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# Programs Available for Use with the I.C.L. Sirius Computer

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## Introduction

The use of three I.C.L. Sirius computers has been made available to the Merlewood Research Station by courtesy of Mr. D. McAllister of the Blackburn College of Technology and Design. Sirius is a rather old computer, but the same model of computer was bought by the Forestry Commission Research Branch more than five years ago, and there now exists a very large library of programs generally useful in biological research, and, particularly, in woodland research. This paper describes the programs which are likely to be of interest to the members of the Merlewood Research Station, or of other Branches of the Nature Conservancy. The information has been taken from a similar paper by J. N. R. Jeffers and Joyce Hudson and issued as Statistics Section Paper No. 118 by the Forestry Commission Research Branch, but programs listed in that paper which are unlikely to be of interest to the Nature Conservancy have been omitted, and the list of programs brought up-to-date. An index to the programs has been added by Mrs. P. A. Ward.

Most of the programs described briefly in this paper have been written in the Sirius Autocode, or in the Sirius Matrix Interpretive Scheme, and are, therefore, only available for use with the Sirius computer. The Autocode is, however, basically a subset of FORTRAN, and experience has shown that it is very easy to translate the Autocode programs into other languages. These programs may also be used, therefore, as a source of practical algorithms for the many problems covered by the list.

All of the programs outlined briefly in this paper are described fully in the relevant program specification, copies of which are available on application to the Director, Merlewood Research Station, Grange-over-Sands, Lancashire.

A number of general programs which are available on Sirius are not given in this paper. These include programs for linear programming, critical path analysis, engineering calculations, etc.

**AS 2** **Analysis of Variance (Single Classification)**

Computes the between-group sum of squares and mean square. The within-groups sums of squares, mean squares and standard errors, and tests the within groups mean squares for heterogeneity by Bartlett's test. Angular, logarithmic, and square root transformations are available.

AS 3 Analysis of Variance for a Randomised Block

Calculates and prints the sums of squares, mean squares, and degrees of freedom for blocks, treatments and error, also the treatment means and standard error. Angular, logarithmic, and square root transformations are available.

AS 7 Working Plan Enumeration Program (Mark 1)

Reads the number of trees in each girth class represented in a sample plot, by non-fomes and fomes classifications, and the girths and heights of the measured sample trees; converts these data into volume and basal area; and prints the volumes by size classes and total basal area for each species, and for the sum of all species.

AS 9 Working Plan Enumeration Program (Provisional)

Reads the number of trees in each girth class represented in each sample plot, by fomes and non-fomes classifications, converts these data into basal areas, and prints the basal areas by species and size classes.

AS 11 Working Plan Enumeration Program (Mark III)

Reads the number of trees in each girth class represented in a sample plot, and the girths and heights of the measured sample trees; converts these data into volumes and basal areas; and prints the volumes by size classes and the total basal area for each species, and for the sum of all species. When the volumes for all plots in the survey, or the stratum of a larger survey, have been calculated and printed, the program calculates the mean basal area and mean volume per unit area, the standard error and standard deviation of the volumes, and the percentage standard errors and deviations. The distribution of the volume by species and size classes for the stratum as a whole is also printed.

AS 12 Testing Poison Distribution - Small Samples

Calculates and prints the mean and corrected sum of squares of each of a number of groups of data, and the index of dispersion. Also printed is the total number of observations, the cumulated total and the cumulated sums of squares.

AS 14 Calculation of Number of Rings per Inch

Calculates and prints the periodic increases in the number of rings per inch between given ages of a tree's life.

AS 15 Increment Percent for Yield Tables

For each of a series of plots (or quality classes) the program copies the quality class, and states whether the increment percent is being calculated for basal area or volume. For each quality class the increment percents (basal area and volume) are computed and printed for each of the three grades. The increment percents are printed in one column below the appropriate heading.

AS 16 Conifer Stand Tables

Computes for each girth, the logarithm of the girth and the probit transformation corresponding to the proportion of trees in the stand with girths greater than or equal to the girth. Finally, computes the regression of probit on log girth, together with the $x^2$ for dispersion.

AS 17 Analysis of Covariance for a Randomised Block

Calculates the analysis of covariance from the data and results of two randomised block analyses (AS 3).

AS 18 Calculation of Means from Nursery Assessment Forms (Seedbeds)

Calculates the mean height and number of trees on each assessed plot from data on the field assessment sheets.

AS 19 Calculation of Means from Nursery Assessment Forms (Transplants)

Calculates the mean height and number of trees assessed from the data on the field sheets.

AS 20 Analysis of Variance for a One-Third Replicate of a Five-Factor Experiment in Nine Blocks

Computes the experimental mean, the means, sums of squares, and variances for all main effects and first order interactions, and the corresponding F-ratios. A component, with two degrees of freedom, of the first-order interaction between two treatment-factors is confounded with blocks, and, for this interaction, the unconfounded component is estimated.

AS 22 Orthogonalised Regressions

Calculates the orthogonalised regression of a dependent variable on the principal components of up to 20 independent variables. The basic data required are the correlation coefficients between the independent variables and the dependent variables, and the latent roots and standardized vectors of the correlation matrix of the independent variables. These latent roots may be readily obtained by the use of the Sirius Library Subroutine S.1530.

AS 24 Comparison of Rates of Growth

Calculates the estimated growth rate calculated from Rao's empirical method which assumes average growth curves can be made linear by a common time metameter.

AS 25 Calculation of Discounted Revenues

Discounts revenue at a selected percentage rate using data supplied for a chosen set of rotation ages between 1 and 170 years. Data may be supplied at any integral age between 1 and 50 years. After 50 years the age must be a multiple of 5 years.

Corrects the discounted revenue values to allow for subsequent rotations and if required, reduces these corrected values by a chosen factor to allow for production based on the forest acre being lower than production based on the model acre of the yield tables. Gives the discounted expenditure and corrects the reduced revenue to account for this factor.

AS 26 Calculation of Linear, Quadratic, etc. Components for Analysis of Variance

From treatment means and a polynomial matrix, the regression coefficient and the estimated treatment means are calculated.

AS 27 The Size of a Small Population of Animals Estimated by Removing Animals

From successive catches in a trapline made at short uniform intervals the program estimates a maximum likelihood size for the population at risk of capture. Also estimates the probability of an animal at risk being captured during a single trapping interval. Calculates a standard error for each of these estimates.

AS 28 Exponential Fitting

Fits the curve $Y = AC^{BX}$ to a given set of points P (X, Y) by successive least squares adjustment of given initial estimates of A and B. Estimates are computed of the standard deviations of A and B and of the residuals of Y. The values of Y only are assumed to subject to error. They are also assumed to be of equal weight.

AS 30 Bartlett's Test

Calculates the corrected CHI square of Bartlett's test for any number of samples.

AS 31 Calculation of Standard Errors from Three and Four Factor Results

From the components which make up the error, calculates the error mean square, the standard errors and F ratios appropriate to the factors and interactions nominated.

AS 32 Analysis of Variance - Hierarchal Classification

Computes for every group, the between sub-groups sum of squares and variance and the standard error of the group mean. It computes the within sub-groups sums of squares, variances and standard errors and tests the within sub-group variances for heterogeneity by Bartlett's test. Also the between groups sum of squares, variance and standard error of the overall mean are computed. The pooled within sub-group sum of squares and variance and the pooled between sub-group sum of squares and variance over all groups are computed. Bartlett's test for homogeneity of variance is applied to both the preceding sets of variance.

AS 33 Calculation of Ridits

From the numbers in the categories the ridits are calculated and printed, ridits for the comparisons chosen can also be calculated and their confidence limits printed.

AS 34 Analysis of Variance of Pole-Stage Manuring Experiments

Calculates the means and the analysis of variance for N, P, K, Ca, and Mg, with first order interactions, together with Bartlett's test on the first order interactions.

AS 35 Randomised Blocks

This program will accept unsorted data (i.e. data in field order) consisting of either one or two variables per plot, from a randomised block experiment, carry out a variance analysis of the data, and print out treatment (or variety) means, grand mean, F-Ratios for treatments and blocks with associated degrees of freedom, and the standard error of a treatment mean.

AS 36 Analysis of Variance of a Confounded $3^3$ Factorial Design

Results of a $3^3$ factorial experiment, confounded in blocks of 9 are accepted in field order (Block by Block), and F-Ratios, one-way and two-way tables of means, and standard errors are printed out. There is no provision for missing plots.

AS 39 Test Normality for Samples Less Than 1000

For a sample of less than 1000 observations, the program estimates whether distribution departs significantly from normal due to skewness or kurtosis.

AS 43 Preparation of Conversion (or other) Tables

Prints out for a given factor (F) values from either (a) 1 x F to N1 x F, or (b) Divisor Table F ÷ 1 to F ÷ N1. The print out is arranged in lines of 10 values.

AS 44 Randomised Blocks with Missing Values

This program will analyse data consisting of either one or two variables per plot from a randomised block experiment. The print-out includes treatment means and their standard errors and a variance analysis table. Individual plot residuals can also be printed out if required. If there are missing values, this is indicated on the data tape by entering L in place of the missing figures. The program estimates any missing values by a method of successive approximations, and prints out the estimated values before starting the main analysis.

AS 45 Compute Total Basal Area of Species and Mean Height of Species for Each Plot

Uses the data prepared for working plan enumerations to calculate the total basal area of each plot to 4 decimal places, and the mean height of the plot to 4 decimal places. The calculation is carried out for each individual species in each plot. It also sums the basal areas and the mean heights to give totals over the stratum.

AS 46 Calculations of Areas of Triangles and Traverses

Calculates the areas of triangles and adds the triangles together to give a section area which has been surveyed and mapped. The areas are given in square yards from original data in links.

AS 48 Volume Calculations for Felled Plots

Converts the breast height girth into feet from inches and calculates the basal area of each tree. Calculates the square of the height, and finds the logarithm of the breast height girth and the height. If the volume given is in true measure, the program converts this to quarter girth measure.

AS 49 Extension to Volume Tables

Calculates the volume for trees of heights from $\frac{1}{2}$ ft, 1 ft, and then by whole numbers up to a height of 50 ft. The girth may be specified by the user of the program, and the volume is calculated in half inch intervals for the range of girths required. In order to speed a somewhat slow program the volumes are calculated for 5" range in girths at one time. For example, for each height, the program computes the volume from 50" to $54\frac{1}{2}$" at once.

AS 50 Pole Stage Manuring. Preliminary Calculations

Calculates the basal area of each tree in a plot, and the volume of the tree, taking into account all forks. Then calculates the height of each tree in feet at each of five dates. Adds these heights and also the basal areas and volumes of all trees in the plot. Gives the mean basal area and volume, and the mean height at each of the dates.

AS 51 Mean, Sum of Squares, Mean Square and Standard Error of N Numbers

Computes and prints the mean, the sum of squares, the mean square and the standard error of "N" numbers. "N" may take any value between 2 and 1369.

AS 52 "Fisher's Exact Comparison of Two Percentages (or Ratios)"

From data of the form of A 2 x 2 contingency table, computes the exact probability that this set of frequencies and any more extreme sets on the same tail of the binomial distribution might be observed by chance.

AS 54 Calculation of Numbers Survived to Survival Percent Transformed

Calculates the transformed percent survival from the numbers survived. A correction of .25 is made for 100% and 0% for original numbers between 13 and 49. The transformation used is the square root of the arcsine.

AS 55 Calculation of Treatment Means

From the replicates of plot totals, calculates individual treatment means.

AS 57 Extension to Tariff Tables

Calculates the volume in hoppus feet over bark for quarter girth and a given tariff number. The calculation is carried out for eleven tariff numbers at any quarter girth at one time.

AS 58 Non Repeating Pseudo Random Numbers

Generates a set of random numbers from a basic set of 1,000 numbers. The range within which the numbers are required should be a complete number of thousands, e.g. 1-2000, 1-5000. The number of random numbers is specified together with the size of a block of numbers, e.g. 250 numbers may be required in blocks of 50 numbers, giving 5 blocks.

AS 59 Breakdown of Randomised Blocks

From original data and the error mean square the subdivision of the treatment sum of squares into the following is performed:-

0 vs is treated
within treatments
between treatments. 20 treatments.

AS 60 Analysis of Covariance for a Single Classification

Calculates the sum of products for each treatment and between treatments, with their regression coefficients.

AS 61 Test that Sample Values of R are drawn at Random from the same Population, and Combination into a Single Estimate

Tests the hypothesis that several sample correlations are drawn from a population with correlation coefficient p and combines the separate R's to give an estimate of p.

AS 62 Covariance Analysis for $2^5$ Pole Stage Manuring Experiments

Computes the analysis of covariance for successive sets of measurements of the $2^5$ pole stage manuring experiments. The first data set on the tape is taken as the dependent variable, and each successive set is regarded as a new dependent variable.

AS 63 Calculation of Volume per Plot Using Dendrometer Readings

Calculates the height and diameter corresponding to each dendrometer reading, and then uses these to compute the volume of each sample tree in a plot.

If there is more than one sample tree in the plot, calculates the volume - basal area regression coefficients. Then computes the volume per plot, if the number of trees and the total basal area are given.

AS 64 Elimination of Seasonal Effects. Trend Values, Seasonal Indices, and Adjusted Values

Calculates the seasonally adjusted values of a set of monthly data for eight years or less.

AS 65 Two Factor Analysis of Variance Plus Blocks

Calculates the analysis of variance for two factors plus blocks and produces means for blocks, A treats, B treats and A x B treats with their standard errors.

AS 67 Calculation of Basal Area and Volume Increment

Calculates the volume increment per acre and the basal area increment per acre. The data required are the area of the plot, the present form height, the past form height, and the girths and radial increments for each girth.

AS 68 Ascending Contingency Tables in Ordered Nests

A version of AS 52 which computes exact probabilities of successive 2 x 2 tables. Designed for use as an idle-time program.

AS 69 Randomised Blocks with Subdivision of the Treatment Sums of Squares into Control VS Treated, within Control, between and within Treated.

Extends the randomised block program (AS 3) to calculate the subdivision of the treatment sum of squares into:-

Control VS Treated
Within Control
Between Treated
Within Treated.

There is also a provision to transform the data to angles, square roots or logarithm.

AS 70 Analysis of Variance for a Split Plot (with Sub Plots Subdivided)

The program calculates the analysis of variance for a split plot design.

AS 71 Analysis of Variance with Subdivision of Treatments into Between and Within Treatments

An extension of the randomised block program - in addition to the treatment sums of squares there is a subdivision into between and within treatments. There is provision for the data to be transformed into angles, square roots or logarithms.

AS 72 Linear Regression for Two Variables by the Method of Least Squares

Calculates the regression constant and coefficient for one dependent variable on an independent variable. Also gives the sample standard deviation from regression, the value of 'T' and the degrees of freedom associated with the value of 'T'. Up to 500 values of each variable are permitted.

AS 73 Calculation of Means, Standard Deviations and Correlation Matrix for Principal Component Analysis

Computes the means and standard deviations for each of P variables, and then calculates the matrix of linear correlation coefficients between every pair of variables. The output from the program is in a form

suitable for direct input to the sirius latent root and vector program (S.1530) and is intended to serve as the first stage of a principal component analysis.

AS 74 Calculation of Means and Plant Numbers from Nursery Assessment Forms and Calculation of Analysis of Variance for a Randomised Block

Calculates the mean height and number of seedlings in each plot from field assessment sheets. These are derandomised and an analysis of variance for a randomised block is calculated and printed for heights and numbers of seedlings or transplants.

There are three versions of the program:-

(a) For seedlings: Height classes form .25, .75, 1.25 to 10.

(b) For transplants: Height classes starting at 3 inches.

(c) For transplants: Height classes cover any range.

Transformations into logs and square roots are available.

AS 75 Step by Step Multiple Regression

Computes a multiple regression analysis in which the independent variables are added or deleted successively so as to find the set of independent variables which accounts for the greatest proportion of the variability of the dependent variable.

AS 76 Calculation of Basal Area and Volume Increment by Girth Classes

Reads in a list of plot details and dates of measurements which are used as a control to subsequent computations, then computes the regression of volume on basal area for sample trees for the standing crop and for thinnings where there are more than 14 in the plot. These regression constants and coefficients are printed out and also stored in the machine for subsequent use. The trees in the General Register are read into the Computer one tree at a time, and basal area and volume increment per tree calculated and stored by girth classes, finally the proportion of increment per girth class is calculated. Output consists of girth class, increment and proportion alternatively for basal area and volume. All output is in hoppus measure irrespective of whether original data were calculated in true measure or not.

The regression constants and coefficients are used in stage 3 of this investigation (see AS 78) where basal area and volumes by girth classes are calculated. The output tapes from stages 1 and 3 will be combined in order to calculate increment percent and relative increment percent. (Stage 4 see AS 79). The output tape from this program (AS 79) will be used as the data tape for AS 88 to calculate the regression of increments on basal area.

AS 77 Calculation of Numbers of Trees by Girth Classes

Lists from the General Register of a permanent sample plot the numbers of trees in each $\frac{1}{2}$ inch girth class, separately for both standing crop after thinnings, and for thinnings. Using data tapes prepared for AS 76. Output is in such a form that it may be used immediately as data tape for AS 78.

AS 78 Calculation of Basal Area and Volume of Standing Crop and Thinnings by Girth Classes

From data provided by AS 77, the basal area and volume in a sample plot are computed by girth classes, separately for standing crop and thinnings. The regression constants and coefficients from AS 76 are used to calculate the volume.

AS 79 Calculations of Increment Percent and Relative Increment Percent by Girth Classes

The plot data tape is used to calculate the periods during which growth has taken place between successive measurements. The output tapes from AS 76 and AS 78 are used as data tapes. They are combined by this program to provide an output tape for AS 88 and all relevant figures are converted to a per acre basis.

AS 80 Calculation of Range/Standard Deviation

From n numbers the program calculates the range and from the range it calculates the standard deviation.

AS 81 Check Sums

The program calculates the total of n numbers and prints this total.

AS 82 Preparation of Data for Analysis

Accepts data from several types of height and number assessment forms and produces mean heights of a plot, numbers or percentage survival per plot. They are printed out in a derandomised form as specified for each species.

AS 83 Calculate Transformed Variables

Calculates the transformed variables derived from the vectors of principal component analysis.

AS 84 Program to Insert Headings in Summaries of Experimental Data

Prints titles on to summaries of data.

AS 85 To Sort General Register into Form Suitable for Use with AS 76 and AS 77

Reads the tree number and the stem classifications and girths for that tree which appear on the first sheet of the general register. If the tree has been thinned in the first set of measurements, the tree number, stem classifications and girths are printed out. If the tree has not been thinned the program reads a tree number from the second tape reader and compares it with the tree number from the first reading. If the tree numbers differ the program comes to a 90-Group wait, indicating an error. If the tree numbers are the same, the program reads the stem classifications and girths on the second sheet of the General Register and sorts these with the readings from the first sheet. It prints out the tree number, followed on a new line by the stem classifications for all measurements. On another new line the girths are printed and the results are terminated by an 'L' and blank tape for each tree.

AS 86 To Sort Data from One Layout to Another Layout

Reads a matrix of numbers giving the original position of the data, then reads another matrix of the desired position of the same numbers. Data are read in, sorted, and printed out in blocks and treatment order as specified.

AS 87 Checking Data by Check Sums

To check the punching of data by check sums. The check sums being read in by tape reader 'B'.

AS 88 Regression of Periodic Annual Increment/Acre on Basal Area

Using the output tape from AS 79 as data tape, the program calculates the regression of increment on the initial basal area at the beginning of the period. It also adds titles to those parts of AS 79 where headings were not previously printed.

AS 89 Homogeneity Tests for Seed-Testing Laboratory

A set of programs for carrying out the Long Homogeneity Tests on duplicate determinations of germination percent, purity percent, and moisture content. Each test is contained on a separate program tape.

AS 90 Analysis of Variance for a Split Plot Design

Calculates the analysis of variance for the main plots, sub plots and interaction for a split plot design.

AS 91 Mechanical Analysis

Computes percentage moisture, percentage organic matter, percentage sand, percentage silt, and percentage clay in soil samples.

AS 92 Compute Minimum, Maximum, Mean and Standard Deviation

Calculates the minimum, mean and maximum value of any number of sets of any number of variables, presented in a standard order. The standard deviation is also calculated and printed.

AS 93 Overturning Moments by Degrees

Calculates the bending moment at the base of a tree, for each degree deflection from the vertical from a series of values of measured pull (applied at one third the tree height) and the tree weight. Calculates the moment M, from the formula $M = P \frac{H}{3} \text{ Cos } + W \frac{H}{3} \text{ Sin } O$ - lbs. ft.

Where O is the deflection in degrees from 1 to 40
P is the pull applied in lbs. at each of the 40 values of O
H is the tree height in ft.
W is the tree weight in lbs.

AS 94 Linear Regression Analysis

Provides for a general linear regression analysis, under the guidance of a steering tape, by which any combination of the desired aspects of regression analysis can be selected. The facilities included are:-

(a) Minimum, mean, maximum and standard deviation of each variable;
(b) Calculation of the regression equation;
(c) Calculation of the regression coefficient and its standard error;
(d) Calculation of the regression constant and its standard error;
(e) Calculation of the coefficient of the regression through the origin, and its standard error;
(f) The analysis of variance for the regression and deviations components;
(g) Estimated values of the dependent variable for given values of the independent variable, and their fiducial limits;
(h) Inverse estimates, and their fiducial limits, for given values of the dependent variable;
(i) Estimated tolerances of the dependent variable for given values of the independent variable;
(j) Inverse tolerances of the independent variable for given values of the dependent variable;
(k) Estimated values of the dependent variable from a regression through the origin, and their fiducial limits;
(l) Inverse tolerances of the independent variable from a regression through the origin, for given values of the dependent variable.

Provision is also made for preserving all the necessary data so that further selections can be made from the facilities available, without recomputing from the basic observations.

AS 95 Provenance Experiments from Field Data

From field sheets, calculates the mean of each replicate of each treatment and the overall mean for each treatment.

AS 96 Linear Regression with Grouped Data

Computes the linear regression of a dependent variable on given values of the independent variable, where there is more than one observation of the dependent variable at each level of the independent variable. The significance of the deviations from linearity is also tested by the program.

AS 97 Industrial Ready Reckoner

Calculates the hourly rates and overtime rates for given weekly rates of pay. AS 97A deals with a 39 hour week, AS 97B a 42 hour week, and AS 97C a 43 hour week. For all three ready reckoners, the overtime rate is worked as for a 42 hour week.

AS 98 Percentage Organic Matter

Computes percentage moisture and percentage organic matter.

AS 100 To Find the Standard Errors for the 4-Factor Analysis of Variance Program

The program calculates the standard errors associated with the means of the four factors and blocks program.

AS 101 Fit Orthogonal Polynomials

Fits orthogonal polynomials to sets of data of any size, computing successively the linear, quadratic, cubic, quartic and quintic terms, and the appropriate variance components and deviations. The intervals between the values of the independent variable must be equal.

AS 103 Capture Recapture

Estimates the net daily survival rate and population size of an animal community. The data required for the program is conveniently expressed in the form of a trellis diagram.

AS 104 General Multiple Regression

Provides all the facilities of a general multiple regression analysis, including a summary of the data, the half-matrix of correlation coefficients, and the sums of squares and coefficients for the regression of any variable on any selection of the other variables. No significance testing procedure is provided, but an optional facility to preserve the basic matrices is available, and can be used to test any additional or removal of variables desired, in a further analysis of the data.

AS 105 Calculation of Canonical Variates

A set of six sub-programs designed to provide a complete analysis of canonical variates. For the n; individuals of k groups, on each of which p variables have been measured, the program computes the mean of each variable for each group, the correction sums of squares and products and the "Within Group" sums of squares and products, the "Between Groups" sums of squares and products for each group and the pooled "Within Groups" sums of squares and products, the determinantal matrix, the latent roots and vectors of the determinantal matrix, and the values of the canonical variates for each group.

AS 106 Pole-Stage Manuring; Standard Errors of Adjusted Means

Computes the standard errors of adjusted means after analysis of covariance of a $2^5$ fractional factorial experiment.

AS 107 Randomised Block with Subdivision of Treatment Sums of Squares into Within Control, Within Treatments, Control Vs Treated, Between Treated

This is a development of programs AS 3 and AS 69 which it supersedes in addition to subdividing the treatment sums of squares, provision is made for annotation of the plot and treatment means, significance value of the 'F' test is indicated and transformation of the data into angles, square roots or logarithms provided.

AS 108 Missing Values for Randomised Block

Accepts an amended output tape from AS 82 or AS 86 and will copy each set of data, with title headings, for which no missing values are required; but compute and insert a missing value for each zero element in the data. The computation uses a non-iterative technique. It has been arranged that the output of this program may be subsequently used as input to AS 3 using the same parameter tape for both programs.

AS 109 Variation Constant Temperature/Humidity Cabinets

A Kent recorder automatically plots the doubled wet and dry bulb centigrade temperatures in each cabinet at fixed time intervals. From each pair of readings the program evaluates a relative humidity. After computing a run of paired readings, it prints the number of pairs then the minimum, mean, maximum and standard error of the relative humidities in clear and the mean and S.E. of the same values when each is in angular form.

The minimum, mean, maximum and S.E. of the dry bulb temperatures follow.

The program interpolates vapour pressures for centigrade temperatures between $1^{\circ}$ and $39^{\circ}$. Doubled values should, therefore, lie between 2 and 78.

AS 110 Randomised Block with Subdivision of Treatment Sum of Squares into Control Vs Treated, Within Control, A Treatments, B Treatments, A x B Treatments

This program extends the randomised block program to subdivide the treatment sum of squares into the above comparisons. The output annotates the treatment, gives a mean figure for each plot and the treatment means. This is followed by the analysis of variance table and the A and B treatment means, together with their standard error. The 'F' values of the significance test are given the conventional signs, transformation of the data can be made into square roots, logs or angles.

AS 111 Test of Significance of Principal Components

Provides an approximate test of the 'Significane' of the components derived from a principal component analysis. The test is first applied to the entire structure of the correlation matrix, and the successive components are then extracted and the residuals tested.

AS 112 Plot Cartesian Co-ordinates

This program plots the values of cartesian co-ordinates. It is intended mainly for the plotting of the transformed values derived from principal component or canonical variate analyses, but it will also plot correlation scatter diagrams. A variety of symbols may be used in the plotting, and the data do not have to be sorted before entry to the program.

AS 119 Calculate Matrix for Canonical Correlations

Takes the correlation matrix and partitions it in two ways. The resulting matrices have identical roots, which are the squares of the correlation coefficients, and the vectors of the corresponding roots represent the vectors of the two sets which have that degree of correlation. If the correlation matrix is to be partitioned as

$$\begin{array}{c|c} A & B \\ \hline B & C \end{array}$$

Then the program calculates both $(BC^{-1}B^{1}-A)$ and $(B^{1}A^{-1}B-C)$.

AS 120 Sick Pay Ready Reckoner

Computes the sick pay ready reckoner for industrial staff. The sickness and injury benefits are computed separately.

AS 122 Analysis of Covariance for a Randomised Block

Computes the analysis of covariance for a randomised block.

AS 125 Polynomial Fittings (-6th Degree)

Fits polynomials to pairs of data up to a maximum of 500 pairs, fitting successively polynomials of degrees 1 to 6 as far as required.

AS 126 Principal Component Analysis: Summary of Results

Takes the slightly edited results of the Sirius Latent Roots and Vectors Program (S.1530) and tabulates the results of the component analysis, giving the percentage of the variability accounted for, and the vector loadings of the successive components.

AS 131 Calculation of Wind Profile Parameters

Uses a least-square method to estimate the three parameters of wind profile; roughness length, zeropoint displacement, and surface stress, in the adiabatic surface layer of the atmosphere.

AS 132 Evaluation of Model for Length of Life Distribution

Takes the number of individuals failed after a certain number of years and forecasts the expected average length of life together with a standard error for the forecast.

AS 134A Discounted Revenues (Main Program)

Calculates discounted revenues obtainable from any yield model specifying a pattern of thinning and felling yields under varying assumptions of rate of discount, expenditure and price. Revenues and expenditures are discounted to the year of origin of the stand.

AS 134B Discounted Revenues (Max Program)

Gives the maximum revenues obtainable as total DR for one rotation, nett DR for one rotation, and nett DR for rotations repeated in perpetuity, together with the rotation lengths at which they occur.

AS 134C Conversion of Yield Model Data Acceptable to AS 25 to a Form Acceptable to AS 134A, B, D, E.

From a data tape containing AS 25 data, the program will produce yield models acceptable to AS 134A, B, D, E. It will delete the five initial parameters, and insert an 'L' sequence at the end of the yield model. Titles will be reproduced with preceding 'N' sequence. A 2-inch gap is left between yield models.

AS 137 Calculation for Index Plots

Takes the girths and number of trees at each girth and computes the total basal area for each plot. The figures for the plots are combined to give a figure for a sub-compartment and sub-compartment figures are combined to give a figure for the stratum. The P-year and top height are also computed for the stratum and each figure has its standard error.

AS 138 Numerical Sort

Takes a list of numbers and sorts them into a monotonic ascending sequence. It omits numbers which are repeated. Numbers up to six figures are allowed. There is room for over 2000 numbers at one sort.

AS 139 Tree Profile Fitting (B.H. Omitted)

Fits polynomials from linear up to a specified degree $< 6$ to a set of height (ft) / sectional area (sq.ft.Q.G.) data. The total volume of a tree is estimated using the polynomial of highest degree fitted, below timber height (3" Dia.); and treating the tip above timber height as a cone. Using this polynomial, the heights and volumes to 3", 4", 5" Dia. etc., are estimated down to B.H. All volumes estimated are also expressed as a percentage of volume to timber height. Predicted values of S.A. corresponding to input heights are optionally obtainable. Coefficients of each polynomial fitted together with R.M.S. residual S.A. are given automatically .

AS 140 The Calculation of Data for Use on AS 26 from Split Plot Data

By the use of data in a form for use on the split-plot program. AS 90, this program calculates means and error sums of squares for use as data on the AS 26 program (calculation of linear quadratic etc. components of the variance).

AS 143 Price/Size Curves (Type II)

To produce a curve of $Y = a-b\ (x-c)^2$ passing through a given point and having a given maximum, and then to produce similar curves passing through a given point, and touching the original curve at a given point. Points on all curves are printed at unit intervals to a specified value of x. a,b,c are given for each curve in that order.

AS 145 Evaluation of Price/Size Functions

Calculates values of Y (Price) for given values of x (B.H.Q.G.) in functions of the form:-

$$y^a = b + cx + dx^2 + ex^3 + fx^4 + gx^5 + hx^6$$

AS 146 Form Pentad Means of Temperature and Rainfall

Data consists of starting date, and, for each day, the maximum and minimum temperatures and the rainfall. Each line of output is dated and, after the first four lines, gives maximum, minimum, mean, temperature, mean temperature over five days' rainfall, day's rainfall, rainfall totalled over 5 days and rainfall averaged over 5 days. For the first four lines the three pentad values are tabulated as zero.

AS 147 Minimum Aggregate Distance

A set of N points is situated on a network of arcs. Locates a point on the network with the minimum aggregate distance from the other points on the network.

AS 148 Nearest Neighbour Analysis

Computes, for each set of points, the nearest neighbour in N-dimensional space. The distance is also computed.

AS 149 Compute Means of Groups

Computes the centres of gravity of groups that have been derived from nearest neighbour analysis.

AS 150 Compute Groups from Nearest Neighbours

Computes the basic groups of individuals from the data of the nearest neighbours to each individual. Each group contains those individuals which are nearest neighbour to one of the original chain of individuals, the chain being terminated by two individuals which are mutually nearest.

AS 153 Binomial Probability

Computes the probability of obtaining a value greater than a given value when sampling from the binomial distribution. The test can be carried out on either the single tail or the double tail of the distribution.

AS 154 Calculation of Means from Port-a-Punch Card Data

Calculates the means of plots when they are punched on to cards and converted to paper tape format.

AS 155 Transformation of Tree Percentage Volume Curves

Carries out the transformation of the basic data and prints out the results in a form suitable for one of the linear regression programs.

AS 156 Calculation of Large Correlation Matrix

Computes the lower half of the correlation matrix for up to 60 variables, and prints the results in a form suitable for direct input to the latent root and vector program AO 114.

AS 160 Analysis of Variance for Randomised Block with Subdivision of Treatments Sum of Squares into within Treatments and Between Treatments.

This programme is an extension of programme AS 71 giving a provision for annotation of plot and treatment means, and an indication of significant values for the 'F' ratios.

AS 162 Test of Randomness of Plant Distributions from Measurements of Nearest Neighbours.

The program calculates two tests of the randomness of plant distributions from measurements to the nearest neighbours of a sample of points. If n sample points are chosen in an area under study and $X_1$ and $X_2$ are the distances from a given sample point to the nearest and next nearest plants, the two tests are defined as follows:-

(i) The ratio test, based on the sample mean of the ratio $Z_{12} = X_1^2/X_2^2$ of the squares of the distances to the 1st and 2nd nearest plants from each sample plot.

(ii) The correlation test, based on the sample correlation coefficient /12 between the square of distances to the 1st and 2nd nearest plants from each sample point.

Aggregation will tend to increase both these statistics, while regular arrangements, e.g. a square lattice, will tend to decrease both.

AS 163 Calculation of Percentage Light in the Wood of Light in the Open, and the Standard Deviation of the Percentage within Plots

This program accepts readings of light intensity from inside each plot and from in the open, finds the percentage of light in the wood of that in the open and the standard deviation of the percentages within each plot.

AS 166 Sequential Sampling Characteristics for Normal Distribution

This program computes the characteristics of a sequential sample from a normally distributed population with a known standard deviation.

AS 167 Calculation of Sample Plot Data

This program is compiled for calculating sample plot data.

AS 168 Analysis of Variance (Single Classification)

This program is a new version of AS 2 which has been written to allow the easier representation of data. The program computes the between-group sum of squares and mean squares, the within groups sum of squares, mean squares and standard errors, and tests the within-groups mean squares for homogeneity by Bartlett's test.

AS 169 Three Factor Analysis of Variance (7000 Word Autocode)

This program is an extension of program SS 2 which calculates the analysis of variance for three factors and blocks. The program has been amended so that it prints the plot and treatment means in an annotated table, provides a significance test for the F ratios and allows the data to be transformed to angles, square roots or logs.

AS 170 Progressive Discriminatory Analysis (7000 Words)

This program evaluates the best discriminant function based on q characters from each of two populations, where q starts at one and increases by one on each pass through the program until all p characters specified for the two populations have been used. The character chosen on each pass is the character which yields the most information (the greatest generalised distance of Mahalonobis). On each pass the program calculates the discriminant function coefficients and the value of the discriminant function for each population based on q characters, and also the significance of the addition of the q th character to the resulting discriminant functions.

AS 171 Cumulate Sums of Squares and Products Matrices

The program enables the data from successive sets of regression analyses, output under the PRESERVE facility of the General Multiple Regression program (AS 104) to be cumulated and printed in a form suitable for reinput to AS 104 by the RESTART instruction.

AS 172 Compute Co-ordinates for Stereographic Plotting

The program computes, for a given set of three-dimensional data, the co-ordinates required to plot the points on two-dimensional diagrams capable of being viewed by a lens stereoscope to produce a stereoscopic or 3-D effect.

AS 173 Compute Distance Between Species

The program computes for a given set of three-dimensional data, the distances between the separate species or nodes, with the object of providing the necessary information for building a three-dimensional model.

AS 174 Computation of Permanent Sample Plot Summaries and Regressions

Using the methods described in the Code of Sample Plot Procedure, 1959, the program (a) computes the volume of sample trees and prints their mean height, girth, volume, form height, crown width, etc. (b) computes the linear regression of volume on basal area for the volume sample trees and prints the constant, coefficient, deviation from regression, etc., (c) repeats (a) and (b) for the thinnings, (d) computes and prints out totals per plot of number of trees, basal area and volume for various tree size categories, (e) computes and prints a summary of the tree classification, (f) computes and prints the characteristics of a curvi-linear regression of height on girth and (g) prints a summary of the plot measurements per acre.

AS 175 Association Analysis

The program carries out a monothetic subdivision of a population of individuals specified by binary attributes. The program is designed to subdivide the population a stage at a time, the output tape from each stage being the input for all stages except the first.

AS 179 Diagrams for Association Analysis

This program is designed to plot the diagram of a monothetic subdivision (association analysis) on the Calcomp plotter.

AS 180 Compute Approximate F and t values

The program computes approximate values of F and t for given degrees of freedom and levels of probability (0.05, 0.01, or 0.001).

AS 181 Calculation of Means from Porta Punch Card Data

A program to calculate the means of plots when they are punched on to cards and have a tape produced from them. One measurement only for each tree.

AS 182 Mean Wind Velocity Profiles

The program selects batches of 12 consecutive scars, as indicated on the parameter tape, from the output tape of SS 8 (Westinghouse data Logger check program), and calculates the mean value for each channel.

AS 183 Analysis of Variance for a Balanced Lattice Design

The program calculates the analysis of variance for Balanced Lattice Designs as follows:-

| | | | | | |
|---|---|---|---|---|---|
| Treatments | 9 | 16 | 25 | 49 | 64 |
| Units per block | 3 | 4 | 5 | 7 | 8 |
| Replicates | 4 | 5 | 6 | 8 | 9 |

AS 184 Program to Average Ring Radii Measurements from Benson Lehner Tapes and Convert to Inches

The Benson Lehner data processing bureau at Aldershot is given X-ray plates of discs cut from each internode of the tree. There are four lines marked on the X-ray plates and the radii of each ring along these lines is measured and punched on to tape (or cards) at the same time. If the measurements are punched on to cards, the cards are fed into the computer at Benson Lehner to give a paper tape copy. A print-out of the paper tape is obtained. The tapes and print-outs are returned. This program finds the mean ring radius for each ring on each plate and converts this radius to inches. The Benson Lehner tapes give the measurements on a scale of 1000 divisions to 6 inches. The result tape is suitable for input to AS 185.

AS 185 Volume Increment from Tree Discs

The program takes the radii of the discs, ( the results from AS 184), together with the internodal lengths and calculates the volume increment for each year of measurement. The radii data has been checked by Entomology to ensure that there are not more rings than possible years of life of the tree. For example, a disc measured from the 1950 internode cannot have more than 17 rings since these rings would be for 1950-1966 growth inclusive.

AS 187 To Compute a, b and c of a Quadratic Regression

Using Gauss's method of pivotal condensation, the program computes the regression constant a and regression coefficients b and c of the quadratic regression of x on y.

AS 188 Metric Tariff Tables

The program computes a table which gives the volume of the tree in cubic metres for a given tariff number and breast height diameter in centimetres.

The range of tariff numbers, the range of diameters and the intervals between the tariff numbers are specified by the user, thus making the program more general.

AS 189 Analysis of Variance for a Latin Square

The programme calculates the analysis of variance for a latin square and prints the plot and treatment means and the analysis of variance table. Provision has been made to transform the data to Angles, square roots (x+ .5) or logs (x + 1).

AS 190 Analysis of Covariance for a Latin Square

This program calculates the analysis of variance for the independent (x) and dependent variable (y) then calculates the analysis of covariance with adjusted plot and treatment means. Provision has been made for the use of one set of x values for a succession of sets of y values or a different x for each set of y values. Transformation can be made into Angles, Square roots (x+ .5) or Logs (x + 1)

AS 195 Calculation of a Determinant and its Logarithm

The program calculates the value of the determinant for the matrix of numbers read in and also its logarithm.

AS 199 Evaluation of a Polynomial

This program calculates values of y given values of x and the coefficients of a nth degree polynomial with coefficients $c_0, c_1, \ldots\ldots\ldots c_n$. where

$$y = c_0 + c_1x + c_2x^2 + \ldots\ldots\ldots + c_nx^n$$

AS 200 Analysis of Information from Multinomial Distributions

The program computes an information statistic which closely follows the $x^2$ distribution, and which may be used to test null hypotheses from multinomial distributions.

## A.N. Specifications

AN 1 **Analysis of Variance for a one-third Replicate of A $3^5$ Experiment Nine Blocks**

Computes the experimental mean, all main effects and unconfounded first order interactions between the factors, and the corresponding mean squares and F-Ratios. A component with two degrees of freedom of the first order interaction between two treatment factors is confounded with blocks. The component of this interaction which remains is included by this program in the estimate of experimental error.

AN 2 **Four Distribution Statistics**

Computes and prints the sample size, and moment estimates of the mean, standard deviation, $G_1 = \sqrt{B_1}$ and $G_2 = B_2 - 3$, for any number of samples of size not greater than 1280.

AN 4 **Randomised Blocks**

Calculates the treatment means, their common standard error, the analysis of variance, the experimental mean, error standard deviation and coefficient of variation. The quantities are printed with annotations including the non-linear transformation when used and the treatment names. There is provision for an optional addendum to the program if a special transformation is required for any of the sets of data to be analysed by one reading of the program.

## A.O. Specifications

AO 1 **Manner of Growth Studies**

The purpose is to evaluate the graphs described by Pearce (Biometrics, 16, 1-6). The three standard errors are denoted in the output by $S_1$, $S_2$, $S_3$. The initial year is year 0; the others are numbered 1, 2, ..... etc.

AO 2 **Data Transformation**

The purpose is to take "Field Variates", to operate on them as may be desired to form "Derived Variates" and to output the derived variates in canonical form A ready for analysis.

The total number of data (i.e. of field variates and derived variates together) should not exceed 2,200 at any point of the calculation. If space is limiting, derived variates may over-write field variates or derived variates no longer needed. Not more than 50 variates can be carried at one time.

There is no limit on the range of field variates, but all values derived variates should lie between 0.000, 001 and 10,000,000.

AO 3 **Variance Components in a Hierarchic Classification - Division into Two at Each Level**

There are U primary units (Level 0) each of which is divided into two (Level 2) and so on, as far as level V (V not greater than 9). The ultimate units are measured and the computation is for finding the variance component, both as a variance and a standard error, for each level of splitting.

AO 4 **Presentation by Plots instead of Variates**

Univariate data are commonly available in canonical form A. If these are to be combined for a multivariate computation they may be wanted in canonical form D. In this program the transposition is made,

a plot being wholly discarded if it is defective in respect of any variate. Data are assumed to be mostly between 0.01 and 10,000. If P is the number of plots and V the number of variates, P (v + 1) must not exceed 1680.

AO 5 Data Selection

The purpose is to take data in canonical form A, and, from a segment of them, to select according to a systematic pattern, e.g. to take every other, to omit every third, to select two and leave two, etc. as may be required. There should not be more than 500 unselected data.

AO 6 Plot Totals and Means

The purpose is to take a series of figures for each plot, their number being unpredictable, and to produce a table of totals or means or both as required.

AO 9 Calculation of Large Covariance and Correlation Matrices

Calculates either (i) the lower half of the covariance matrix for P variates or (ii) the lower half of the correlation matrix or (iii) both (i) and (ii). It is assumed that P does not exceed 50. The number of plots N is unlimited. If a covariance matrix is required the data should for the most part lie between 0.01 and 100. If only a correlation matrix is required there is no limit.

AO 10 Analysis of Variance for a One-Way Classification

There is no further assumption about design except that the number of data should not exceed 144. Data are assumed to lie mostly between 0.01 and 10,000.

AO 11 Analysis of Covariance for a One-Way Classification

It is assumed that data mostly lie between 0.01 and 10,000.

AO 12 Analysis of Variance for an Orthogonal Two-Way Classification.

It is assumed that data mostly lie between 0.01 and 10,000 and do not exceed 144 in number. Replaces an older version, which was however the same for both input and output.

AO 13 Analysis of Covariance for an Orthogonal Two-Way Classification

It is assumed (i) that the number of data does not exceed 144, and (ii) that most data lie between 0.01 and 10,000.

AO 14 Analysis of Variance for an Orthogonal Three or Four-Way Classification

Calculates the analysis of variance for an orthogonal three or four-way classification, and also calculates means of treatments and their standard errors. Will also estimate missing plots. The data are assumed to lie between 0.01 and 10,000 and not to exceed 144 in number.

AO 16 Analysis of Variance for a Latin Square

This program is quicker than AO 14 because the data are presented in their order in the field, not in arbitrary order. It is assumed that the square is not larger than 12 x 12 and that data mostly lie between 0.01 and 10,000.

AO 18 Values of Vectors for Each Plot from a Component Analysis

There are V variates from P plots and these have been submitted to a component analysis, the results of which are available. The vector found number F. It is desired to find the value of each vector to be ascribed to each plot.

AO 19 Linear Regression Equations and Tests for Parallelism and Identity of Regression Lines (One Independent Variate)

Calculates A, B in Y - A + Bx, mean square of deviations from regression (error) and standard error of B, also $\bar{x}$, $\bar{y}$ for each line. For each line there may be from 3 to 300 pairs of values of x and y. For more than one line the program tests (optionally) whether the B's differ significantly and if they do not whether the A's differ significantly. A joint estimate of B is obtained for parallel or identical lines and the general means $\bar{\bar{x}}$, $\bar{\bar{y}}$ if there are more than 2 lines. Maximum 50 lines.

AO 20 Analysis of Variance for a Design of Type T

It is assumed that there are not more than 144 plots and that data mostly lie between 0.01 and 10,000. Designs of type T include balanced incomplete blocks.

AO 21 Partitioning of Treatments s.s.

The purpose is to partition the treatments s.s. presented to the machine, in a manner also presented to the machine, and to produce the appropriate analysis of variance table. It is assumed that the number of treatments is not greater than 100.

AO 22 (MkII) Analysis of Variance for a Randomised Block Design with Split-Plots

By a "Randomised Block Design" is meant one on which each main plot treatment occurs once and only once in each block. It is assumed also that each sub-treatment occurs once and only once on each main plot, that the total number of sub-plots does not exceed 144 and that data mostly lie between 0.01 and 10,000.

AO 23 Analysis of Variance for a Multiple Latin Square

It is assumed that the squares are physically distinct, though possibly adjacent, and that the interaction of squares and treatments is not required. If it is, the whole experiment should be analysed using this program to obtain an error sum-of-squares of S'. Then each square should be analysed separately to give error sums-of-squares that total to S. The analysis from this program should then be adopted, except that its error sums-of-squares, S', should be partitioned into two components:-

S' - 3 for the interaction of squares and treatments, and S for error.

This program can be used for a single latin square. There will then be zero degrees of freedom, and sums-of-squares "Between Squares". It is assumed that the data lie mostly between 0.01 and 10,000 and do not exceed 144 in number.

AO 24 Randomised Block Design, Treatment 2 x 2 x 2 x 2 Analysis of Variance

Intended for $2^4$ designs without confounding in randomised blocks. It is assumed that there are not more than nine blocks, with data that lie mostly between 0.01 and 10,000.

AO 25 (Mk2) Multiple Regression Analysis

Computes the regression coefficients and means for each variate, for up to 19 independent variates. There is no limit upon the number of points. An analysis of variance into a component due to regression and a residual is formed, and standard errors are given for the regression coefficients.

AO 26 Analysis of Variance for a Design of Type T:00

Designs of this type arise when a treatment is omitted from a latin square. It is assumed that data mostly lie between 0.01 and 10,000 and that their number does not exceed 144.

AO 27 Analysis of Variance for a Design of Type O:TO

The most usual designs of this type are youden squares in which the treatments are orthogonal to rows but not to columns. It is assumed that the data mostly lie between 0.01 and 10,000, and that there are not more than 144 of them.

AO 28 Analysis of Variance for a Design of Type O:OT

The most usual designs of this type are youden squares in which the treatments are orthogonal to rows but not to columns. It is assumed that the data mostly lie between 0.01 and 10,000, and that there are not more than 144 of them.

AO 29 Evaluation of a Linear Regression Function for Given Values of the Independent Variates

Given the coefficients and constants in a regression equation expressed in either of the forms:-

1. $y = B_0 + B_1 x_1 + \ldots\ldots + B_N x_N$

2. $y = \bar{y} + B_1 (x_1 - \bar{x}_1) + \ldots\ldots + B_N (x_N - \bar{x}_N)$

The program evaluates Y for a given set of values of $x_1, x_2, \ldots\ldots x_N$.

AO 30 Correlation Coefficient between Increment in First Variate to Nth Power (...) and a Second Variate

Variates A and B are powered and differenced to give the variate $(A^N - B^N)$, called the first variate, which is then correlated with a second variate C. The power N, which may be fractional and negative is raised by successive increments The initial power, increment and number of increments to be added are given by the design tape. There is provision for transforming to natural logarithms either or both the first and second variates, also for correlations of the variate $A^N$ with C. The value for each plot of the second variate can be printed for any specified set of powers. Number of plots is limited to 160.

AO 32 Analysis of Variance for Design of Type X with Omega Known

Available for any block design (i.e. two-way classification) provided omega, the variance - covariance matrix of the treatment parameters, is known. It is assumed that the data mostly lie between 0.01 and 10,000 and do not exceed 144 in number. Missing plots are dealt with by modifying omega.

AO 36 Analysis of Variance for a Design of Type O:TT

There is only one design of type O:TT of useful size, i.e. that with six rows, six columns, and four treatments. The program is intended to deal with such a design however randomised. It is assumed that most data lie between 0.01 and 10,000.

AO 38 Analysis of Variance for a One-Way Classification of Unlimited Size

It is assumed that the number of treatments does not exceed 200 and that data mostly lie between 0.01 and 10,000.

AO 39 Analysis of Variance for an Orthogonal Two-Way Classification of Unlimited Size

There is no limit to the number of plots but neither blocks nor treatments must be more than 200 in number and each must be orthogonal to the other. The data for the most part should lie between 0.01 and 10,000

AO 44 Analysis of Variance for a Randomised Block Design

For this purpose a randomised block design is defined as an orthogonal two-way classification with all blocks of equal size and all treatments equally replicated. Accordingly, AO 44 is a specialised version of AO 12. In respect of running time it has little advantage, but it carries out a more thorough check on the design information. Data tapes and design tapes are the same for both programs; consequently if AO 12 were already in the computer there would be little point in changing to AO 44 unless a better check were needed on the design tape.

AO 45 Dispersion and Correlation Matrices on Data with a Two-Way Classification

Limited to not more than ten variates number of divisions of first classification (x) must not be such that xn 100, where n is the number of variates. Maximum number of divisions of second classification about 100 with ten variates, more with less variates or on compiled programme. Number of sets of data (plots) unlimited. There is provision for transformation of initial data to natural logarithms before analysis.

AO 47 (MkII) Calculation of Evapo-Transpiration using the Method of Penman

The purpose of the programme is to calculate on a daily basis the loss of moisture by vegetation. By taking into account rain and irrigation, this is used to find the total change in soil moisture. These figures can be accumulated if needed. The method is set out in J. agric. Sci. (1962), Vol. 58, pages 343-348.

AO 100 Examination of Residuals in Randomised Block Data

The routine analysis of variance makes a number of assumptions about the data including (1) additivity and (2) constant variance. Data suspected of not conforming to one or other of these requirements is often arbitrarily transformed without investigation of whether the suspicion is justified or whether the transformation used is, or is likely to be, effective. This program enables data from a randomised block or similar source to be tested for these two defects, and calculates constants which can be used to indicate transformations likely to remove the non-additivity or non-constant variance ("Heteroscedasticity") should either of them be significant.

AO 101 & 101A Improved Graph Plotter

These programs each assume a common interval between successive ordinates and plot y-values for given x-values. AO 101 plots a graph between 0 and the maximum value for y, or between minimum and maximum y-values, with the origin or axis denoted by an asterisk. AO 101A is a variation of AO 101, that moves the origin or axis to the lowest value of y. This ensures that if all the values are fairly large and positive, the plot will be over the actual curve itself, the better to show its characteristics. Both programs scale the data up or down so that all values are plotted within the limitation of the creed model 75 teleprinter. (This has been set at 65 spaces). There are two tapes for each program. One tape fills in the distance between the axis and the y-value with a dash. The other tape puts in a space so that all that is printed is the asterisk at the axis and the y-value denoted by a '+' in the appropriate space.

AO 102 Occupancy Probability Distribution

Given a random distribution of R objects in N cells the program calculates the probability $P_{(M)}$ of finding exactly M cells empty.

$$P_{(M)} = \binom{N}{M} \sum_{v=0}^{N-M} (-1)^v \binom{N-M}{v} \left(1 - \frac{M+v}{N}\right)^R$$

For N = 2, 3, 4, ....., 20
R = 2, 3, 4, ..... 12
M = (N-R), .....(N-1)

Assuming that the R objects are faults in pieces of glass the program also calculates expected yields of fault-free glass.

AO 103 Centred 12 Monthly Moving Averages

Given a series of monthly values, $x_1$, $x_2$, .....$x_N$, the program calculates centred 12-monthly moving averages and prints out the averages against the actual value.

AO 104 Control Limits for Averages and Ranges

Given a set of sample measurements divided into equal sub-groups the program calculates the range and mean for each sample and the average range and overall mean. From these results and the corresponding control chart factors, the program calculates the control limits for the $\bar{X}_1$R chart.

AO 105 Time Series, Moving Averages

Given a series of values corresponding to equal time intervals the program calculates moving averages of any order.

AO 106 Periodogram Analysis

Calculates the values of the intensity $S^2$ for a time series, based on various values of period $\mu$.

AO 107 Correlation Matrix

Accepts tapes punched by the multiple regression tape preparation program ($M_4$) and calculates the correlation coefficients, means and standard deviations required for component analysis.

AO 108 Guassian Curve Fitting

Uses an iterative method to fit an equation of the form

$$y = A_1 e^{-B_1 (x - C_1)^2} + A_2 e^{-B^2 (x - C_2)^2}$$

To a series of experimental points ($x_i$, $y_i$,). $C_1$ and $C_1$ are fixed and the program attempts to successively reduce the sum of squared deviations between experimental and calculated values by adjusting $A_1$, $B_1$, $A_2$ and $B_2$ using the linear corrections.

AO 109 Multiple Regression Analysis

Standard multiple regression analysis of a single dependent variable against up to 26 independent variables.

AO 110 Quality Control Limits

Calculates the control chart limits for average and range based on a series of equally sized samples.

AO 111 Correlation Matrix

Takes a series of observations on a number of 'Independent' variables $x_i$ and a number of dependent variables $y_j$ and calculates the correlation coefficients, means and standard deviations.

AO 112 Periodogram Analysis

Calculates values of the intensity $S^2$ for a series of observations at equal time intervals based on various values of the period, $\mu$.

AO 113 Time Series Analysis, Moving Averages

Calculates moving averages of any order R, for a series of observations taken at equal intervals of time, $x_1$, $x_2$ . . . $x_t$, $x_{t+1}$ . . .$x_T$

Moving average, $\bar{x}_{t + \frac{(r-1)}{2}} = \frac{1}{r} \sum_{s=0}^{r} x_{t+s}$

For r odd, the averages correspond to tabulated values.
For r even, the average of each pair of consecutive moving averages is taken to give this correspondence.

AO 114 Latent Roots and Vectors

Finds all the latent roots lying within a given range of a symmetric matrix, together with the corresponding latent vectors.

AO 115 Correlogram Analysis

Calculates $v_k$ for a correlogram.

## MS Specifications

MS 2 Non-Orthogonal Analysis of Variance. Two Constraints

Calculates the analysis of variance for two constraints, which may be orthogonal or non-orthogonal. One of the constraints is assumed to be due to experimental treatments, and the other due to blocks, and the means for the treatments are adjusted to allow for the effects of the blocks contributing to each mean.

MS 3 Non-Orthogonal Analysis of Variance. Three Constraints

Calculates the analysis of variance for data with three constraints, which may be orthogonal or non-orthogonal. One of the constraints is assumed to be due to experimental treatments, and the others due to row and column effects of the experimental design, or block and previous treatment effects.

MS 7 Calculation of Discriminant Function between Two Groups

Calculates the linear function which best discriminates between two groups of observations of P variables, and the value of the coefficient of multiple correlation of this discriminant.

MS 8 Normalise and Solve Population Equations

Designed to carry through the computations described by Dempster in J. Anim. Ecol. 30, 1961, 429-432. The observed numbers of organisms present at the various stages of development for each sampling date are presented as a system of simultaneous equations. These equations are first normalised and then solved to find the mortality between each stage of development.

## SS Specifications

SS 2 Three Factor Analysis of Variance

The analysis of variance for three factors and blocks is calculated. In addition the means for each main treatment and the first order interactions with their standard errors are produced.

SS 3 Compare Two Tapes

The program reads characters alternatively TRO (A) and TRI (B), compares them, and if they are the same steps the tapes on to repeat the process. If the characters are not the same the machine stops at a 99-wait, from which it can be restarted by pressing "Continue".

SS 4 Four Factor Analysis of Variance

The analysis of variance for four factors and blocks is calculated. In addition, the means of each treatment, main effects, and first order interactions are printed.

SS 6 Eliott Data Conversion

This is a program to convert data in Eliott 5-Channel Paper Tape Code to Ferranti 5-Channel Paper Tape Code.

## SO Specifications

SO 2 Convert 7-Hole Paper Tape to 5-Hole on Sirius

Converts 7-track Lector tape to 5-track Sirius tape.

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