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TABLE OF CONTENTS — SDR

1. OVERVIEW

This application guide describes the operation of the SDR Electronic Field Book. The SDR collects and stores observations from survey instruments such as Sokkisha's SET3 and SDM3F. A complete range of field data collection programs and calculation programs are provided so that observations can be checked and verified in the field. Observations are taken automatically from electronic survey instruments and can be entered via the keyboard for optical instruments. The stored data in the SDR can be transmitted to a variety of different types of data processors in a variety of ways.

If you have not used the SDR before it is recommended that you first read Section 2 which contains instructions on setting up the SDR, connecting it to survey instruments, changing batteries and maintenance. After reading Section 2 read the Getting Started Guide which explains the operation of the unit and provides examples for you to follow. The remaining sections of this guide explain the operation of the SDR in detail.

Section 3 contains general information on the keyboard layout, data entry and menu selection.

Section 4 contains a description of the storage of data within the SDR and instructions on how to use the review keys to examine the table.

Section 5 contains a full description of the menu of functions provided by the SDR. These include functions for defining and reviewing the survey job, printing, communications and examining and changing parameters.

Section 6 covers the configuration variables and Section 7 describes the procedures for taking and recording instrument readings.

Section 8 covers the input of notes. The calculating methods used throughout the system are specified in Section 9 and the ten programs are described in Section 10.

This document relates to software version SDR V03 re-check the parameters (detailed in Section 5.8 of this manual). Browse through this manual; you will find that your SDR will perform simple tasks simply, and yet it has features that make it the most powerful and most flexible electronic field book.

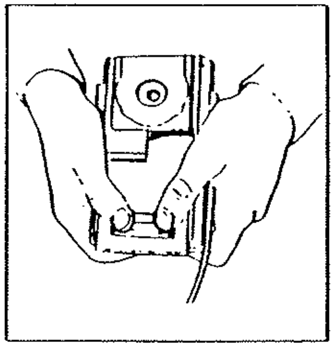
2.2 Changing Batteries

When the batteries are getting low the SDR will display a battery symbol in the right-most position on the screen. It will also warn with the message "Battery is low". You should replace the batteries as soon as possible. If the batteries get very low the SDR will warn with the message "Battery is dead" and switch itself off.

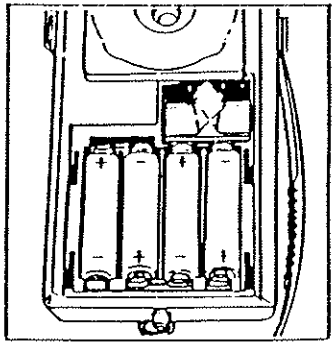
The procedure for changing batteries is as follows:

1) Turn the SDR off.
2) Remove battery compartment cover (see diagram).
3) Remove old batteries.
4) Install new batteries in direction indicated (see diagram).
5) Replace battery compartment cover.

Ensure that the new batteries are installed within 3 minutes of the old batteries being removed, or loss of data may occur. For safety, you may wish to change the batteries only when the SDR has no data in its memory. Alkaline "AA" size batteries should be used.



Removing the battery compartment cover



Position of batteries

2.3 Malfunctions

If a malfunction with the SDR occurs, follow the check list below. If none of the listed remedies is successful, it may be necessary to unlock and restart the SDR (described in Section 2.3.2); if this is unsuccessful it may be necessary to reset the SDR (described in Section 2.3.3); however, this procedure erases all data in the SDR and should be used only as a last resort. If resetting is not successful, or the malfunction is clearly a hardware problem, or if the message "EPROM failed" or "RAM test failed" appears at any time, contact your distributor.

2.3.1 Check List

1) Do the batteries need replacement? If the SDR gives the message "Battery is dead" when you press the ON key, or if the display is blank and there is no response to the ON key, replace the batteries as soon as possible according to the instructions in Section 2.2.

2) Is it unfamiliarity with the software? If so, try pressing the CLEAR key repeatedly; if the SDR asks any questions, or you see the word 'CONFIRM', answer by pressing the Y key or the N key. Soon the SDR should return to the "Select operation" display.

3) Did you remove a battery without first pressing the OFF key? Replace the battery and press the ON key. The SDR should display "Busy...", then "Data is OK", then "Select operation".

4) Has the SDR locked up? If the SDR won't respond to any keys, then it is said to have "locked up". This can occur through hardware fault (such as improperly inserted EPROM), software fault, or disruption through radio interference or connection to a non-standard or faulty communications device.

2.3.2 How to Unlock and Restart the SDR

If the SDR has locked up, follow these steps:

Step 1:	Remove the battery compartment cover.
Step 2:	Remove one of the batteries, then re-insert it.
Step 3:	Replace the battery compartment cover.
Step 4:	Press the ON key.

The SDR will check that your data is intact. If so, it will display "Data is OK", then "Select operation". See section 4.6.

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3. GENERAL OPERATION

3.1 Keyboard Layout

The keyboard comprises 33 keys, as shown in Figure 1. Certain keys have standard functions:

ON turns the SDR on. The SDR will also be started up if it is connected to an instrument which is then turned on.

OFF turns the SDR off. The SDR will also turn itself off if it is not used for approximately 1 minute. It does this to save battery life. However, even when turned off the memory of the SDR is always retained.

CLEAR is used for two purposes. First, during data entry, press the CLEAR key to remove all characters entered so far. This allows you to start entering the field again. Second, in other situations, pressing the CLEAR key will cause the SDR to exit or escape from the current operation.

BKSP removes the last character entered in a field of data.

SHIFT is used to change the shift of the keys when entering an alphanumeric field. Entry begins in alphabetic shift. When in alphabetic shift an underline cursor appears under the current position in the data field.

SP is used to enter a space character in either upper or lower shift.

ENTER is used to indicate the end of input when entering a field of data and sometimes to accept values which the SDR displays.

EDIT is used to change some parameter values.

In addition, two other keys are used for special purposes:

Y is referred to as the YES key, and is used in response to questions, such as "Resume?"

N is referred to as the NO key.

Whenever a key is pressed, the SDR emits a brief tone or key click. All keys except ON and OFF will auto repeat. That is, if a key is held down for more than half a second, it will repeat at 6 times per second until it is released. This has the same effect as pressing the key 6 times per second.

3.2 Starting Position

When the SDR is turned on it will display:

```
Select   operation
MENU  PROG  ^  NOTE
```

This is referred to the starting or base position. The different operations of the program are selected from this base position, as shown in Figure 2.

Reminder: If you wish to quit or escape from any situation, press the CLEAR key. By pressing the CLEAR key several times and answering questions with Y or N you will always be returned to the starting position.

The allowed operations are initiated by the following keys:

[MENU]

MENU causes the SDR to display the functions menu. Refer to Section 3.5 for instructions on menu operation and Section 5 for information on the functions menu.

[CNFG]

CNFG causes the SDR to display the configuration menu. Refer to Section 6 for detailed information.

[PROG]

PROG causes the SDR to display the programs menu. The twelve resident programs are described in Section 10. External programs are described in Section 5.7.

[READ]

READ causes the SDR to take an instrument reading. Refer to Section 7 for more details.

[AUTO]

AUTO causes the SDR to take an automatic instrument reading. See Section 7.

[↑]

UP causes the SDR to display the data which is stored in memory. Refer to Section 4.3 for a discussion on data review.

[NOTE]

NOTE causes the SDR to record a note. Refer to Section 8 for details.

[STAT]

STAT causes the SDR to display a software version number, copyright message, perform a self test and show memory utilization. Refer to Section 4.4 for details.

When an operation is complete the SDR returns to the starting position.

If you are using the SDR for the first time, the operations which need to be performed initially are the setting of parameters (Section 5.8) and the definition of your first job (Section 5.1).

3.3 Data Entry

Whenever data entry is required, the display shows a prompt (e.g. "Dist") and either a datum field (e.g. "______") which defines the maximum size of the entry or the current value for the field (e.g. "Dist 712.492").

If the context allows, you may press the CLEAR key at the beginning of the field to escape entry. If a current value or default is shown, you may press ENTER at the beginning of the field to indicate that the displayed value is to be retained.

For simple (integer) numeric entry, only digits can be entered. For full floating-point (real) numeric entry, a minus sign ("-") may be entered at the start of the field, and the number may contain a decimal point.

For alphabetic entry, the letters, digits and special characters may be entered. The SHIFT key toggles between alphabetic and numeric shifts. Alphabetic shift indicated by an underline cursor gives access to the letters, BKSP, SPACE, SHIFT, CLEAR and ENTER. Numeric shift, indicated by a flashing rectangle cursor, gives access to the digits, "-" and ".", EDIT, the four arrow keys, BKSP, SPACE, SHIFT, CLEAR, and ENTER. The EDIT key toggles between insert and overwrite mode. The LEFT and RIGHT arrow keys allow you to move the

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4. DATA STORAGE AND REVIEW

All survey data held by the SDR can be examined by the operator. The data can be visualized as a large table which is organized and maintained automatically.

Data is stored in records of different types; each row of the table contains one record. Whenever a new record is to be stored, for instance when an observation is recorded, it is added at the bottom of the table. In this way the SDR maintains a chronological log of all survey data for each job.

4.1 Record Types and Format

Since the SDR deals with a wide variety of data, there are different types of records in the table. A complete list of the different record types and their contents is shown in Figure 29. It should be noted that the units or dimensions of stored quantities generally depend on the current settings of system parameters; these are described fully in Section 5.8.

The first field of every record contains identification data; this allows the operator to instantly recognize the record's type, the origin or derivation of the data, and any point identification numbers associated with the record.

The general format of the identification display is:

RRR DD SSSS-TTTT

where RRR is a record type code; see Figure 29.
DD is a derivation code; explained below.
SSSS is the source (or "from") point number, if any.
TTTT is the target (or "to") point number, if any.

Derivation codes are:

F1 - observation uncorrected for instrumental and environmental factors and measured with face 1 (direct position) of the theodolite

F2 - as above, but measured with face 2 (reversed position) of the theodolite

MC - measurement corrected for instrumental and environmental factors

AR - Area program

where

a is the software version
b is the release number of the software version.
(There can be several releases of the same software version)
c is the total amount of memory available
d is the memory size
e is the processor speed (2 or 4 MHz)

The status message scrolls across the screen like a NOTE, and the arrow keys can be used to stop and reverse the scrolling direction.

After displaying the status message, the SDR performs a diagnostic test on its memory (EPROM and RAM). If the SDR shows "EPROM failed" or "RAM test failed", contact your distributor.

4.5 Space Allocation

There can be any number of jobs in the SDR, as long as they all fit into the total memory size available. However, any one job is limited to a total size of about 30 Kbytes, which is about 1100 observations or coordinates without codes. When this limit is approached, the SDR warns "Job nearly full" and finally "Job is full". To continue, just create a new job. Of course, if the SDR memory is totally full, this will not be possible. At least one job must be transmitted and cleared to make room. The status message given by the STAT key indicates how much memory is left in the entire SDR.

From the information on record sizes given in Figure 29, the total memory requirement for a particular application can be calculated. Two additional factors must be taken into account:

1) The given record sizes do not include space used for storage of alphanumeric codes or notes. Codes require one byte each plus one byte per character entered.

2) There is a fixed overhead of space used internally by the program. This is approximately 4570 bytes.

Example

Fixed overhead	4,570
JOB record	13
ATMOS record	16
INSTR record with no theodolite note	41
20 STN records with 10-character notes (20 x 42 = 840)	840
1000 OBS records without notes (1000 x 26 = 26,000)	26,000
Total use of available space	31,480

The amount of memory available in an nK SDR is calculated by n x 1024. For example, a 64K SDR has 64 x 1024 = 65536 bytes.

4.6 Data Integrity

The SDR maintains a checksum of the data in its table, which is updated whenever data is added or removed. Consequently it is able to determine if the data has been accidentally changed. This check is made in three places: just before transmission, after a restart (section 2.3.2), and when the STAT key is pressed (section 4.4).

The SDR will show "Busy..." while it checks the data. If the data has changed, the message "job is corrupt" will appear on the display, and the user must press a key to continue. If this happens, transmit your data as soon as possible and reset the SDR (section 2.3.3). Examine the transmitted data to determine if parts have been corrupted.

To select an existing job, press the UP or DOWN arrow keys to look at the menu of jobs present. Press ENTER to select one. The message "Job found" is displayed briefly, indicating that the job is now current. Any subsequently-entered data will be appended to this job.

5.1.2 Scale Factor

```
Job
S.F.      1.0000000000
```

The SDR will display the current scale factor if job details are being reviewed. It is not possible to alter the scale factor of an existing job as it will have been used in calculations. For a new job the default scale factor of 1.0 will be displayed which can be changed by keying a new value or retained by keying ENTER. The scale factor is applied as a point scale factor in projection corrections (see Section 9.2). The scale factor must be greater than zero.

5.1.3 Job Notes

The purpose of this prompt is to allow entry of additional descriptive detail about the job. For example:

Weather details
Operator and crew members
Pressure and temperature (If not recorded under station details)

For new jobs the SDR will ask:

```
Job
Note ____________
```

The descriptive detail is entered as per note input, Section 8. To exit from notes input, key ENTER in the first character position.

For existing jobs the SDR will display the job notes by scrolling them across the screen. Keying ENTER will terminate the review and move on to the next note record, if any. On completion of the review, or if there were no notes, the SDR will prompt for further notes to be added:

After the job notes have been completed the SDR will record the current date and time.

5.1.4 Job sizes

An SDR job can contain up to about 1100 observation or coordinates without codes, that is about 30 Kbytes. Once a job is full, a new job must be created before any more data can be recorded. See Section 4.5 (Space Allocation) for more details.

5.2 Printed Output

The Printed Output function generates a printed report of all survey data held by the SDR. The entire contents of memory may be printed or jobs may be printed selectively. The data format of the report is identical with that used for data review, except that the degrees sign (°) is replaced by the hyphen (-). All records are headed by an identification display, and all fields are preceded by an explanatory prompt. Print lines do not exceed 80 characters, and each is terminated by a carriage return and line feed. Figure 3 shows an example printed report.

To print the report, set up the printer and connect it to the SDR with the RS232 interface cable. Alternatively set the ACOUSTIC parameter to yes and connect the SDR to the telephone for remote transmission of the report. Ensure that the transmission speed and parity options are correct by checking the SPEED and PARITY parameters under 'Comms Setup' (See Figure 5 on Parameters for details.) Then select the Printed Output function.

The SDR asks:

```
Printed   output
Print all jobs?
```

At this point press the YES key to begin printing all the data held in the SDR. To print a single job, press the NO key, to which the SDR will respond with a menu of the current jobs in memory.

```
Select   job
>Job  Id   TOPOJOB
```

The job displayed may be selected for printing by pressing the YES or ENTER keys. Other jobs may be selected by pressing the UP or DOWN keys.

The printed report may also be initiated from the review function. If the SP key (SP for Special Print) is pressed while

5.3 Data Transmission

The Comms Output function is used to transmit the data held by the SDR to a computer or backup storage device using either the built-in acoustic coupler or the RS232 interface. Data transmission will generally be used for one of two purposes:

(1) Transfer of all collected data to a computer for further processing.

(2) Transfer of collected data to another device for storage.

The format of the data transmission depends on the setting of the FORMAT Comms setup parameter. If this is ASCII, a standard SDR2 format is sent as described in Appendix B. If it is set to Binary, a compressed binary format is sent. This is faster, but requires a special program on the receiving computer to decode the information. (i.e. SDRlink or SDRmap)

To transmit the data, connect the SDR to the receiving device with the RS232 cable or establish the telephone link and connect the SDR to the phone. Ensure that the current settings of the Comms setup parameters SPEED, PARITY, ACOUSTIC and FORMAT are correct. Then select the Comms Output function.

The SDR asks:

```
Comms   output
Send  all  jobs?
```

Press the YES key to begin transmitting all the data held in the SDR. To transmit a single job, press the NO key, to which the SDR will respond with a menu of the current jobs in memory. The job displayed may be selected for transmission by pressing the ENTER or YES keys. Other jobs may be selected by pressing the UP or DOWN keys.

Transmission may be interrupted by holding the CLEAR key, as for the Printed Output function.

5.4 Data Input Using Communications

Known coordinates, directions and other survey information can be transferred en masse from a computer to the SDR. For example coordinates can be loaded for subsequent use in the setting out program or backsight directions for use in the

traverse program. The Comms Input function can be used to load the SDR with data before it is taken into the field; afterwards, the Comms Output function, which is described in Section 5.3 can be used to transmit all the loaded and collected data to another computer.

Feature codes can be automatically loaded into the SDR from a computer via the Comms Input function. Send the feature codes in the form of SDR NOTEs with a derivation code of FC, for example"13FCLamppost". The SDR will replace any existing feature codes with the new ones in the received data, but will not store the FCNOTEs in the table with the other data.

The format of the transmission expected by the Comms Input function is described in detail in Appendix B. Several jobs can be sent in one session. Trailing blanks on a record are optional.

Before initiating the Comms Input function, ensure that current settings of the PARITY and SPEED parameters are correct. The maximum speed for comms input is 4800 baud.

The function will add received data to the existing table; if the existing data is not required, first use the Clear Memory function described in Section 5.6. Connect the SDR to the data source with the RS232 cable. Then start the Comms Input function. The SDR will display "Receiving..." and the cursor will begin to flash on receipt of the first record.

While receiving, the SDR issues XON/XOFF flow control commands while it reorganizes internal data. This allows it to receive almost the maximum amount of data that it can transmit. This feature only works at up to 2400 baud.

If too much data is sent to it, the SDR warns "Job is full" and retains all data sent to it up to that point.

When the transmission phase is complete the SDR displays "Loading..." while it reorganizes the data into the required internal representation.

The function checks parity, record sizes, the amount of free memory space, data content and the checksum value. If the input is satisfactory, the SDR displays "Input accepted" until any key is pressed. If there is an error, the correct data is saved, and an appropriate error message is shown. These messages are described in Appendix A.

Note that if coordinates are loaded for use in the traverse program, they must have a keyboard input (KI) derivation code.

Wrong version - the external program version did not match the SDR version.

5.7.2 External Program Operation

External programs loaded via a tape or disk appear as the last programs on the programs menu. They are selected in the same manner as the twelve resident programs. Operating instructions are supplied with each external program. When you have finished with an external program the memory space it occupies may be reclaimed by deleting the program using the facilities provided in the Clear Memory function (section 5.6). The program can be reloaded when it is next required.

5.8 Time and Date

The SDR will display 24 hour time in the form:

```
Time  and  date
Time  HH:  MM
```

If this time is correct key ENTER. To enter a new time key the hours (in 24 hour time), ENTER and then the minutes. e.g. Time 09:05

The SDR will next display the date in the form:

```
Time  and  date
Date     DD-MMM-YY
```

If the date is correct key ENTER. A new date may be entered by keying the day, ENTER, the three character month, ENTER and then the year. e.g. Date 04-Jun-88. The clock starts at 00 seconds following the ENTER when the "YY" year is input.

If either the time or date was changed a note record with the new time and date will be generated with derivation code KI.

The current time and date may be recorded whenever the SDR is showing "Take reading" or "Select operation". This is done by pressing the "T" key. The SDR will ask "Record time?" and if the YES key is pressed then a note record containing the time and date will be generated with a KI derivation.

The time stamp interval is used to record the time and date whenever an activity occurs except where two or more activities

occur within the time stamp interval. A note record is generated showing the current date and time, with derivation code TS. The time stamp interval has a default of zero meaning that no time stamping will occur. After the date has been reviewed or corrected the time stamp interval in hours and minutes is displayed:

```
Time  and  date
Interval    00: 00
```

If this is correct key ENTER. To enter a new interval key the hours, ENTER, and then the minutes, ENTER.

SDR Survey parameters

There exists a wide range of methods and standards for surveying practice throughout the world. To meet the different requirements, a large amount of flexibility is incorporated into the SDR. This is effected by a set of parameters which can be examined and set. Generally, it will only be necessary to set these parameters once when the SDR is purchased.

There are two types of parameters. Menu parameters such as "Angle: Degrees" can be changed by pressing the EDIT key and examining the range of settings available by pressing the UP and DOWN arrow keys. At this point you may press CLEAR to restore the original setting or ENTER to select the displayed value. The other parameters such as "Tol H.obs: 0'00" or "Sea level crn:Y" can be changed directly by entering the desired value.

Figure 5 has a full description of all parameters and the options available.

5.9 Corrections menu

These three parameters control whether the calculations apply:

1) Sea level correction
2) Curvature and refraction correction
3) Atmospheric correction

as specified in section 9.

If any of these values are changed, a NOTE with a derivation code of CP (for Corrected Parameter) is automatically generated indicating the new value. In this way, it is possible to deduce from a printout what corrections were applied to any given calculation.

Figure 4 - continued

INSTRUMENT PARAMETERS

PARAMETER (prompt) Description	OPTION Default *	NOTES Explanatory section
EDM OFFSET (EDM o/s)	default null zero	Height of the EDM above the theodolite. Asked only for non total station instruments (9.1.2).
REFLECTOR OFFSET (Refl O/s)	default null	The height of the reflector prism above the theodolite target. Asked only for non total station instruments (9.1.2).
PRISM CONSTANT	zero *	The value (P.C.mm-) representing the optical distance from the plumb-line to the reflective surface of the prism. Must always be entered in millimeters irrespective of distance parameter. (9.1.3).

Figure 5

PARAMETER (prompt) Description	OPTION Default *	NOTES Explanatory section
	UNIT PARAMETERS	
ANGLE UNIT (Angle:) All angles	Degrees * Gon	360° to the circle 400 gon to the circle
DISTANCE UNIT (Dist:) All distances, heights and coordinates except prism constant and EDM tolerances	Metres Feet *	feet x 0.3048 = metres
PRESSURE UNIT (Press:)	MmHg Inch Hg * mbar	Millimetres of mercury Inches of mercury Millibars (10.1.2)
TEMPERATURE UNIT (Temp:)	Celsius Fahrenht	Degrees Celsius Degrees Fahrenheit
COORDINATE PROMPT (Coord:)	N-E-Elv * E-N-Elv	North, East, Elevation East, North, Elevation
	CORRECTION PARAMETERS	
SEA LEVEL CORRECTION (Sea level crn:)	Y N *	Yes - applied No - not applied (9.2.2)
CURVATURE & REFRACTION CORRECTION (C and R crn:)	Y N *	Yes - applied No - not applied (9.1.6)
PRESSURE & TEMPERATURE CORRECTION (Atmos crn:)	Y N *	Yes - applied No - not applied (9.1.5)

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6. CONFIGURATION VARIABLES

This menu gives access to variables that are more frequently changed. The configuration menu can be reviewed and the variables altered by keying CNFG at either:

Select operation
Take reading (or Take face one, Take BS reading etc)
Programs menu

The current setting of each variable is displayed as the list is reviewed with the UP and DOWN arrow keys. The current setting may be changed by directly keying in the change. At this point CLEAR restores the original setting and ENTER selects the displayed value.

The configuration variables and their options are shown in Figure 6.

distance, vertical angle and horizontal angle from the instrument. The configuration variable "Record dist" determines what will be read, and the type of instrument determines how measurements will be read, either electronically or input manually from an optical instrument. For example if the distance configuration variable is set to not request distance and the instrument type is SET (Lietz' fully electronic total station) only the two angles will be requested and the distance recorded as null. If the instrument type was manual only the vertical angle and horizontal angle would be requested from the keyboard.

The instrument reading routine has three further features:

- Multiple distance readings
- Offset readings
- Theodolite-only mode

OPERATION MANUAL SDR

Figure 7

Instrument Reading

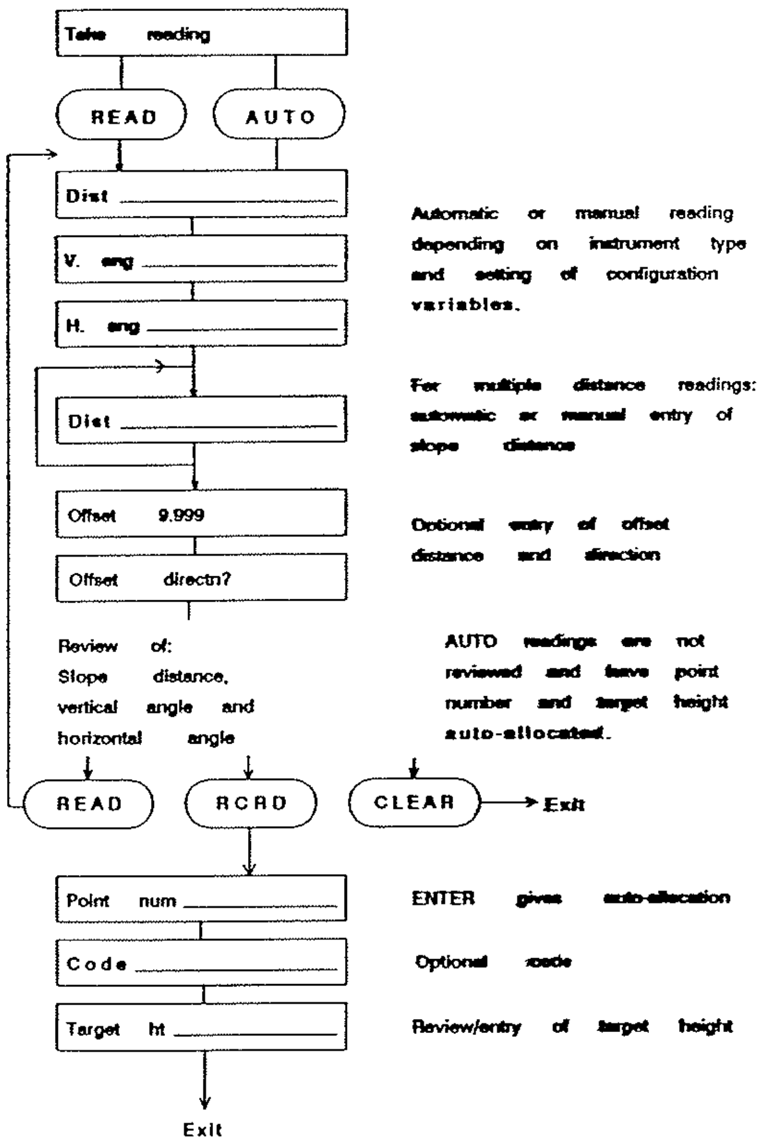
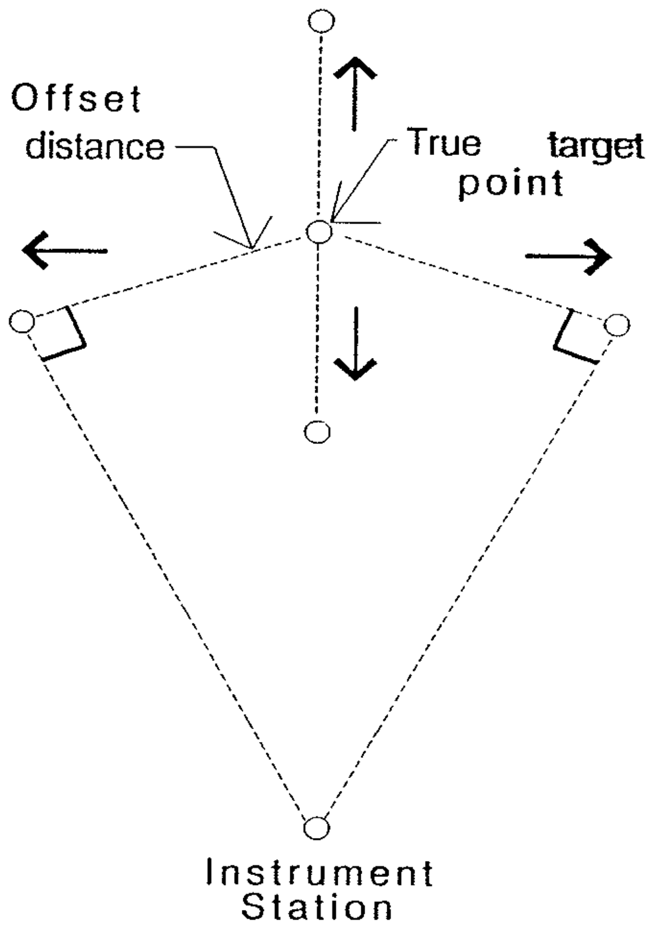


Figure 8

OFFSET CALCULATION



Offset direction:

→ Prism is Right of object

← Prism is Left of object

↓ Prism is in Front of object

↑ Prism is Behind object

7.3.2 Calculated offsets

In this method, the prism is placed at a known offset distance from the true target, such that the offset and the distance measured are at right angles (or in line) as in Figure 8. The offset calculation is performed by setting the configuration variable "Offset" to a non-zero value and taking an instrument reading.

To make an offset measurement by calculation, press CNFG at the "Take Reading" prompt and set the configuration variable "Offset Distance" to the actual offset distance, then initiate a reading with READ or AUTO. The SDR will display the offset distance:

```
Program   title
Offset    0.700
```

which may be confirmed by keying ENTER or changed by entering a new distance. (Zero ENTER will zero the distance and bypass the calculation). You will then be asked for the offset direction:

```
Program   title
Offset    directn?
```

Use the arrow keys to enter the direction from the target to the prism as viewed by the instrument operator. For example, press the RIGHT arrow key if the prism is to the right of the target from the instrument operator's view. (See Figure 8)

The SDR will then calculate the horizontal and vertical angles and slope distance to the true target point. Note that the calculated result is stored, not the original observation. However, a NOTE is automatically generated giving the original measurements plus offset distance and direction used in the calculation.

If the offset distance is not set to zero via the configuration menu, it will be displayed on the next reading. It may then be set to zero and the calculation bypassed if required.

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8. NOTES

The notes facility of the SDR allows the input of unlimited descriptive text, point codes, layer codes, joining codes etc. The NOTE key is used for this function and can be pressed when the display is showing:

Select operation
Take reading (or Take face one, Take BS reading etc)

or while in Review mode
or Programs menu

8.1 Note Entry

When the NOTE key is pressed the display shows the prompt:

```
Enter   note
Note    ________
```

Up to 60 characters can be keyed in per note record. The display scrolls to the left after the first eight characters. If more than 60 characters of text are required key NOTE again to continue the note in a second record.

In data review mode, the NOTE will scroll to the left. The LEFT and RIGHT arrow keys can be used to stop and reverse the direction of the scrolling.

While in data review a note may be inserted in the data. The note record will be inserted before the currently-displayed record. For example, if an earlier observation was in error then it is possible to search for the applicable point number and insert a comment to ignore the next observation.

8.2 Feature codes

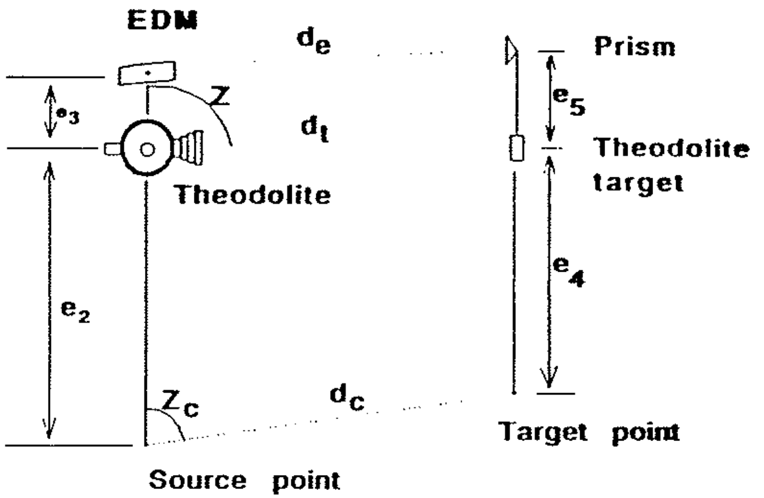
The SDR allows entry and use of user-defined feature codes to reduce keying time and to help you remember standard codes. The feature codes are available at the "Code" and "Note" prompts.

To access the list of feature codes, press the UP or DOWN arrow key while in numeric shift. The last entered feature code is displayed.

```
Select   code
04:   Tree  Oak
```

Figure 9

Equipment Configuration



where

- e_1 = Prism constant
- e_2 = Theodolite height
- e_3 = EDM offset
- e_4 = Theodolite target height
- e_5 = EDM reflector offset
- d_e = EDM slope distance
- d_t = Theodolite slope distance
- d_c = Slope distance, source to target point
- Z = Theodolite vertical angle
- Z_c = Corrected vertical angle

FACTOR	OPTION
Reflector offset*	INSTR record
Prism constant*	INSTR record
Backbearing azimuth	BKB record
Backbearing horizontal observation	BKB record
EDM type and mounting	INSTR record
Atmospheric pressure	ATMOS record
Atmospheric (dry) temperature	ATMOS record
Instrument refraction** constants I and N	Internal values associated with EDM type
Spheroid radius, R	Constant = 6,370,000 m
Coefficient of refraction, k	Constant = 0.14

The current settings of the DIST UNIT, ANGLE UNIT, PRESSURE UNIT and TEMPERATURE UNIT parameters are used to determine the units of all data stored in records. Conversions are carried out automatically as necessary.

Notes
 * Defined in Figure 9.
 ** From manufacturer's specifications.

9.1.1 Angle Conversions

The vertical angle measurement in a raw observation (defined in the instrument's vertical observations parameter) is converted to an equivalent zenith angle.

The derivation of the raw observation is determined as follows:

(1) If the vertical observation is in the range 0° to 180° (0 to 200 gon) the derivation is F1. If it is in the range 180° to 360° the derivation is F2.

(2) If the vertical angle observation is not present, then for all instruments, except those with F2 mountings, the derivation is assumed to be F1. For those instruments with F2 mountings the derivation is assumed to be F2.

If the vertical observation falls outside the range 0° to 180° it is converted to an equivalent angle within that range.

For raw observations measured on all instruments except those with F2 mountings, if the derivation code is F2, this is taken to mean that the telescope was reversed, so 180° is added to the horizontal observation.

Similarly, if a F1 observation is taken on an instrument with a F2 mounting, 180° is added to the horizontal observation.

$$V = \frac{a_r - a_1}{2}$$

where: a_r is the face I vertical angle converted to zenith, and
a_1 is the equivalent face II measurement

Face one measurements (F1) are defined as when the instrument is measuring 0° (zenith) descending to 180°.

Horizontal collimation error is defined similarly, by:

$$H = \frac{b_r - b_1}{2}$$

The application of the corrections depends on the derivation of the observed data (see Section 4.1), that is, whether the measurements were taken on the first or second face.

DERIVATION	CODE	CORRECTIONS	
Face one	F1	$a_2 = a_1 + V$	$b_2 = b_1 + H$
Face two	F2	$a_2 = a_1 - V$	$b_2 = b_1 - H$
Other data	MC	$a_2 = a_1$	$b_2 = b_1$

where: a_1 is the vertical angle expressed as a zenith distance,
V is the vertical collimation,
a_2 is the corrected vertical angle expressed as a zenith distance,
b_1 is the measured azimuth,
H is the horizontal collimation, and
b_2 is the corrected azimuth

9.1.7 Pressure and Temperature

Pressure and temperature corrections are applied to all electronically measured distances provided the "Atmos crn" parameter is set to Y and pressure and temperature details have been entered. The correction applied is:

$$S_3 = S_2 + S_2\left[J - \frac{NP}{273.2 + T}\right] \times 10^{-6}$$

where: S_2 is the slope distance,
J is the group refractive index for the EDM's carrier,
N is a constant for the EDM's carrier,
P is the atmospheric pressure in mm Hg,
T is the dry air temperature in °C, and
S_3 is the corrected slope distance

When the instrument is Manual, no atmospheric correction is applied.

9.1.8 Curvature and Refraction

Provided that the Curvature and Refraction value is set to Y, then the following correction is applied to vertical angles:

$$-\frac{(1-k)S_3}{2R} \qquad \text{(units:radians)}$$

where: k is the coefficient of refraction, and
R is the spheroid radius

in application, this term is:

$$-\frac{0.86}{2 \times 6.37 \times 10^6} \times \frac{180}{\pi} S_3 \qquad \text{(units:degrees)}$$

9.2.2 Sea Level Correction

If the Sea Level Correction value is set to Y the horizontal distance at the elevation of the source point is reduced to the sea level chord (d_2) using the mean height of the vector:

$$d_2 = d_1 - \left[\frac{(h_1 - h_t)d_1}{2R} \right]$$

where: d_1 is the horizontal distance at the elevation of the source point,
h_1 is the elevation of the source point,
h_t is the elevation of the target point, and
R is the radius of the spheroid

9.2.3 Chord-to-arc Conversion

Reduction of the sea level chord (d_2) to the spheroidal arc (d_3) involves a correction of:

$$\frac{d_2^3}{24R^2}$$

where R is the radius of the spheroid. This correction exceeds 1mm only on distances greater than 9.9 kilometres. Consequently, the correction term is ignored, and the spheroidal arc is taken to be the sea level chord: $d_3 = d_2$

9.2.4 Projection Corrections

The correction of the spheroidal arc (d_3) to a projected distance (d_4) depends on the projection that is used. Since the locally-used projection is not known by the SDR, a simple scale factor is used for this correction. For short and medium distance EDM work, this generally provides sufficient accuracy.

The projection correction is:

$$d_4 = d_3 \times sf$$

where sf is the scale factor in the current scale record; if no scale factor has been entered, the correction is not applied.

9.3 OTHER FORMULAE

9.3.1 Coordinates Calculation

The coordinates of a target point are calculated from observed measurements and the coordinates of the source point (or station) using:

$$N_2 = N_1 + d_4\cos(b)$$

$$E_2 = E_1 + d_4\sin(b)$$

$$Elv_2 = Elv_1 + v_2$$

where: N_1, E_1 and Elv_1 are the coordinates of the source point,
d_4 is the projected distance between the two points,
b is the azimuth,
a_3 is the zenith angle, and
v_2 is the vertical distance

The calculation yields null results if the coordinates of the source point are not known.

$$P_j = P_i + \frac{V_{ij} - V_{ji}}{2}$$

where: P_i is the position of the backsight,
V_{ij} is the corrected vector from i, the backsight, to j, the instrument station, and
V_{ji} is the corrected vector from j to i

The traverse closure calculations generate the horizontal angle misclose, the x-y plane distance misclose, the misclose ratio, the northing misclose, the easting misclose and the elevation misclose.

The angle misclose is defined as the difference between the known azimuth from the instrument station to the close point and the azimuth calculated from an observation taken to that point.

The distance misclose is given by:

$$D_{ij} = \sqrt{\left(X_i - X_j\right)^2 + \left(Y_i - Y_j\right)^2}$$

where: X_i, Y_i and Z_i are the calculated coordinates of the closing point, and
X_j, Y_j and Z_j are the known coordinates of the closing point

The misclose ratio is:

$$R = \frac{D_{ij}}{L}$$

where: D_{ij} is the X-Y plane distance misclose, and
L is the total length of the traverse route, based on the most current X-Y positions

The northing, easting and elevation components of the misclose are given by $X_i - X_j$, $Y_i - Y_j$ and $Z_i - Z_j$

9.3.5 Resection Calculations

Fundamentally, the resection program determines the position of the current station from measurements to known points.

Angles may be measured by repetition or direction to obtain a set of readings. Because the instrument position is unknown, the set of angles has no orientation.

The resection is performed in two stages: firstly north-east determination and secondly height determination. In order to unambiguously define the current station the SDR needs a minimum of either

> two measurements of vertical angle observations, horizontal angle observations and slope distances to points with known north-east positions; or
>
> three measurements of horizontal angle observations to points with known north-east positions.

An initial result is first determined. This is done by finding two observations in the set which have distances, vertical angles and horizontal observations. If these cannot be found it looks for three observations which have horizontal angle observations. If these cannot be found the SDR returns a null result.

The initial result is then used together with all measurements to points with known north-east positions to determine a better estimate using a least-squares algorithm. The orientation of the set of observations is also adjusted. The process is repeated until two consecutive estimates are less than 0.001m apart in both north and east directions, and the difference in orientation is less than 10 seconds. If more than 9 iterations are required then the SDR gives a null (indeterminate) result. This could happen if horizontal angle observations were nearly 180° apart, or if the observed points were situated on a circle

Once the north-east position is determined, the height is found. This is done by considering each observation with a vertical angle observation and slope distance to a point of known height. An estimate of height of the current station is produced for each observation. These are averaged to determine the resultant height of the current station.

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10. PROGRAMS

The menu of programs can be examined by pressing the PROG key at "Select operation" or in the functions menu. Twelve programs are provided:

Program	Description
1. Traverse	Provides the field data collection procedures necessary for a 3-D traverse including side shots, coordinates and closure calculations. Angles may be measured by any method.
2. Inverse	Computes distances and angles between two known points.
3. Topography	Automatic recording of raw data, reduced data or coordinates for topographical surveys.
4. Resection	Determines the coordinates of the instrument station from sets of observations to known points. (Angle and distance observations are supported).
5. Remote elevation	Calculation of the relative height of an object directly above or below a sighted target.
6. Collimation	Determination of the instrument's collimation error for automatic correction of single face observations.
7. Slope reduction	Calculation of the vertical and horizontal components of an observation.
8. Coordinates	Calculation of the coordinates of a point.
9. Setting out	Location of points in the field using known coordinates.
10. Keyboard input	Input of known coordinates, directions or raw data.

10.1 Instrument Station and Orientation

At the start of most of the programs the instrument station, pressure and temperature and backsight orientation can be reviewed and amended if required. This facility is available in:

Traverse
Topography
Resection (theodolite height, pressure and temperature only)
Remote elevation
Slope reduction
Coordinates
Setting out

10.1.1 Instrument Station Set-up

The procedure for reviewing the current instrument station or setting up a new station is shown in Figure 11.

If the SDR has previously been given an instrument station, you will be asked to confirm that the station point number is correct. If no station has been previously entered, one must be set up and the first prompt is:

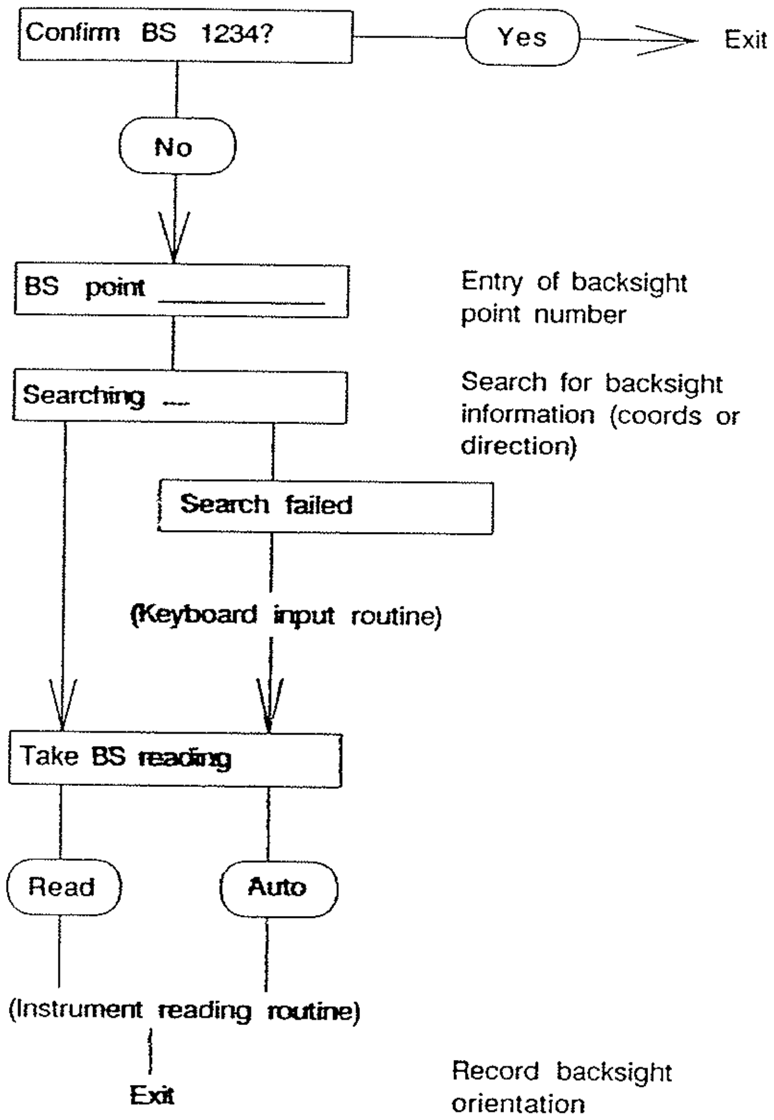
```
Program   title
Instr   stn   ______
```

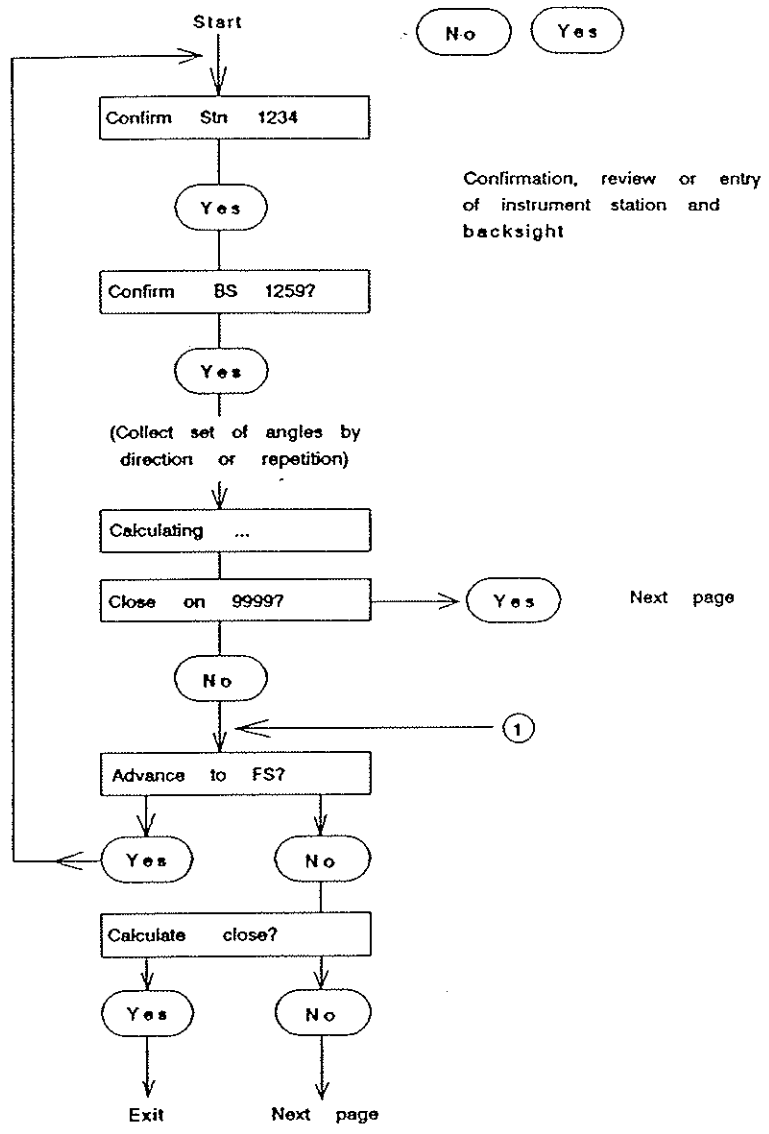
When a new station number is entered, the SDR searches for the coordinates of the point and if found they are displayed as the default values. If not found you will be prompted for them.

The station detail prompts conclude with review and entry of the atmospheric pressure and temperature.

Figure 12

Backsight Orientation




Start
No
Yes
Confirm Stn 1234
Yes
Confirmation, review or entry of instrument station and backsight
Confirm BS 1259?
Yes
(Collect set of angles by direction or repetition)
Calculating ...
Close on 9999?
Yes
Next page
No
1
Advance to FS?
Yes
No
Calculate close?
Yes
No
Exit
Next page

10.2.2 Traverse observations

The SDR provides two optional methods for recording observations to the backsight, foresight and any side shots. These are the angles by direction method and the angles by repetition method. The method used is selected by a parameter setting, see Figure 5.

During set collection, the SDR searches for logical defaults for the point number, code and target height. First it searches for a previous observation in the same direction. If one is found its values are used to provide defaults for the current observation. If one is not found, the SDR prompts for the point number, then searches for an observation to that point from the current station. If found, it is used to provide defaults for code and target height. In many situations, just pressing the AUTO key will store the correct point number, code and target height and allow faster reading.

1) Angles by direction

The operational procedure is shown in Figure 14. Any number of points may be sighted, and the observations may be taken in any order. Care must be taken if a target is sighted twice within a set as generally only the most recently entered observation in a set will be used in subsequent calculations. The only exception to this rule is made when return sightings are made to the backsight; that is, when the first and last sightings are made to the same point. In this case, any consecutive duplicate sightings at the beginning of the set are ignored and the last of these is used instead of the first.

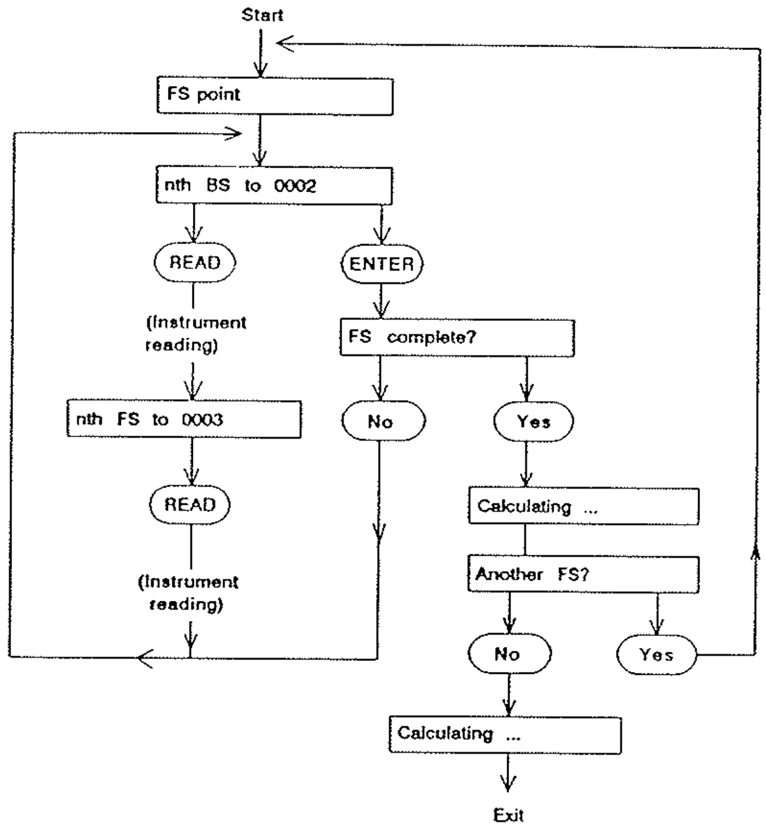
When the operator indicates that all sightings have been taken by pressing "ENTER" the SDR performs the following procedures:

1. The observations to be used are selected according to the method described above. If measurements are taken on both faces, the two sets of observations are treated independently until they are combined at step 4.

2. The instrumental and environmental corrections detailed in Section 9.1 are applied to the selected observations. Collimation correction is applied if measurements are taken on only one face.

Figure 15

Angles by Repetition



station point number. This may be over-ridden if necessary. If the question was answered with NO then the SDR asks:

```
Traverse
Calculate     Close?
```

If answered with YES then the SDR calculates the closure as described in section 10.2.5. NO allows a temporary exit from the traverse, maintaining the traverse as 'current' while other work from the traverse point is performed. The orientation of the theodolite is also calculated and stored.

10.2.5 Traverse closure

The SDR requests the close point number and searches for the fixed (traverse station or keyboard input) coordinates of that point. If they cannot be found you will be prompted to enter the data manually.

The SDR also checks to see if the traverse route is unbroken. If the traverse does not consist of a sequence of backsight and foresight shots where the backsight was always the last instrument station occupied, the route will be requested. The SDR asks for the starting point of the traverse ("Start point") and then the intermediate points ("To point"). The route is complete when the close point number is entered.

To calculate the angle misclose, the SDR searches for a measured corrected observation from the close point to the last instrument station. If it is not found, the "FS Az _____" prompt requests the true foresight azimuth from station to close point. If it is not known, keying ENTER will cause a null angle close to be calculated.

The SDR then computes the coordinates of the closure point and the closure error on the true closure point coordinates.

The SDR calculates and allows review of:

- difference in horizontal angle (provided a foresight azimuth was known)
- closure distance. The horizontal distance between calculated and true coordinates.
- precision, given as a ratio of the horizontal closure distance to the horizontal distance traversed from the start point to the observed close point.
- difference in northing between calculated and true coordinates.
- difference in easting between calculated and true coordinates.
- difference in elevation between calculated and true coordinates provided elevation coordinates were supplied for the start point and the close point.

This closure can be stored in the SDR in a NOTE record by keying RCRD or discarded by pressing CLEAR and then YES in response to the "Discard result?" question.

10.2.6 End of traverse

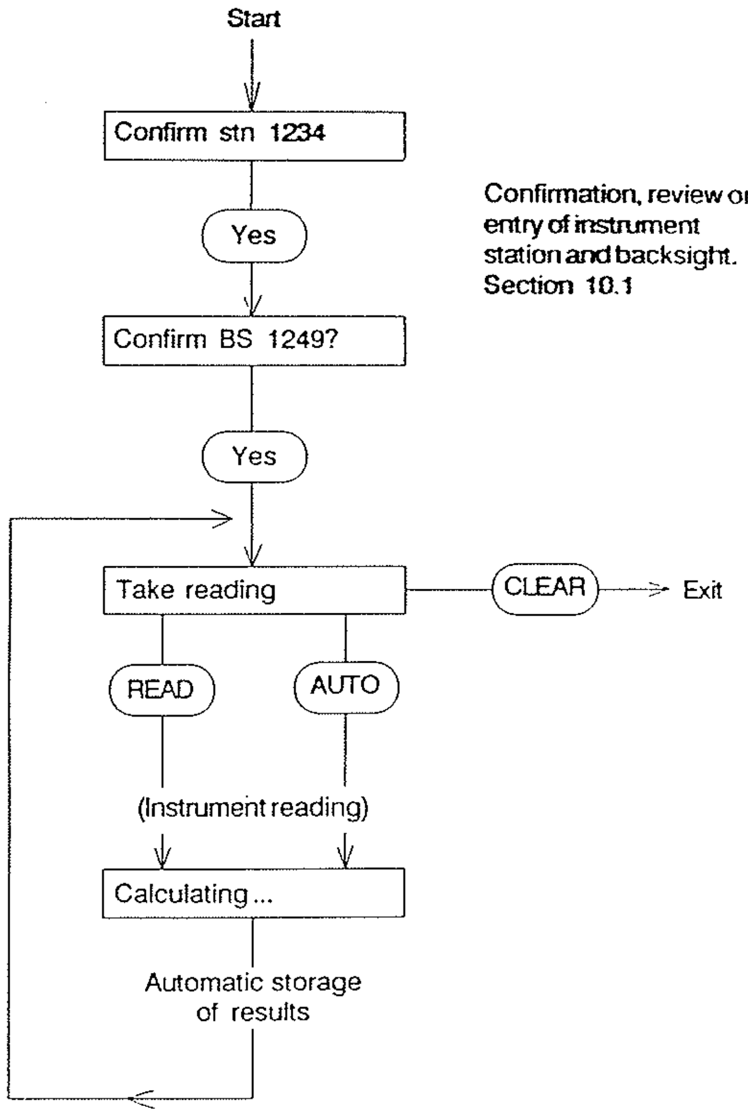
After computing the close the SDR asks:

```
Traverse
End   of   Traverse?
```

If the traverse is to be continued keying NO goes back to the 'Advance to FS?' question. Keying YES discards the automatic traverse route and exits to the programs menu.

Figure 17

Topography



Confirmation, review or entry of instrument station and backsight. Section 10.1

10.4 Topography

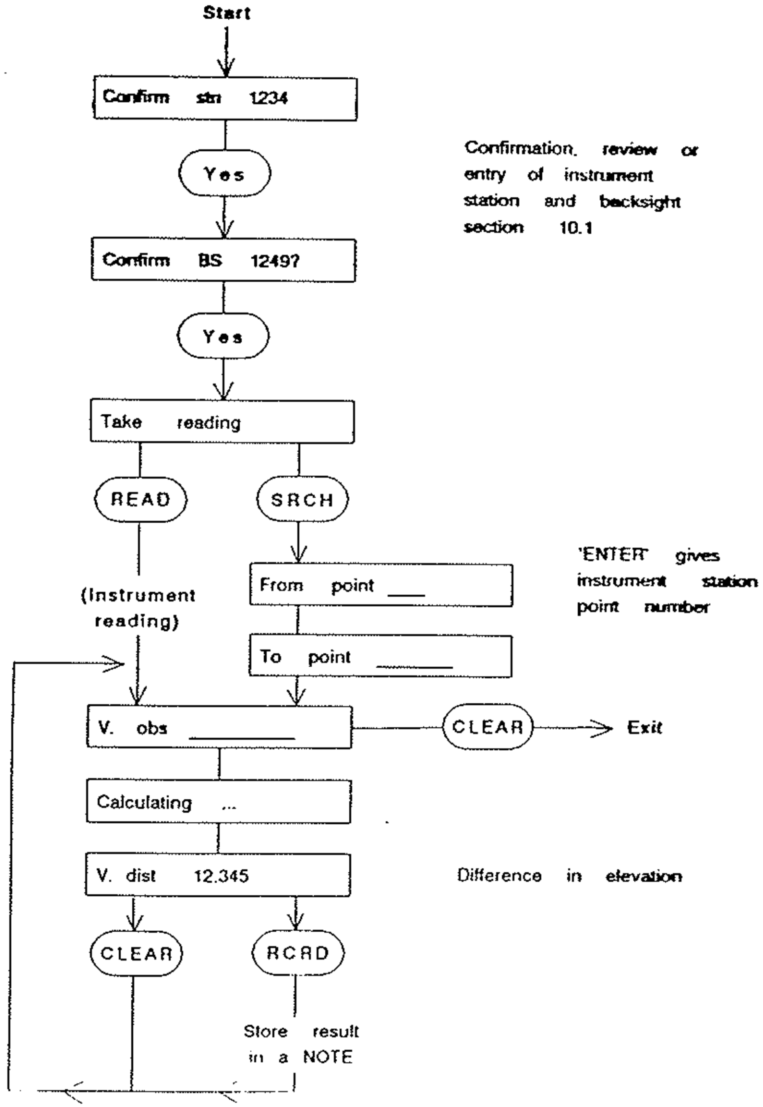
This program provides automatic calculations of reduced measurements or target point coordinates or raw observations as is required for topographical work.

The type of results required are determined by the topography option as set in the parameters menu (see Figure 5). For the second two options only, the calculated reduction or position records are stored but the observation records are discarded for economy of memory space.

After selecting the topography program the instrument station and backsight are confirmed and observations recorded using the READ or AUTO keys. The READ key is used to manually allocate point numbers, to alter target heights or where offset calculations are required. The AUTO key enables measurement and recording with a single keystroke.

Figure 19

Remote Elevation



10.6 Remote Elevation

This program is used to calculate the elevation of an object when a reflector cannot be placed on the target point, but can be placed directly above or below that point. The height of the object is calculated from an observation taken to the target (or from an existing observation stored in the table), and from the vertical angle to the object which lies directly above or below the target.

The first stage of the operation is the confirmation of instrument station and backsight. The operator then takes an observation to the target or initiates a search for the required data. Allowed search options are (1), (2), and (3) as described in Section 9.4.

In the second stage, the vertical angle to the object is entered manually. The angle is used to calculate the elevation of the object thus:

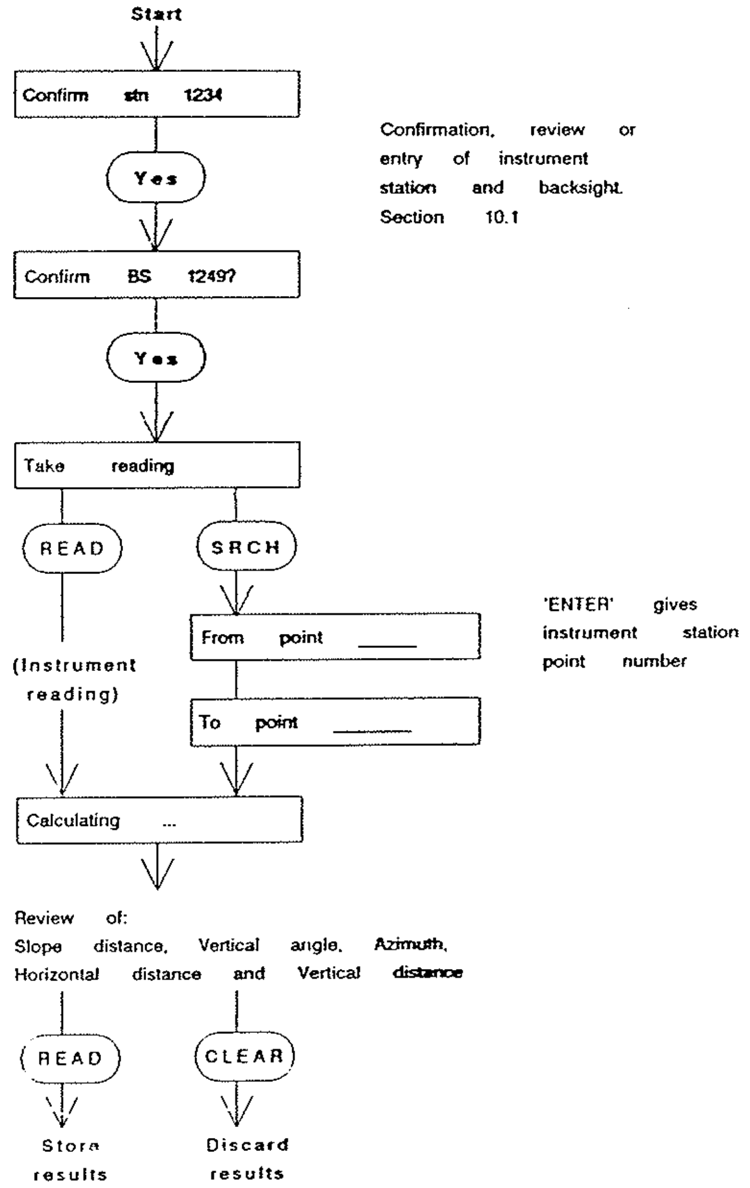
$$h' = \frac{d_4}{\tan(a')} - v + h_{th}$$

where: h' is the difference in elevation between instrument station and the object being observed,
a' is the zenith angle to the object,
v is the vertical distance from source to target points,
h_{th} is the theodolite height, and
d_4 is the projected distance to the target point

The SDR displays the calculated difference in elevation. The operator has the option of re-doing the calculation by entering the vertical angle again, recording the vertical distance in a note by pressing the RCRD key, or exiting from the program by pressing the CLEAR key.

Figure 21

Slope Reduction



10.8 Slope Reduction

This program determines the horizontal and vertical components of a sighting. The operator may either take an observation while using the program or recall existing data from the table.

The operational procedure is shown in Figure 21. After confirmation of instrument station and backsight, a reading is initiated when the operator presses the READ or AUTO key. The SDR then applies those corrections and calculations described in Section 9.4 for a raw data observation, option (1).

If the SRCH key is pressed instead, the operator is prompted to identify the source and target point numbers, and the SDR searches the table for existing measurements. It will search for either (1) a raw data observation, or (2) a corrected observation, or (3) existing reduced measurements. These options correspond to search options (1), (2) and (3) as described in Section 9.4. As explained in that section, if the search is successful, the SDR performs the appropriate calculations.

When the calculations have been completed, the operator can review the corrected slope distance, vertical and horizontal angles, and the calculated horizontal and vertical distances. Review begins on the slope distance display; the operator can use the LEFT and RIGHT arrow keys to examine the other results. The calculated distances are stored as a reduced record if the RCRD key is pressed.

10.10 Setting Out

This program enables a series of points to be set out or an old point found using known coordinates. The points to be set out are first loaded into the SDR by keyboard input or comms input. As illustrated in Figure 23, after confirming instrument station and backsight, the operator enters the sequence of points to be set out. If there are points remaining to be set out from the last time the program was used the operator has the alternative of continuing the previous set out or cancelling the list of points and entering a new series.

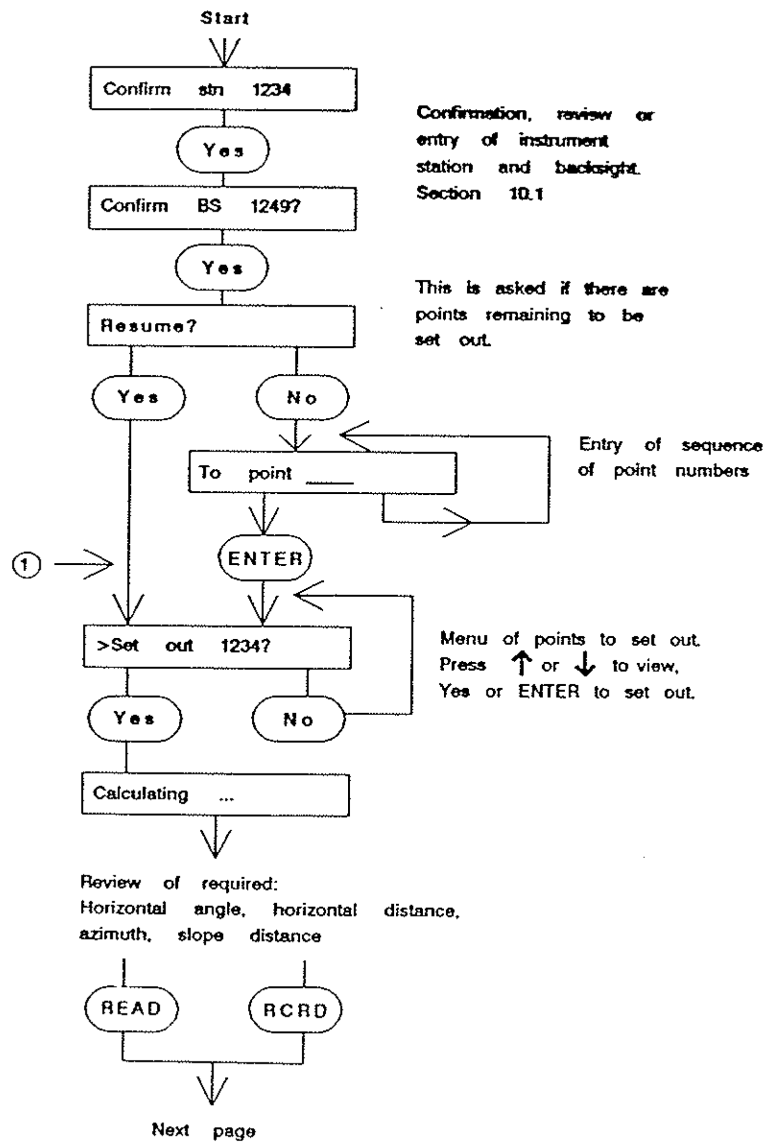
After entering the points the operator sets out each point in turn. After selecting the next point, the SDR searches for the coordinates of the point and calculates the reduced values from instrument station to target point. These values are displayed and the operator may record them by pressing the RCRD key.

The horizontal plane is set out first. The operator initiates a reading to the target, and the SDR performs a slope reduction calculation. The SDR2 displays rod person instructions, i.e. how far in/out or left/right to move. Press the LEFT arrow key to find the correct horizontal angle that will appear on the theodolite when observing the correct point. Press READ or AUTO to take another reading.

When this is completed, press RCRD. Vertical setting out of the point can now be done by answering the "Set elevation?" question with YES. The cut or fill value is shown along with the correct vertical angle that will be shown on the theodolite when observing the design elevation. Press READ or AUTO as before to take another reading. The final coordinates of the point as set out can be stored in a POS record by pressing the RCRD key. This record is given the next auto point number, and the code field contains the original point number and the final cut or fill value.

Figure 23

Setting Out



10.11 Keyboard Input

The keyboard input program is used to record known coordinates and observations. Three menu options are provided:

Key in azimuth
Key in obsvn
Key in coords

The operational procedure is shown in Figure 24.

10.11.1 Keyboard Entry of Azimuth

This option is used to record the direction of a backsight. The operator is prompted for the source and target point numbers, the azimuth from source to target point and a point code. The data is stored in an observation record with null vertical angle and distance and with a derivation code of MC.

Quadrant bearings can also be entered with this program. If the operator keys "B" in the first character position of the azimuth, the prompt changes from "Az" to "Brng". The first digit of the bearing defines the quadrant and the remaining digits the direction:

1st digit	Quadrant	Angle measured
1	NE	East of North
2	SE	East of South
3	SW	West of South
4	NW	West of North

The bearing input is converted to an azimuth.

Examples:

1.

Prompt	Input
Azmth	B
Brng	142.1632 Enter

Converted and stored as 42°16'32"

2.

Prompt	Input
Azmth	B
Brng	442.1632 Enter

Converted and stored as 317°43'28"

10.11.2 Keyboard Input of Observations

This option is used to normally record of an observation between two points. The operator is prompted for the source and target point numbers and the slope distance, vertical angle, azimuth from source to target point and point code. These are stored in an observation record with a derivation code of MC.

As described in 10.11.1, the azimuth may be entered as a quadrant bearing. The slope distance may also be entered in chains. If the operator keys "C" in the first character position of the slope distance, the prompt changes from "Dist" to "Chains". The distance is then entered in decimal chains (e.g. 100.56 is 100 chains, 56 links) and this is converted automatically by the SDR. (The conversion from chains to metres involves multiplication by the factor 20.1168).

10.11.3 Keyboard Entry of Coordinates

This option is used to enter the coordinates of control points, points of beginning or points for setting out. The operator is prompted for the point number, the north, east and elevation coordinates and the point code. The coordinates are stored in a position record which is marked with a derivation code of KI.

10.12 Plotting

The SDR plotting program allows output of any job directly to a plotter without going through an office computer. This saves time and allows plotting in the field. Plotters from the Hewlett Packard, Houston Instruments and Graphtec lines are supported, plus compatibles. A wide range of plot sizes and annotation options are available. Point plotting is done, plus traverse stations are joined.

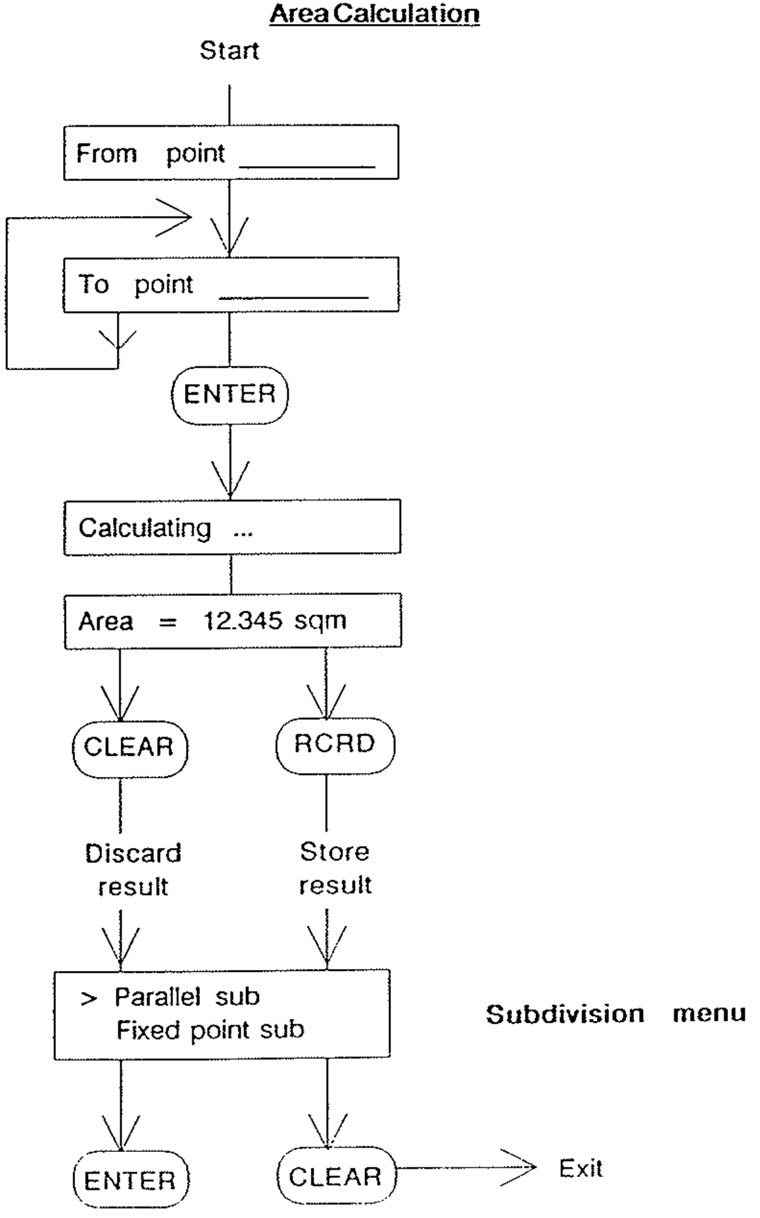
A menu of supported plotters is shown first.

```
>HP    plotter
   DMP   plotter
```

The last one used is the default. Select by pressing ENTER. The operator is then prompted for the plot size.

```
     HP   plotter
Plot   size   A1
```

Figure 26



The prompt for the first point number is "From point", and for the remaining point numbers is "To point". For each point entered the program checks:

that the point exists.
that both northing and easting are non null.
that the point is not one of the points already entered.
that the edge between the point and the previous point does not cross any of the existing edges. This avoids "figure 8" shaped areas.

When all of the point numbers on the area boundary have been entered, press ENTER at the "To point" prompt. The program then checks that:

at least three points have been specified.
that the edge from the last point entered to the first point entered does not cross any of the other edges.

Note - it is not necessary to enter the initial point number at the end of the list of point numbers to "close" the description of the area (in fact a duplicate point error will occur if this is attempted). This edge is included implicitly.

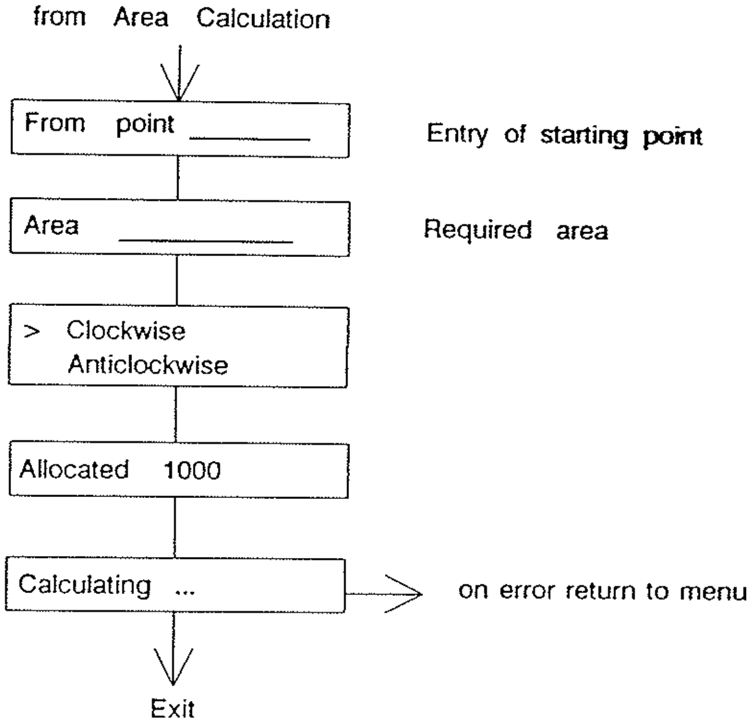
The SDR then displays the area calculated. This can be recorded in a NOTE by pressing the RCRD key or discarded by pressing CLEAR. Extra note(s) are generated, which record the point numbers which outline the area.

If the area is recorded, you will be given the two the options previously outlined for subdividing figures.

```
>Parallel    sub
  Fixed   point   sub
```

Figure 28

Fixed Point Area



10.13.3 Fixed point subdivision

Figure 27 illustrates the steps involved in subdividing an area by specifying one of the corner points, and then going around the perimeter in the given direction until it has accumulated the required area.

The "From point" must be one of the corner points specified in the AREA CALCULATION phase. The area entered must be larger than zero and smaller than the area of the figure.

After all of the input has been completed, the number of the point to be calculated is allocated, and its coordinates calculated. A line from the given point is rotated in the given direction until the given area has been enclosed. Errors of the ILLEGAL SHAPE type are also possible in this type of subdivision.