on the campus developed their own programs to meet their computational needs. Howard W. Jespersen, associate and chief programmer, acted as consultant in numerical analysis and instructed and assisted those who came to do their own programming. Research workers were assisted in the mathematical formulation of their problems, preparation of their programs, and ways to transcribe experimental and survey data to be suitable for punching and in setting up tables after the data were on punched cards.

For many types of work the IBM 650 has been the most practical computing machine on the campus. However, the computing services of the Laboratory have expanded tremendously, and for certain problems in biological simulations and in certain engineering problems the higher speed and larger capacity of the Cyclone are essential. Modifications to the Cyclone were completed in November 1961, replacing the old 1024 word tube memory with a 16,384 word core memory; revamping and expanding the other code structure, particularly in the input/output area; and adapting flexowriters and 8-level paper tape for input/output. This was accomplished through a $100,000 grant from the National Science Foundation.

The Cyclone Group, under the supervision of William Hemmerle, concerned itself with several areas of work. The members prepared and tested programs in the new machine for general purposes and for library programs; they gave analytic and programming assistance on theses and other research problems; they assisted with the integrated engineering education program; and they offered special problems courses (Stat. 599 courses).

Hemmerle was responsible for supervision of the Statistical Laboratory Numerical Analysis Group and the operational use of the Cyclone. He cooperated with instructors in industrial, mechanical, and electrical engineering and assisted with computer usage and programming during Cyclone laboratory periods. He conducted special problems courses (599), and he completed writing and testing a Cyclone simulator, a program to simulate programs prepared for the old machine on the new machine, thus making the old program library available to computer users of the new machine.

LaFarr Stuart, graduate assistant in statistics, assisted in debugging the SAR assembly program and modifying the Erie interpretive routine for the new machine. He wrote two random number subroutines and delivered a seminar on random numbers. Stuart also wrote independently a "music compiler" permitting the notes of a song to be punched in a coded format on paper tape and subsequently "played" on the Cyclone, using amplified fluctuations of the accumulators sign bit. Tapes were punched for a number of popular songs which were played during Veishea, the student festival held in May. The sole purpose of the musical stunt was to make the computer do something that everybody can understand, to show how obedient the computer is and how much control the operator has over it.

George Byrne, graduate student, gave programming assistance to computer users and helped with the integrated engineering education program. He was loaned to the mathematics department as part-time instructor. Edward J. Carney, instructor in Industrial Engineering, helped arrange computer time with the Industrial Engineering Department.

Lawrence Prince, associate until his resignation March 1, 1962, wrote and debugged a program for the new machine to compute correlation coefficients, sample means, variance and covariances for 176 variables. The program output was annotated in such a manner as to allow easy referencing and interpretation of results.

June Fisher, undergraduate assistant, modified a considerable number of programs for the new machine and successfully checked out many of them, a matrix inversion routine, several input/output subroutines, some function subroutines and diagnositc programs. In addition to this, she programmed an extensive research problem for a project in bacteriology. Basically, this program consisted of the analysis of strains based on similar features, selecting pairs of strains with the greatest number of features in common, as well as strain grouping based on common features. Through shrewd analysis and clever programming techniques, she was able to cut to a minimum the computer time required for solution.

Hemmerle helped with the planning of the National Science Foundation-Undergraduate Participation program and the interviewing and selection of those students interested in computer research. Robert Croft, National Science Foundation-Undergrate Participation Research student, worked on a minimal ALGOL compiler.

Hartley served on the computer Advisory Committee to the Graduate Dean, which selected the IBM 7074-1401 to be installed in the fall of 1962. Hemmerle and Jespersen assisted in determining hardware specifications of the new computer system prior to its installation. Hemmerle and Carney held primary consultations relative to the development of a general analysis of variance system for the IBM 7074.

Courses on the new IBM machines were given during the year. In October a representative from IBM, E. H. Hietbrink, came to the campus to give information about the IBM 7074-1401 system and a survey of its potentialities. In the winter a course was offered by Hietbrink on basic machine language, basic autocoder and full autocoder language, as well as the use of the input/output control system. This course was offered for those with prior experience in programming electronic computers and those who expect to be involved in the use of the machine for their own programming. Shorter courses in FORTRAN were also scheduled for occasional users. Courses were repeated during the spring quarter.

Research and consulting services were given by the Scientific Computing Group of the Statistical Laboratory to staff and graduate students from many departments of the university on their statistical problems. H. O. Hartley was head of this group. Assistance was given in computational tasks, in preparation of data for processing, in explaining the capabilities of the various computational facilities for their particular tasks, and in programming.

H. O. Hartley consulted with C. K. Titus, a representative of Collins Radio Corp., and other on-campus personnel who were interested, on the use of high speed computers for "Program Evaluation Research Tasks" (PERT). Titus presented a seminar in the computer science seminar series. Subsequent to this talk the group was concerned with a modification of PERT, using a stochastic model in place of the deterministic model, still utilizing the same machine program used for the former model.

Hartley and Grosvenor consulted with members of the Engineering Extension Service, and also with representatives of the Maytag Company, on the possibilities of using the IBM 650 or other high speed computers for a simulation of production processes.

Hartley consulted with an industrial engineer, David Thompson, in connection with his M.S. thesis on multiple channel queueing problems. The problem arose in a study of queueing problems in the University Book Store. It involved a distribution of arrival times following an Erlang distribution and a multiplicity of channels of which a varying number were manned by a server serving the arrivals. The theoretical problem has a mathematical solution if it is assumed that arrivals and serving times follow an exponential distribution; however, a study of the data showed that this could not be assumed. In the absence of a mathematical solution for the Erlang distribution problem, the industrial engineer in consultation with Hartley was able to simulate the process on the Cyclone computer.

Jespersen and Hartley consulted with a physicist who was concerned with an investigation of how the diffusion constant $\underline{k}$ varies as a function of absolute temperature in the classical thermo-conductivity equation. The case previously considered and programmed involved a rectangular cross section of the medium carrying the heat flow. The present problem involved a circular cross section. Advice was given on a transformation of the heat flow equation which avoided certain singularities previously observed. The problem is related to the application of Bessel function series.

Dale Grosvenor consulted with graduate students in Agricultural Economics and assisted with the mathematical formulation of their problems for analysis by linear programming, for which he has developed numerous programs on the 650. A special program, written by Grosvenor and Hartley, was prepared as a detailed write-up (No. 10. 1. 001) and was requested by over one hundred off-campus users of the IBM 650. Harold Rosenberg, Bert Webster and James Kosmiski assisted with the programming on the 650. Among the problems for which programs were written were (1) problems in distributions of ratios of linear forms of mean squares arising in studies of genetical heritability by Bert Webster; (2) tabulation of variance formulas of composite estimators in rotation designs of panel surveys by Harold Rosenberg; and (3) assistance on the extensive laboratory work conducted in conjunction with courses 589A and 380 by Rosenberg and Kosmiski.

William Hemmerle consulted with David Palmer of the Agricultural Engineering staff on the preparation of computer programs for analysis of rainfall statistics; and he conferred with John Gill in the preparation of

his computer programming on his study in genetic selection.

In connection with some consulting work in the field of reliability, H. T. David, Dale Richards and E. J. Carney made preliminary exploration of the problem of building reliability estimates for complex systems on the basis of estimates of reliability and estimates of parameters of sub-systems by Monte Carlo methods.

Off-Campus Advisory Assignments

Staff members, in addition to their regular consulting duties, are often called upon to act as consultants with off-campus groups. In June 1962, T. A. Bancroft completed a second three-year assignment on the Epidemiology-Biometry Panel of the National Institutes of Health. He has been invited to serve as advisor to the National Cancer Institute Epidemiology-Biometry Panel. Bancroft served on a committee in Washington, D.C. in September 1961 to assist the Bureau of State Services, U.S. Public Health, with a review of statisticians in certain civil service grades. H. O. Hartley continued to serve as a member of the Advisory Committee on Mathematical Statistics of the U.S. Bureau of the Census. Oscar Kempthorne served again as a member of the National Science Foundation Advisory Panel on Weather Modification.

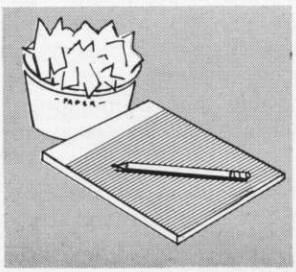
Hartley gave a series of lectures on programming as visiting professor at the University of Michigan Engineering Summer Conference on Operations Research in July 1961. In October he consulted with staff at Continental Oil Company, Ponca City, Oklahoma, and gave ten lectures on statistical and numerical methods. Brown University and International Business Machines Corp. sponsored a series of lectures on **Applications of Digital Computers** at Brown University Computing Laboratory in Providence, R.I. during 1961-62. Hartley was invited to lecture there in April on "The Analysis and Design of Experiments with the Help of Computers."

Bancroft prepared a paper for the meeting of International Instituto Tecnologica Azucarero Veracruzano, Carlos A. Carillo, Vera Cruz, Mexico, in July 1961 on "The Role of Statistics in the Planning and Analyzing of Agronomic Experiments." A paper of Bancroft's, "The Teaching of the Fundamental Sciences in Higher Agricultural Education", was given at a conference sponsored by UNESCO at Medellín, Colombia, in May 1962, the second Latin-American Conference in Higher Agricultural Education.

In October Kempthorne gave a lecture in the Colloquium Series of the Computing Center and Statistical Laboratory of Case Institute of Technology on "The Design and Analysis of Experiments."

Kempthorne participated in the Southern Regional Graduate Summer Session in Statistics in 1962, sponsored by the National Science Foundation, at Oklahoma State University, Stillwater, Oklahoma. Kempthorne taught a course in Advanced Design of Experiments and gave a seminar, "Statistics in Genetics."

Current Research



The research program of the Laboratory is closely related to the other activities of staff members and consequently emphasizes both the development and extension of basic theory and its application to new statistical methods and techniques. The Laboratory cooperates with other research institutes and experiment stations on the campus in arranging programs of statistical research and obtaining support through joint grants and contracts. The number of such grants and contracts with off-campus agencies continues to increase, and many studies of a fundamental nature are supported in this manner. In most instances they provide for supervised graduate research on topics proposed by the staff. However, the Statistical Laboratory budget supports only projects which are of specific interest to regular university research programs.

Statistical Laboratory Research Projects

In survey methodology

H. O. Hartley carried on a research project which provides a general methodology for multiple frame surveys. The situations encompassed by this term may be described as follows: In sample survey methodology one often finds that a frame known to cover approximately all units in the population is one in which sampling is costly, while other frames, special lists of units, for example, are available for cheaper sampling methods. However, the latter usually cover only an unknown or approximately known fraction of the population. The project has developed a general methodology of utilizing any number of such frames without requiring any prior knowledge as to the extent of their mutual overlap. The technique employed is that of domain estimation, which has been found useful in analytic studies. A spelling out of the details reveals that considerable reduction in cost can be achieved.

Hartley's basic research on Unequal Probability Sampling Theory and the Time Series Aspects of Survey Panels, which is described on page 22, is also concerned with survey methodology.

In computational methodology

H .O. Hartley, Dewey Harris and Bert Webster developed new formulas and methods for computing exact values for the distribution of heritability measures, using expansions in terms of χ^2 distributions followed by analytic integrations. Results will be compared with certain approximations developed by Graybill and will form part of the master's thesis of Bert Webster.

Hartley and Harris have developed a new method of considerably reducing the amount of computational labor in Monte Carlo calculations for heritability studies. Such calculations require the generation of large numbers of associated triplets of two sample variances and one sample covariance for two correlated traits. While the conventional approach has been to generate first large samples of paired traits following a bivariate normal distribution, the present method directly generates the above three statistics. This direct approach may result in a reduction of computation labor varying from 1 and 20 to 1 and 200.

Hartley and Ronald Hocking, working under an NSF Grant, reported on page 23, developed a new method of nonlinear programming. The problem solved is to find the minimum of a convex function of n variables when the variable-vector is restrained to lie within an intersection of convex spaces each bounded by a convex smooth function. The geometrical interpretation of the method is similar to that of the Cutting plane method by Kelley. However, the principle of the method is completely different. It is based on approximating to the convex surfaces by a dense set of tangential planes, and thereby reducing the problem to linear programming for a very large number of restraints. By turning the problem to the dual problem, it is possible to make the linear programming computationally feasible. Numerical trials in three small examples shows that the method compares very favorably with any other method heretofore published.

In general theory

T. A. Bancroft worked with Dr. Harold Larson of Stanford Research Institute in preparing two manuscripts for publication: "Biases in Prediction by Regression for Certain Incomplete Specified Models;" and "Sequential Model Building for Prediction in Regression Analysis, I."

The first manuscript, based on Larson's M.S. thesis, is concerned with a derivation of the bias and mean square error of a perdicted dependent variate in case a preliminary test of significance is used to determine the retention or rejection of a group of 'doubtful' independent variates in the regression model.

The second manuscript, based on Larson's Ph.D. thesis, is concerned with a derivation of the bias and mean square error of a predicted dependent variate in case a sequential preliminary test of significance procedure is used to determine the retention or rejection of one or more of a group of 'doubtful' independent variates in the regression model. After a ranking of the independent variates, two rules of procedure were investigated, depending upon at which end the sequential testing began.

A program was prepared for the calculation on a high speed computer of tables to be used as a guide in evaluating the usefulness of these methods involving incompletely specified regression models.

In engineering research

Herbert T. David held a joint appointment with the Engineering Experiment Station during the year and assisted with the research of some twenty engineering students.

Although a considerable variety of problems was encountered, much of this research was concerned with the evaluation and correlation of soil strength measurements, and with the investigation of filtration mechanisms, settling tanks and bacterial oxygen—regeneration systems.

Much research has been done in the past few years on problems concerned with what is called "life testing" and the estimation and/or testing of hypotheses involving the reliability of components or systems. One problem which remains to be solved is that of the specification of the underlying distributional properties of observed data. Current research is being done by Dale Richards in an attempt to provide at least some understanding of the consequences of some of the more commonly proposed procedures and models.

In econometrics

Gerhard Tintner continued research on econometric models, operations research, stochastic linear programming and tests of significance in the variate difference method.

In the investigation of the validity of a stochastic theory of economic development, Tintner developed a generalized stochastic births and deaths process which is designed to explain a logistic trend in economic development. These ideas have been applied tentatively to long-term British and German data. Work in this direction continues and it is hoped that this theory can be generalized for multiple stochastic process. The theory of stochastic linear programming has been applied tentatively to problems of planning Indian economic development.

Tintner continued his work on Carnap's theory of probability and its application to operations research.

NIH Training Grant in biostatistics

A grant from the National Institutes of Health, administered under the Statistical Laboratory and the Industrial Science Research Institute, has continued to support a graduate training program in biometry in the Statistical Laboratory and the Department of Statistics. The program has provided six traineeships to students working toward the M.S. and Ph.D. degrees in statistics, with a view to stimulating their interest in, and orienting them toward, a career in Public Health or medical statistics. T. A. Bancroft has directed the program, and he, C. Philip Cox, and H. T. David, together with a number of other members of the statistics staff, directed the graduate programs for the trainees during the year.

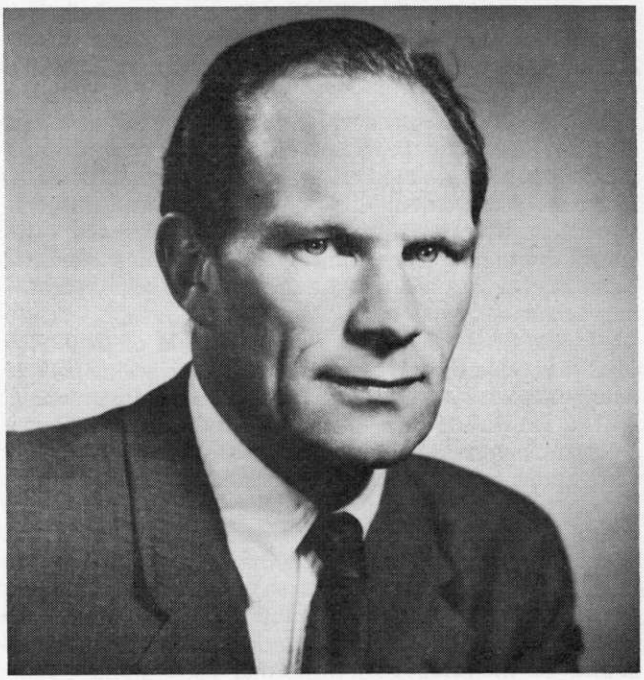
The research of Carol B. Edwards toward her Ph.D. degree, with H. T. David as her major professor, involved the derivation and description of multivariate and multivariate multiple Poisson distributions. Multivariate and multivariate multiple Poissons can be derived (1) as joint distributions of linear combinations of independent Poisson variables; (2) as materialization counts for suitably defined Markov processes; and (3) as the limit distributions of numbers of different kinds of runs and more general configurations. In the course of this investigation, a number of subsidiary results were obtained. 1. A theorem of Fréchet (1940) recently re-discovered by Iyer (1958) expressing factorial moments in terms of suitable probability sums was generalized to the multivariate case. 2. It was shown that the multivariate Poisson distribution satisfies the multivariate Carleman Moment uniqueness criterion. 3. A bivariate distribution was constructed that possesses Poisson marginals and satisfies

$$E(XY)=E(X)E(Y), \qquad E(XY^2)=E(X)E(Y^2),$$
$$E(X^2Y)=E(X^2)E(Y),$$

but that is not bivariate Poisson. Miss Edwards and David will present a paper based on these investigations at the American Statistical Association meeting in Minneapolis in September 1962. Miss Edwards and John Gurland published a paper based on her M.S. degree thesis, "A Class of Distributions Applicable to Accidents" (See Publications, page 31) and gave a paper on this subject at the annual meetings of the American Statistical Association in New York in December 1961.

Paul Leaverton continued his investigation of estimating the components of mixed logistic distributions, under the direction of C. Philip Cox. Stemming from his M.S. thesis (1961) on this subject, a paper will be submitted for possible publication by Leaverton and Stanley Nash of the University of British Columbia entitled "Estimation of Parameters of a Mixture of Two Logistic Distributions." Estimation of parameters were obtained using the method of moments. The derived procedure is most applicable to mixtures of logistic distributions encountered in the fitting of quantal response data such as arise in bioassay. Research for Leaverton's doctorate in the area of distribution-free bioassay has begun. Leaverton attended the 1962 Graduate Summer Session in Statistics in the Health Sciences, Stanford University, Palo Alto, California, under special arrangements made by T. A. Bancroft, the director of the NIH program at Iowa State.

Statistical studies in the epidemiology of the toxoplasmosis were undertaken by Eugene B. Cohen in his work for a master's degree in statistics under C. P. Cox, using data kindly provided by the Institute of Agricultural Medicine, State University of Iowa, Iowa City, Iowa, under the direction of Dr. F. H. Top and Dr. W. F. McCulloch. In their study, carried out during 1960-61, 783 veterinary and medical students (Universities of Iowa, Minnesota, Illinois, and Iowa State University) were skin-tested for toxoplasmosis, and individual blood samples were taken. Dye-test antibody titers were measured by the Sabin-Feldman serological techniques. A questionnaire covering data concerning age, sex, place of birth, residence since birth, and degree of animal contact was completed by each student. Statistical analysis of the relationship of skin-test positives as well as dye-test positives to the previously named epidemiological factors has been carried out. Cohen's statistical analysis necessitated an extensive examination of first and second order interactions in $2 \times 2 \times 2$ contingency tables. In agreement with findings by other workers, significant associations (at the 5% significance level) were detected between contacts with farm animals and toxoplasmosis.



Charles Philip Cox, associate professor, joined the staff of the Statistical Laboratory and the Department of Statistics in October 1961. He conducts research in the area of biological statistics and guides trainees in the National Institutes of Health program in statistics in their graduate work at Iowa State. He also teaches courses in statistical methods (401-402) and experimental design for research workers (411), and a course in bioassay (535).

Born in Derbyshire, England, Cox was educated at Oxford University where he took his M.A. degree with honors in mathematics. He was granted the honorary rank of Captain after war service in the Royal Artillery and in a Ministry of Supply Experimental Station as head of a section of the Army Operational Research Group. He was awarded a Post-Graduate Research Scholarship to study statistics under F. Yates at Rothamsted Experimental Station. Before coming to Iowa State, he was head of the Section of Statistics at the National Institute of Research in Dairying, University of Reading, England, for 13 years. During that time he spent a year (1959-1960) as Visiting Associate Professor of Statistics at Iowa State.

Cox is the author of some 40 published papers, many of which are in the fields of dairy research and animal experimentation. He is a member of the Biometric Society (ENAR), the American Statistical Association, and a Fellow in the Royal Statistical Society.

Ilbok Lee worked with C. Philip Cox on a number of statistical techniques which are commonly employed to analyze quantal response bioassay data. Particular attention was given to the study of White and Graca on "multinomially grouped response times for the quantal response bioassay" and to the study by Gurland et al on "polychotomous quantal response in biological

assay" in which moribund subjects were treated distinctively in the analysis. Lee's work involves the combination of these two studies. He has attempted to introduce a technique of analyzing bioassay data in which more than two distinct types of quantal responses are observed at more than one pre-specified time interval; and in particular, to make the best use of all experimental data, it would seem advisable to treat moribund subjects separately. The main problem, therefore, is to assess the contribution gained by utilizing the proportion of moribund subjects in estimating the parameters and asymptotic variances.

James R. Zweifel, under the direction of C. Philip Cox, has investigated the analysis of experiments on anesthetics used in childbirth, using data kindly provided by Dr. Roy M. Pitkin, Dept. of Obstetrics and Gynecology, University Hospitals, Iowa City, Iowa. The investigations gave rise to some special statistical problems because delivery can preclude the observation of the entire interval of effectiveness. Further the more desirable agents are those which on the average last for the longer times and hence are also the ones for which the proportion of incomplete observations will be large. The data are, therefore, multicensored at random censoring points. On the assumption of normal distributions, maximum likelihood estimators have been derived together with asymptotic variances. These statistical findings have general applications to problems involving censored data.

On April 1 Ross Adams, graduate student in statistics, became a trainee on the NIH program. Working under the direction of T. A. Bancroft, he investigated missing values by regression techniques for a long-term biological experiment, a problem which keeps recurring in physiological investigations and which has not been attacked before.

During the year Betty Eberle and Howard Marsh, NIH trainees from Western Reserve University Medical School, have done work under the supervision of T. A. Bancroft in statistics and epidemiology at Iowa State under a cooperative arrangement between the two universities.

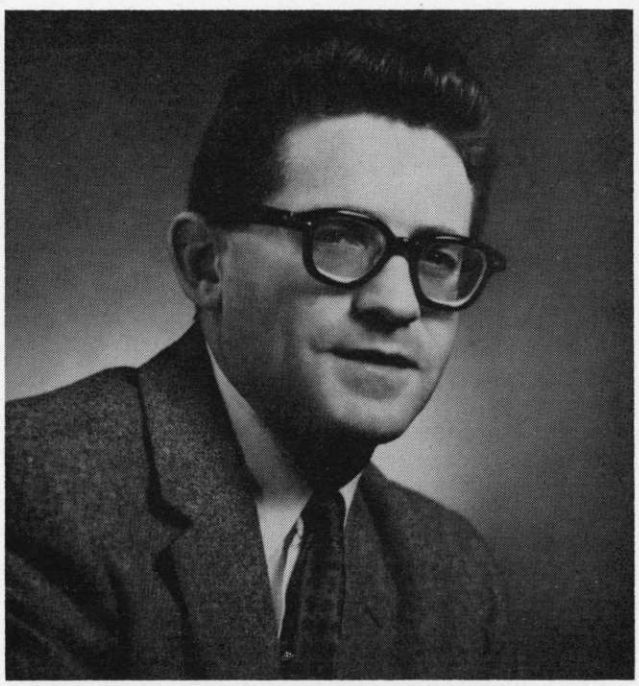
Darrol Heggen, a statistical consultant in the Institute of Agricultural Medicine at the State University of Iowa, Iowa City, and a candidate for the master's degree in statistics from Iowa State, is working under Cox on the problem of the potential toxicity of chemicals used in modern agriculture on human beings. Three cell lines are being studied: mouse cells, human adult liver cells and human intestinal epithelial cells. Many new chemicals must be studied and rapid methods are required for establishing toxic levels for humans. Heggen has been concerned with the effects of DDT, Dieldrin, Phosdrin and other insecticides on the protein synthesis of tissue cells derived from human beings. The measure of toxicity is taken to be the 50% inhibitory dose of the insecticide, i.e., that dose at which 50% of the cells have been inhibited from growing in an arbitrary time interval, such as 48 hours. Cox and Heggen are engaged in developing statistical procedures to estimate the 50% inhibitory dose.

WASD project on analysis of variance procedures

The final report of the work done for Wright Air Systems Development under a 1958-61 contract was published in November 1961. Three publications on the research, two by Sidney Addelman and one by Addelman and Kempthorne, appeared during the year. All these publications are abstracted in the publications section of this report. (See page 28).

The research under the new WASD contract AF33(616)8269 to extend until June 30, 1964, got under way in 1961-62 with Oscar Kempthorne as chief investigator. George Zyskind, leader, B. V. Shah, postdoctoral fellow (July through October), and Eugene Dayhoff, Gary Sutter, Thomas Doerfler (July through December), and Rodney Basson (since March 1), all graduate assistants, worked on the project.

A draft of a substantial portion of an account of the general linear hypothesis theory relating and synthesizing the different mathematical approaches has been prepared. The exposition used clearly exhibits the interplay of several alternative mathematical formulations. For example, the ideas of projection of the cor-



George Zyskind, associate professor of Statistics, (July 1, 1962) was born in Poland and became a naturalized citizen of Canada in 1954. He received his B. S. from McGill University in 1953 and his M.S. from the University of Toronto in 1954. In 1958 he was granted a Ph.D. in statistics from Iowa State University. The following year was spent at the University of North Carolina as a post-doctoral associate in the Department of Statistics.

Zyskind came to Iowa State in 1959 as assistant professor in the Statistical Laboratory and the Department of Statistics. He teaches courses in experimental design and theory of linear hypothesis. His research is in the general area of experimental design with particular concentration on the logical basis for the mathematical form of experimental models. He was written a number of papers on the randomization theory, paying particular attention to the role of relations in experimental structures. He has developed some unifying formulae applicable to a large class of experimental structures.

He is a member of Sigma Xi, Phi Kappa Phi, and the Institute of Mathematical Statistics.

responding invariant matrix projection operator and of corresponding idempotent matrices are used extensively. Some investigations on topics with complex error structures, particularly error structures resulting from this randomizing operation, have also been carried out. A number of necessary and sufficient conditions have been obtained for the best linear unbiased estimators of all estimable functions to be identical with the simple least square estimators. An invited paper by Zyskind on these matters will be given at the annual meetings of the Institute of Mathematical Statistics in Minneapolis in September 1962.

The major part of a monograph by Rodney Basson, O. Kempthorne and George Zyskind on missing plot techniques has been prepared. It comprises largely cases that are already available in the literature and consists essentially of a comprehensive, easily accessible summary of such methods. Emphasis is being placed on the method of covariance, since this method has general validity and is applicable to concrete problems with relative computational ease.

A critical note has been written by George Zyskind on some aspects of residual analysis. It shows clearly the relation between residual analysis in the sense of Freund, Vail, and Clunies-Ross and the analysis of covariance. The note establishes exact expressions for the difference between the "true" additional regression sum of squares obtained by simultaneous regression analysis and the regression sum of squares due to additional variables by residual analysis. The difference is given some simple interpretations. A residual analysis test statistic proposed by Freund et al is subject to certain serious defects.

In randomization theory and the study of experimental structures, previous investigations are being generalized and extended to the consideration of a class named "Balanced Partially Crossed". Examples of structures belonging to this class are the Finney partition (a generalization of the Graeco-Latin square), the Modified Latin square, n-dimensional lattices, a large class of incomplete block designs, and the incomplete Latin square, a special case of which is the Youden square. Thus, most of the important classical experimental structures are in the Balanced Partially Crossed class. R. F. White, who has been associated intermittently with the WASD project, has recently observed that, for a balanced partially crossed observational structure sampled from a balanced complete inferential structure, the expected value of the square of the sample mean admits the standard cap-sigma expansion. This is dealt with extensively in the previous Aeronautical Research Laboratory Report No. 149, which was published in November 1961. (See Publications, page 32). A similar theorem obtains also for the expectation of products of partial sample means. The two theorems together yield a powerful tool in obtaining the expected values of mean squares in the analysis of variance pertaining to most of the classical experimental designs.

Variances of Variance Components is the subject of research carried on by Eugene Dayhoff under the direction of Oscar Kempthorne. When errors are assumed normally and distributed independently, variances of quadratic forms, specifically estimates of variance components, are easily obtainable. However, when no distribution is assumed and finite populations are considered, the task becomes quite arduous. Current research is aimed toward obtaining these variances where derived models are involved, and hence under no assumptions of normality and independence. A definition for generalized polykays of degree two has been developed, and the equivalence of generalized polykays and the Σ functions developed at Iowa State has been shown.

A technical note on progress achieved in problems on constrained randomization has been submitted to WASD by Gary Sutter, Zyskind and Kempthorne. The enumeration of possible constrained designs with no stratification of experimental units can be seen to be equivalent to the enumeration of resolvable balanced incomplete block designs. The findings in the literature with regard to the latter problem have been brought together. As a consequence, the known possible constrained designs are very numerous. Some study of distribution of error sum of squares in unconstrained and constrained sets under a hypothesized linear trend of experimental unit contributions has been made. Results indicate that, with nearly linear basal yields, a constrained set, for which the variance of the error sum of squares is less than that under complete randomization, has greater power than that holding under complete randomization. Incidentally, it was observed that increases in treatment differences are not always accompanied by increases in power of the randomization test.

In factorial experiments, the practical problems is to study effects of several factors with limited number of observations. The conventional approach is to use a fractional factorial design which utilizes only a small fraction of the total number of combinations possible with all the factors. The primary objective of the research on this topic was the study of the use of randomization and its consequences in such experiments.

Procedures suggested by Dempster (Ann. Math. Stat. 31:4 and 32.2) have been examined and found to have considerable limitations.

As a partial solution to the problem a new alternative method is suggested for fractional factorials. The method consists in taking more than one random fraction of a factorial design, and writing down the joint analysis of variance table. It is possible to write down proper tests for several hypotheses from the resulting analysis of variance table. The work considers only the three-factor design in detail.

The problem of evaluating the effect of the compounding of gradient error on the performance of steepest descent and steepest descent partan has been considered by Doerfler in his M.S. thesis under the direction of Oscar Kempthorne. (See thesis summary, page 38). This work is an out-growth of previous formulations done by Shah, Buehler and Kempthorne.

ONR project on determination of the maximum of a function

An Office of Naval Research project under the direction of Oscar Kempthorne, and administered by the Statistical Laboratory and the Industrial Science Research Laboratory, was terminated in 1961 with the publication of three technical reports. In addition to Kempthorne, investigators on this project, which began

in 1959, were Robert J. Buehler, B. V. Shah and Thomas E. Doerfler, graduate assistant.

The general problem under consideration was the study of strategies for finding optimum conditions—that is, for finding values of variables $x_1, \ldots, x_n$ which maximize (or minimize) an unknown but observable function $f(x_1, \ldots, x_n)$.

Technical Report 1, "Some Properties of Steepest Ascent and Related Procedures for Finding Optimum Conditions," by Buehler, Shah and Kempthorne, defines a "path method" as follows: One proceeds from an initial point in the factor space along a path determined by derivatives at the initial point. When the maximum is reached on the first path, the derivatives there are used to determine the second path, and so on. Criteria are put forward for the success of a path method, and comparisons are made between "steepest ascent," "one factor at a time," and other special cases. Some numerical results are presented, based on IBM 650 calculations made by Doerfler. The performance of iterated steepest ascent is spelled out in detail for the case of quadratic functions.

Technical Report 2, "The Method of Parallel Tangents (partan) for Finding an Optimum," by Shah, Buehler and Kempthorne, presents two new algorithms. In these the paths depend not only on information at the last point reached, but on earlier information as well. It is shown that for a quardratic function the new procedures converge exactly to the optimum in (2n-1) steps.

Technical Report 3 deals with properties of the methods of parallel tangents and the method of conjugate gradients which has been developed for problems of numerical analysis. (See Publications, page 29, for a summary of this report). Copies of reports 2 and 3 in mimeograph form are available from O. Kempthorne, Statistical Laboratory, Iowa State University, Ames, Iowa.

NASA study of a statistical correction model

A study was initiated under the direction of H. O. Hartley in June 1961 for the National Aeronautical Space Administration and administered by the Statistical Laboratory and the Industrial Science Research Institute. It will test by numerical evaluation a new statistical regression technique developed at the Statistical Laboratory for reducing the error field of the Joint Numerical Weather Prediction Unit's current barotropic short-range weather forecasts. Approximately 2,000 forecast grid-points of the northern hemisphere are to be classified into regions which are meteorologically homogeneous for the purpose of the new prediction technique. Data which the Weather Prediction Unit has prepared will be used.

Programs have been written or are being prepared for the following steps to be carried out on an IBM 650:

(a) The computation of two sets of 10 consecutive error fields for the field function in 24-hour forecasts, five error fields in 48-hour forecasts and one error field in 72-hour forecasts.

(b) The computation of all sets of predictor variables as well as the dependent variables for the above forecasts and all 2000 points of the hemispheric grid.

(c) The classification of the grid points into meteorologically homogeneous regions for the purpose of the regression analysis in (d).

(d) The computation of the statistical regression laws of Y on X_1, X_2, X_3, and X_4 and a test of the effectiveness of each regression law in the forecast period subsequent to the one from which the law was computed.

Certain difficulties have been encountered when analyzing the data resulting from "calm" periods. For such periods the error field of the present forecasts is small and does not permit a reduction by statistical correction equations. The more turbulent periods will therefore have to be used to put the method to an "acid test".

OOR project on fundamental statistical functions

Under the direction of H. O. Hartley, research was continued on development of a guide for approximations to the incomplete beta function, under a contract with the Office of Ordnance Research and administered by the Statistical Laboratory and the Industrial Science Research Institute. The project was completed and a major part of the time was spent on the preparation of the x^2 table and auxiliary tables of A′, B and log x. Special methods had to be developed to check all tables and in particular the x^2 table. The most useful and searching checks of this table consisted of a summation over the degrees of freedom ν for constant x^2 using the relation between this integral and the Poisson distribution. A second useful check consisted in numerical integration at argument x^2 for constant degrees of freedom ν, using the well-known recurrence formula for the x^2 integral.

Final tables were listed in a form suitable for photographic reproduction on the IBM 1401 by a program specially prepared by Dale Grosvenor. At the suggestion of the Office of Ordnance Research, the tables resulting from this project are being offered to **Biometrika** for publication. Edwin J. Hughes has prepared the manuscript copy of the "Guide to Tables."

ARO project in survey methodology and sampling theory

H. O. Hartley, J. N. K. Rao and Carl F. Schach began investigations in September 1961 on a project sponsored by the Army Research Office, and administered by the Statistical Laboratory and the Industrial Science Research Institute, on Unequal Probability Sampling Theory and the Time Series Aspects of Panel Surveys. Progress was made with both items of the project, as already reported in the 1959-61 biennial report.

The first item is concerned with unequal probability sampling. In cooperation with W. G. Cochran of Harvard, Rao and Hartley developed an alternative method of sampling with unequal probability and without replacement. More specifically the method is concerned with the following problem: Given a finite population of N units ($t = 1,2,\ldots N$) with characteristics y_t whose total $Y = \sum_1^N y_t$ is to be estimated. If a sample of size n is to be drawn from such a population, it is often advantageous to select the units with unequal probability. For example, such a procedure may be useful when

measures of sizes x_t are known for all N units in the population which are positively correlated with the characteristics y_t. In such cases, one may utilize the knowledge of the x_t by selecting units with probabilities proportional to sizes x_t (p.p.s.) although this is, of course, not the only way of using the known x_t.

The present method has the following properties:

1. It permits the computation of an estimator $\hat{Y}$ of Y which has always a smaller variance than the standard estimator in sampling with unequal probability and with replacement.

2. Unlike the procedures entailed in Narain (1951), Yates and Grundy (1953) and Das Raj (1956), the present method does not entail heavy computations (not even for $n > 2$) for drawing the sample or computation of the estimator and its variance estimate.

3. It enjoys the advantage of exact variance formulas for any N as compared with the asymptotic variance formulas in Hartley and Rao (1962). (See publications, P. 31). However, a comparison with the latter method shows that the present method will, in many situations, lead to an estimator with a slightly larger variance.

4. An unbiased sample estimator of variance that is always positive is available for any n, N.

The second item of the project is concerned with "Sampling of a Finite Population on Repeated Occasions." Rao and Hartley have made progress with the finite population theory of rotational sample designs. The results obtained can be regarded as the finite population analogue to the methods and formulas used by the Bureau of the Census in their "Current Population Survey." Although general results have been obtained for the expectation and variance of the estimator of the "Current Total" of the population, certain simplifications are possible when a model is used in which there is an exponentially decaying lag-correlation between the records observed for a sampling unit on repeated occasions. As with the work of the Bureau of the Census, "composite estimators" are developed. These utilize both the currently observed records as well as records observed in the past which are projected through the lag-correlations. Tables have been prepared which permit the determination of the optimum weighting system for current and past records depending on the lag-correlation and the rotation pattern used in the design. Carl F. Schach has been assisting in the development of the latter formulas and tables, and his results were made part of his master's degree thesis.

NSF project relating statistical estimation and mathematical programming

A two year grant (NSF-G 14236) from the National Science Foundation, administered by the Statistical Laboratory and the Industrial Science Research Institute, expires in August 1962. During the current year, H. O. Hartley as principal investigator, J. N. K. Rao (July 1 - August 31, 1961) and Jack E. Graham, Ronald Hocking, Edwin J. Hughes, Brenda Morrison and Dale Grosvenor, graduate assistants, worked on the projects, which covered three main areas of research:

(i) Statistical estimation in linear models with the parameters constrained to convex spaces.

(ii) Estimation theory for parameters in nonlinear models.

(iii) Contributions of nonlinear programming to the statistical theory of estimation.

Technical Report 1, "The Application of Mathematical Programming to Statistical Least Squares Estimation with Constraints," by H. O. Hartley, summarizes the results achieved in the first area of research. Section 1 of this report assembles in concise matrix notation the standard results of classical (unrestrained) least squares theory. Section 2 deals with linear equation restraints of the parameter vector and the restriction of the parameter point to a convex space.

The starting point for the second area of research was an earlier paper by H. O. Hartley (Technometrics 3, p. 269, May, 1961). This paper developed a modification of the classical Gauss-Newton process for solving nonlinear least squares problems. While the latter does not necessarily converge, it can be shown that the modified Gauss-Newton procedure converges to either the absolute minimum, or at least to a local minimum, of the original least squares form. Unfortunately at the present state of our knowledge it is only the point which yields the absolute minimum of the least squares form which enjoys optimality properties of statistical estimation. The present project was therefore concerned with the important question in nonlinear regression estimation.

Technical Report 2, "Efficient Nonlinear Least Squares Estimation without Absolute Minima", by H. O. Hartley and Aaron Booker, does not answer this question but circumvenes it by providing an estimator which has the same asymptotic properties as that yielding the absolute minimum of the least squares form.

The third section of this study deals with contributions of nonlinear programming to the statistical theory of estimation. Least squares estimation of a parameter point, constrained to lie in a convex space by the method described in Technical Report 1, leads to the technique of quadratic programming.

The other reports deal with more specific peripheral items. They are Technical Report 5, "The Distribution of the Ratio of the Variances of Variate Differences in the Circular Case" and Technical Report 6, "On the Variate Difference Method", both by J. N. K. Rao and G. Tintner.

NSF project on the foundation of statistical inference

R. J. Buehler, chief investigator, and Alan P. Feddersen, graduate assistant, have worked on a National Science Foundation Grant (14831), administered by the Statistical Laboratory and the Industrial Science Research Institute. Work has been primarily concerned with conditional validity of inferences, particularly fiducial inferences.

For the 50 percent fiducial limits based on Student's t with one degree of freedom, a subset of the observations has been exhibited in which the probability of covering the true mean is greater than 0.518 for all parameter values. This example, which was suggested by earlier unpublished work of Stein, casts some doubt on Fisher's criticism (J. Roy. Statist. Soc. B, 1956) of Welch's solution of the Behrens-Fisher problem.

Other investigations have been concerned with fiducial distributions derived by the use of ancillary statistics. Since ancillary statistics need not be unique,

there exists a problem of uniqueness of the fiducial distributions to which they lead. Some partial uniqueness results depending on the theory of complete sufficient statistics have been obtained for the case of two non-equivalent ancillaries of which one is "more informative" than the other.

It is possible that a sample may consist solely of two observations x and y which are separately but not jointly ancillary. For this case it is not immediately evident whether one will obtain two different fiducial distributions or just one, or none at all. It has been shown that the last case invariably holds, owing to a failure of Condition B (monotony of the distribution function) of Lindley (J. Roy. Statist. Soc. B, 1958).

NSF project on residuals in random experiments

A new National Science Foundation Grant (14237) for research on the properties of computed residuals in randomized experiments began in September 1961 under the direction of Oscar Kempthorne. Donald J. Mallory, graduate assistant, worked on this project which is administered by the Statistical Laboratory and the Industrial Science Research Institute.

The aim of this research is to find adequate tests for distinguishing cases in which a linear model does not hold. A possible basis for evaluating observations with the alternative of a multiplicative model in mind using signs of computed residuals has been suggested. The first and second moments under randomization of computed residuals have been evaluated.

A progress report on the residuals study was prepared in May 1962.

NSF project on methods of finding optimum operating conditions

Oscar Kempthorne, chief investigator, B. V. Shah, associate, and Thomas E. Doerfler, graduate assistant, are doing research on a project sponsored by a National Science Foundation Grant (No. 19940) and administered by the Statistical Laboratory and the Industrial Science Research Institute.

The prior work on the same subject, carried out jointly by B. V. Shah, R. J. Buehler and O. Kempthorne, contains properties of iterated steepest ascent and of the method of parallel tangents (PARTAN).. T. E. Doerfler has investigated the performance of the method of steepest ascent and the method of PARTAN in the presence of error and when the yield contours are elliptical, in two dimension only. Efforts are now being initiated to achieve the following objectives: (1) to investigate the performance of the method of steepest ascent and PARTAN, with or without error for non-elliptical yield-contours, in two dimensions; (2) to search for ways and means to extend the above investigation to higher dimensional surfaces; (3) to derive a suitable method for locating an optimum along a line and to study some properties of the method; (4) to obtain some information on the efficiency of second order designs in the presence of error by Monte Carlo methods.

NSF project on crosses of genetic material

A study supported jointly by The National Science Foundation (G-16491) and the Agricultural Experiment Station (Project 1478) was begun in February 1961 with Oscar Kempthorne as principal investigator and Klaus Hinkelmann, graduate assistant.

The basic experimental plan underlying this study for investigating quantitative inheritance is the diallel cross, both in its complete and incomplete form. The complete diallel plan has been used quite extensively to estimate the general and specific combining ability. Since its use is restricted to a rather small number of inbred lines, the partial diallel cross has been developed recently.

To make the situation more realistic the partial diallel cross has been considered from the point of view of finite population size. It then arises by a two stage sampling procedure. In the first stage a random sample is taken of inbred lines from the total population. In the second stage the genetic crosses actually involved in the experiment are determined according to the underlying experimental structure. By using the theory of finite sampling and randomization, the estimates for the general combining ability and for the average variance of the differences of any two general combining abilities have been worked out.

NSF project in genetic statistics

Under a project sponsored jointly by the National Science Foundation (G-18093) and the Agricultural Experiment Station (Project 1505), a two-year program of research in the role of errors of parameter estimation in index selection was started by Dewey L. Harris and Oscar Kempthorne. The goals of this project are to assess the influence of errors of parameter estimation upon index selection procedures. This project is an extension of the work initiated in the Department of Animal Science by Harris as his doctoral thesis.

Considerable Monte Carlo calculations have been carried out for this study on the IBM 650 electronic computer. Of particular interest have been the estimation procedures associated with analyses of variances and covariances of several traits of individuals arranged into paternal half-sib groups. Due to the magnitude of the sampling errors involved in the estimation of components of variance and covariance, the expected response to selection based upon an index involving these estimates may be considerably less than the maximum progress which would be attainable if the true parameters were known and used for index construction. Work during this year has been directed primarily toward evaluating the improvement in indexes attained by modifying estimates which are outside the known limits of the true values which are being estimated. For example, with limited amounts of data, negative estimates of components of variance may be obtained. In such cases it seems reasonable to conclude that the true variance components are actually zero. Similarly, when estimates of the sire components of variance are greater than one-fourth the estimates of total variance, it seems reasonable on the basis of quantitative genetic theory to replace the estimate of the sire component by one-fourth the total variance estimate. Likewise, when the estimates of the sire components of variance and covariance are such that a value for the correlation between sire means for two traits would be greater in absolute magnitude than unity, the estimate of the covariance is set equal

to the geometric mean of the components of variance, retaining the original algebraic sign for further calculations. The overall effect on the average of these modifications of unreasonable estimates has been found to increase the gain from selection. In some cases over one-half of the loss in response to selection due to errors of estimation may be regained by these modifications. A paper entitled "A Critical Look at Selection Indexes" was given by Harris before the National Poultry Breeder's Roundtable in Kansas City, Mo. on May 5-6, 1962. This paper included the work of the author in errors of estimation as well as other theoretical aspects of selection index procedures.

Investigation of the theoretical aspects of the estimation of random elements of statistical models shows promise of leading to techniques which will be pertinent to a wide class of experimental situations, especially to various genetic situations.

NSF project on Monte Carlo studies in genetic selection

The National Science Foundation (G-19218) and the Agricultural Experiment Station (Project 1508) jointly supported studies in genetic selection by Oscar Kempthorne and L. N. Hazel of the Department of Animal Science, College of Agriculture, and Dewey L. Harris. John Gill, associate, and Mauritz van Aarde, graduate assistant, also worked on the project, which began in the fall of 1961. Some time was spent defining the problems to be examined and beginning the preparation of computer programs.

The development of the mathematical theory of genetic selection for polygenic characters has necessarily been restricted almost entirely to the case of genetic effects originating from the genes at one locus or a number of independently segregating loci without epistacy. Mathematical description of the basic facts of polygenic inheritance in complex genetic situations results in equations too cumbersom for solution. Simplifying assumptions leads to large departures from reality, somewhat in proportion to the simplification achieved. It appears that the most feasible approach to increased understanding of genetic selection is by the study of mathematically defined systems by numerical methods. The Cyclone computer at Iowa State is suitable for the numerical processes involved in simulating the complex situations required.

Gill is making an empirical investigation of the effects of environmental variance, population size, degree of truncation selection, modes of gene action, and linkage relations on the progress of genetic populations under selection. Mathematical populations taking account of these features will be created. The successive generations will be generated by numerical procedures, utilizing routines which simulate reproduction and selection. Statistical properties of the resulting populations will be examined, evaluating the genotypes and phenotypes of both selected and unselected populations. Related to this study is the examination of what happens under selection to covariances of relatives and regression of offspring on one or both parents.

Van Aarde has been developing the general topic of covariation of relatives in random mating populations. In particular formulae have been developed for the covariances of relatives bearing both collateral and ancestral types of relationships to each other, providing these individuals are not inbred. Special attention has also been given to problems which arise when metric traits are studied in the presence of marker genes. The application of a random mating operator provides further information with regard to statistics of the first degree. The consequences of position effects on genotypic value have been considered.

An investigation of the consequences of disequilibrium is under way.

AES research on design of experiments and analysis of data

Project 890 is a continuing project supported by on-campus funds of the Agricultural Experiment Station and directed by Oscar Kempthorne. Research has been conducted in three areas: (1) the design of general comparative experiments; (2) the logic of experimental inference; and (3) and the theory and design of investigations on quantitative inheritance. The general principals of experimentation and inference are useful in most empirical science, and the investigations on quantitative inheritance will be useful in breeding research. A campus-wide seminar series has been conducted on quantitative genetics. (See page 43).

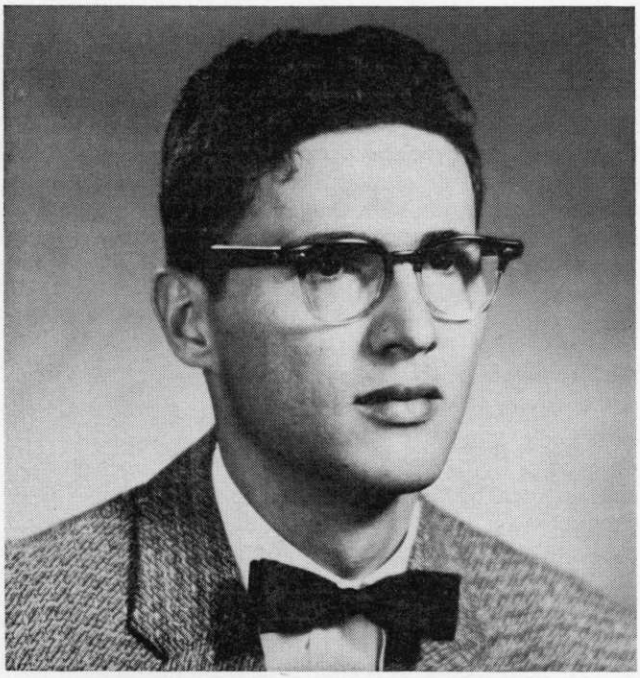
Research has resulted in the population of a paper on "The Partial Diallel Cross" in Biometrics in June 1962 by Oscar Kempthorne and R. N. Curnow. "The Interpretation of Twin Data" by Kempthorne and Richard W. Osborne appeared in the September 1961 issue of The American Journal of Human Genetics. A paper on "The Role of System of Mating in the Determination of Means, Variances and Covariances in Genetic Populations", given at the Symposium on Statistical Genetics and Plant Breeding at North Carolina State College in March 1961, is being published by the Agricultural Board of National Research Commission, National Academy of Science (Jour. paper J-4148, Iowa Agr. Exp. Sta. Project 890).

In addition, some joint research and consulting activities have been carried on in connection with the various areas of this research.

AES Research in mathematical genetics and genetics statistics

Project 1448, which is also a continuing project supported by on-campus funds of the Agricultural Experiment Station, provides for consultation (See page 11) and research in mathematical genetics and genetics statistics under Dewey L. Harris and Francis Giesbrecht, graduate assistant. Research in statistical methodology has been carried out as motivated by the consultation. Some research has been done by Giesbrecht on an experimental design proposed by Goodwin, Dickerson and Lamoreux for the estimation of environmental and genetic changes in the performance of poultry. Giesbrecht worked on the analysis for a design for separating genetic and environmental changes in animal populations under selection.

Harris also spent some time on the relationships between the genetic parameters of three traits where



Wayne A. Fuller, associate professor (July 1, 1962), joined the staff of the Statistical Laboratory and Department of Statistics in 1959, upon receiving his Ph.D. degree in agricultural economics from Iowa State University.

His work is in the area of agricultural and economics statistics, in which field he teaches and does research and consulting with his own graduate students and with staff members from the College of Agriculture. He also supervises project work in Survey Sampling. He is the author of several publications in economics and statistics.

Born and educated in Iowa, he has earned three degrees from Iowa State, where he was research assistant and associate for four years before joining the staff as assistant professor in 1959. Before coming to the University he served for two years in the United States Army in the Philippines and Korea.

He is a member of the American Farm Economics Association and the American Statistical Association.

one trait is the ratio of the other two, such as in dairy cattle where butterfat "test" is the ratio of total butter fat production and total milk production. Similar relationships occur among the economically important traits of other species.

AES Research on design of surveys and analysis of data

Wayne A. Fuller continued his research under Project 1005, a continuing project supported by on-campus funds of the Agricultural Experiment Station. In cooperation with members of the Animal Science Department, growth curves of the exponential type were estimated for characteristics of pork muscles. Estimates of growth curves for percent fat, percent water, muscle fiber size, and fat saturation for certain porcine muscles were presented. A paper by C. E. Elson, Wayne Fuller and E. A. Kline was given at the meeting of the American Society of Animal Production in Chicago in November on "Effect of Age on the Growth of Porcine Muscle." Research was also conducted on methods of estimating regression lines from survey data wherein the observations are clustered. Emilio Ellena's M.S. thesis, "Estimation of a Corn Forecast Equation for a Cluster Sample", dealt with this subject. (See Thesis Abstracts, page 37). Work on the analysis of year to year variability in fertilizer response was initiated. It is hoped that models permitting the estimation of economic optima over time will be developed and estimated.

Fuller continued his research on distributed lags under Project 1355 which is supported by funds of the Agricultural Experiment Station. It included research on the estimation of equations containing autocorrelated errors, the estimation of management indexes and the extraction of animal production functions from successive observations on the same lots of animals. Estimation procedures for equations containing autocorrelated errors have been used by George W. Ladd in estimating demand and inventory models. Three publications resulted from this research: "A Dynamic Quarterly Model of the Beef and Pork Economy", by Fuller and Ladd; "Estimating the Reliability of Quantities Derived from Empirical Production Functions", by Fuller; and "A Note on the Effects of Autocorrelated Errors and the Statistical Estimation of Distributed Lag Models", by Wayne Fuller and James E. Martin. (See Publications page 31).

USDC, Bureau of the Census, Research in sample census methods in agriculture

A contractual research project in statistics supported by the U.S. Department of Commerce, Bureau of the Census and administered by the Agricultural Experimental Station, has as its purpose to identify the magnitude and types of errors made by farmers on mail questionnaires. Total acres in place and certain crop acreages are the items for which reporting errors are being studied. A sample of farmers in five regions of the U.S. were sent a mail questionnaire. Personal interviews were then obtained from a subsample of the respondents. Acreages obtained by these two procedures, after certain reconciliation procedures, constitute the data to be analyzed. The Survey Group provided professional assistance in planning the experimental design and procedures and took primary responsibility for drafting the questionnaires and instruction manuals. The operational work performed on this study is described on page 13. Norman V. Strand, Wayne Fuller and Harold Baker have worked on this study.

Work was continued on the 1959 Census Evaluation Project, the purpose of which was the evaluation of errors in the agricultural census of that year. Harold Baker prepared a report on the procedures used in the evaluation study. Part of his report was included in a monograph on Census Evaluation Studies prepared by the Census Bureau at the request of FAO. Baker is writing his M.S. thesis on this project.

SRS, USDA, Research

The Laboratory's Production Studies for Corn, Grain Sorghum and Pasture were continued by agreement with the Research and Development Branch, Statistical Reporting Service, USDA. This work was performed under Project 1207, a joint project of the Statistical Laboratory

and the Agricultural Experiment Station which is supported mainly by funds from the Statistical Reporting Service. Principal personnel were Norman V. Strand and Wayne A. Fuller, assisted by Harold Baker, associate, and Robert Cochran and Kenneth Simons, graduate assistants.

Reports on last year's work on objective methods for estimating corn and grain sorghum yields were prepared. Improving the accuracy of yield estimates and forecasts serves to improve the efficiency of administration of government programs as well as aiding farmers and feeders in planning their operations.

During the summer of 1961 sample ears of corn were collected by USDA from 11 midwestern states. Harold Baker supervised the processing of the corn samples, and the resulting measurements were forwarded to Bruce W. Kelly, Chief of the Research and Development Staff of the Agricultural Estimates Division, USDA, Washington, D.C.

Cochran and Baker worked on the grain sorghum study conducted in the summer and fall of 1961. Observations on plant and head characteristics and the number of plants were obtained from plots located on a sample of 50 farms in nine southwest Iowa counties. Each plot was visited four times between August 7 and October 15. These data were used in an attempt to develop an early season yield forecast for sorghum yields as well as an "at harvest" objective yield estimate. A double sampling technique for estimating the number of kernels per head was investigated, and an analysis leading to the determination of optimum plot size was made.

In the summer of 1961 work began on the development of objective methods for determining pasture production. Kenneth Simons worked on this project. Plots were laid out in one of the university pastures to furnish preliminary information on the practicability of the cage technique for estimating pasture production and harvest through grazing. Plots were relocated and clipped at one and two week intervals during a ten-week period late in the pasture season. Research work on the grain sorghum and pasture studies will continue in 1962.

Hartley, Fuller and Carlos Cavallini began work on methods for handling extreme observations (outliers) obtained in the continuing surveys conducted by USDA.

SCS, USDA Special survey projects involving applied research

Sampling in Soil Surveys, Project 1312, under the cooperation of the Statistical Laboratory and the Soil Conservation Service, USDA, and the Agricultural Experiment Station, was continued under the direction of Norman V. Strand. A pilot study to determine suitability of soil and water conservation data for estimating the irrigation potential of the Coastal plain and Piedmont regions of North Carolina was made. The objective was to separate these regions into general irrigability classes and also into irrigability classes for soil suitable for raising tobacco on open land.

USDA Research Field Office

A research field office of the United States Department of Agriculture is located within the Statistical Laboratory. This field office, in recent years attached to the USDA's Agricultural Marketing Service, was functionally realigned, effective spring 1961, as part of the Statistical Standards Division of the new Statistical Reporting Service established by the federal government. Its general function is to conduct research in connection with sampling problems, survey procedures and theory of mutual interest to the Statistical Standards Division and the Statistical Laboratory. The field office is staffed on a part-time basis by N. V. Strand and M. Kirwin. Its work during 1961-62 was mainly connected with the Corn and Sorghum Production and Pasture Study already described on Page 26.

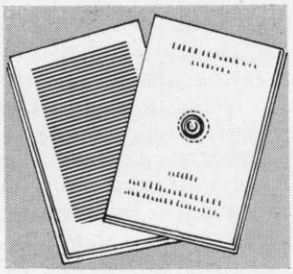
NSF Grant for expansion, modernization and renovation of facilities

A National Science Foundation Grant was made to the Statistical Laboratory and the Department of Statistics of a sum of money, matched by the Board of Regents, to aid in the expansion, modernization and renovation in two areas of mathematical statistics research facilities. One, in programming and numerical analysis of statistically oriented computations, is to be completed in the coming year. The other, in Experimental Design-Genetic Statistics, resulted in new offices for this group, completed in March 1962. Oscar Kempthorne, George Zyskind and Dewey Harris of the professional staff, B. V. Shah, post doctoral associate, and John Gill, research associate, and Thomas E. Doerfler, Gary Sutter, Eugene Dayhoff, Donald Mallory and Klaus Hinkelmann, as graduate assistants, have conducted research which is described in the preceding pages of this report.

Undergraduate research

Two programs of undergraduate research participation have been carried on in the Statistical Laboratory under a grant of funds from the National Science Foundation. The first of these programs permitted two undergraduates to participate in computer programming activities and related research in the Cyclone Computer Laboratory under the direction of H. O. Hartley and William Hemmerle. Starting in June 1961 and throughout the 1961-62 period, Robert Croft and Arthur Warrick, until his graduation in February 1962, have worked on construction of an ALGOL compiler, in cooperation with the electrical engineering staff, and on associated assembly routines and interpretive systems on the Cyclone.

The second program has involved participation research in sample survey methodology under the direction of Norman V. Strand. Leon Burmeister, statistics junior, starting in the summer of 1961, took part in the Laboratory's work for the Bureau of the Census on evaluation of the accuracy of the 1959 federal agricultural census in the North Central region.



Several staff members served in major editorial capacities for professional journals during the year. Oscar Kempthorne continued as associate editor, and Robert J. Buehler served as a cooperating member of the editorial staff, of the Annals of Mathematical Statistics. Kempthorne is also editorial associate for Biometrics.

Gerhard Tintner is an associate editor and book review editor for Econometrica, associate editor of Unternehmensforschung and on the editorial board of Metroeconometrica. He is abstractor for the Mathematical Review.

Buehler is in charge of abstracting articles in the Journal of the American Statistical Association for the International Journal of Abstracts, Statistical Theory and Methods.

Record of Published Research

Listed in the following pages are the publications dealing with the research of the Statistical Laboratory. Some of these publications are included in the Reprint Series of the Laboratory and are available upon request. These are indicated by an asterisk.

***Sidney Addelman** (Research Triangle Institute, Durham, N.C.)**: "Orthogonal Main-effect Plans for Asymmetrical Factorial Experiments." Technometrics 4: 1, 21-47. February 1962. Reprint Series No. 103, Statistical Laboratory, Iowa State University.

Plans are described for asymmetrical factorial experiments which permit uncorrelated estimates of all main effects when the interactions are negligible. The construction of these plans is based upon the principle of proportional frequencies of the factor levels. The possibilities of blocking these main-effect plans, the randomization procedure and the method of analysis are presented.

Sidney Addelman (Research Triangle Institute, Durham, N.C.) and **Oscar Kempthorne**: "Orthogonal Main-effect Plans." Aeronautical Research Laboratory, Office of Aerospace Research, United States Air Force. Wright-Patterson Air Force Base, Ohio. November 1961. vi + 167 pp.

This is one of two technical reports which were written for Wright Air Development Division, Aeronautical Research Laboratory, under Contract No. AF 33-(616) - 5599, "Investigation of the Analysis of Variance."

The report on orthogonal main-effect plans was concerned with the development and presentation of orthogonal main-effect plans. These plans permit uncorrelated estimates of all main effects of both symmetrical and asymmetrical factorial experiments with a minimum number of trials.

Chapters II and III outline some background material on fitting linear models and factorial experiments which the user of this manuscript may find informative. These two chapters give a short review of existing knowledge of factorial experiments and methods of analyzing them.

Chapter IV gives an account of the development of orthogonal main-effect plans for symmetrical and asymmetrical factorial experiments. The plans for asymmetrical experiments are based on the proposition that if the levels of a factor occur with the levels of another factor with proportional frequencies, then the two factors are orthogonal. The possibilities of blocking these plans, the efficiencies of the estimates, the randomization procedure and the method of analysis are discussed.

The report concludes with a catalog of orthogonal main-effect plans. This catalog consists of the treatment combinations of twenty-six basic plans, involving factors with up to nine levels and with up to eighty-one trials, from which all orthogonal main-effect plans which can be constructed with eighty-one or fewer trials may be deduced.

***Sidney Addelman** (Research Triangle Institute, Durham, North Carolina): "Irregular Fractions of the 2^n Factorial Experiments." Technometrics 3: 4, 479-496. November 1961. Reprint Series No. 97, Statistical Laboratory, Iowa State University.

The development of fractional replicate plans which consist of irregular fractions of factorial experiments is presented. The method of constructing irregular fraction plans is developed for the general S^n factorial experiment. However, the plans which are found to be of greatest practical value are plans for the $3/2^m$ replicate of the 2^n experiment. Although these plans introduce correlations between some of the estimates, the correlations do not affect individual tests on the parameters. Some irregular fraction plans permit the estimation of main effects and two-factor interactions with fewer trials than is required with an orthogonal plan. A straightforward procedure for obtaining estimates of the main effects and "important" interactions and estimates of their variances, covariances and correlation coefficients is presented for the $3/2^m$ replicate plans.

***Sidney Addelman** (Research Triangle Institute, Durham, North Carolina) and **Oscar Kempthorne:** "Some Main-effect Plans and Orthogonal Arrays of Strength-two." Annals of Mathematical Statistics 32:4, 1167-1176. December 1961. Reprint Series No. 101, Statistical Laboratory, Iowa State University.

In this paper a method is presented of constructing main-effect plans for symmetrical factorial experiments which can accommodate up to $[2(s^n - 1)/(s - 1) - 1]$ factors, each at $s = p^m$ levels, where p is a prime, with $2\ s^n$ treatment combinations. As main-effect plans are

* Indicates reprints are available
** When research was done by staff members who have gone on to other positions, the institutions with which they are now connected are given in parentheses.

orthogonal arrays of strength two, the method presented permits the construction of the orthogonal arrays $(2s^n, 2\,[s^n - 1] / [s - 1] - 1, s, 2)$.

This research was supported in whole or in part by the United States Air Force under Contract No. AF 33(616)-5599, monitored by the Aeronautical Research Laboratory, Wright Air Development Division.

*T. A. Bancroft: "Practical Organizational Plans for a Complete University Computing Service." The American Statistician 15: 5, 10-13. December 1961. Reprint Series No. 98, Statistical Laboratory, Iowa State University.

This paper discusses the organizational aspects of university computing programs from an administrative point of view.

An organizational plan should (i) be geared to present and future computing needs, (ii) be evolutionary, (iii) take into account the financial resources available, (iv) be uncomplicated and (v) provide for growth and change.

Most universities will require computing facilities for administrative data processing, educational uses, and research. The problem is to consider organizational plans designed to meet these requirements with the resources available.

Small colleges with limited resources may be able to afford only a small digital computer installation with part-time staff and director. Medium-sized universities with limited resources may be able to provide only one digital computer installation, which should be adaptable to data processing and scientific research computing. Universities with greater resources may wish to consider separate computer installations, one for administrative data processing services and another for scientific research computational services.

Larger universities with adequate resources and a large computing educational program may find it feasible to establish a computing center administered by a director with academic standing and a background in the mathematical sciences. The largest installations should also require an operations manager, a supervisor, a section of computer-oriented numerical analysts and programmers and a panel of consultants in numerical analysis. An inter-disciplinary advisory committee might be desirable to provide impartial advice on computing matters for the best interests of the whole university.

In order to keep abreast of the growth and change in computing requirements and opportunities, reappraisal of the program at frequent intervals is important.

Robert J. Buehler, B. V. Shah, and **O. Kempthorne:** "Some Further Properties of the Methods of Parallel Tangents and Conjugate Gradients." Technical Report No. 3, Office of Naval Research, Contract No. 530(05) NR-042-207. September 1961. i + 37 pp.

The minimum of a known quadratic function $Q(x_1, \ldots, x_n)$ can be determined by the method of conjugate gradients in n steps starting with any trial vector of x-values. Equivalently, the method determines the solution of the simultaneous linear equations, grad $Q=0$. When Q is an unknown regression function such that Q plus a random error is observable at chosen points, the minimum may be found from experimentally determined values of Q and grad Q by the method of parallel tangents. In the idealized case of quadratic Q and no experimental error, convergence occurs in (2n-1) steps, for in fact even-numbered points correspond exactly to the totality of points of the method of conjugate gradients. In the present paper a new determinantal representation is obtained for the coordinates of these points in terms of the characteristic numbers $(\alpha_1, \ldots, \alpha_n)$ of the quadratic function and the projections of the initial point P_0 on the principal axes. From this representation are obtained for $m=1, \ldots, n-1$: (i) the values of $\Phi_{2m} = (Q(P_{2m}) - Q_{min}) / (Q(P_0) - Q_{min})$; (ii) the maximum over P_0 of Φ_{2m} as a function of $(\alpha_1, \ldots \alpha_n)$; (iii) the maximum of this maximum, taken over intermediate α-values, for a fixed value of the "condition number" $\lambda = \alpha_{max}/\alpha_{min}$; (iv) for large m and λ, an asymptotic maximum of Φ_{2m}, given by $\cosh^{-2}(2m\lambda^{-1/2})$, independent of n. A comparison is made between the methods of parallel tangents and steepest descent at the first point at which they do not coincide, namely P_4. These results can be used to obtain an idea of the performance of the method of parallel tangents for the determination of the minimum of any unknown regression function and of the method of conjugate gradients for the numerical solution of linear systems.

Robert J. Buehler: "On Functions Satisfying Certain Differential Inequalities." Proceedings of the American Mathematical Society 13: 255-261. April 1962.

If all derivatives of a function $f(x)$ are bounded in absolute value by e^{-x} for all positive x, then $f(x) = ce^{-x}$. A new proof of this known result is given using Liouville's theorem. A number of generalizations and related results are established. For example, let the n-th derivatives $D^n f$ be replaced by $T^n f$ where T is a linear differential operator. For certain first and second order operators it is shown that if $Tg = -g$ and if $T^n f$ is bounded in absolute value by g, then $f = cg$.

Edwin S. Campbell, **Robert J. Buehler,** J. O. Hirschfelder and D. Hughes: "Numerical Construction of Taylor Series Approximations for a Set of Simultaneous First Order Differential Equations." Journal of the Association for Computing Machinery 8: 374-383. July 1961.

A procedure is described for finding numerically the coefficients in the Taylor expansions of the solutions of simultaneous first-order ordinary differential equations. This procedure has been used to find 20 to 30 terms in the solutions of 3 to 7 simultaneous hydrodynamic equations arising in the theory of flame propagation.

Foster B. Cady and W. V. Bartholomew (North Carolina State College, Raleigh): "Influence of Low pO_2 on Denitrification Processes and Products." Soil Science Society of America Proceedings 25:5, 362-365. September-October 1961.

Soil samples were incubated in a laboratory apparatus constructed to maintain constant partial pressures of oxygen. The effect of oxygen on aerobic denitrification was studied using N^{15}-tagged nitrate as a tracer material. Periodic analyses of the gaseous phase for oxygen and volitile nitrogen products were made on a mass spectrometer.

A marked effect of oxygen on the rate of denitrifica-

tion was exhibited. Losses after a given period of time with 7% to 8.5% oxygen by volume were approximately 20% of those at 4% to 5.7% and 4% of the losses at 1.0% to 1.6%. Both atmospheric oxygen and combined oxygen (nitrate) were utilized, but the decreased gaseous loss of nitrogen at the higher levels of free oxygen disclosed a preferential use of the former. The amount of denitrification was closely associated with the level of the biological pressure or need of oxygen by the microbial population. Studies showed that only under conditions of high levels of carbonaceous material, an available nitrate supply, and an oxygen level of $> 7\%$ by volume would an appreciable amount of nitrate be reduced to gaseous forms.

Nitrous oxide (N_2O) was produced in the aerobic systems. Processes leading to gaseous losses of nitrogen in the presence of oxygen are discussed.

C. Philip Cox: "A Practical Application of a Theoretically Inefficient Design." Biometrics 17: 4, 646-649, December 1961.

In experiments on milking machine techniques for reducing the time taken to milk each cow, it was desired to compare milking times given by combinations of two pulsation ratios, P_1 and P_2 with two levels V_1 and V_2 of vacuum in the machine line. As substantial animal to animal variability for the different treatments was expected, it was decided to limit the experiment to two treatments per animal. The main restriction determining the design arose because the treatment P_1V_1 was of such special interest that it was desired to obtain an estimate of the corresponding milking time from all available animals. The analysis nicely illustrates the dual features of estimation and discrimination which often interplay in biological operational research.

An unbiased estimate of the milking time of P_1V_1 is obtained, and the loss of discrimination is compensated by the fact that this mean milking time is estimated with only half the variance which would have obtained if all the paired differences had been used.

***C. Philip Cox:** "The Relation Between Covariance and Individual Curvature Analyses of Experiments with Background Trends." Biometrics 18:1, 12-21, March 1962. Reprint Series No. 104, Statistical Laboratory, Iowa State University.

When the two variates in covariance analysis are the means of groups of observations subject to trends which differ for different experimental units, an alternative analysis, in terms of individual regressions, is available. This latter analysis has been used to examine the dependence of the covariance regression coefficient and the residual variance on the individual regression parameters.

Applied to the continuous trial used in dairy cattle experiments the analysis shows that, beyond the usual procedure of minimizing differences between yield levels, it is important for precise experimentation to minimize differences between individual rates of lactation decline. The analysis further shows how the precision of such experiments may be expected to fall off for longer experiments as differences between individual slopes introduce more variation than is compensated for by the reduction of the within animal contribution.

C Philip Cox: "Fitting a Circle by Least Squares." Laboratory Practice, Vol. 11, 368-369. May 1962.

In food research at the National Institute for Research in Dairying (England) evaluations were made in terms of the resistive and reactive components of a transducer. On theoretical grounds it was known that pairs of observations (x,y) lay on a circle of unknown center and radius. A least square method for estimating these parameters is described.

R. N. Curnow (Unit of Biometry, University of Reading, England): "The Estimation of Repeatability and Heritability from Records Subject to Culling." Biometrics 17: 4, 553-556. December 1961.

The maximum likelihood estimation of repeatability from first and second lactation records of a dairy herd subject to culling is discussed. The method is applicable only when it can be assumed that, had there been no culling, the variances of the first and second lactation records would have been equal, and when all the first records are available whether or not the cow has a second record. The efficiency of the more usual estimate of repeatability, based on the regression of second records on first records, is shown to be low when repeatability is high. In many cases the calculation of the maximum likelihood estimate would seem to be well worthwhile. The use of the method in estimating heritability is mentioned. An illustrative example is given.

C. A. O'Flaherty, **H. T. David** and D. T. Davidson: "Relationship between the California Bearing Ratio and the Unconfined Compressive Strength of Sand-Cement Mixtures." Proceedings of the Iowa Academy of Science, 68: 341-356. 1961.

Two soil-strength measurements were correlated. Material error was reduced by matching samples. The log transformation was found both to stabilize the bivariate covariance structure and to produce near-linearity of the sample correlation function. A simple technique was devised for computing the confidence band for this correlation function in the face of error in both measurements. Although the fit was excellent for purposes of quadrature, the 95% confidence band was found to be empty, indicating it unlikely that a single linear functional relation underlay the large amount of data involved in the fit.

C. E. Beer, **H. T. David,** and W. D. Shrader: "Response of Corn Yields in a Planosol Soil to Surface Drainage, Cropping System and Variable Fertilizer Treatments." Research Bulletin R-499, Iowa Agricultural and Home Economics Experiment Station, October 1961.

This bulletin contains the analysis of an experiment designed to test the influence on corn yields of drainage position, of rotation system, and of amount and type of fertilizer application. The analysis was carried out according to a split-split plot model. The analysis indicated the presence of interactions of drainage position with several other factors, in particular nitrogen application rate.

***H. T. David,** D. T. Davidson, C. A. O'Flaherty: "Detecting Outliers in Soil-Additive Strength Tests." Materials Research and Standards 1: 12, 947-950. December 1961. Reprint Series No. 99, Statistical Laboratory, Iowa State University.

A nomographic procedure is given which attempts to control the rate of unwarranted data disqualifica-

tions in a given experimental series. The procedure assumes a constant coefficient of variation for the series and involves the graphical computation of a disqualifying percentage corresponding to this coefficient of variation. An extension of the procedure allows for the assessment of the experimental series as a whole for reliability, homogeneity and normality.

*A. W. Nordskog, **H. T. David** and H. B. Eisenberg (System Development Corp., Santa Monica, Calif.): "Optimum Sample Size in Animal Disease Control." Biometrics 17: 4, 617-625. December 1961. (Jour. paper J-4047, Iowa Agri. and Home Ec. Exp. Sta., Project 1326). Reprint Series No. 102, Statistical Laboratory, Iowa State University.

This paper investigates the extent to which 100 percent blood testing is justified, assuming random, that is binomial, infestation of adult flocks with a disease such as Salmonella pullorum in poultry. Specifically an attempt was made to determine the most economical flock proportion to be blood tested in any given year and locale, as a function of certain values and costs and of the prevailing binomial infestation rate.

Economic optimizations in the presence of a priori distributions have been studied previously. However, this prior work was almost entirely concerned with industrial inspection problems. This paper is intended in part to illustrate the fact that such methodology, initially intended for industrial application, is equally applicable in the biological realm.

***Carol B. Edwards** and **John Gurland** (University of Wisconsin): "A Class of Distributions Applicable to Accidents." Journal of the American Statistical Association 56: 295, 503-517. September 1961. Reprint Series No. 95, Statistical Laboratory, Iowa State University.

This paper presents an extension of the mathematical model used to justify accident proneness. It assumes that the distribution of accidents incurred by an individual in non-overlapping intervals is a correlated bivariate Poisson (C. B. P.). On compounding this correlated bivariate Poisson through a Gamma distribution an extended bivariate negative binomial, or more precisely, a compound correlated bivariate Poisson (C. C. B. P.) distribution is obtained. Recurrence relations and expressions for the required probabilities are illustrated for two sets of data. The C. C. B. P. proved to fit as well as the bivariate negative binomial when the estimate of B_{12} was not close to zero.

Wayne A. Fuller and George W. Ladd: "A Dynamic Quarterly Model of the Beef and Pork Economy." Journal of Farm Economics 43:4, Part I, 797-812. November 1961. (Jour. paper J-4138, Iowa Agri. and Home Ec. Exp. Sta., Project 1355.)

Estimates of consumer demand, retail margin, wholesale margin and storage equations for beef and pork are presented in this paper. Estimates were obtained from post-war quarterly data. The equations were formulated to include certain nonstatic elements and were estimated by autoregressive least squares.

Wayne A. Fuller: "Estimating the Reliability of Quantities Derived from Empirical Production Functions." Journal of Farm Economics 44: 1, 82-99. February 1962. (Jour. paper J-4178, Iowa Agr. and Home Ec. Exp. Sta., Project 1005.)

Methods for constructing variances and confidence intervals and for testing hypotheses for quantities derived from two-variable quadratic and Cobb-Douglas production functions (e.g., marginal products, isoclines and optima) are presented. Many of the procedures generalize immediately to multiple variable functions and functions of differing algebraic form.

Wayne A. Fuller and James E. Martin: "A Note on 'The Effects of Autocorrelated Errors on the Statistical Estimation of Distributed Lag Models." Journal of Farm Economics 44:2, 407. May 1962. (Jour. paper J-4290, Iowa Agr. and Home Ec. Exp. Sta., Projects 1355 and 1005.)

This note presents the modification in the Gauss-Newton iteration procedure which has been used to obtain convergence of the iteration process.

H. O. Hartley: "Analytic Studies on Survey Data." Studi in Onore di Corrado Gini, 1: 213-244. Instituto di Statistica, Universita degli Studi di Roma, 1961.

One of the main objectives of a sample survey is the computation of estimates of means and totals of a number of characteristics attached to the units of a population. Often the data are also used for an analytic study, which usually involves the comparison of means and totals of certain subgroups of the population. Such subgroups of the total population have been termed "domains of study".

Although such domains are usually fairly well defined, which of the domains any particular unit belongs to often will not be known until after sampling. Thus the domains with which an analytic study is concerned are normally not represented in the sample in prescribed fixed sample proportions, and the number of sampled units in each domain will itself be a random variable. This is perhaps the most characteristic difference between domains in analytic studies and treatment groups of experiments; but there are others, and the main departures from standard analysis of variance conditions may be summarized under three headings:

i. The number of units in the domains (subgroups) are random variables.
ii. The population from which the samples are drawn is finite.
iii. Sampling is often not simple random but stratified and/or multistage, resulting in correlations of the characteristics of units in the same domain as well as of units in different domains.

This paper gives the formulas for estimation of domain means and totals and their associated variances applicable to any survey design.

***H. O. Hartley** and **J. N. K. Rao:** "Sampling with Unequal Probabilities and Without Replacement." Annals of Mathematical Statistics 33:2, 350-374. June 1962. Reprint Series No. 109, Statistical Laboratory, Iowa State University.

The problem of the theory of sampling with unequal probabilities and without replacement is here formulated: Given a population of N units, it is required to draw a random sample of n distinct units in such a way that the probability for the i^{th} unit to be in the sample is proportional to its "size" x_i (sampling with

p. p. s. without replacement). From a number of alternatives of achieving this, one well known procedure is here selected:—The N units in the population are listed in a random order and their x_i are cumulated and a systematic selection of n elements from a "random start" is then made on the cumulation. The mathematical theory associated with this procedure, not available in the literature to date, is here provided:—With the help of an asymptotic theory, compact expressions for the variance of the estimate of the population total are derived together with variance estimates. These formulas are applicable for moderate values of N. The reduction in variance, as compared to sampling with p. p. s. **with** replacement, is clearly demonstrated.

***S. K. Katti** (Florida State University, Tallahassee, Florida) and **John Gurland** (Mathematical Research Center, University of Wisconsin): "The Poisson Pascal Distribution." Biometrics 17: 4, 527-538. December 1961. Reprint Series No. 100, Statistical Laboratory, Iowa State University.

Elementary distributions, such as the Poisson, the Logarithmic and the Binomial, which can be formulated on the basis of simple models, have been found to be inadequate to describe the situations which occur in a number of phenomena. The Neyman Type A, the Negative Binomial, and the Poisson Binomial, which combine two of the elementary distributions through the processes of compounding and generalizing, have been fitted with varying degrees of success to data from a number of biological populations. The aim of this paper is to study what may be called the Poisson Pascal distribution which includes the Neyman Type A and Negative Binomial as particular limiting cases and serves as a natural complement of the Poisson Binomial.

On the basis of this study, we observe that the Poisson Pascal distribution acts as a bridge between the Neyman Type A and the Negative Binomial distributions and may be used with advantage when the latter distributions are inadequate to represent the population accurately.

***S. K. Katti** (Florida State U., Tallahassee) and **John Gurland** (Mathematics Research Center, U. of Wisconsin): "Efficieny of Certain Methods of Estimation for the Negative Binomial and the Neyman Type A. Distribution." Biometrika 49: 1 and 2, 215-226. 1962. Reprint Series No. 108, Statistical Laboratory, Iowa State University.

Maximum likelihood equations for estimating the parameters in the case of negative binomial as well as Neyman Type A distribution involve infinite series in unknown parameters. The solving of such equations being cumbersome, various authors have suggested alternate methods which lead to relatively simple estimates, e.g., the method of moments, and the method of the first moment and first frequency. A drawback of these methods is that they have high efficiency in a restricted region of the parameter space. As an improvement over these methods, methods of estimation using three statistics and minimizing a "chi-square" among these statistics following the general principals as set out in Barankin and Gurland (University of California Publications in Statistics, 1951) are proposed. Special cases in which use is made of the first three moments, the first two moments and the first frequency and the first two moments and the ratio of the first two frequencies are discussed, their asymptotic efficiencies tabulated and an example worked out to illustrate the method of fitting. It is observed that the methods using the first two moments and the proportion of zeros has remarkably high efficiency in a considerably wide region. It is noted that while the equations for estimation are more complex than the ones using two statistics only, they are considerably simpler than the corresponding full scale minimum chi-square and maximum likelihood methods—especially for the Neyman Type A distribution.

***S. K. Katti** (Florida State U. Tallahassee) and **John Gurland** (Mathematics Research Center, U. of Wisconsin): "Some Methods of Estimation for the Poisson Binomial Distribution." Biometrics 18: 1, 42-51. March 1962. Reprint Series No. 105, Statistical Laboratory, Iowa State University.

The methods of estimating the parameters of the Poisson Binomial distribution using (i) the first two moments and (ii) the first moment and the first frequency have been discussed by Sprott in Biometrics 1958 as alternatives to maximum likelihood estimates. It is apparent from the table of efficiency given therein that while those methods have high efficiency in certain regions of the parameter space, the regions are not wide enough to include the parameter vectors of most of the populations that arise in practice. In this paper, the distribution is regarded as a two parameter family and a method of estimating the parameters by minimizing a certain quadratic form in three functions of parameters is discussed. The particular case in which the functions used are the first two factorial cumulants and the logarithm of the zero frequency is considered and the asymptotic efficiency of the estimators is tabulated. On the basis of these tables, it is believed that this method can be used as a reasonable substitute for the highly complex efficient methods. The simplicity of equations for estimation relative to the maximum likelihood equations is noticeable.

Oscar Kempthorne, George Zyskind, Sidney Addelman (Research Triangle Institute, Durham, N.C.), **T. N. Throckmorton** (Aerojet-General Corp., Sacramento, Calif.) and **R. F. White** (Smith, Kline and French Laboratories, Philadelphia): "Analysis of Variance Procedures." Technical Report (Final) on Air Force Project AF 33(616) 5599, with Wright Air Development Division, published by Aeronautical Research Laboratory, Office of Aerospace Research, U.S. Air Force, Wright-Patterson Air Force Base, Ohio. November 1961. vii +205 pp.

Research on Analysis of Variance is described in this final report. Chapter I is introductory, giving a general outline of topics covered in the report. Chapter 2 presents a new series of orthogonal main-effect plans, allowing for the testing of $[2s^n-1)/(s-1)^{-1}]$ factors each at s levels in $2s^n$ observations and two classes of main-effect plans for factors with unequal numbers of levels. Chapter 3 extends previous work on the analysis of variance by developing general rules for the structure of the analysis of variance and expectations of mean squares for balanced samples from balanced populations which involve nesting crossing and random confounding. Chapter 4 contains results of research on one class

of partially balanced structures, the symmetric Latin cube, and Chapter 5 contains early results on an attempt to obtain a general formulation for partially balanced structures, based on orthogonal partitions. Chapter 6 deals with the role of covariance structures induced by randomization and the relevance of these to the use of least squares. Chapter 7 describes some initial work on the power of randomization tests and Chapter 8 gives some preliminary work on constrained randomization.

***Oscar Kempthorne** and Richard H. Osborne (Sloan-Kittering Institute, New York): "The Interpretation of Twin Data." American Journal of Human Genetics 13: 3, 320-339. September 1961. (Jour. paper J-4141, Iowa Agr. and Home Ec. Exp. Sta. Project 890) Reprint Series No. 96, Statistical Laboratory, Iowa State University.

Traditional pedigree analysis and genealogical methods, which can be used with quantitative attributes exhibiting bimodal or multimodal distributions in the population, are not effective in interpreting environmental and genetic causes of variance in the majority of human characteristics. In theory at least, twins provide an effective method for appraising the heredity-environment problem with respect to these common non-bimodal characteristics. Considered here are: a. the theoretical problems relating to the use of twin data; b. the basic statistical situation with measurement data occurring in pairs; and c. interpretation of the statistical estimates of genetic and environmental causes of variance.

The statistical models developed are illustrated, first, by application to a physiological measurement, (erythrocyte sedimentation rate), and then to morphological measurements, (height, weight, and ponderal index). The latter are examined also by a model for multiple attributes. With these observational data, some of the possibilities for interpreting genetic and environmental causes of variance in quantitative attributes are demonstrated. It is found that interpretation of the observational data would be extended by information concerning mating pattern, and by more definitive descriptions of the common and competitive forces affecting within pair trait variability. This information could be provided, for the greater part, by observations on mated pairs, parent and offspring, twins and siblings raised together and apart, and half siblings. The interpretation of twin data could also involve consideration of the role of genotype-environmental interaction by use of co-twin control methods, but such methods are difficult to apply to man.

O. Kempthorne: "Discussion: On the Foundations of Statistical Inference." Journal of the American Statistical Association 57: 298, 319-322, June 1962.

This material contains a critique of some aspects of a paper by A. Birnbaum entitled "On the Foundations of Statistical Inference," in which three principles—the principle of sufficiency, the principle of conditionality, and the likelihood principle—are examined with regard to the evidential meaning of the data. It also contains a possible interpretation of the fiducial argument in one of the simplest situations.

O. Kempthorne, with Sidney Addelman (see Addelman, December 1961.)

Gilbert C. Knollman and **Joseph J. Moder** (Postdoctoral fellow, Iowa State U.; Georgia Institute of Technology): "Design Criteria for Pellet-dispersing Warheads." Operations Research 9: 4, 500-521. July-August 1961.

A warhead is presumed to be so designed as to provide a radial dispersion of small pellets without significantly altering their collective forward motion. Thus, at the moment of target interception, the pellets are taken as randomly distributed over either a circular or an elliptical lamina, and those distributions that lead to optimum target-kill probabilities are derived. Design criteria are noted that tend to yield the largest over-all kill probability. Target and lamina size, individual pellet mass, overall mass, kill probability of a single pellet that hits the target, and the random errors of predicting target position and of placing the pellet array in that position are all taken into account. An assessment is made of the basic proposition that the kill probability of every pellet striking the target is the same, independent of the number of previous hits; thereby some "limits of probability" are established for the present study. In conclusion, an adaptation of the mathematical results to a shot-gun-bird system is presented.

***J. N. K. Rao:** "On the Estimate of the Variance in Unequal Probability Sampling." Annals of the Institute of Statistical Mathematics XIII: 1, 57-60. 1961. Tokyo. Reprint Series No. 106, Statistical Laboratory Iowa State University.

In unequal probability sampling without replacement, the estimate of the variance of the estimated total can sometimes take negative values. Therefore it would be of interest to identify sampling systems for which the estimate of variance is always positive. Two such sampling systems have been identified in the literature. In this paper a new sampling system is identified for which the estimate of variance is always positive.

***J. N. K. Rao:** "Asymptotic Equivalence of Efficiency for Three Procedures of Unequal Probability Sampling Without Replacement." Proceedings of the Social Statistics Section of the American Statistician. pp. 231-234. 1961. Reprint Series No. 107. Statistical Laboratory, Iowa State University.

When sampling with unequal probabilities and without replacement, the following three procedures have been widely used:

1. The N units in the population are listed in a random order and their measures of size x_j are cumulated and a systematic selection of n units from a random start is then made on the cumulative sum of the x_j.
2. The first unit in the sample is selected with probability proportional to x_j (p. p. s.), the second unit in the sample is selected with p. p. s. of the remaining units and so on.
3. Make n selections with p. p. s. and with replacement. If any unit is selected more than once, reject the n selections and make further n selections with p. p. s. and with replacement, the process being continued until n different units are selected in the sample.

The estimate of the population total is $\hat{Y} = \Sigma_n(y_j/\pi_j)$ where π_j is the probability for selecting j^{th} unit in the sample. It is well known that by making π_j proportional to x_j, considerable reduction in var $(\hat{Y})$ can be achieved. Procedure 1 insures this condition exactly with the original size measures, x_j, whereas for procedures 2 and 3 revised size measures x^*_j have to be found to insure this condition. Assuming that π_j is $O(N^{-1})$, for N large, it is shown here that all three procedures have the same var $(\hat{Y})$ to $O(N^{-1})$. Since the terms of $O(N^{-1})$ are the important terms that contribute to the gain in precision of sampling without replacement over sampling with replacement for N large, the three procedures have practically the same efficiency. However, in procedure 1 there is no need to compute revised size measures so that it is more advantageous than procedures 2 and 3.

J. N. K. Rao, with H. O. Hartley (see Hartley, June 1962).

B. V. Shah, with R. J. Buehler and O. Kempthorne (see Buehler, September 1961).

Gerhard Tintner: "Application of the Theory of Information to the Problem of Weighted Regression." Studi in Onore di Corrado Gini, Instituto di Statistica, Universita degli Studi di Roma. Roma, 1961.

It is shown that the method of weighted regression can be interpreted as minimizing the information about the divergence between two populations.

Leroy Wolins: "Prediction of Success Among Assembly Line Workers." Validity Information Exchange No. 15-04. Personnel Psychology 15: 2, 227-229. Summer 1962.

The performance of female workers on an assembly line was evaluated by their supervisor. These workers were also tested by psychological tests which determined that there is a relationship between performance on the job and performance on the tests.

George Zyskind, with Oscar Kempthorne and Sidney Addelman (see Kempthorne, November 1961.)

***George Zyskind:** "On Structure, Relation, Σ, and Expectation of Mean Squares." Sankhya, The Indian Journal of Statistics, Series A, Vol. 24, Part 2, 115-148. 1962. Reprint Series No. 110, Statistical Laboratory, Iowa State University.

Some properties of balanced population structures are investigated. The forms for the expected value of squares of balanced sample means from balanced population structures are obtained, and this is done also for the type of sample mean arising in a class of randomized experiments. The canonical form of the Σ expansion of the expected value of the square of the sample mean is demonstrated. The form of the expected value of mean squares in the analysis of variance for a large class of situations is then derived as a consequence.

Books

J. Arthur Greenwood (Stanford U.) and **H. O. Hartley:** *Guide to Tables in Mathematical Statistics.* Princeton University Press, Princeton, N.J. 1962. lxii + 1014 pp.

The Guide to Tables in Mathematical Statistics, which was more than twenty years in the process of preparation, has been completed under a project sponsored by The National Academy of Sciences—National Research Council. While similar guides covering mathematical tables in general are in existence, this is the first work of its kind in the area of mathematical statistics.

The Guide catalogues a large selection of tables belonging to the field of mathematical statistics and a small selection of mathematical tables lying outside statistics but often used together with statistical tables. The bulk of the tables treated were published between 1900 and 1954; occasional entries relate to works as early as 1799 and as late as 1960. While for the better known tables a classified Index is presented, the more specialized tables are described in the form of abstracts. Introductory material gives the relevant mathematical formulas, relationship between the different functions and approximations to them. As well as filling an important need for those actively engaged in the computational side of mathematical statistics, this work offers valuable reference to the professional computer faced with a statistical problem, and the statistician called upon to compute.

This book will aid the rapid selection and location of tables for purposes of statistical and numerical analysis and researches. In addition to the above, the book provides:

(1) Sources and characteristics of the principal published tables of random numbers

(2) A ninety-page list of tables of combinatorial patterns used in the design of experiments

(3) Annotated tables of contents of sixteen collections of statistical tables

(4) An exhaustive subject index

Gerhard Tintner: *Econometrics,* a Japanese translation. Tokyo, Japan. Chikura-shobo Publishing Co. 584 + viii pp. 1961.

This is a translation into Japanese of a book by Tintner originally published in 1952 by John Wiley and Sons, Inc., New York.

Gerhard Tintner: *Mathematiques et Statistiques pour les Economists,* a French translation. Dunod, Paris, 1962.

This is a French translation of a book by Tintner originally published in 1953 by Rinehart and Company, New York.

Book Reviews:

Gerhard Tintner:

B. Romer: "Das Haupt Theorem Der Linearen Programmiegung", P. 1570;

S. Vajda: "Inequalities in Stochastic Linear Programming," P. 1571; in Math. Reviews, Vol. 22, No. 9B, Sept. 1961.

M. A. Hanson: "Errors and Syochastic Variations in Linear Programming," P. 1117;

H. Scarf: "The Optionality of (S. s) Policies in the Dynamic Inventory Problem." P. 1119; in Math. Reviews, Vol. 22, No. 7B. July 1961.

Papers presented at professional meetings

Papers presented at professional meetings reflect the work that has been done in the Statistical Laboratory. Many of these papers will appear later in publications. Abstracts are often published in professional journals. In such cases, references are given.

T. A. Bancroft: "The Role of Statistics in the Planning and Analyzing of Agronomic Experiments," a paper presented at a meeting of the International Instituto Tecnologica Azucarero Veracruzano, Carlos A. Carillo, Vera Cruz, Mexico, July 1961.

T. A. Bancroft: "The Teaching of the Fundamental Sciences in Higher Agricultural Education," a paper read at a conference sponsored by UNESCO, the Second Latin-American Conference in Higher Agricultural Education, Medellín, Colombia, May 1962.

T. A. Bancroft and **David V. Huntsberger:** "Summer Conferences for College and University Teachers of Statistics," a paper presented at the annual meeting of the American Statistical Association, New York City, December 1961.

Neeti R. Bohidar (University of Utah, Logan, Utah): "Monte Carlo Investigations of the Effect of Linkage on Selection," at the Biometric Society (WNAR) meeting at the University of Washington, Seattle, June 14-17, 1961. Biometrics 17:3, September 1961. Abstract No. 774.

Robert J. Buehler: "New Proofs and Generalization of an Optimum-Gradient Theorem," American Mathematical Society Notices, 8:1, August 1961.

Foster B. Cady and **C. P. Cox:** "Some Applications of Inefficient Statistical Methods," a paper presented at the annual meeting of the American Statistical Association and the Biometric Society at New York City, December 1961.

Foster B. Cady and **D. D. Mason:** "Statistical Analysis of a Short-term Rotation Experiment," a paper given at the American Society of Agronomy meeting in St. Louis, Mo., November 27-30, 1961. Agronomy Abstracts, page 67, November 1961.

H. T. David: "Multivariate Normal Probabilities," a paper presented at the annual meeting of the Institute of Mathematical Statistics, Seattle, Washington, June 1961.

Herbert T. David and **Allen H. Lipis:** "Noisy Duels as Limits of Game Iterations," a paper presented at the Central Regional meeting of the Institute of Mathematical Statistics at Champaign-Urbana, Illinois, November 24-25, 1961.

Louis J. Circeo, D. T. Davidson and **H. T. David:** "Strength-Maturity Relations of Soil-Cement Mixtures," a paper given at the annual meeting of the Highway Research Board, at Washington, D.C., January 8-12, 1962. Proceedings of the Highway Research Board of the National Research Council. June 1962.

Carol B. Edwards and **John Gurland** (U. of Wisconsin): "A Class of Distributions Applicable to Accidents," a paper presented at the 121st annual meeting of the Biometric Society in New York City, December, 1961.

A. W. Nordskog and **Francis Giesbrecht:** "Accuracy of Estimating Age at Sexual Maturity for Pen Records of Egg Production," and

W. W. Marion, A. W. Nordskog, **Francis Giesbrecht** and R. H. Forsythe: "Some Chemical and Physical Characteristics of Egg Shells," both papers presented at the American Poultry Science Association meeting at Pennsylvania State University, August 7-11, 1961.

John Gill and L. N. Hazel: "Factors Affecting Gain and Carcass Traits of Angus Cattle," a paper given at the annual meeting of the American Society of Animal Production in Chicago, November 24, 1961.

John Gurland (U. of Wisconsin): "Methods of Estimation for Some Generalized Distributions," at the meetings of the American Statistical Association and the Biometrics Society, New York City, December 27-30, 1961.

Dewey L. Harris: "A Monte Carlo Study of the Influence of Errors of Parameter Estimation upon Index Selection," a paper given at the American Statistical Association-Institute of Mathematical Statistics meetings at Cornell University, April 21-22, 1961. Biometrics 17:3, September 1961.

Dewey L. Harris: "The Influence of Errors of Parameter Estimation upon Index Selection," a paper presented at the Symposium on Statistical Genetics and Plant Breeding at North Carolina State College, Raleigh, March 20-24, 1961. Iowa Agr. and Home Ec. Exp. Sta. Journal paper, J-4133.

Dewey L. Harris: "A Critical Look at Selection Indexes," at the Poultry Breeders Round Table in Kansas City, Mo., May 1962.

H. O. Hartley: "Analytic Studies of Sample Surveys," a paper presented at the meeting of the Biometric Society, at Cornell University, April 1961. Biometrics 17:3, page 502. September 1961.

H. O. Hartley: "Some Theorems in the Construction of Experimental Designs," at Purdue University, July 1961.

H. O. Hartley: "Training Statisticians to Use Computers," a paper given at the annual meeting of the American Statistical Association in New York, December 27-30, 1961.

H. O. Hartley and **Aaron Booker:** "Efficient Nonlinear Least Squares Estimation without Absolute Minima," a paper presented at the meetings of the American Statistical Association, Biometric Society and Institute of Mathematical Statistics, in New York City, December 27-30, 1961.

H. O. Hartley: "Samples and Methods for Aggregation of Supply Functions," a paper given at a meeting of the Farm Foundation, NCR-4 Workshop, Chicago, March 1962.

H. O. Hartley: "Some Uses of High Speed Computers in the Food Industry," a talk given at a meeting of the Ames Section of the Institute of Food Technologists at Cedar Rapids on March 16, 1962.

H. O. Hartley: "Some Balanced Experimental Designs," at Texas A and M, April 1962.

D. K. Hotchkiss et al: "Different Roughages at Low Levels in Steer Rations," and "Pelleted Low-Roughage Complete Rations for Steers," papers given at the annual meeting of the American Society of Animal Production in Chicago, November 24-25, 1961, and published in the Proceedings of the meeting. Abstracts in Journal of Animal Science 20: 955 and 956, 1961.

Oscar Kempthorne: "Experimental Design," a colloquium lecture at Case Institute of Technology, October 27, 1961.

J. N. K. Rao and **Gerhard Tintner:** "The distribution of the Ratio of the Variances of Variate Differences in the Circular Case," a paper given at the meeting of the Institute of Mathematical Statistics June 14-17, 1961 in Seattle. Annals of Mathematical Statistics 32:3, 924, September 1961.

J. N. K. Rao: "An Exact Test in Variate Difference Method," a paper presented at the summer meeting of the Econometric Society at Oklahoma A and M, Stillwater, Oklahoma, August 29-September 2, 1961.

J. N. K. Rao with **H. O. Hartley** and W. G. Cochran (Harvard U.): "A Simple Procedure of Unequal Probability Sampling Without Replacement," a paper given at the regional meeting of the Institute of Mathematical Statistics, April 12-14, 1962, at Chapel Hill, N. C. Annals of Math. Stat. 33: 2, page 822, June 1962.

B. V. Shah and **Oscar Kempthorne:** "Randomization in Fractional Factorials," a talk given at the Institute of Mathematical Statistics, Eastern Regional meeting, University of North Carolina, April 12-14, 1962. Annals of Math. Stat. 33:2, page 823, June 1962.

B. V. Shah and **Oscar Kempthorne:** "Some Properties of Random Allocation Designs," a talk given at Florida State University, April 16, 1962; also at the North Carolina meeting of IMS, April 12-14, 1962. Annals of Math. Stat. 33:2, page 822, June 1962.

R. H. Shumway: "Fitting Procedures for Some Generalized Poisson Distributions," at the meetings of the American Statistical Association and the Biometric Society in New York City, December 27-30, 1961.

T. N. Throckmorton: "Structure Diagrams and Their Uses in Experi-

mental Design," at the annual meeting of the American Statistical Association, New York City, December 27-30, 1961. Biometrics 18:2, June 1962. Abstract No. 807.

Gerhard Tintner and E. V. Thomas: "Un Models Stochastique de Development Economique avec Applications a L'Industrie Anglaise," a paper presented at the European meeting of the Econometric Society, Paris, August 28-30, 1961.

Gerhard Tintner and **J. N. K. Rao:** "An Exact Test in the Variate Difference Method," a paper presented at the summer meetings of the Econometric Society, 1961.

Gerhard Tintner, E. V. Thomas, J. K. Sengupta; "A Stochastic Theory of Economic Development," a paper presented at the annual meeting of the Econometric Society in New York City, December 27-30, 1961.

Gerhard Tintner: "Present State of Econometrics," and "Economic Planning in India," at the University of Pittsburgh, January 19, 1962.

Gerhard Tintner: "A Generalization of the Stochastic Birth and Death Process with Applications to Economic Development in Great Britain and Germany," speech given at Purdue University, February 6, 1962.

Leroy Wolins, A. C. MacKinney and Donald Goodrich: "Are Attitude Scales Metathetic?" a paper presented at the Midwestern Psychological Ass'n. in Chicago, May 3-4, 1962.

Leroy Wolins: "Analysis of Variance Applied to Factors Which Do Not Have Comparable Scales," Psychology Colloquium, Northwestern University, October 19, 1961.

ABSTRACTS OF THESES

Donald Ray Jensen: "Influence of Soil Variability on Optimum Soil Sampling and Fertilizer Use." Ph.D. thesis. Iowa State University Library. May 1962.

In this thesis the production of crops was considered for cases in which heterogeneous environmental conditions prevail within a production site, and where yield was taken to be a function of resource inputs and environmental factors. It was found that failure to account for variable environmental conditions may lead to incorrect specification of yields, profits, and profit-maximizing resource inputs. For the special case of a second-degree polynomial yield function and a stratified field, specification errors for both yields and profits were found to be linear functions of within-stratum population variance-covariance properties for variable soil nutrients; however, no corresponding errors were found in specified optimum resource inputs. For functions which are convex with respect to environmental factors, both yields and profits were found to be overestimated for a particular stratum when within-stratum variability is ignored.

A statistical sample may be used to estimate stratum profits; however, the sample stratum profit was shown to be a biased estimate of the corresponding population quantity. An unbiased estimator was constructed by adding a linear function of the sample moments.

Stratification techniques were evaluated in terms of expected maximum stratum profits. For the case of a second-degree polynomial yield function, expected maximum stratum profit for variable conditions differs from that obtained by ignoring variability, the difference being a linear function of population within- and among-strata variance-covariance properties.

Each of nine 40-acre fields, representing a variety of soil conditions in Iowa, was intensively sampled to provide some indication of natural soil variability. Using an index of soil variability, it was found that the fields with Nicollet-Webster and Tama-Muscatine soil groups could be characterized by indices in the range 8 to 22; in contrast, fields containing Sharpsburg-Shelby and Ida-Monona soils were considerably less variable, with an index range of 1 to 5. Predicted average yields were found to increase as a result of stratification and separate fertilizer application. However, the increase was smaller for fields with lower indices of variability.

Evidence obtained empirically suggests that (a) natural bases for stratification in certain cases may be inferior to alternative procedures which ignore soil type, slope, and erosion differences, (b) relatively large areas may be rather homogeneous with respect to soil test results as presently determined in the laboratory, and (c) variability of soil test quantities within a field does not necessarily increase with greater topographical differences exhibited in the field.

Heterogeneous soil materials were composited and subjected to laboratory tests. When results of the composite analyses were compared with averages of the individual determinations, it was concluded that the two types of analyses were indistinguishable. It appears that recommended fertilizer rates may be based on results of a composite soil sample when the sample is taken from a stratum for which a second-degree polynomial function holds.

Andris Fogelmanis: "Application of Composite Designs in Fitting Quadratic Response Surfaces." M. S. thesis. Iowa State University Library. July 1961.

In response surface analyses the general problem is to find experimentally the levels of a number of quantitative input variables at which some dependent response has an optimum value. The problem can be solved by exploring the whole experimental region; but the number of individual experiments necessary to do this would usually be prohibitively large. When the experimental error is small and experiments are conducted sequentially, the first order effects determined in a given subregion may be used to locate another subregion in which the response is greater. By repetition of this process a near-stationary region is found. This region may then be explored to determine effects of higher order. Multi-level factorial and fractional factorial designs will accomplish this; but when the number of treatment combinations must be held to a minimum and when there is reasonable expectation that the generalized second degree polynomial approximation to the true response surface will be satisfactory, new types of designs, the composite designs, may be used. These designs, when applied to n input factors, combine a 2^n factorial with a so-called star design which may be regarded as a one-factor-at-a-time experiment and results in $2n+1$ additional experimental points. As the number of factors increases, these designs also will have an excessive number of points in relation to the number of coefficients of the response sur-

face. To remedy this, fractional factorials of the 2^n series are used.

Chapter 3 of this thesis presents a number of these plans which are believed to be the most useful in practical applications. It is shown that plans usually recommended as fractional replicates **per se** are not necessarily best when used in composite designs; hence alternate plans, permitting the estimation of all or a maximum number of coefficients in the second order surface, have been developed.

Chapter 4 discusses the methods of analysis of these designs, while in the last chapter these methods are illustrated by an example.

Enathical John Thomas: "Stochastic Processes Obeying Two or More Separate Regimes." M. S. thesis. Iowa State University Library. August 1961.

The problem of discrete change in parameters, at some unknown stage in models representing stochastic processes, is considered in this thesis. R. E. Quandt, in the *Journal of the American Statistical Association,* Vol. 53, 1958, and Vol. 55, 1960, has discussed the method of estimation and testing of hypotheses in linear regression models obeying two separate regimes; i.e., when there is one switch over where the parameters change discretely. Models representing processes in economics, especially long run data, can be expected to obey two or more regimes. The switch over may depend on time or on some variable entering into the system. Usually the switch over period or switch over value is unknown. The method of estimation and testing of hypotheses for the case of linear regression models and first order linear difference equation models (stationary and explosive cases) are studied for switch overs depending on time and on a variable entering into the system. Thus the models in case of linear regression are

$$\begin{aligned} y_t &= a_1 x_t + b_1 + \epsilon_t \qquad t \leqslant k \\ &= a_2 x_t + b_2 + \epsilon_t \qquad t > k \end{aligned}$$

for switch over depending on time, and

$$\begin{aligned} y_t &= a_1 x_t + b_1 + \epsilon_t \qquad x_t \leqslant c \\ &= a_2 x_t + b_2 + \epsilon_t \qquad x_t > c \end{aligned}$$

for switch over depending on x_t. For the first order linear difference equation model the two cases are

$$\begin{aligned} x_t &= a x_{t-1} + \epsilon_t \qquad t \leqslant k \\ &= b x_{t-1} + \epsilon_t \qquad t > k \end{aligned}$$

and

$$\begin{aligned} x_t &= a x_{t-1} + \epsilon_t \qquad x_{t-1} \leqslant c \\ &= b x_{t-1} + \epsilon_t \qquad x_{t-1} > c \end{aligned}$$

British industrial production for 1700-1938, given by W. G. Hoffmann in *British Industry 1700-1950,* is analyzed using the first order difference equation model. The aim of the analysis is to locate the switch over periods and hence the different regimes or stages of economic development in Britain. The possibility of two, three, and four regimes is studied and the partitions are in general agreement with the switch overs given by economists.

Emilio Ellena: "Estimation of a Corn Forecast Equation from a Cluster Sample." M.S. thesis. Iowa State University Library. November 1961.

The estimation of the average yield of grain per ear (D.K.W.) when expressed as a linear function of the ear length at different times during the growing season is the subject of this study.

The problem was one of finding estimates of the parameters of certain linear models. The available data were such that they did not meet the conditions required in order that straight forward least squares methods be efficient and yield good estimates of the variances. As the sampling procedure was of a cluster nature, it was to be expected that the errors would be correlated within the cluster.

Estimators were developed from two points of view: for samples from a finite population and for samples from an infinite population.

In the first case, consistent estimates of the coefficients of the linear regression equation and limiting expressions for their variances and covariances were presented under the minimum of assumptions generally required in sampling theory. It was required only that the means and variances of new variables be finite. These new variables were the sum of squares and cross products of the original variables within each cluster.

In the infinite case, a transformation was developed and maximum likelihood estimators and their limiting variances were obtained for the parameters of the linear equation and the intraclass correlation coefficient.

Larry Joel Ringer: "The Use of an Approximation to the Beta Function." M. S. thesis. Iowa State University Library. February 1962.

The tabulation of the values of the incomplete Beta function for all possible values of the three parameters and at an interpolative interval for $\underline{x}$ is a Herculean task and would require a rather unwieldy amount of tabulation. But since so many statistical problems involve statistics which can be transformed to Beta variables, some method of evaluating $I_x(a, b)$ which has adequate precision over all ranges of the three parameters but which does not involve a large amount of tabled values would be welcome. This method would then take the place of the tables for those statistics which can be transformed to an incomplete Beta variable.

M. E. Wise, in *Biometrika* 1950, has developed an approximation to the Incomplete Beta function involving the probability integral of x^2. Using this method as a starting point and attempting to eliminate its disadvantages, while at the same time improving its accuracy, the author has in this thesis presented a modification of Wise's method involving four tables. One of these is a table of "upper tail" probabilities of the x^2-table and another small table of natural logarithms for $0.1 < x < 1$. The other two tables, both of which are small, involve values used in the approximation.

This approximation, with the use of the approximate transformations, may be used in applications involving F, t, and binomial statistics. With the x^2-table, which is required for the approximation, problems involving x^2 and Poisson statistics may also be solved. Thus the tables necessary for this approximation may be used in many statistical applications. The advantage of the transformation used in this derivation is that the computations are easily programmed for electronic computers.

The present thesis gives in particular the program for computing the extensive tables of the probability integral of χ^2 using a well known recurrence formula and is also concerned with various summation checks.

Thomas E. Doerfler: "The Compounding of Gradient Error in the Method of Parallel Tangents." M.S. thesis. Iowa State University Library. May 1962.

This study considers the general problem of determining by experiments the input conditions which optimize a yield or response. Only iterative methods, whereby one proceeds in a systematic manner to obtain successively better responses, are discussed. By making use of first-order information at some prescribed starting point, sequential straight-line directions are taken until an optimum is achieved.

In previous work it has been assumed that first derivatives, and consequently tangent directions, are determined exactly. This study deals with the role of observational error on the performance of two competing path methods, steepest descent and steepest descent partan. The investigation is limited to responses represented by a positive definite quadratic form. Only the two-dimensional case is considered, and it is assumed that the optimum on any chosen line is obtained without error. Equations are developed which represent the response after three iterations of steepest descent and steepest descent partan in terms of a surface, contour, and starting point. Furthermore, independent errors in the estimation of each partial derivative are assumed, thus associating a gradient error with the first direction taken. To evaluate the effect of the compounding of this gradient error, a criterion measuring performance was developed and averaged over a collection of starting points and errors for each competing method. Since it was impossible to arrive at an analytic solution for average performance, discrete starting points were selected over a contour of equal response, and the calculations were performed on the IBM 650. In this manner, an effective measure of the relative and absolute value of the path techniques was obtained for a collection of surfaces, contours, starting points and error structures.

The results favor the partan method when the gradient error is relatively small. As the error increases, partan is less efficient and steepest descent exhibits peculiar irregularities, and at certain starting values it actually performs more to the experimenter's advantage. The over-all pattern of the results exhibits the superiority of partan in the range of input values considered. Both methods appear to be satisfactory for nearly circular contours regardless of the magnitude of the errors.

Marvin Lentner: "Inferences Concerning the Scale Parameters of Two Gamma Distributions." M.S. thesis. Iowa State University Library. May 1962.

The subject of life testing is concerned with the distribution of times to failure of electronic or mechanical devices. This thesis is concerned with the life of a system of several components, in particular with a system of two components in which both must operate (that is, a "series system"). It is desired to draw conclusions regarding the life of the system from data relating to the separate components.

If components from population i have exponential time to failure with mean life Θ_i, then a series system comprising one component from each population has exponential time to failure with mean $1/\Sigma(1/\Theta_i)$. The theory for the parallel system (any one component must operate) is more complicated because no single function of the Θ's characterizes the distribution.

The problem of setting confidence limits for $1/\Theta_1 + 1/\Theta_2$ is considered. When data are available separately for the components, then Θ_1 and Θ_2 appear in the joint distribution of their estimators as the scale parameters of independent gamma variates. It is found that the nuisance parameter which arises in this problem can be eliminated by a conditional argument. The resulting confidence intervals and associated tests have optimal properties by virtue of known theory of "exponential families" of distributions. A number of conditional distributions which are relevant for problems of this general character are given explicitly.

Allen H. Lipis: "Noisy Duels as Limits of Game Iterations." M.S. thesis. Iowa State University Library. May 1962.

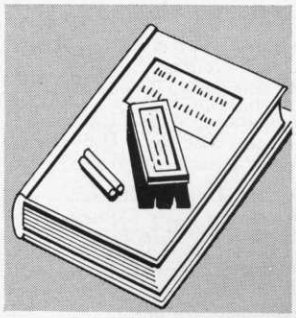
The theory of games has been used in problems dealing with the timing of decisions. This thesis was concerned with the noisy duel G(0, 1, 2) with equal accuracy functions, which starts at a time when kill probability is zero, with player I having one bullet and player II two bullets.

This two-person zero-sum game has an ϵ-good strategy for Player I, or alternatively (Dresher) a good strategy calling for a mathematically imprecise "split-second hesitation" at a certain time T.

To understand this mathematically imprecise strategy, we consider a sequence of approximations to G(0, 1, 2), each approximation possessing a saddle point, and study the limiting behavior of these saddle points as this sequence tends toward G(0, 1, 2).

In solving games of this nature, it is necessary to show that if all games at a particular stage of a game tree have saddle points and values, then the games at the next-lowest stage have saddle points and values.

Using a geometric approach, it is possible to develop some mathematically precise counterparts to the mathematically imprecise split-second hesitation. They are:
1. The saddle point strategies for player I and II call, respectively, for decreasing and increasing probabilities of fire at and after time T.
2. The limits of the above probabilities, as the approximating sequence tends toward G(0, 1, 2), are respectively zero and non-zero.
3. The limits of the expected waiting times till first firing, starting at any time greater than T, are respectively non-zero and zero.



The Department of Statistics in the College of Sciences and Humanities at Iowa State offers work leading to the degrees of Bachelor of Science, Master of Science, and Doctor of Philosophy with majors in statistics. Each major is built around a common core of courses in theory and methods, with other courses being chosen to fit the individual student's background and interests. At all levels, the program in statistics is designed to emphasize the close relationship between sound applications and modern statistical theory. The Department also offers minor and supporting work in statistics. When desired, a joint-major program may be arranged between statistics and a substantive field of application for the Ph.D. degree.

Training facilities include two student laboratories equipped with 65 electric calculating machines for course instruction and for student use during non-class hours. Use is also made of the high-speed computing equipment and electrical equipment for punched-card analysis of data which are located in the Cyclone Computer Laboratory, the Statistical Laboratory Computing Service, and the Business Office Data Processing Service. The Cyclone, Iowa State's high-speed digital computer, was expanded in 1961, increasing its memory capacity as well as its rate and range of operation. A new IBM 7074-1401 high speed computer will be installed in the fall of 1962.

The Statistical Laboratory Library now has reprints of 4,677 articles considered important in theoretical and applied statistics. These are kept for student and staff reference, along with reprints of staff publications, graduate theses, various statistical journals, reference books and other publications obtained on an exchange, loan or gift basis.

SUMMER INSTITUTE, 1961

A Summer Institute in Statistics, with Kansas State University, Utah State University, University of Wyoming, and Iowa State University as cooperating institutions, was held at Iowa State June 5 to August 18, 1961. It was supported by a National Science Foundation Grant. The participants were fifty-two college and university teachers of statistics.

The major objective of the Institute was to provide supplementary training in statistics for present and prospective teachers of statistics in American colleges and universities. It was believed that a summer institute in statistics for teachers who had not had adequate training in the subject would (1) raise the general level of instruction in statistics; (2) lead to the offering of more intermediate and advanced courses in statistics in American colleges and universities; (3) provide more and better technical assistance for teachers and research workers in other disciplines who require the aid of statisticians in the solutions of their problems; (4) result in an increase in the number of students working for an advanced degree in statistics; and (5) stimulate the application of statistical methods in all branches of science.

The courses offered and the professors who taught them follow:

401B, 402B	Statistical Methods	H. C. Fryer, Head of Dept. of Stat. Dir. of Stat. Lab. Kansas State U.
447, 448	Theory of Statistics	T. A. Bancroft, Head of Dept. of Stat. Dir. of Stat. Lab. Iowa State U.
411	Experimental Design	Rex L. Hurst, Head of Applied Stat. Dir. of Stat. Lab. Utah State U.
421	Survey Designs	H. O. Hartley, Prof. of Statistics, Iowa State U.
599A1 (1st session)	Topics in Foundations of Probability and Statistics	Robert J. Buehler, Assoc. Prof. Stat. Iowa State U.
599A2 (2nd session)	Intermediate Applied Decision Theory	Herbert T. David, Assoc. Prof. Stat. Iowa State U.

T. A. Bancroft acted as Director of the Institute with David V. Huntsberger serving as Associate Director.

Fifteen special seminars were held, scheduled at times when all Institute participants could attend, and presented by prominent statisticians. The function was to acquaint participants with modern developments relative to statistical methods and their applications. Guest lecturers and their topics follow:

June 13	N. L. Johnson: Some Connections between Different Statistical Distributions.
June 15	N. L. Johnson: Cross Classifications with Unequal Frequencies.
June 16	N. L. Johnson: An Introduction to Sequential Analysis.
June 20	Harold Hotelling: Purposes, Types, and Organization of the Teaching of Statistics.
June 22	Harold Hotelling: Relations of Teaching, Research and Practice in the Teaching of Statistics.
June 29	Morris H. Hansen: Response Errors in Censuses and Surveys.
June 30	Morris H. Hansen: Recent Developments in Census Methods.
July 6	Leroy Wolins: Judgments of the Intensity of Attitude Statements as a Function of Grammatical Complexity.
July 7	Leroy Wolins: Prediction of Freshman Grades at Iowa State University.
July 18	Edward C. Bryant: Multi-Way Stratification I.
July 20	Edward C. Bryant: Multi-Way Stratification II.
July 25	Gerhard Tintner: Statistical Problems of Econometrics I.
July 27	Gerhard Tintner: Statistical Problems of Econometrics II.
August 8	Oscar Kempthorne: Analysis of Variance.
August 10	Oscar Kempthorne: Procedures for Determining Optimum Operating Conditions.

Participants in the Summer Institute in Statistics

Fifty participants were in residence for the full 11-week term of the Institute, and one attended the second session only. There was one withdrawal after seven weeks. The 52 participants originally accepted were distributed among the academic ranks as follows:

Instructors	17
Assistant Professors	26
Associate Professors	6
Professors	3

They hold degrees as follows:

Bachelors	2
Masters	40
Doctorate	10

The participants were:

Alders, Clarence Dean
Mankato State College
Mankato, Minnesota

Benrud, Charles Harris
South Dakota State College
Brookings, South Dakota

Brewer, Jeneva Joy
University of Wichita
Wichita, Kansas

Britten, Margaret Regina
University of Denver
Denver, Colorado

Cook, Charles Caruthers
West Virginia University
Morgantown, West Virginia

Copoulos, Nicholas John
Massachusetts State College
Fitchburg, Massachusetts

Cowan, Donald Ross
University of Michigan
Ann Arbor, Michigan

Craig, Albert McKinley, Jr.
University of Tennessee
Knoxville, Tennessee

Daley, James Myron
University of Wyoming
Laramie, Wyoming

Ecker, Edwin Duain
MacMurray College
Jacksonville, Illinois

Fortson, James Camp
Athens, Georgia

Grunwald, George B.
Minot State Teachers College
Minot, North Dakota

Hahn, Samuel Wilfred
Wittenberg University
Springfield, Ohio

Heed, Joseph James
St. Johns University
Jamaica, New York

Hickman, Edgar Powell
State University of Iowa
Iowa City, Iowa

Johnson, Lynwood Albert
Georgia Institute of Tech.
Atlanta, Georgia

Jones, Albert C.
University of Miami
Miami, Florida

Kaye, John
George Washington U.
Washington, D. C.

Komorita, Samuel Shozo
Vanderbilt University
Nashville, Tennessee

Lasher, David Elmer
West Texas State
Canyon, Texas

Lawrence, Willard Earl
Marquette University
Milwaukee, Wisconsin

Leidig, Robert Donald
Clarkson College
Potsdam, New York

Leonard, Sister Mary
John Catherine
Clarke College
Dubuque, Iowa

Lindstrom, Ralph Raymond
Mich. C. of Mining and Tech.
Houghton, Michigan

Livermore, Paul Edward
Arizona State University
Tempe, Arizona

Lowenberg, Vernon Fred
West Virginia University
Morgantown, West Virginia

McBryde, Vernon Eugene
University of Arkansas
Fayetteville, Arkansas

Maddox, Thomas Kier
Southeastern Louisiana Col.
Hammond, Louisiana

Manuel, Nan P.
North Carolina A. and T. Col.
Greensboro, North Carolina

Monks, Herbert Victor
Northeast State College
Tahlequah, Oklahoma

Noland, John Hugh
Chico State College
Chico, California

Olson, Roger Frederick
Tarkio College
Tarkio, Missouri

Phelps, Samuel A.
Hampton Institute
Hampton, Virginia

Pleasant, James Carroll
East Carolina College
Greenville, North Carolina

Plybon, Benjamin Francis
Marshall College
Huntington, West Virginia

Pittman, Joseph Avery
North Carolina College
Durham, North Carolina

Poole, Meredith
Memphis State University
Memphis, Tennessee

Poorman, Alan G.
Ashland College
Ashland, Ohio

Potratz, Clarence John
Pacific Lutheran University
Tacoma, Washington

Prince, Lawrence J.
Colorado School of Mines
Golden, Colorado

Richards, Dale Owen
Iowa State University
Ames, Iowa

Richert, Abraham Allen
Nebraska Wesleyan University
Lincoln, Nebraska

Schlossnagel, Jack Edward
Grove City College
Grove City, Pennsylvania

Shuman, John R.
North Dakota State U.
Fargo, North Dakota

Swafford, Earol Garrod
U. S. Naval Academy
Annapolis, Maryland

Swanson, E. Keith
Wisconsin State College
La Crosse, Wisconsin

Thimm, Alfred L.
Union College
Schenectady, New York

Waggoner, Wilbur James
Central Michigan University
Mt. Pleasant, Michigan

Weber, Donald Chester
Wisconsin State College
Platteville, Wisconsin

Widmark, Merrill John
Hibbing Junior College
Hibbing, Minnesota

Wilson, Charles William
Johnson City, Tennessee

Wu, Shih-Yen
Los Angeles State College
Monterey Park, Calif.

COURSE OFFERINGS IN STATISTICS

With increased interest in statistics in all branches of research and industry, the Department of Statistics at Iowa State continues to grow. Five years ago 180 students enrolled in the introductory course, Stat. 201; during 1961-1962, 580 completed the five-credit course. Likewise enrollment has more than doubled in Stat. 401-402, Statistical Methods for Research Workers, a four-credit course taught largely as a service course in statistics for graduate students from other departments on the campus. New courses in 1961-1962 include Stat. 380, Introduction to High Speed Computers, listed jointly with the Department of Mathematics; Stat. 539, Operations Research Methods, listed jointly with the Department of Economics and the Department of Mathematics; and Stat. 554-555, Probability, listed jointly with the Department of Mathematics. Foster Cady taught a course on an experimental basis, 499B, Elementary Biological Statistics, which is designed primarily as a course for undergraduate students in the biological sciences.

The courses offered by the Department of Statistics during the year 1961-1962 follow:

Courses for Undergraduate Students Only

		Cr.		
201	Principles of Statistics	5	FWS*	Huntsberger, Heard, Lentner, Lipis, Sampson, Tetreault, Veale
327	Elementary Business Statistics	3	F	Lipis
341, 342	Introduction to Theory of Statistics	3	FW	Huntsberger
380	Introduction to High Speed Computers	3	FWS	Jespersen

Courses for Graduate Minors and Undergraduates

401, 402	Statistical Methods for Research Workers	4	FW	

* FWS—Fall, Winter and Spring quarters

	A. Animal Sciences			Hotchkiss
	B. Plant Sciences			Cady
	C. Physical Sciences, Mathematics, Engineering			David
	D. Economics			Fuller
	E. Undergraduate			Lentner
	F. Psychology, Sociology, Child Development and Vocational Education			Wolins
	401, 402—2 sections, general	4	W	Cox, Tetreault
	402—2 sections, general	4	S	Harris
411	Experimental Design for Research Workers	3	S	Cady, Hotchkiss
421	Survey Designs for Research Workers	3	S	Fuller
431	Elementary Statistical Quality Control	3	S	Richards
446, 447, 448	Statistical Theory for Research Workers	3	FWS	Huntsberger, Richards, Tetreault
480	Processing of Data	2	F	Mosier
481, 482	Processing of Data	2	WS	Mosier
499	Special Problems as arr.		FS	Fuller, Hemmerle, Jespersen, Strand
	Elementary Biological Statistics (499B)	3	W	Cady

Courses Primarily for Graduate Students, Major and Minor

501	Intermediate Statistical Methods	3	F	Bancroft
505	Psychological Statistics	3	S	Wolins
511	Design of Experiments	3	W	Zyskind
512	Design of Experiments	3	S	Kempthorne
521	Design of Surveys	3	W	Rao
522	Design of Surveys	3	S	Hartley
531	Industrial Statistics: Sampling Inspection	3	F	David
532	Industrial Statistics: Design of Experiments	3	W	David
535	Biological Statistics	3	S	Cox
536	Genetic Statistics	3	F	Harris
538	Econometric Statistics	3	F	Tintner
541, 2,3	Theory of Statistics	3	FWS	Bancroft, Buehler
580A	Scientific Machine Computing	3	W	Hartley
599	Special Topics as arr.		FWS	Bancroft, David,
	A. Theory			Fuller, Harris,
	B. Methods			Hotchkiss, Rao,
	General			Zyskind
	Scientific Computing			
	C. Design of Experiments			
	D. Design of Surveys			

Courses for Graduate Students, Major or Minor

601	Advanced Statistical Methods as arr.		F	Hartley
621	Advanced Design of Surveys	3	W	Rao
622	Seminar on Design of Surveys	3	S	Hartley
638	Advanced Econometric Statistics	3	W	Tintner
641	General Theory of Linear Hypothesis	3	F	Zyskind
642	Distribution Theory	3	F	Buehler
643	Theory of Estimation and Testing of Hypothesis	3	W	Buehler
646	Time Series	3	S	Tintner
647	Multivariate Analysis	3	S	David
688	Seminar on the Theory of Statistics and Probability as arr.		S	Hartley
699	Research		FWS	Bancroft, Buehler, Cox, David, Fuller, Hartley, Kempthorne, Tintner

Summer Quarter

The summer quarter is divided into two 5½-week periods. Since the fiscal year began on July 1, 1961, and ended on June 30, 1962, only the courses offered during the second summer session of 1961 and the first summer session of 1962 are given in this report.

Second Summer Session 1961

402	Statistical Methods for Research Workers	4	Fryer, Harris, Sisson
421	Survey Designs for Research Workers	3	Fuller, Hartley
448	Statistical Theory for Research Workers	3	Richards
499	Special Problems	3	Strand
599A2	Special Topics	3	David
699	Research		Bancroft, Buehler, Fuller, Tintner

First Summer Session 1962

401	Statistical Methods for Research Workers 2 sections	4	Cox, Tetreault
411	Experimental Design for Research Workers	3	Cady
447	Statistical Theory for Research Workers	3	Harris
499	Special Problems as arr.		Staff
599	Special Problems as arr.		Staff
646	Time Series	3	Tintner
699	Research as arr.		Staff

Roster of Graduate Majors and Special Students

Ph.D. Candidates:

Rodney Basson
Edward J. Carney (Joint Stat.-Ind. Engr. major)
Robert S. Cochran
Charles E. Cress
E. Eugene Dayhoff
Carol Bates Edwards
Ahmed H. El Mawaziny
Francis Giesbrecht
John E. Graham
Dale Grosvenor
Jose S. Gutierrez
William J. Hemmerle (Joint Stat.-Math. major)
Klaus Hinkelmann
Ronald Hocking
Edwin J. Hughes
Donald R. Jensen (Joint Stat.-Agron. major)
William D. Lawing
Paul Leaverton
Ilbok Lee
Marvin Lentner
Frederick Loo
Donald Mallory
Howard E. Marsh
Lawrence T. Prince
Dale O. Richards (Joint Stat.-Ind. Engr. major)
Harold Rosenberg
Chang-Sheng Shih
Lee Smith
Florence G. Tetreault
Mauritz van Aarde

M. S. degree candidates:

Ross D. Adams
Harold Baker
Charles E. Caudill
Carlos M. Cavallini
Eugene B. Cohen
Thomas E. Doerfler
Betty J. Eberle
Emilio Ellena
Alan P. Feddersen
James F. Kosmiski
Allen H. Lipis
Rodolfo M. Mengido
Philip M. Mills
Brenda Morrison
Esmat M. Nouri
Fred L. Ramsey
Larry Joel Ringer
Carl F. Schach
Kenneth K. Simons
LaFarr Stuart
Gary J. Sutter
Phrensi Svasti-Salee
Fred C. Thorp
Bert R. Webster
James R. Zweifel

Special Students:

Sudswart Chansomsadhki
Carlos Gadpaille
Fazil Momand Rahim
Beryl Reckord

Degrees granted and positions taken

During the 1961-62 academic year 4 students were recipients of the B.S. degree in Statistics, 7 students were granted M.S. degrees, and 1 was granted a Ph.D. degree. Titles and summaries of theses written as part of the requirement for advanced degrees are given in pages 36-38 of this report.

Recipient of the Ph.D. degree

Donald Ray Jensen (joint major in Statistics and Agronomy, May 1962, under Herbert T. David and John Pesek), who joined the staff of Oregon State University, Corvallis, Oregon, as assistant professor and statistical consultant in the Department of Statistics.

Recipients of M.S. degrees

Andris Fogelmanis (August 1961, under H. O. Hartley), who became statistican in The Research Office, U. S. Army CDEC, Stanford Research Institute, Ford Ord, California.

Enathical John Thomas (August 1961, under Gerhard Tintner), who returned to the Agricultural College, Vellayani, Trivandrum, at Kerala, India.

Emilio Ellena (November 1961, under Wayne A. Fuller), who is teaching and conducting research at The National Institute for Technical Agriculture at Pergamino, Argentina.

Larry Joel Ringer (February 1962, under H. O. Hartley), who entered military service as 2nd Lt. U. S. Army, Artillery Corps, stationed at Forst Sill, Oklahoma.

Thomas Eugene Doerfler (May 1962, under Oscar Kempthorne), who is continuing his studies toward a Ph.D. degree at Iowa State.

Marvin Lentner (May 1962, under Robert J. Buehler), who has accepted a position as instructor in statistics at University of Wyoming, Laramie, Wyoming, beginning September 1, 1962.

Allen H. Lipis (May 1962, under Herbert T. David), who took a position as statistician at Battelle Memorial Institute, Columbus, Ohio.

Recipients of the B.S. degree

Donbe Foster Whiting (February 1962), who accepted a position in the Aerospace Division, Quality Control Dept., Boeing Aircraft Co., Seattle, Washington.

Roy Morio Ikeda (May 1962), who is employed by the Bureau of the Census, Washington, D. C.

Patricia Lea Rogers (May 1962), who has taken a position with the Bureau of the Census, Washington, D. C.

Gregory R. Sampson (May 1962), who is employed as a statistician in the Planning Research Department of Eastman Kodak Co., Rochester, N. Y.

Seminars

Statistical Laboratory— Department of Statistics series

Each year the Statistical Laboratory and the Department of Statistics sponsors weekly seminars which are offered on a noncredit basis and are open to students and faculty from other departments as well as those of the statistical center. Talks on current staff or graduate research projects and on more general developments in particular areas of statistics precede informal discussion. The 1961-62 program included the following topics and speakers:

Fall Quarter 1961

September 13: Open house in the new addition. T. A. Bancroft
September 20: Some further properties of the methods of parallel tangents and conjugate gradients. B. V. Shah
October 4: Uniqueness and consistency of fiducial distributions. Robert J. Buehler
October 11: Statistical corrections of numerical weather forecasts. H. O. Hartley
October 19: Joint seminar with Central Iowa Chapter ASA, Statistical applications in climatology. Dr. Harold L. Crutcher, U. S. Weather Bureau, Asheville, N. C.
October 25: Application of the theory of information to the problem weighted regression. Gerhard Tintner
November 1: Sampling with partial replacement and its application to forest inventory. Kenneth D. Ware, Department of Forestry
November 8: Statistical analysis of composition data. Oscar Kempthorne

Winter Quarter 1961-62

November 29: Nonlinear regression estimation by modified least squares. H. O. Hartley and Aaron Booker
December 6: Estimation of random variables. Dewey L. Harris
December 13: Conditional test procedures in time series analysis. J. N. Rao
January 3: Design of animal breeding experiments. L. N. Hazel, Department of Animal Science
January 10: Practical statistical problems from the feed industry. Donald K. Hotchkiss
January 17: Some applications of inefficient experimental designs. C. Philip Cox and F. B. Cady
January 24: Analysis of variance applied to factors which do not have comparable scales: empirical results. Leroy Wolins
January 31: Joint Statistics-Soils Engineering Seminar. Control of data quality in unconfined compressive strength testing. C. A. O'Flaherty, H. T. David, D. T. Davidson
February 7: Some developments for incomplete data analysis. Edwin L. Hughes
February 14: A commonly occurring incomplete multiple classification model. Klaus Hinkelmann

Spring Quarter 1962

March 14: The relation between covariance and individual curvature analysis of experiments with background trends. C. Philip Cox
March 21: On conditions for equality of best and simple least square linear estimators. George Zyskind
March 23: Joint Statistics—Mathematics seminar. Some basic theorems in distribution free statistics. Dr. Charles Bell, San Diego University
March 28: Combining biological data from European corn borer experiments over the years and locations. Donald V. Sisson
April 4: Influence of soil variability on optimum soil sampling and fertilizer use. Donald R. Jensen
April 11: Some composite experimental designs used in agronomy experiments at Iowa State. John Pesek, Department of Agronomy
April 18: On the efficiency of two sample Mann-Whitney tests when the populations are discrete. Dr. K. C. Chanda, Washington State University

April 25: Noisy duels as limits of game iterations. Allen Lipis
May 2: Poisson limits of multivariate run distributions. Carol B. Edwards
May 9: Multiple frame surveys, the poor man's sampling method. H. O. Hartley
May 16: Joint Statistics—Industrial Engineering seminar. Cost comparisons of optimally designed Shewhart and cumulative sum control charts. Dr. A. J. Duncan, Johns Hopkins University

Quantitative Genetics series

At regular intervals seminars are held on topics in the area of quantitative genetics, participated in by staff members and graduate students in the departments of Statistics, Animal and Poultry Science, Agronomy, Horticulture and Genetics. The chairman of this interdepartmental group for the year 1961-62 is Oscar Kempthorne. Seminars have been given by members of the group and by invited off-campus speakers.

The following seminars were held:

October 3: Theory of truncation selection. Francis Giesbrecht
November 14: On the probability of fixation of mutant genes in a population.
Dr. Motoo Kimura, on leave from the National Institute of Genetics, Misima, Sizurka-Ken, Japan
January 16: Convariance of relatives in random mating populations with linkage. Part I. Mauritz Van Aarde
January 30: Gene structure, gene function and quantitative inheritance.
Dr. Allan B. Burdick, Purdue University
February 13: Convariance of relatives in random mating populations with linkage. Part II. Mauritz Van Aarde
March 13: Genetic variation in learning ability in swine. R. Willham and D. F. Cox, Department of Animal Science
March 27: Theoretical relationships among two-way, three-way and four-way crosses fo fixed lines. S. A. Eberhardt, USDA
April 24: Investigations on allelic and non-allelic interactions. Dr. W. Seyffert, University of Cologne, Vogelsang, Germany

Computer Science series

The Computer Science seminars, organized by the Scientific Computing Group, with H. O. Hartley as chairman for 1961-62, are held almost weekly for all individuals on campus interested in numerical analysis, machine language and logic, and other topics relating to the use of high speed computers in scientific research.

The following seminars were held:

September 25: Monte Carlo computations in the physical and biological sciences. H. O. Hartley
October 2: A Cyclone simulator. W. J. Hemmerle
October 9: Field indexing on the IBM 7070 and the IBM 7074. D. R. Fitzwater, Chemistry Department
October 16: On the 'Runge Cutta solutions' of differential equations. R. J. Lambert, Mathematics Department
October 23: New programming systems for the Cyclone. R. A. Sharpe, Electrical Engineering Department
October 30: Pep/Pert, a critical path planning method for the IBM 7070. C. K. Titus, Collins Radio Company
November 6: The generation of random and normal numbers. LaFarr Stuart
November 13: Methods of constructing rational approximations. E. W. Cheney, Mathematics Department
January 12: A survey of linear and nonlinear programming methods. H. O. Hartley
January 26: A general storage allocation scheme for the IBM 7074. D. R. Fitzwater, Chemistry Department
February 2: Index—and loop—MACRO instructions and their use on the IBM 7074. D. R. Fitzwater, Chemistry Department
February 9: Some nonlinear least squares problems in molecular quantum mechanics. K. Ruedenberg, Chemistry Department
February 16: Central processing of dairy herd improvement association records. W. R. Taylor, Department of Animal Science
March 9: Simulation in certain statistical models. D. W. Harris
March 23: Solution of parabolic differential equations arising in certain diffusion problems. Paul D. Maycock
March 30: "Eerie," an interpretive system for the Cyclone. Robert A. Sharpe, Department of Electrical Engineering.
April 6: POGO and his friends, an IBM 7074 operating system. D. R. Fitzwater
April 13-May 11: (Weekly seminars) Systems analysis for POGO, an operating system for the IBM 7074. D. R. Fitzwater

Special lectures on programming high speed computers

October 25: Introductory lecture: Description of the IBM 7070 system and a survey of its potentialities, E. H. Hietbrink, IBM representative October-November: Basic programming—programming in "basic language," in "basic autocoder" and "full autocoder" language, and the use of input/output and other peripheral equipment. (A series of 12 lectures) E. H. Hietbrink
February: 7074 FORTRAN programming. (A series of six 3-hour lectures) E. H. Hietbrink
March-April: 7074 basic machine language, autocoder and IOCS course. (A series of 12 3-hour lectures) E. H. Hietbrink

Miscellaneous seminars:

Members of the staff of the statistical center occasionally participated in seminar programs sponsored by other departments of the university. The following list is representative, although not all-inclusive:

History and Philosophy seminar: Rudolf Carnap's philosophy of probability. Gerhard Tintner on November 14, 1961.
Dairy and Food Industry seminars: Optimum diet in food mixes by linear programming. H. O. Hartley on October 20, 1961.
Some quantitative aspects of butter making. C. Philip Cox on November 3, 1961.
Geology seminar: The application of statistics in geological study. David V. Huntsberger on January 9, 1962.
Mathematics seminar: Two algorithms for minimizing an observable function. Robert J. Buehler on May 1, 1962.
Mathematics Club: Probability. D. V. Huntsberger in December.
Veterinary Medicine special problems class: The function of statistics in the field of epidemiology. Paul Leaverton in February.

A publication of the Statistical Laboratory
Iowa State University
Eleanor F. Bolton, editor