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Fritz Engineering Laboratory

FLEDP--COMPUTER PROGRAM FOR EXPERIMENTAL DATA PROCESSING

by

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This report is still being prepared and lacks good copies of some of the appendices to be complete.

In the meantime this copy of a partial draft is placed in the Fritz Laboratory Library for the use of staff in planning tests which use the MINC Computer.

11-15-84

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SYNOPSIS

FLEDP (Fritz Laboratory Experimental Data Processing) is a package of BASIC computer programs developed for a MINC 11/23 Modular Instrument Laboratory Computer. The package is a portable and versatile system designed for performing computations, producing graphic displays, monitoring laboratory processes, controlling experiments, and acquiring data.

The program FLEDP is written mainly for use by reseach workers and students at the Fritz Engineering Laboratory of Lehigh University. It can be used to acquire, store, identify, calculate and graphically display experimental structural test data measured from strain gages, strain gage rosettes, and linear variable displacement transformers (LVDT's).

A few additional individual and auxiliary programs are included herein for convenience sake to deal with data and file processing.

All these programs were written in BASIC, because of its usefulness as a standard language for microcomputer application. An initial version of the program package was developed on the DEC-20 at the Lehigh University Computing Center.

1. INTRODUCTION

1.1 Purpose of the Program System

For a complex strutural test, the data processing is heavy and complicated, especially when hundreds of strain gages and other transducers must be measured and processed. Under varied loads, thousands of data items and results must be collected, stored, calculated, and graphed. This process places a heavy premium on the researchers time. Therefore, using a laboratory computer (MINC-23), which can be kept at the investigators elbow in the office or laboratory to do such work is valuable. It is convenient, fast, and accurate. For these reasons the FLEDP programs were developed to deal with data processing of structural tests on the MINC computer.

1.2 Outline of Text

The text contains three groups of programs to perform data processing, as summarized in the following table:

A. FLEDP Main Program and Overlays:

1. FLEDP1.BAS
2. FLEDP2.BAS(OVERLAY)
3. FLEDP3.BAS(OVERLAY)
4. FLEDP4.BAS(OVERLAY)
5. FLEDP5.BAS(OVERLAY)
6. FLEDP6.BAS(OVERLAY)
7. FLEDP7.BAS(OVERLAY)

B. Auxiliary Programs for File Processing

1. FLEDP8.BAS
2. RDVIRT.BAS
3. RDASCI.BAS
4. DEVICE.BAS
5. RDLOAD.BAS
6. RDDATA.BAS
7. PRINTT.BAS and STOPRI.BAS

C. Individual Programs for Manual Input and Processing

1. BUDDGA.BAS
2. ARMYGA.BAS
3. PACMAN.BAS

Programs in Group A were written to record and process data collected from a B & F Data Acquisition System. The programs were planned to work with on-line data collection or with data previously stored on paper tape. Selected graphs can be produced either between input of load points during testing or after all data have been stored.

Programs in Group A are a lengthy set used to identify, calculate, store, display, and graph measured data and results. Since the MINC provides only 6000 words in the workspace. Using an EXTRA_SPACE statement increases the available workspace by 2048 words. Therefore the FLEDP program was divided into 7 segments which can be separately overlaid by using OVERLAY statments to merge each segment with the main program FLEDP1 that resides constantly in the computer workspace.

The second group, B--Auxiliary Programs, is used to form an identification file, to input, to read, and to print part or all of the data in a data file. Some programs also can be used to display any calculated results needed and to plot graphs.

The last group involves three individual programs. The programs BUDDGA and ARMYGA were written to permit manual input of test measurements from instruments which could not be connected by wire to the MINC computer. Selected data can be typed in manually during a test. After a load set is completed, selected graphs and lists of results can be plotted or typed. (The initial version of thse programs was written and executed on-site during a structural test--this indicates how easy it is to program in MINC BASIC.) PACMAN.BAS is a dummy program written to test revisions in the graphing features before they are installed in major operational programs.

Chapter USERSGUIDE--"User's Guide" explains briefly how each program may actually be used. In addition, a dummy example is given in detail in this chapter. Flowcharts and symbols are respectively attached as Appendix and Appendix . Finally, listings of all the programs are given in Appendix .

2. MAIN PROGRAM FLEDP1 AND ITS OVERLAY PROGRAMS

The Fritz Laboratory Experimental Data Processing Program is controlle by a main program FLEDP1. Before running the program, the investigator must prepare a file of information about the TEST SETUP. This file will be described in the article about the auxiliary program FLEDP8. Most of the processing in the program system involves creation and reading of FILES for describing the test setup, storing raw data, storing calculated results, and pointing to the correct place to store new added data. Each file will be discussed in the article on OVERLAY FLEDP2, a program to initialize files and arrays.

The program system is self-prompting. At several points in the program, "MENUs" of choices are listed allowing the user to select from possible courses of action. In OVERLAY FLEDP2, choices of mode of operation depend on whether the program is being executed during an experiment, after an experiment, or when testing is resumed after an interruption.

A special feature of the BASIC language used in the program system is the VIRTUAL ARRAY FILE. A virtual array allows direct read/write random access to data in a permanent file on disk. The array could be as large as available space on the disk will permit rather than being limited to the much smaller space available in central memory.

Later explanations of parts of the program system will require some understanding of the MINC BASIC language convention for VARIABLE NAMES. All variable names must begin with a letter A to Z. An optional second character can be a number 0 to 9. A suffix % indicates an integer variable. A suffix $ indicates a character string variable. Therefore, A1, A1%, and A1$ represent three different values for a real number, an integer number, and a character string respectively.

```
Main Program FLEDP1 -- Control
     OVERLAY FLEDP2 -- Initializing Files and Arrays
     OVERLAY FLEDP3 -- Read and store raw data
     OVERLAY FLEDP4 -- Plotting data assembly
     OVERLAY FLEDP5 -- Plots of results vs position
     OVERLAY FLEDP6 -- Fix hard copies of graphs
     OVERLAY FLEDP7 -- Calculate Rosettes, Stresses,
                          and Deflections
```

2.1 Main Program FLEDP1

Function: Control

The main program contains procedures to begin operation and offers a choice of 9 options for data processing. Each option is connected with an OVERLAY statement leading to a specified statement number in an OVERLAY program. The program also contains the procedures for printing key information on termination of execution.

Additional Remarks

A. D(S8%) is a virtual array in which all the results of data processing are stored. The size of the array D can be determined as follows:

```
S8%=T4%*(4%+C4%-C3%+1%+6%*N1+N5%+N2%)
here      T4%      Load set counter
          C4%,C3%  The highest and lowest channel number
                     respectively
          N1       The number of Rosettes
          N5%      The number of linear gages
          N2%      The number of deflections
```

Currently in this program a dimension of D(6000) accomodates tension flange connection tests in which there are about 50 gages under 50 varied values of load. The size of array D(S8%) would be increased if more space were needed.

B. S1(I%) is a setup array in which some setup information about deflections, rosettes, and linear gages is stored. The size of S1(I%) is determined by

I%=3%+7*(N1)+5*(N5%)+N2%+2*N2%

The meanings of the symbols are the same as above. A dimension of S1(200) was used in this program.

C. The first line of each load set passed by the B & F system to the TAPE**.DAT file is called the calibration constant C0$. In the program the user is requested to input it by typing on the keyboard.

D. Nine options are offered for different situations which may occur in an experimental stress test: zero reading, read new data for a load point, reread, reset of gages, read next line, end of file, on line with B and F acquisition system, plot results, and change print flags. Each option connects with an OVERLAY program to perform some function of data processing.

2.2 OVERLAY - PROGRAM FLEDP2

Function: Initializing Files and Arrays

Reading initial conditions and file names, opening some files, storing data about the test setup in array S1, and defining the program operating mode are the main functions of FLEDP2. The overlay is called automatically from FLEDP1 if the user elects to run the main program.

Additional Remarks

A. Six file names are read here as follows:

- "ROSE**.DAT"--ASCII file containing information about gages in the test setup (especially rosettes). It must be created prior to running the program.
- "TAPE**.DAT"--ASCII file containing raw data images of a punched paper tape.
- "STOR**.DAT"--Virtual array file which contains reduced data and calculated data.
- "SETO**.DAT"--ASCII file which contains values of ke parameters when program execution is terminated normally. The user must rename this file to be SETI**.DAT before executing the program again.
- "SETI**.DAT"--ASCII file which contains values of number of data points previously collected and zero values for all gages for use in making graphs from previously stored information.
- "PLOT**.DAT"--A file for storing information for later plots.

B. Array S1 is formed from the "ROSE**.DAT" file.

C. Four operating modes are offered; they are: "data input from paper tape", "data input from on-line test", "resume interrupted on line test", and "graphs and calculations from previously stored test".

2.3 OVERLAY--PROGRAM FLEDP3

Function: Read and Store Raw Data

The overlay program FLEDP3 is entered when any of the five options involving data reading in FLEDP1 are selected. FLEDP3 has the following functions:

A. Input the load number and the load value of a group of data into array C(I), and then store them into the virtual array D(S8%).

B. To read, check, and interpret a typical data line, then to calculate and store the strain value of each channel into the virtual array D(S8%).

C. It has a subroutine to process reset readings. The channels reading mechanical gages which can be reset must be identified by the user. The the readings are recorded before and after the gages are reset without changing the load on the specimen. The program automatically calculates a revised zero reading so that calculated cumulative differences will be correct.

Additional Remarks

Since incomplete data sometimes occurs during tests due to operator error, a routine to bypass an incomplete data set is included in this program.

2.4 OVERLAY--PROGRAM FLEDP4

Function: Plotting

The program FLEDP4 is used for displaying and printing tables of values and graphs. The overlay is entered when the "Plots" option is selected in program FLEDP1. Five options have been identified for plotting. Four of them can be performed in this program. The options are: "load vs channel strain", "load vs deflection", "load vs rosette results", and "load vs single linear stress". The remaining option, "stress vs position" is considered in program FLEDP5. In the option on "load vs results", six kinds of results: (stress in X direction, stress in Y direction, maximum shear stress, maximum principal stress, minumum principal stress, and the angle from X to maximum principal axis) are also considered.

Additional Remarks

All the kinds of results considered here use the same routine to plot a graph. The graphs have the following features: They can be small or large in height; they also can be of screen width or printer page width; 12 types of graphs can be chosen from among the available options, e.g., point, shade, line, etc. The X and Y variables and coordinates can be exchanged to make a better graph. There are also choices for labels, legend, and units.

2.5 OVERLAY--PROGRAM FLEDP5

Function: Plots of Results vs Position

The overlay FLEDP5 is invoked when the user chooses to plot "the results of data vs position" from the menu in FLEDP4. The options of position plots are as follows:

Channel strain vs X or Y coordinate
Single linear stress vs X or Y coordinate
Rosette functions vs X or Y coordinate

Here the rosette functions include stress in the X and Y directions, maximum and minumum principal stress, and angle from the X axis to the maximum principal axis.

2.6 OVERLAY--PROGRAM FLEDP6

Function: Fix Hard Copies of Graphs

This is a program to doctor basic graphics so the line printer (LA34) hard copy includes alphanumerics of axis units, labels, and legend. The program is needed because of a systematic flaw in the MINC BASIC graph routine. The overlay is executed automatically whenever the user elects to send a graph on the screen to the printer from either FLEDP4 or FLEDP5. Interactive questions allow the user to replace text mode axis labels with graphic mode labels and add a legend to the graph before it is sent to the hard copy printer.

2.7 OVERLAY--PROGRAM FLEDP7

Function: Calculate Rosettes, Stresses, and Deflections

Overlay FLEDP7 is entered automatically after each complete valid set of channel readings is entered. Rosette stresses, linear gage stresses, and deflections are computed using the current channel strain values. All the results calculated are listed and stored in file STOR**.DAT through the D virtual array.

Additional Remarks

A. Formulas

The formulas for computing stress from strain rosettes in the program FLEDP are:

$$F_1 = \frac{E}{1-@g(m)} 2(G6 + @g(m)G8)$$

$$F_2 = \frac{E}{1-@g(m)} 2(G8 + @g(m)G6)$$

$$F_3 = \frac{E}{2(1+@g(m))} (2G7 - G6 - G8)$$

Here F_1 = stress in gage 1 direction (Fig. 5-1) F_2 = stress in gage 2 direction F_3 = maximum stress of the rosette point G6,G7,G8 = strain values of gages 1, 2, and 3

$$P_{1,2} = \frac{F_1+F_2}{2} \pm \frac{(F_1-F_2)^2}{4} + F_3^2$$

$P_{1,2}$ = maximum and minimum principal stresses

$$@g(q) = \arctan\left(\frac{2@g(e)_{45} - @g(e)_0 - @g(e)_{90}}{(@g(e)_0 - @g(e)_{90})}\right) * \frac{90}{@g(p)}$$

@g(q) = angle from principal axis to larger stress of gage (Fig. 5-2)

If G6<G8, $@g(q)' = @g(q)-90$ (Fig. 5-3)
$@g(q) = @g(q)'$

$$@g(q)_1 = @g(q) - T_1 \quad \text{(Fig. 5-4)}$$

Here $@g(q)_1$ = angle from principal axis to X axis

T_1 = angle from X axis to gage 1 axis

$$S_4 = \frac{P_1+P_2}{2} + \frac{P_1-P_2}{2} \cos(2\, @g(q)_1)$$

$$S_5 = \frac{P_1+P_2}{2} - \frac{P_1-P_2}{2} \cos(2\, @g(q)_1)$$

$$S_0 = \frac{P_1-P_2}{2} \sin(2\, @g(q)_1)$$

Here S_4 = stress value in X axis

S_5 = stress value in Y axis

S_0 = shear stress value perpendicular to X axis

B. Signs of Stress Components and Angles

Sign conventions for stress components and angles are illustrated in Fig. 5-5. Tensile stresses are designated positive and compressive stresses are negative. Shear stresses are designated as positive when shears on faces perpendicular to the x direction tend to rotate a free body clockwise.

Counterclockwise angles are designated as positive.

C. Units

In this program, the value of the elastic modulus E as entered has been divided by 10^6 and the measured values of strain have been multiplied by 10^6, so the results calculated for stress are in units of psi.

The readings of deflection are made with devices calibrated to read in ten-thousandths of an inch. The interactions between two or more devices connected so they can average out deflections are calculated using signed multipliers. The resulting deflections are in units of inches.

3. AUXILIARY PROGRAMS

3.1 FLEDP8 -- Create File Describing Test Setup

The program is used to create the file ROSE**.DAT, which stores test setup information needed for running program FLEDP to process the experimental data.

Before running this program, the user should assemble a list of information about the test setup. The information needed includes test identification and identification for rosettes, linear gages, and deflections.

3.2 RDVIRT -- Read a Virtual Array File

Listing contents of a virtual array is the purpose of the program. Because a virtual array file can not be read by an editing program or the TYPE command, use of an auxiliary program such as this is necessary. The contents of a virtual array file such as STOR**.DAT are accessed and equated to a simple variable which is written into an ASCII file LIST.DAT. An ASCII file can then be read by running RDASCI.BAS. In this way, all or part of a virtual array file can be examined and brought forth in hard copy form.

3.3 RDASCI -- Read an ASCII Text File

The program is used to read and display an ASCII file. Each line of a selected ASCII (American Standard Code For Information Interchange) file is displayed on the terminal. If the terminal is set to transmit to the printer, a hard copy is also generated. The program is useful for obtaining paper copies of the file LIST**.DAT which is translated from a virtual array file such as STOR**.DAT. It is also useful for reviewing and obtaining copies of ASCII data files such as ROSE**.DAT, TAPE**.DAT, and SET***.DAT.

3.4 RDTAPE -- Read a Punched Paper Tape

The program is used to read and store on disk experimental data that has been punched on paper tape by an ASR-33 teletype. Before running the program, the computer should be connected with a teletype on which there is a paper tape reader. After running the program, all the experimental data from the paper tape would be stored in an ASCII file TAPE**.DAT on a storage volume.

3.5 DEVICE -- Test Communication Lines Between Devices

When the MINC computer is directly connected on-line with a B & F data acquisition system and an ASR-33 teletype, the experimental data may be directly stored into a data file of the computer while the teletype prints all the data. This program tests to see whether communication has been extablished between the MINC and the two devices before beginning to run the major data processing programs.

3.6 RDLOAD -- Read and Print Load Numbers and Values

Running this program is the simple way to read and print the load number and load values of a test. It is used if you only want to know the information specified as "load" without having to print all the data values in the file.

3.7 RDDATA -- Read and Print Lists of Selected Data

Usually a large number of results are stored in the form of a STOR**.DAT file. By running this program you can read, display on the screen, and print in tabular form selected parts of the data. The following options are offered in this program.

A. Under a certain selected load, it is convenient to read and display all strains, all deflections, all results of a selected rosette or all single linear stresses at the selected load.

B. A table of all loads versus a single selected stress component may also be generated. The selectable stress components are strain, deflection, linear stress, and results from rosette components.

3.8 PRINTT and STOPRI -- Turn Printer On or Off

Commands are needed to instruct the computer to transmit text mode characters from the screen to the LA-34 graphic printer.

Program PRINTT instructs the compute to begin transmitting and also establishes top,bottom, and side margins for the printed page. All text mode characters appearing on the screen thereafter will be transmitted to the printer.

Program STOPRI will instruct the computer to stop transmitting to the graphic printer.

An alternate printing program PRINTQ establishes a 1.5 inch left margin for better appearance of following printouts.

4. INDIVIDUAL PROGRAMS

Special purpose programs were assembled to allow manual input of data in tests having small numbers of readings or using gages which can not be connected directly to the MINC. The programs have been used on connection tests, beam tests, curved girder tests, and industrial tests.

4.1 BUDDGA.BAS

This program is used to input data measured by a manually-balanced gage such as a Budd gage. Then the data can be calculated and plotted on the screen; it also can be stored into a virtual array. It is convenient to display test results immediately during the test. For instance, this program has been used in a beam-to-column connection test to control the processing.

4.2 ARMYGA.BAS

Program ARMYGA was developed for manual input of test measurements and to calculate and display the test results immediately. The test results and calculated results are stored in a virtual file. This program has been used in a beam test for the Army Corps of Engineers.

4.3 PACMAN.BAS

Program PACMAN plots a sine curve superimposed on a sloping straight line. The program has been used to test imporvements on graph routines before they are incorporated into other programs.

5. USER'S GUIDE

5.1 INTRODUCTION

This chapter is intended to provide brief information necessary to use the programs in the FLEDP system on the MINC computer which is presently in use at Fritz Laboratory. The function of each program has already been described in the previous chapters. Here data files will be described and a dummy example will be given. For information related to use of the MINC, users should refer to the MINC--11 manuals which are catalogued in the Fritz Laboratory Library.

5.2 PREPARATION FOR TESTS

Prior to conduct of a test or running a computer program, exact details of the test setup must be determined and assembled as data. The proper execution of the computer programs depends on listing specific information in a certain order.

The lowest and highest channel numbers that will be read on the B & F recorder must be identified. In addition, information is needed on the channel numbers related to strain gages in rosettes and linear strain gages, as well as channel numbers related to LVDT's (Linear Variable Displacement Transformers). An orientation angle and x and y coordinates of location are also used for each rosette and linear strain gage to allow plotting of gage results versus position. Table 5-1 gives a suggested arrangement of data for strain gages and rosettes for a dummy example of an experiment.

In calculation of deflections, two or more LVDT's are usually involved in each deflection in order to average out the effects of bending and compensate for distortions of testing machines and test frames. Information is needed on how many channels and which channel are involved in each deflection calculation. Also needed is a signed multiplier of each channel reading which will allow the electrical readings of gages to be converted into displacements of parts of the structure. Deflection calculations take the form:

$$D_k = C_1 R_1 + C_2 R_2 + \ldots + C_i R_i$$

where

D_k = deflection number k

C_j = multiplier of channel j for deflection k

R_j = cumulative change in reading of channel j

Judicious use of combinations of gage readings and signed multipliers can produce a variety of interpretations of displacements and rotations involved in any given test. Table 5-2 lists the channel numbers and multipliers related to three different deflection components which can be calculated from the readings of four deflection gages.

Certain mechanical gages which have limited stroke may be reset during tests to allow gathering of further readings after the gages have run out of range. The channels connected to such gages must be identified so that the computer program can process the resets properly.

The investigator should be sure to record the serial number of each laboratory instrument used on a test as well as identifying which channel was used to read the instrument. This is necessary because identical instruments often have different calibration factors needed as parameters in calculations.

Once the information about a test is assembled, it can be used to create a file ROSE**.DAT either by text editing or by execution of the program FLEDP8.

5.3 RUNNING PROGRAMS

The first program to be run is FLEDP8.BAS which writes the details of the test setup on a file ROSE**.DAT needed for running other programs in the experimental data processing system.

At this point, the experiment can be conducted and the data recorded either off-line on punched paper tape or on-line using the MINC computer. If the experiment is conducted off-line, the program RDTAPE.BAS should be executed to store the raw data on a disk file TAPE**.DAT.

The main program system FLEDP1.BAS is executed either to collect data on-line from an experiment or to process raw data previously copied from a paper tape. Once data for the complete experiment have been processed and stored, program FLEDP1.BAS can be used to create plots selectively.

The smaller programs RDLOAD.BAS and RDDATA.BAS can be run to produce selected tables and graphs.

Instructions for running the programs will be given in the following sections along with samples of output from the programs.

In describing dialog between the computer and the user, the symbols C: for computer and U: for user will be given preceding the lines. These symbols will never appear in actual execution.

Forming File ROSE**.DAT -- Program FLEDP8.BAS

To prepare for running any program, the user should first issue a DIRECTORY command to assure that the program is present and that no filenames are present with names that would be duplicated by the current run. Valuable files could be lost or destroyed if duplicate names are used.

To permit systematic assignment of filenames, a two-digit number such as 01, for Test 1, is imbedded at the position ** in filenames ROSE**.DAT, TAPE**.DAT, STOR**.DAT, SETO**.DAT, SETI**.DAT, and PLOT**.DAT. If the desired number is already in use, another number should be selected, or else the job should be run on a separate disk.

The terminal should be set to type in upper case letters by depressing the CAPS LOCK key. Otherwise, the Y and N answers to questions might not be recognized.

The program can be run as follows:

```
C:  READY
U:  DIR SY1:
C:  FLEDP8.BAS
    ROSE01.DAT
    ROSE02.DAT
U:  RUN SY1:FLEDP8
```

The computer will then prompt the user with a series of questions as shown in Fig. 5-7. The first seven questions determine the two-digit test number, project number, test date, test number (as specified by the investigator), lowest and highest channel numbers, Young's mudulus E of the material, and Poisson's ratio. The next three questions request the number of deflections,number of three-branch rosettes, and number of linear channels to be analyzed singly.

The computer then cues the user through the appropriate number of steps to store data about all the rosettes, linear gages, and deflections.

For each rosette, the rosette number is requested followed by the channel numbers in counterclockwise order for the 0-deg, 45-deg, and 90-deg legs of the rosette. Then the angle counterclockwise from the rosette is requested. Finally, the x and y coordinates of the rosette location are requested. For a large number of rosettes, the process becomes tedious, but all data must be filled in.

Following the rosettes, information is requested about the linear gages. Some linear gages may actually be single branches of a multi-branch rosette, but the complete information should again be fed in if this is true. For each linear gage, the user will be prompted to type the channel number, the angle of the gage with the reference axis, and the x and y coordinates of the gage.

Finally, the program requests the number of deflections again and then prompts the user for the information on each deflection. The information is the number of channels used for the given deflection and then the channel number and signed multiplier for each channel.

Fig. 5-8provides a listing of the ROSE00.DAT file resulting from a dummy example. Fig. 5-3 explains the sequence of the ROSE**.DAT file as an aid in understanding or making modifications to the computer programs.

Copy Paper Tape -- Program RDTAPE.BAS

When an experiment has been conducted without connecting to the MINC, the results will be stored on a paper tape which can be copied to disk by using program RDTAPE.BAS. Both the paper data tape and a "trailer" tape punched with the single word END should be ready before the program is run.

The output plug of the tape reader is connected to the 110 baud converter attached to serial line unit SLU1 of the MINC. Then it is time to run the program.

```
C:  READY
U:  RUN RDTAPE
C:  Program to Read Paper Tape from Teletype ASR-33
    Type the Name of the File to be Stored in the
    Form  SY1:TAPE**.DAT
U:  SY1:TAPE00.DAT
C:  The Program May Terminate With an Error.
    In Ready Mode Type CLOSE to Save the File
    START the paper tape reader
U:  (Pushes the START switch on the paper tape reader.)
C:  (Lists the data being copied on the screen)
C:  THE TAPE SHOULD BE FINISHED NOW
    READY
U:  CLOSE
```

There is a definite possibility that the tape reading operation may end with an error and result in the system being put into the READY mode. The user should immediately type CLOSE. This will close all open files and preserve any data which have been successfully preserved.

The file TAPE00.DAT resulting from this program is an ASCII file which can be displayed either by the TYPE SY1:TAPE00.DAT command or by running program RDASCI. One advantage of program RDASCI is that it counts and numbers the lines. A sample printout of TAPE00.DAT is given in Fig. 5-6.

Running FLEDP1 -- The Main Program

Execution of the data processing program system begins with the command RUN SY:FLEDP1. The programs FLEDP2 through FLEDP7 are automatically called from FLEDP1 by OVERLAY commands. Before running, the user should assure by a DIR command that all the programs are present as well as the data file ROSE**.DAT for the particular experiment. In addition, the file TAPE**.DAT must be present if the results were previously stored on paper tape.

```
C:  READY
U:  EXTRA_SPACE
C:  ... Are you ready to have the workspace erased?
U:  Y
C:  READY
U:  RUN SY1:FLEDP1.BAS
```

Fig. 5-9 gives a sample run of the program. The initial page shows the consequences of forgetting to issue the EXTRA_SPACE command.[1] After the extra space is opened, the program is able to run successfully.

---

[1] Note the underline _ which is used in some MINC commands instead of a hyphen -.

Plot

If all the results are already in data files,it is convenient just to choose option "plot" to display graphes.

Reading and printing data

Since reading and printing data in virtual array must be used BASIC, so program RDVIRT, RDASCI, RDLOAD and RDDATA are made specially for reading and printing. And RDLOAD and RDDATA can print specified results of test which you only need to know.

5.4 TABLES AND FIGURES

DUMMY EXAMPLE

2.7 OVERLAY — PROGRAM FLEDP 7

2.7.1 Function

Rosette stresses, linear gage stresses and deflections are computed by using the current channel strain values. And all the sesults calculated are listed and stored in STOR**.DAT array.

2.7.2 Additional remarks

A. The formula for computing stress from strain rosettes in the program FLEDP

$$F_1 = \frac{E}{1-\mu^2}(G6 + \mu G8)$$

$$F_2 = \frac{E}{1-\mu^2}(G8 + \mu G6)$$

$$F_3 = \frac{E}{2(1+\mu)}(2G7 - G6 - G8)$$

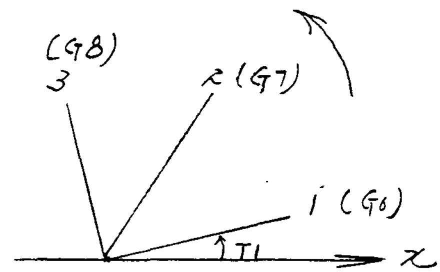


fig1. 3 gages of rosette

Here

F1 —— stress in gage 1 direction

F2 —— stress in gage 3 direction

F3 —— Maximum stress of the rosette point

G6, G7, G8 —— strain values of gage 1, 2 and 3

$$P_{1,2} = \frac{F1 + F2}{2} \pm \sqrt{\left(\frac{F_1 - F_2}{2}\right)^2 + F_3^2}$$

$P_{1,2}$ —— Maximum and Minimum principal stresses

$$\theta = \mathrm{ARCtan}\,\frac{(2\varepsilon_{45} - \varepsilon_0 - \varepsilon_{90})}{(\varepsilon_0 - \varepsilon_{90})} \cdot \frac{90}{\pi}$$

fig. 2

θ — Angle from principal axis to lager stress of gage

if $G6 < G8$, $\theta' = \theta - 90°$. (fig. 3)

$\theta = \theta'$

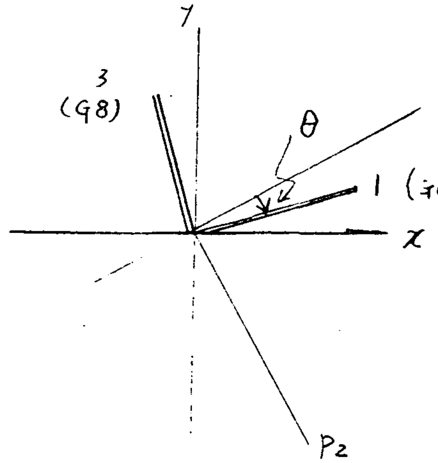


fig 2 if $G6 > G8$

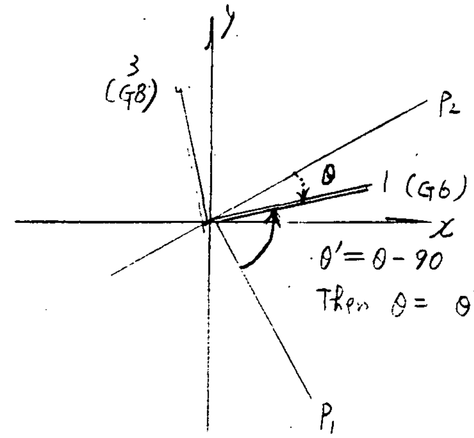


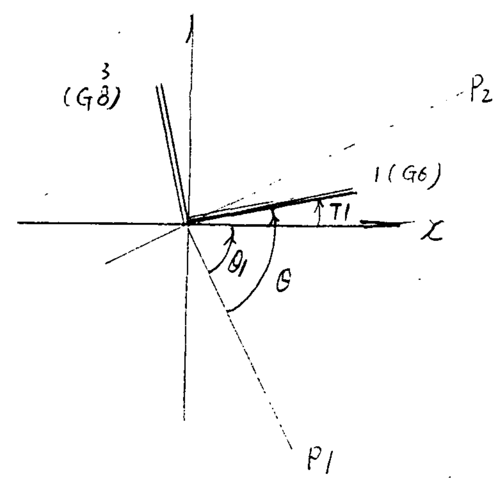
fig3 if $G6 < G8$

$\theta_1 = \theta - T_1$ (fig 4)

Here

θ_1 — Angle from principal axis to x axis

T_1 — Angle from x axis to gage 1 axis



$$S4 = \frac{(P_1 + P_2)}{2} + \frac{(P_1 - P_2)}{2} \cos(2\theta_1)$$

$$S5 = \frac{(P_1 + P_2)}{2} - \frac{(P_1 - P_2)}{2} \cos(2\theta_1)$$

$$S0 = \left(\frac{P_1 - P_2}{2}\right) \sin(2\theta_1)$$

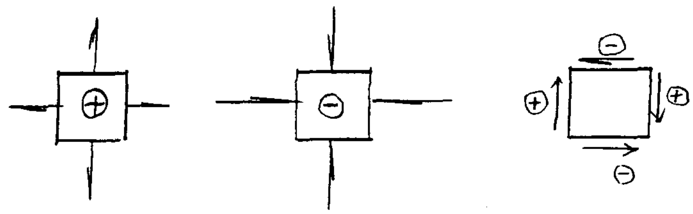
Here

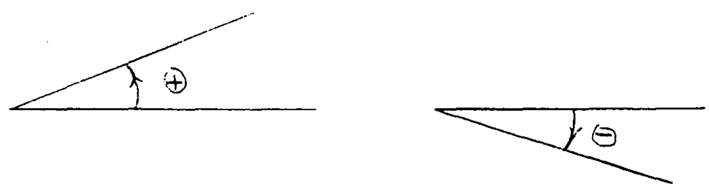
S4 — stress value in x axis.

S5 — stress value in y axis.

S0 — Shear stress value perpendicular to x axis.

b) Sign of stress compenent and angle



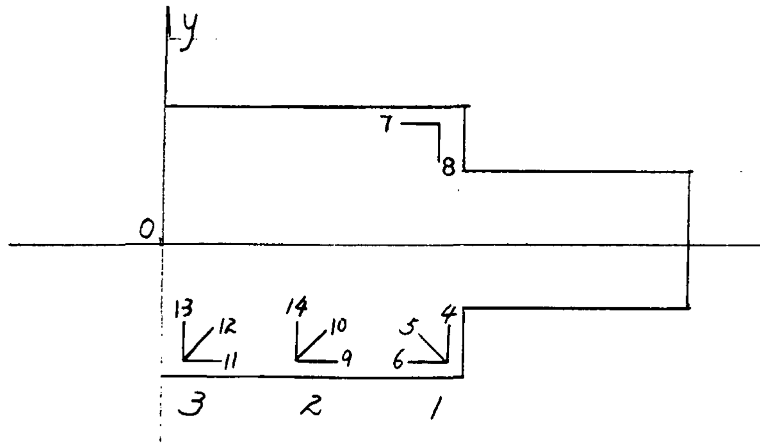


c) Unit of value

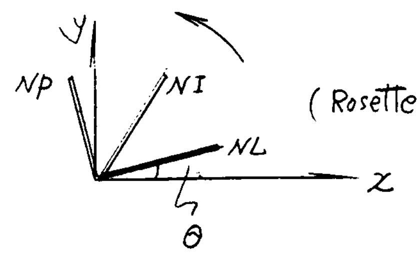
In these program; the value of elastic modulus E has divided by 10^6 and the measured values of strain have multiplied also by 10^6, so the results calculated of stress are not changed and it's unit is psi.

The readings of deflection time by multipliers and then multiply again by 10^{-4}, finally the unit of deflection is inches

§3 Dummy Example



connection Test



(Rosette)

§3.1 Identification Table

Project 469	Test Number 469-T0			Number of Rosette 3	Calibration 0001070820	
Rosette number	Channel Numbers			Angle (θ) (deg)	Coordinates	
	NL	NI	NP		x (in)	y (in)
1	4	5	6	90	8.0	-5.75
2	9	10	14	0	5.0	-5.75
3	11	12	13	6	2.0	-5.75
Linear Gages						
1	7			0	8.0	5.75
2	8			90	8.0	5.75

The lowest Number 0	The highest Number 14	The highest Array Number 369

Deflection No: K	Number of channels j	i	Channel Number R_i	Signed Multiplier C_i
2	1	1	000	-0.5
		2	001	0.5
Total Number of Gages can be Reset 4		3	002	1.0
Resetting Number 0, 1, 2, 3	2	1	002	1.0
		2	003	1.0

Table 5-1: GAGE IDENTIFICATION TABLE

PROJECT	TEST NUMBER	NO. OF ROSETTES	CALIBRATION CONSTANT
469	469-T0	3	0001070820

Rosette Number	Channel Numbers NL	NI	NP	Angle Theta (deg.)	Coordinates x (in)	y (in)
1	4	5	6	90	8.0	-5.75
2	9	10	14	0	5.0	-5.75
3	11	12	13	0	2.0	-5.75

Linear Gage Number	Channel Number	Angle Theta (deg.)	Coordinates x (in)	y (in)
1	7	0	8.0	5.75
2	8	90	8.0	5.75

Lowest Channel Number = 0 : Highest Channel Number = 14
The Next Available Array Number = 369

Table 5-2: DEFLECTION GAGE TABLE

Number of Deflections = 3

$$D_k = C_1 R_1 + C_2 R_2 + \ldots + C_j R_j$$

Deflection Number k	Number of Channels j		Channel Numbers R_i		Signed Multiplier C_i
1	2	1	000	1	+0.5
		2	001	2	-0.5
2	3	1	000	1	-0.5
		2	001	2	+0.5
		3	002	3	+1.0
3	2	1	002	1	+1.0
		2	003	2	+1.0

Total Number of Gages That Can be Reset	Channel Numbers of Gages That Can Be Reset
4	000,001,002,003

Figure 5-1: Three Gages of R

Figure 5-2: Angles if G6 > G

Figure 5-3: Angles if G6 < G

Figure 5-4: Angle Between Pr Axis and Reference Axis

Figure 5-5: Signs of Stress Components and Angles

Figure 5-6: TAPE00.DAT file

Figure 5-7: Running Program FLEDP8.BAS

Figure 5-8: ROSE00.DAT file

Table 5-3: Sequence of a ROSE**.DAT File

Lines 0-5: File Names for the Particular Test

0	Name of Rosette Data File
1	Name of Tape Data File
2	Name of Virtual Array Storage File
3	Setout Data File at End of Run
4	Setin Data File to Resume Program
5	File to Save Plotting Lists and Tables

Lines 6-8: Identification of Particular Test

6	Project Number
7	Date of Test
8	Test Number

Lines 9-15: Constants for Particular Test

9	Number of Lowest Channel to Be Read
10	Number of Highest Channel to Be Read
11	Modulus of Elasticity for First Material (x 10^{-6})
12	Poisson's Ratio of First Material
13	Number of Deflections
14	Number of 3-Gage Rosettes
15	Number of Linear Gages

Groups of 7 Lines per Rosette

1	Rosette Subscript
2	Channel Number of First Gage (Counterclockwise)
3	Channel Number of Second Gage (45 deg)
4	Channel Number of Third Gage (90 deg)
5	Reference Angle of First Gage
6	x Coordinate of Rosette Axis
7	y Coordinate of Rosette Axis

Groups of 5 Lines per Linear Gage

1	Linear Gage Subscript
2	Channel Number of Gage
3	Reference Angle of Gage
4	x Coordinate of Gage
5	y Coordinate of Gage

One Group Equal to Number of Deflections

1	Number of Channels Used for Deflection 1
2	Number of Channels Used for Deflection 2
..	...
n	Number of Channels Used for Deflection n

Groups of 2 Lines per Deflection Channel

1	Channel Number of Gage44
2	Signed Multiplier of Gage

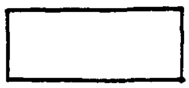
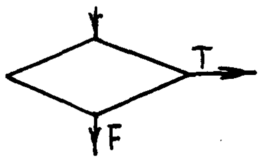
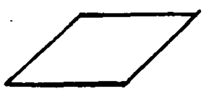
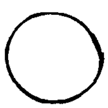
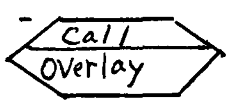
Figure 5-9: Running main program

Figure 5-10: STOR00.DAT file

Figure 5-11: DISPLAY GRAPHS

Appendix 1 FLOWCHART LEGEND

Fig 1 FLOWCHART LEGEND

	Terminal
	Processing
	Decision
	Do statement (or preparation)
	Input—output
	Connection
	Call (or) OVERLAY

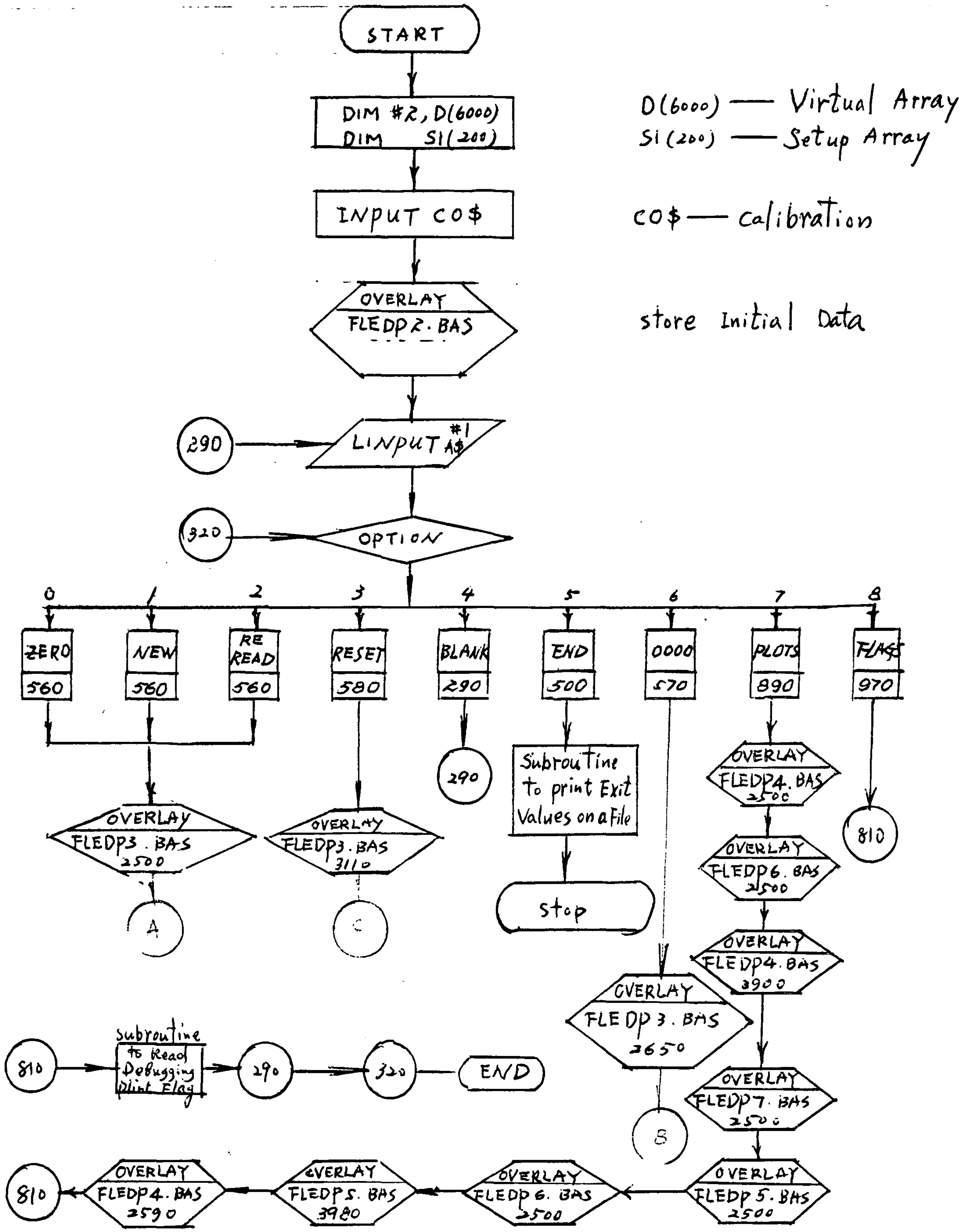


Fig 2 General Flowchart (FLEDP1. BAS)

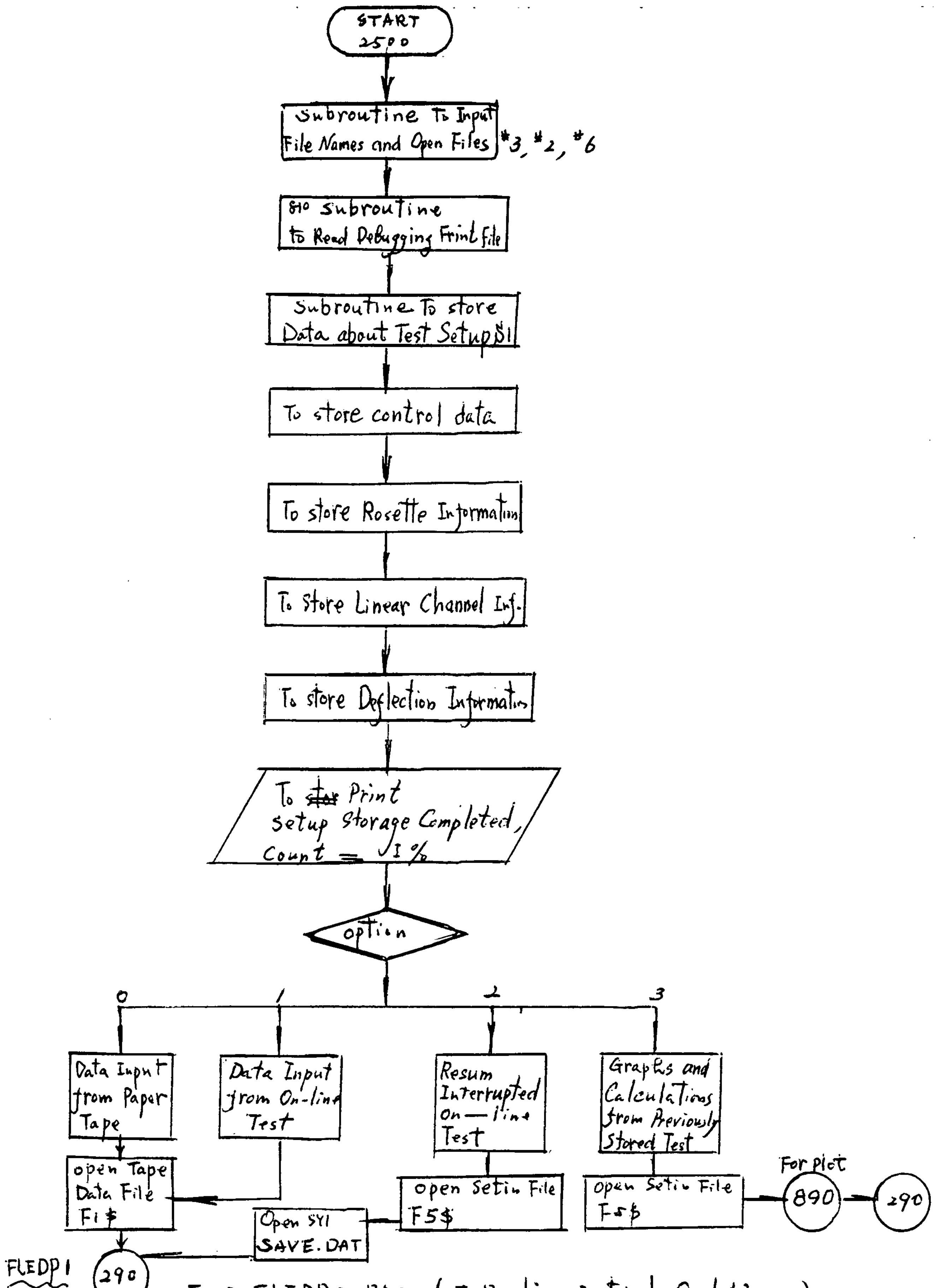


Fig 3 FLEDP2. BAS (Reading Initial Conditions)

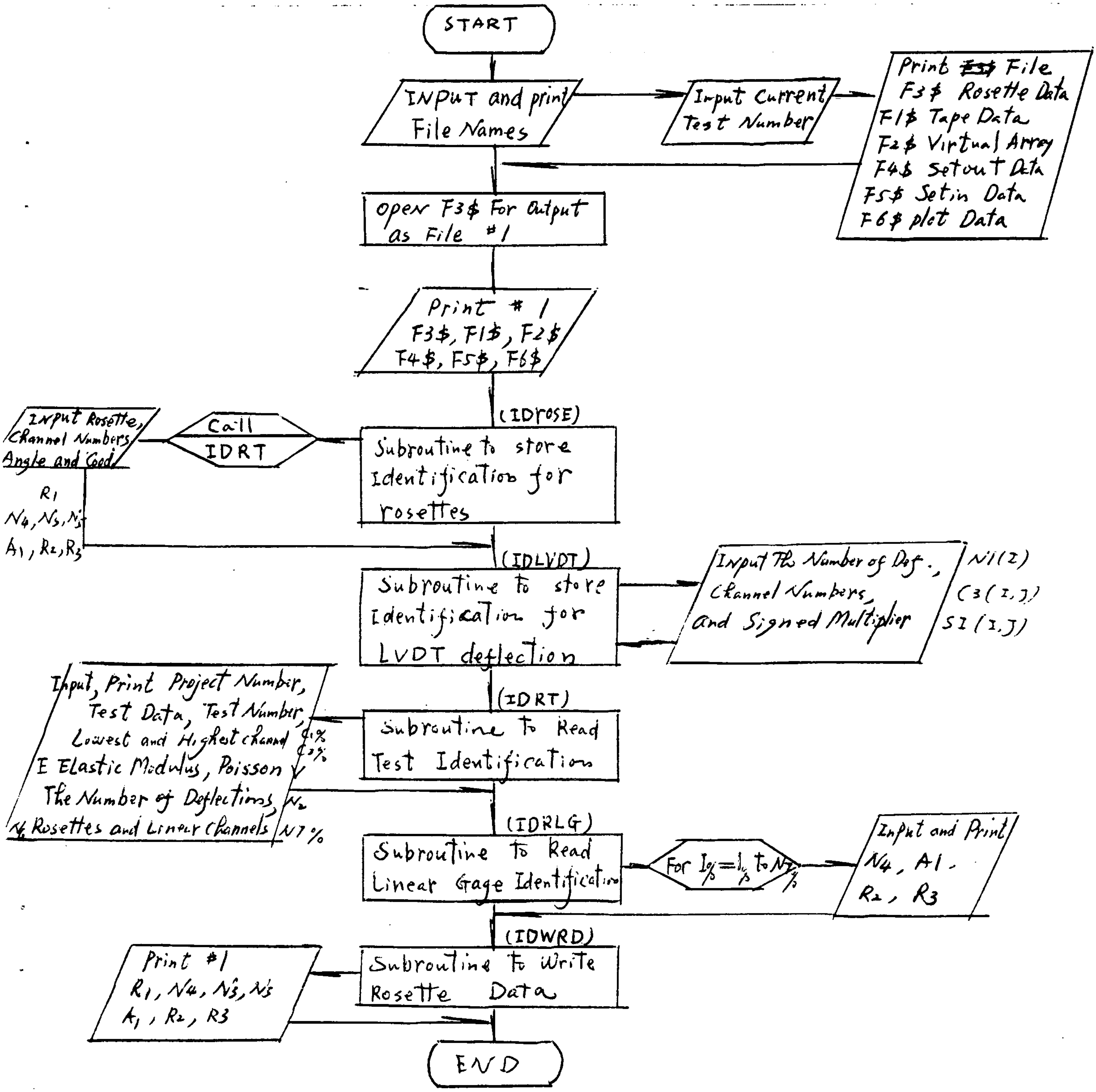


Fig4 FLEDP8.BAS (storing TEST SETUP)

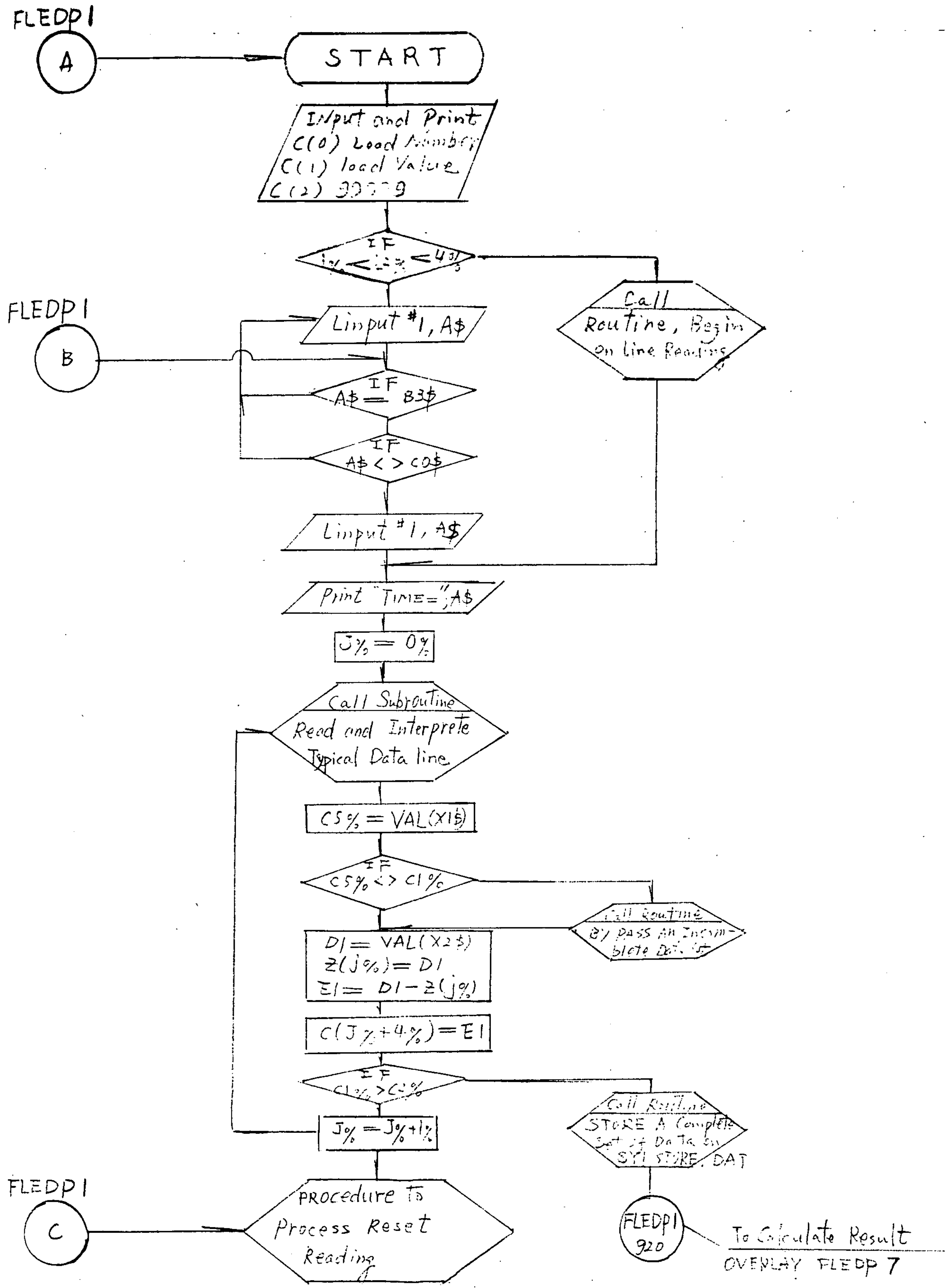


Fig5 FLEDP 3. BAS (Continuing with A Valid Set)
(OverLay)

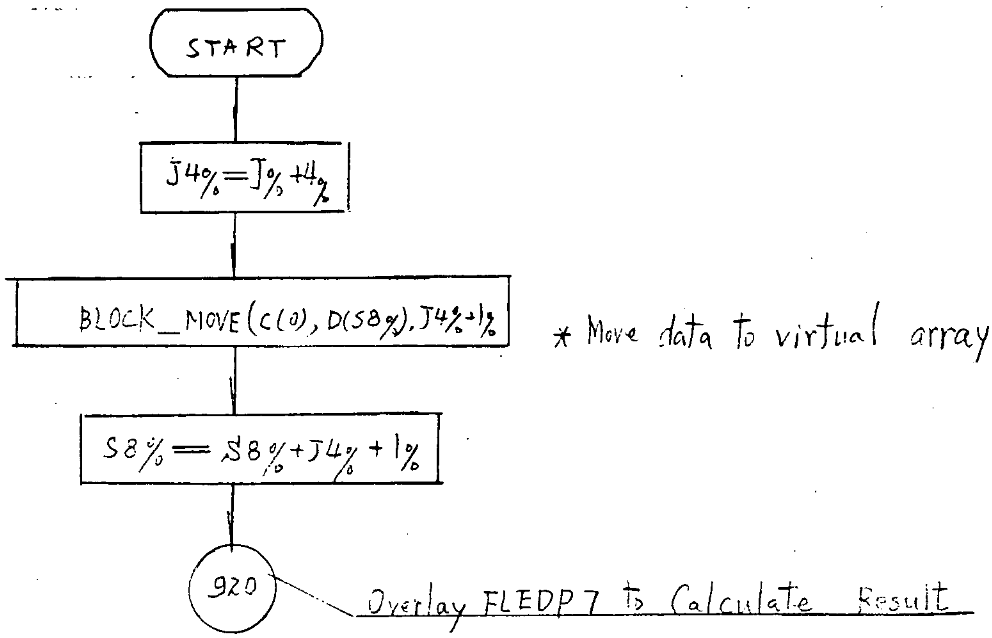


Fig ROUTINE SCSD (To Store A Complete Set of Data on SY1 : STORE . DAT)

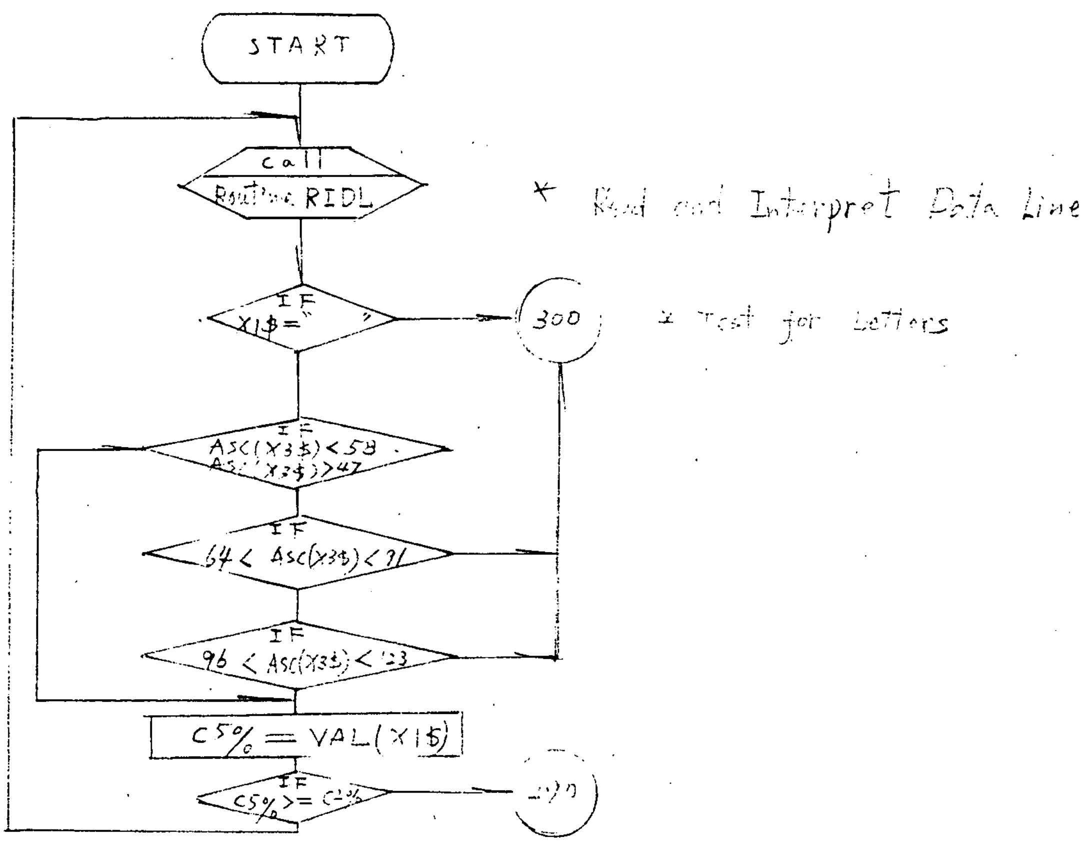


Fig 6 ROUTINE BPIDS (to By-pass An Incomplete Data Set)

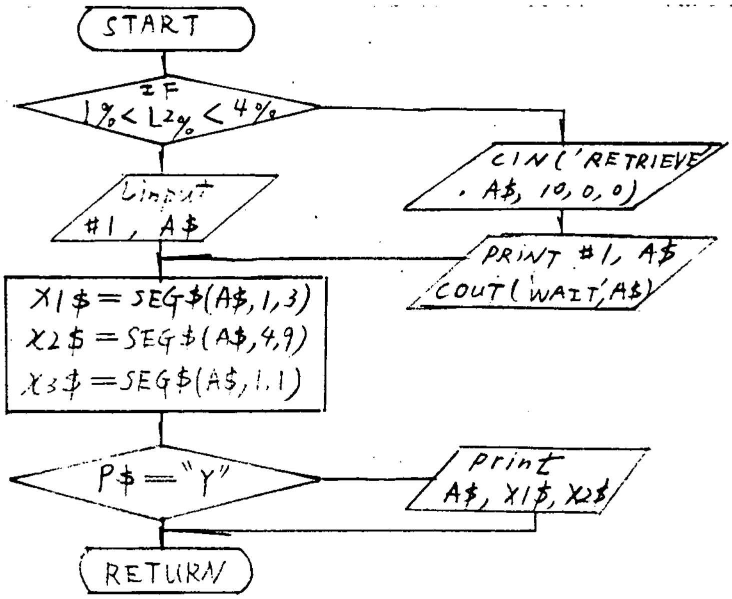


Fig ROUTINE RIDL (To Read and Intepret Data Line)

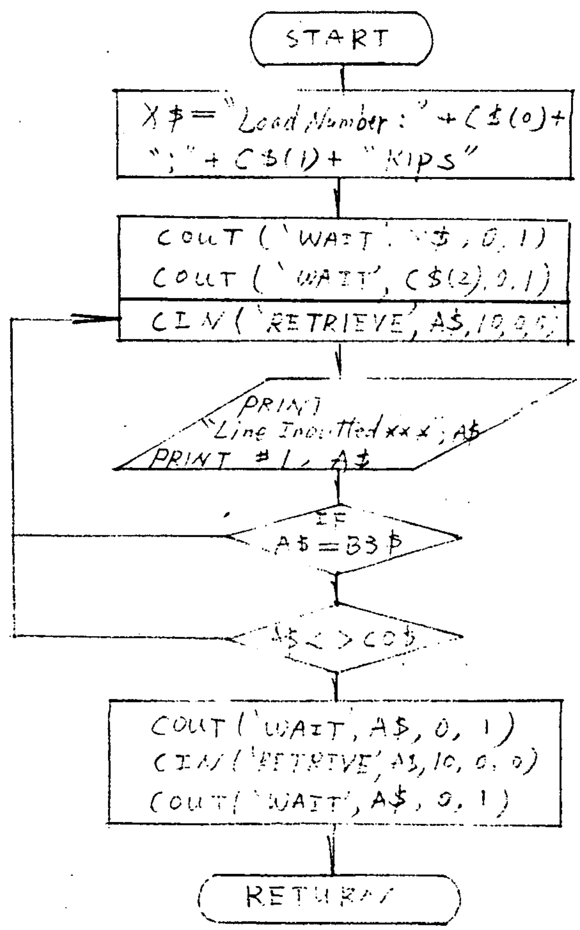


Fig 7 ROUTINE BONLR (To Begin On-Line Reading)

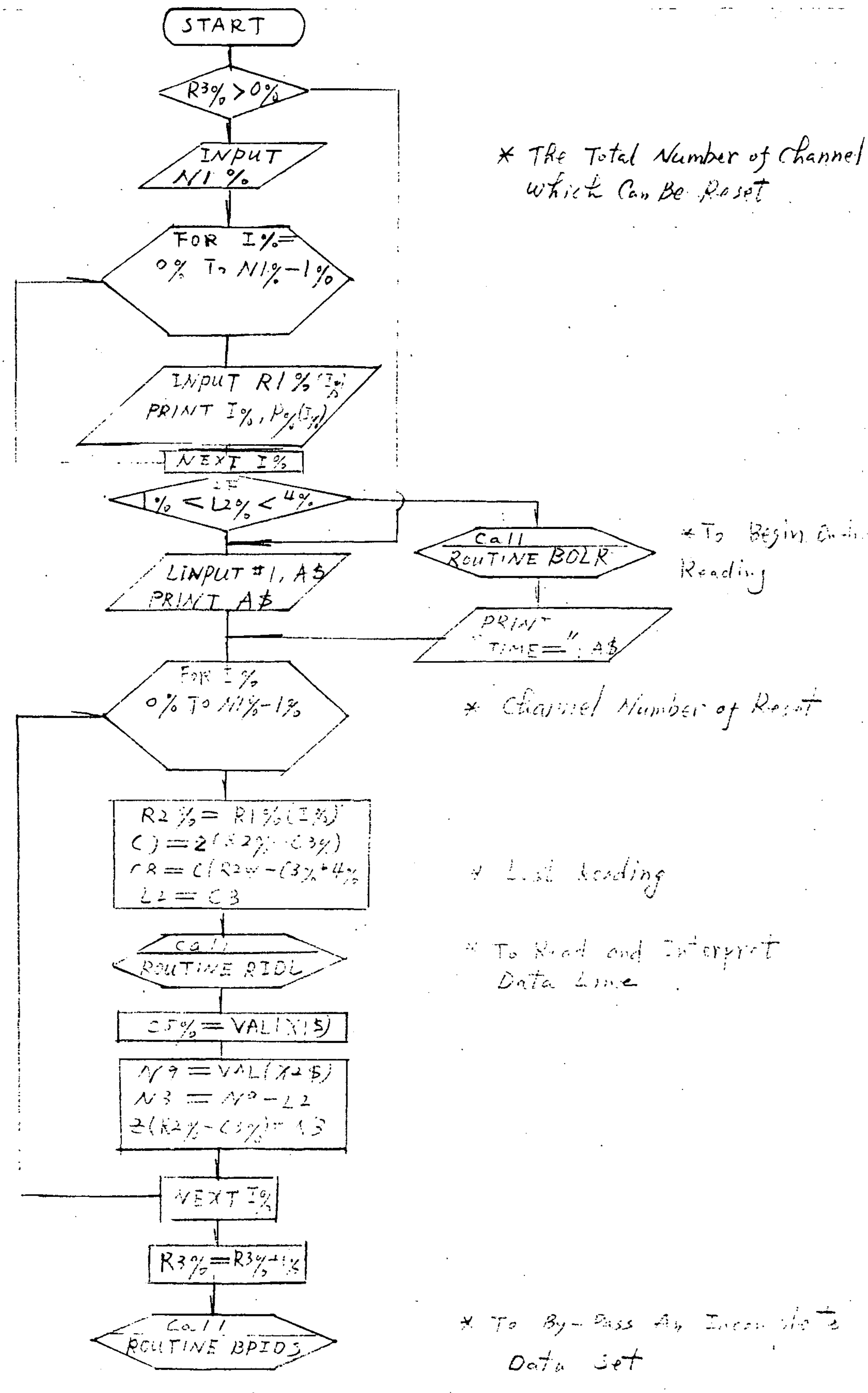


Fig 8 ROUTINE PRR (To Process Reset Readings)

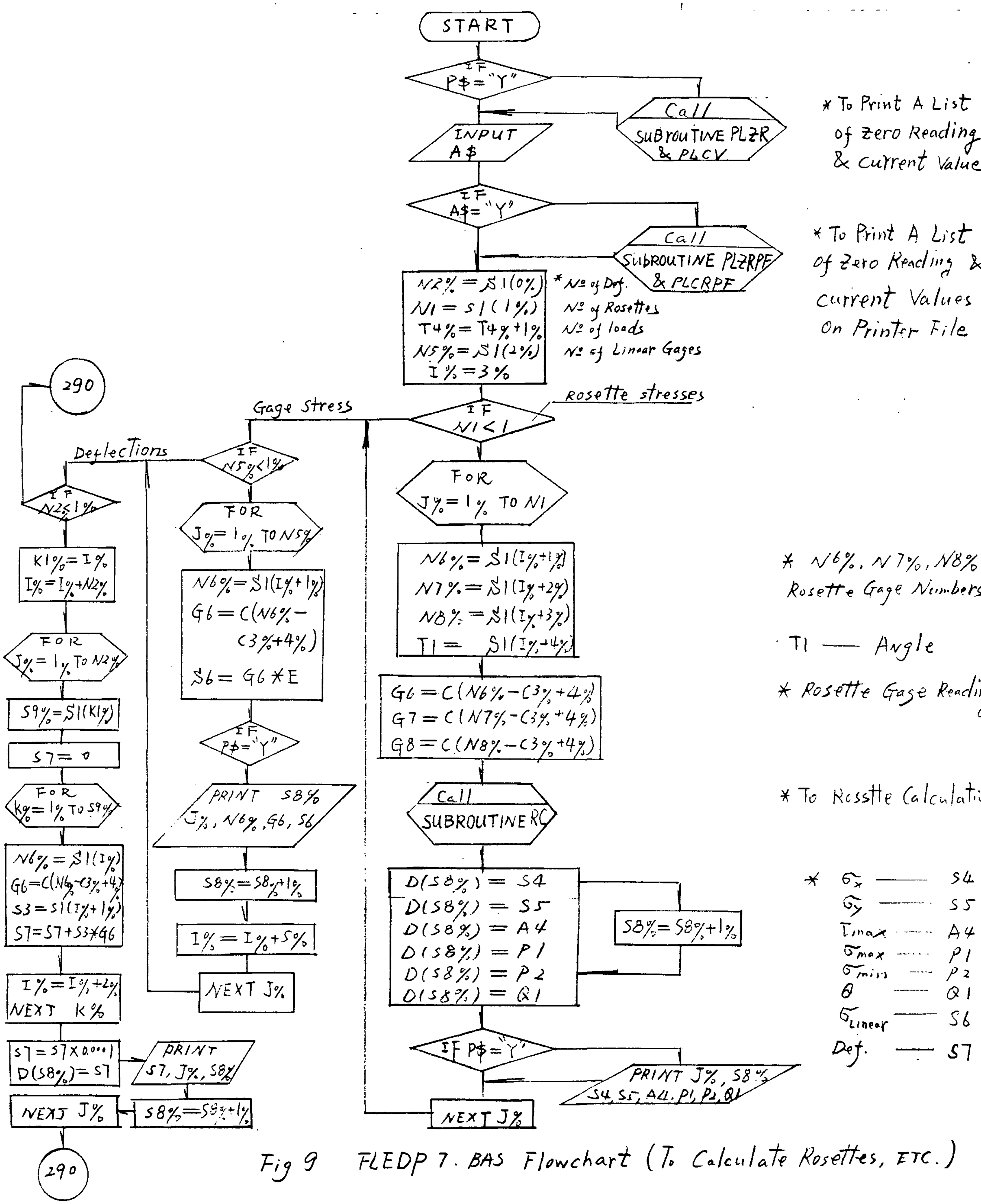


Fig 9 FLEDP 7. BAS Flowchart (To Calculate Rosettes, ETC.)

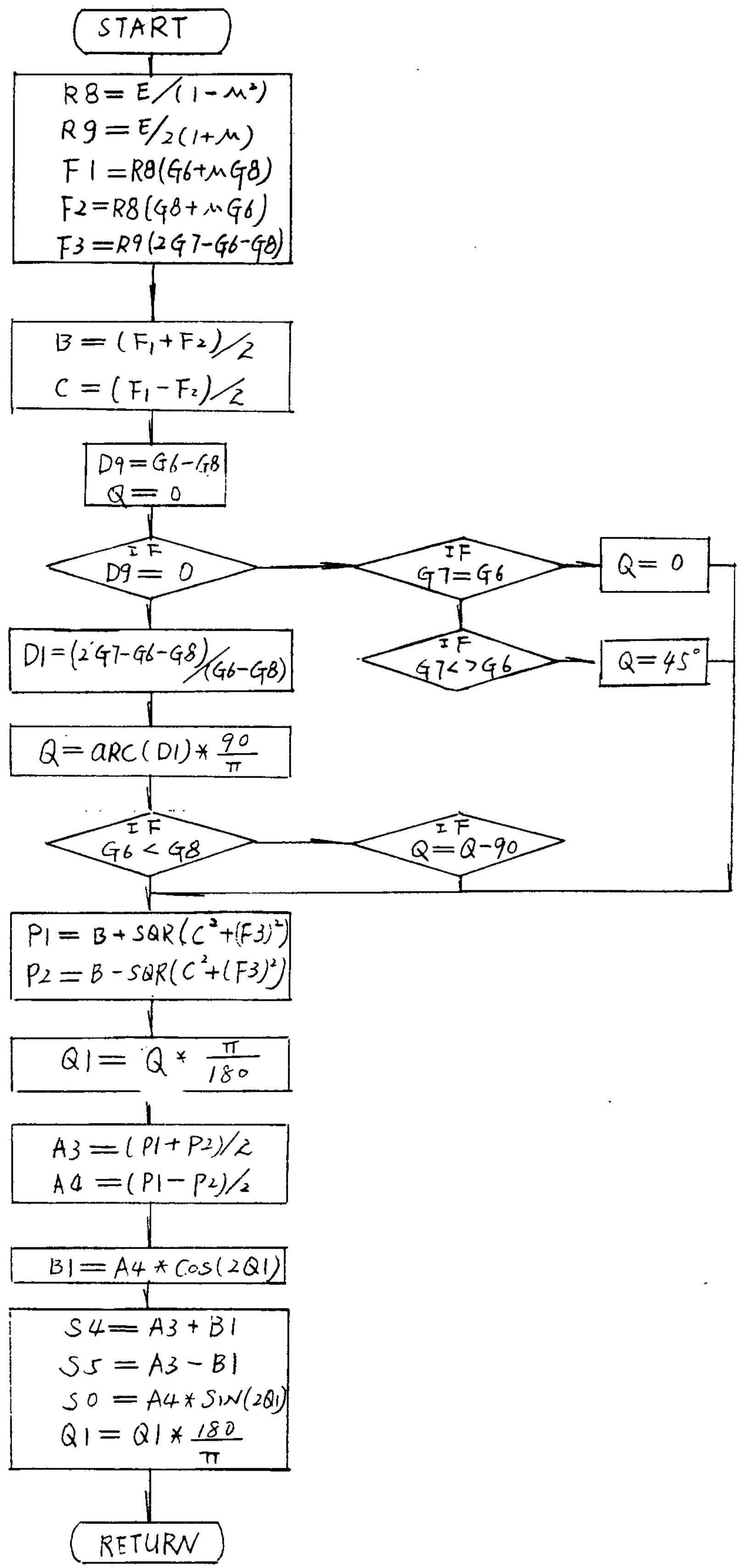


Fig 10 SUBROUTINE RC Flowchart (To Calculate Rosette Results)

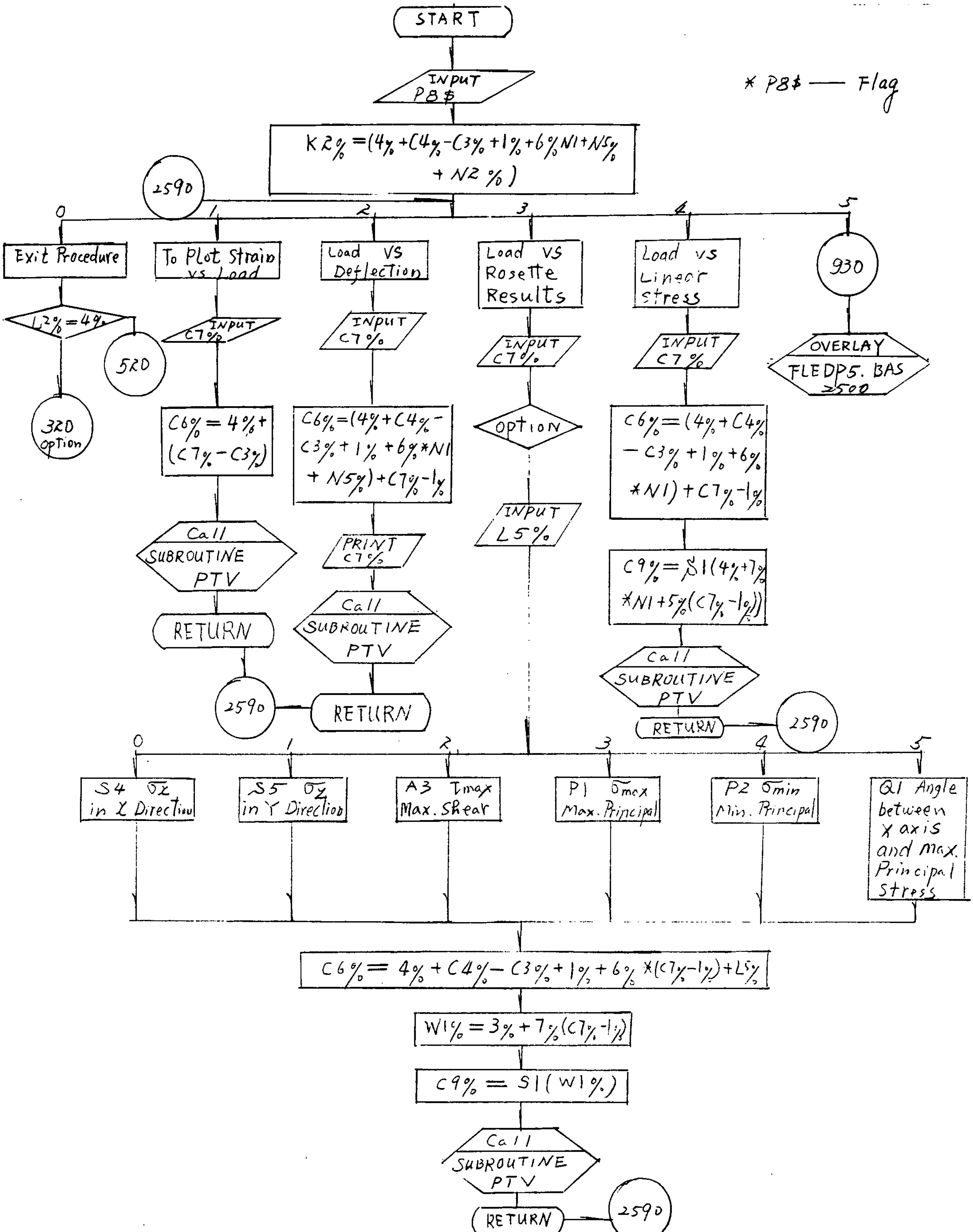


Fig 11 FLEDP4. BAS Flowchart (To Plotting Results)

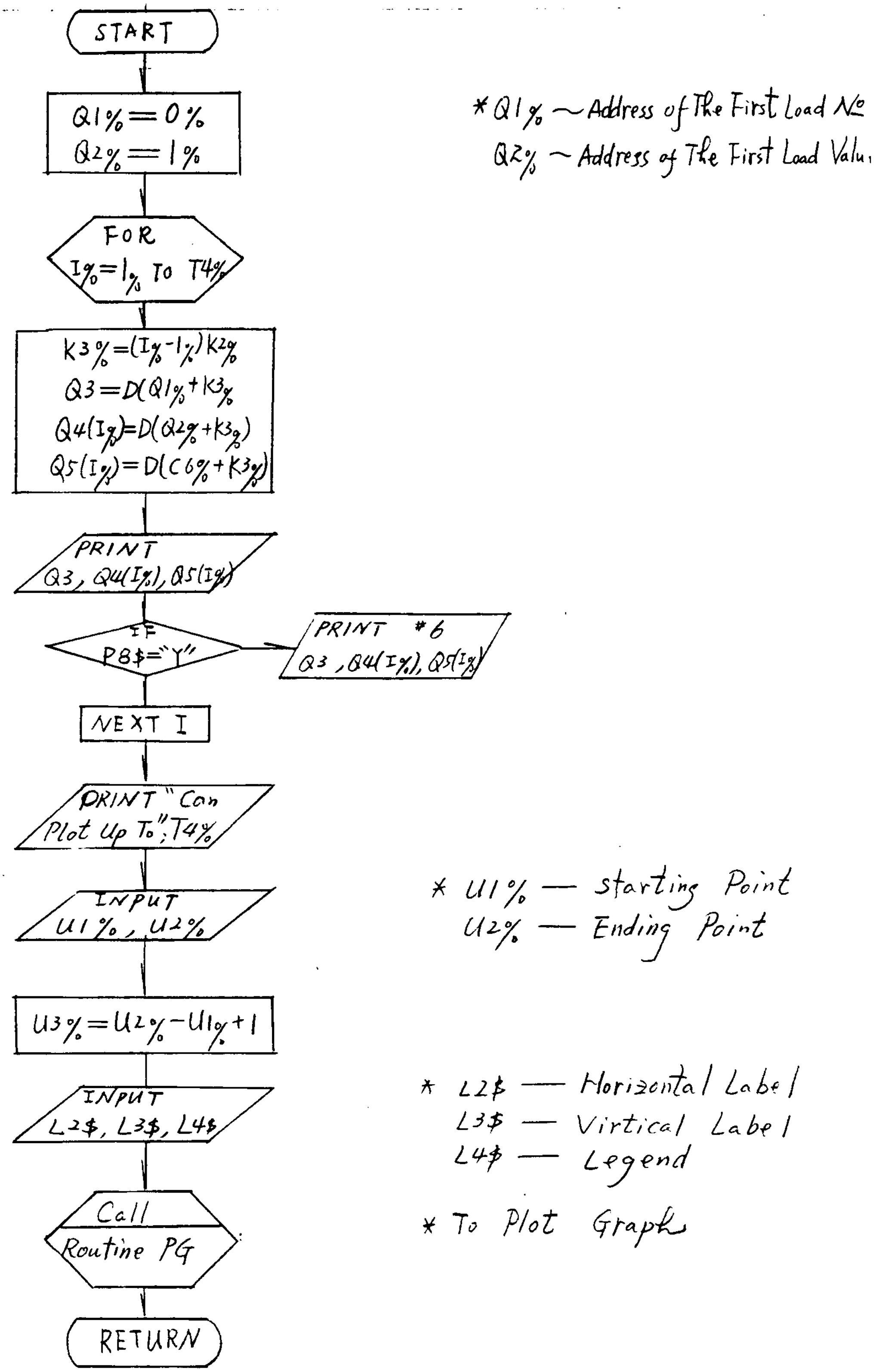


Fig 12 ROUTINE PTV Flowchart (To Print Table of Value)

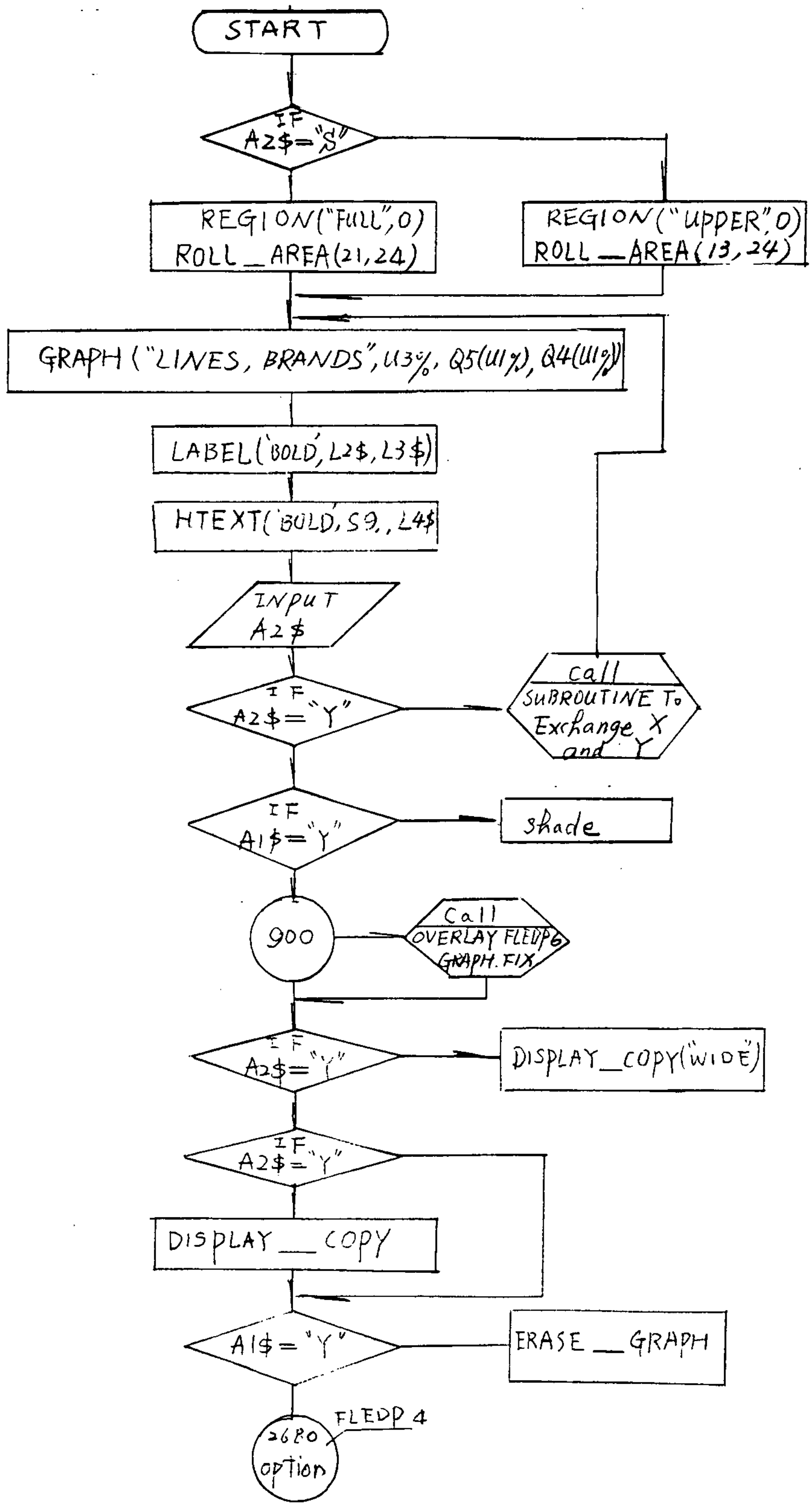


Fig 13 Routine PG Flowchart (To Plot Graph)

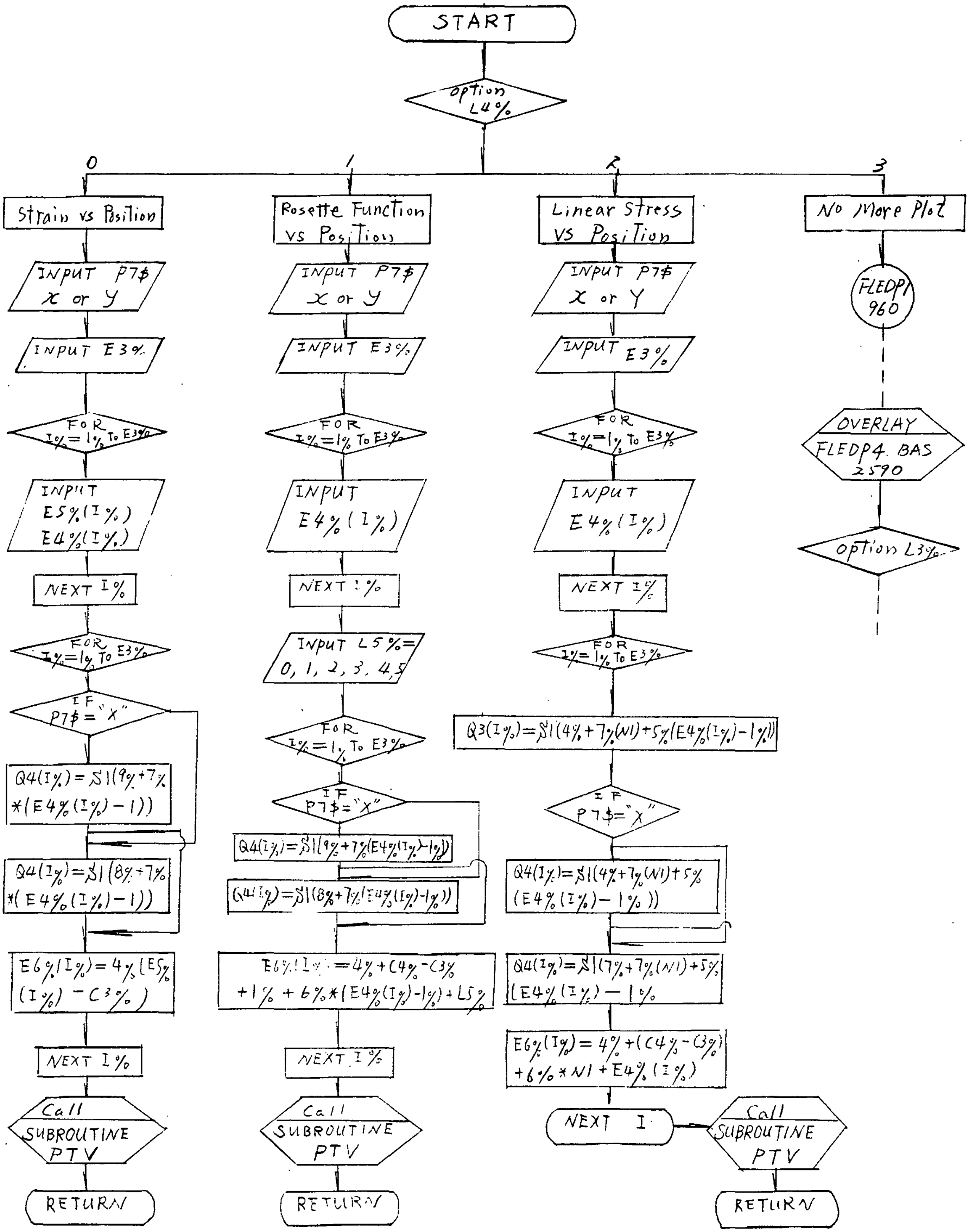


Fig 14 FLEPF5. BAS Flowchart (To Plot Results vs Position)

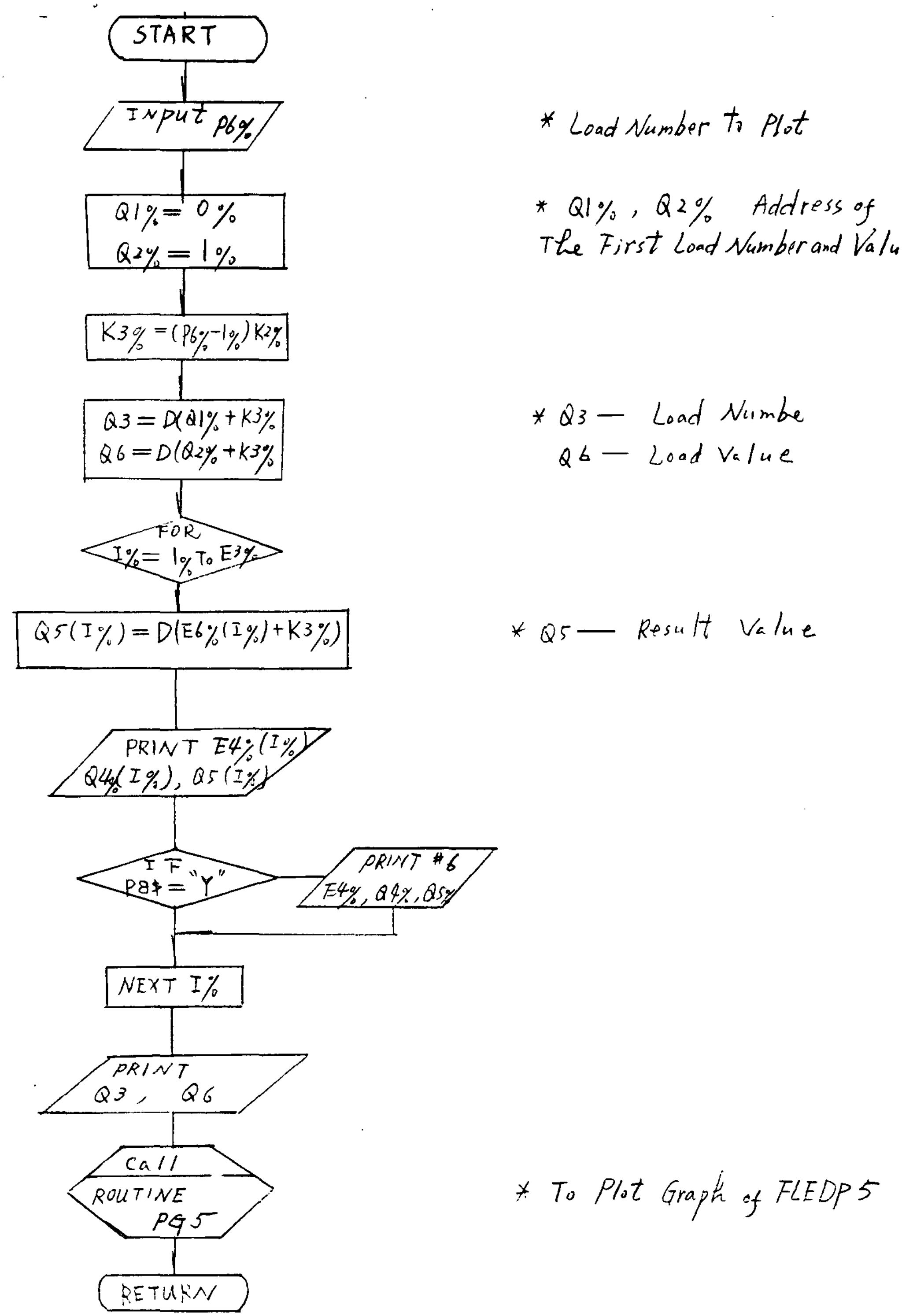


Fig 15 ROUTINE PG5 Flowchart (To Plot Graph of FLEDP5)

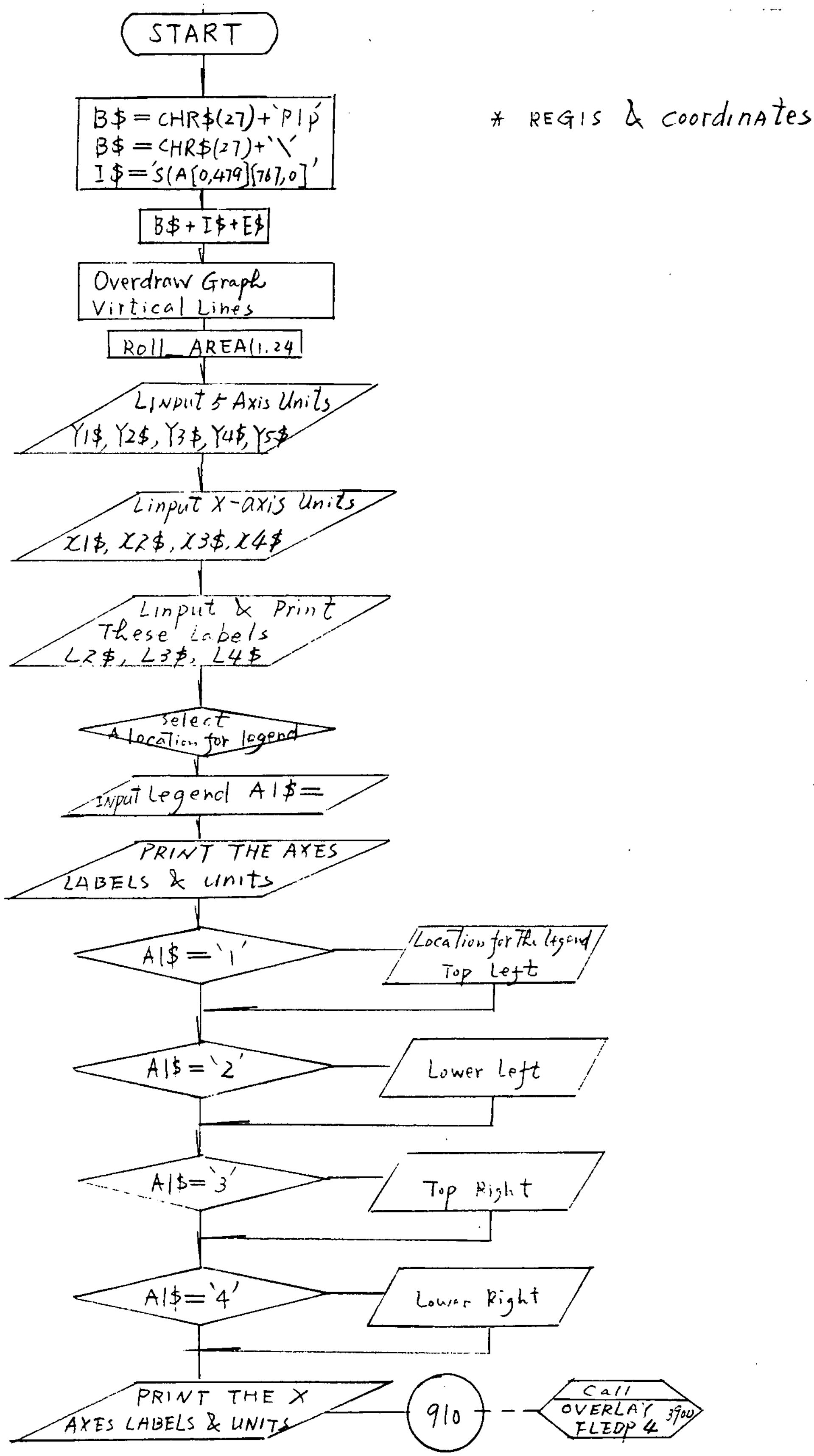


Fig 16 FLEDP6.BAS Flowchart (GRAPH.FIX)

I. APPENDIXES

I.1 Flow Charts

I.2 SYMBOLS

Symbols in Program FLEDP1.BAS

A$	Input string
A1$	Answer (Y or N)
A2$	Answer (Y or N)
A3	Calculation term for rosettes
A4	Calculation term--maximum shear stress
B	Calculation term--average stress
B1	Calculation term for rosettes
B3$	String " (blank) "
B%	
C	Calculation term for rosettes
C(100)	Array storage for readings
C$(10)	Temporary location for string values
C0$	Calibration constant (string)
C1%	Lowest channel number
C2%	Highest channel number
C3%	Lowest channel number
C4%	Highest channel number

C5%	Channel number being checked
C6%	Location of first value of a given reading in the D virtual array
C7%	
C8	Reset channel
C9	Zero reading
C9%	Channel number for plotting linear stress
D1	Current reading
D9	Zero denominator test value
D(6000)	Virtual array
E	Modulus of elasticity
E1	Strain value
E2%	
E3%	Number of rosettes or linear gages in a plotting group
E4%(50)	Array to store subscript numbers of rosettes or linear gages in a group for plotting
E5%(50)	Strain channel number in a group
E6%(50)	First address for a set of results in virtual array
F1	Calculated term for rosettes
F2	Calculated term for rosettes
F3	Calculated term for rosettes
F$	String form in which filenames are defined
F1$	TAPE**.DAT file

F2$	Virtual array file
F3$	ROSE**.DAT file
F4$	SETO**.DAT file
F5$	SETI**.DAT file
F6	PLOT**.DAT file
G6	First gage reading of a rosette
G7	Second gage reading of a rosette
G8	Third gage reading of a rosette
I	For loop index
I%	For loop index
I1%	
J	For loop index
J%	For loop index
J4%	J4%=J%+4%
K	
K%	Number of channels for a selected deflection
K1%	FOR loop index
K2%	Increment for a complete data set in virtual array
K3%	Increment which locates data sets after the first in virtual array
L2	REAL version of last reading of a RESET channel
L1%	Option selection
L2%	Option selection

L3%	Option selection
L4%	Option selection
L5%	Option selection
N1	Number of rosettes
N3	New zero reading
N9	REAL version of new reading
N%(100)	Stored channel number
N1%	Total number of channels which can be reset
N2%	Total number of deflections stored per set
N4%	One less than total number of B & F channels
N5%	Number of linear gages
N6%	Channel number for first gage of a rosette
N7%	Channel number for second gage of a rosette
N8%	Channel number for third gage of a rosette
P1	Maximum principal stress
P2	Minimum principal stress
P6%	Load number selected for plotting
P$	Flag for debug printing
P6$	String value representing load number for a plot
P7$	Selection of coordinate x or y
P8$	Flag for sending plotting results to printer
P9$	Flag for printing debug information during plot preparation

Q	Angle between first gage and principal axis
Q1	Angle between x axis and principal axis Q1 = Q + @g(p)
Q1%	Address of the first load number in virtual array
Q2%	Address of the first load value in virtual array
Q3(50)	Load numbers stored for plotting
Q4(50)	Load values stored for plotting
Q5(50)	Result values stored for plotting
R1	
R2	
R1%( )	Array of channel numbers for reset channels
R2%	Channel number of a selected reset channel
R3%	Flag which indicates whether or not a reset has been made
R7%	Counter
R8%	Counter
R8	Calculation term for rosettes
R9	Calculation term for rosettes
S0	Shear stress (tau xy)
S1(200)	Setup array
S2	
S3	Signed multiplier for deflections
S4	Stress in x direction
S5	Stress in y direction

S6	Single linear stress
S7	Deflection
S7%	Temporary location
S8%	Counter for virtual array
S9%	Temporary location
T1	Angle between first gage and x axis
T2%	Load number to be plotted
T4%	Load set counter
U1$	Flag for short prints
V	Poisson's ratio
W1%	Address of rosette number which would be plotted
X$	
X1$	Segment of reading which contains channel number
X2$	Segment of reading which contains data value
X3$	Segment of reading which contains multiplier
Y%	
Y2%	
Z(100)	Array of zero values
Z1	

Symbols in Program FLEDP8.BAS

A$	Answer (Y or N)
A1	Angle between first channel and local reference axis
C3	Channel number
C1%	Lowest channel number in the experiment
C2%	Highest channel number in the experiment
N1(20)	Number of channels for a deflection
N2	Number of deflections in the experiment
N6	Number of three-branch rosettes in the experiment
N7%	Number of linear channels to be read separately. They may include channels which are part of a rosette.
N3	First channel number for a rosette
N4	Second channel number for a rosette
N5	Third channel number for a rosette
R1	Rosette number
R2	x coordinate of location of a rosette or linear gage
R3	y coordinate of location of a rosette or linear gage

I.3 PROGRAMS

Programs

Copies of Programs can be obtained by listing them on the LA34 Printer Directly from the floppies.

FLEDP*.BAS
JXR*.BAS and others listed in text

Sample Runs

Sample Runs can be obtained by following the beginning steps in RUNNING Programs. The prompts will be some help in executing.

ROSE00.DAT is a file that will setup a test run of the main program.

Files on Disk JHD01

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Data Processing Programs

JHDPRO.BAS -- Original (Obsolete) Program to input data, make calculations, and make plots.

JHDPR2.BAS -- Current Program to input data, correct data, and make calculations. It is too long to make plots. (There are some errors.)

JHDREV.BAS -- Current Program to review results and make plots. (The numbers on the menu list need correction).

ASCII Data Files (Can be read by "Type" or "Edit")

JHDSET.DAT -- Original file with setup data for both tests as one.

JHDSE1.DAT -- Current file with setup data for Test No. 1

JHDSE2.DAT -- Current file with setup data for Test No. 2

LIST.DAT -- A file listing the most recent results of reading a Virtual array data file.

Virtual Data Files: (Can only be read by RDVIRT)

JHDRAW.DAT -- Raw Data of both tests as one test of 19 load sets. (Some errors in Test 2)

JHDRA1.DAT -- Raw Data of Test 1 (8 load sets) as one test. (Probably OK)

JHDRA2.DAT -- Raw Data of Test 2 (11 load sets) as one test. (Needs revision)

JHDANS.DAT -- Answer Data of both tests as one test. Errors in Test 2. Does not have calculations with revised formulas.

JHDAN1.DAT -- Answer Data of Test 1 with revised calculation formulas.

JHDAN2.DAT -- Answer Data of Test 2. (Not yet calculated)

Graph Programs

GRAPH.XXX -- A BASIC program to fix graphs. Called as an overlay. (Short Programs)

GRAPH.YYY -- A BASIC program to fix graphs. Called as an overlay. (Long Programs)

Utility Programs

MNCHLP.HLP -- This program responds when you type: HELP. The system.

PRINTT.BAS -- Turn on the printer with leftmargin column 1. To type text.

PRINTQ.BAS -- Turn on the printer with leftmargin column 13. To type text.

STOPRI.BAS -- Turn of the text mode of printer. Now it can print graphs.

Utility Programs (Continued)

RDVIRT.BAS -- Read a virtual file from a designated first array term to a designated final array term. It creates an ASCII file LIST.DAT which can be read directly.

RDASCI.BAS -- Read an ASCII file.

CPYVIR.BAS -- To transfer values by subscript number from one virtual array file to another.

RDTAPE.BAS -- To copy a punched tape of ASCII characters into the MINC disk.

DEVICE.BAS -- To test connections with devices like B&F and Teletype to the MINC.

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7. REFERENCES