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"KH/KH DIRECTORY": A DIRECTORY OF FORTRAN PROGRAMS FOR THE CALCULATION OF SOIL HYDRAULIC PROPERTIES

(User Manual)

nota

FYSLAB, ICW (version 1.1)

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The FORTRAN programs described in this manual have been written by J.Halbertsma.

This manual has been written by S.Tamari, with the help of J.Halbertsma and G.J.Veerman.

CONTENTS

NOTATIONS AND SYMBOLS

1 - CONVENTIONS FOR READING THIS MANUAL:

*** : "most important"
** : "important"
* : "less important or particular cases"

[ ] : reference to another chapter

2 - MOST IMPORTANT PHYSICAL VARIABLES:

theta	:	volumetric water content	(cm3.cm-3)	[L3.L-3]
h	:	pressure head	(cm)	[L]
k	:	unsaturated conductivity	(cm.day-1)	[L.T-1]

3 - NOTATIONS FOR FILE DESCRIPTION:

yyy : number of experiment (001,002,003,...,999)
xx : number of a sample (01,03,05,07,09,11,13,15,17,19)

.DAT : data file used for calculations

4 - NOTATIONS WHEN USING COMPUTERS:

a) PDP RSX-11M-PLUS:

> : you are connected with the computer
$: you are logged in with one directory
* : you are in edit mode (command)
. : you are in edit mode (insertion)

b) PDP RT-11 OR VAX-VMS:

: you are connected with the computer

c) GENERAL:

CTL^ : control-key

- PART I -

INTRODUCTION

DEFINITION AND REFERENCES

1 - DEFINITION:

*** THIS IS A DIRECTORY OF FORTRAN PROGRAMS FOR THE CALCULATION OF SOIL HYDRAULIC PROPERTIES

*** connection: > HEL KH/KH

** institute: ICW
laboratory: FYSLAB
computer: PDP RSX-11M-PLUS
directory: DL1:[100,100]

2 - REFERENCES:

*** 21. THEORY:

WIND G.P. (1966) - "Capillary conductivity data estimated by a simple method" - Symp. june 1966, Wageningen, "Water in the unsaturated zone" [Miscellaneous Reprints 80,ICW]

*** 22. AUTOMATISATION:

BOELS D.,VAN GILS J.B.H.M.,VEERMAN G.J.,WIT K.E. (1978) - "Theory and system of automatic determination of soil moisture characteristics and unsaturated hydraulic conductivities" - Soil Sci.,126(4),pp 191-199 [Miscellaneous Reprints 222,ICW]

** 23. MATERIAL USED:

HALBERTSMA J., VEERMAN G.J. (1980) - Fyslab, ICW, not published.

* 24. DISCUSSION:

BEUVING J. (1984) - "Vocht- en doorlatendheidskarakteristieken, dichtheid en samenstelling van bodemprofielen in zand-, zavel-, klei- en veengronden." - Rapport 10, ICW, 26 p.

TAMARI S. (1988) and REFERENCES QUOTED - "Comparison of two procedures for the determination of soil hydraulic properties ..." - NOTA 1887, ICW.

THEORY

** For many years, an instantaneous profile method (Wind,1966) is used for the determination of soil hydraulic properties at the soil physic laboratory of ICW (FYSLAB).

An automatic system (Boels and co-workers,1978) has been developed for this type of measurements, and now this system has been used for more than 300 soil samples.

1 - EXPERIMENTAL SET-UP

* A vertical column of soil, initially saturated (or wet) is allowed to evaporate at the top; all other sides are completely closed. A few times per hour, the total weight of the column is read, and sorption potential is measured at different depths of the column [VII.1].

At the end of the experiment, the final water content is determined, so that the changes of mean water content with time can be calculated from the change of weight.

Evaporation rate can also be calculated by multiplying the changes of mean water content by the total height of the sample.

* For the measurements, with the automatic system developed by Boels and co-workers, potentials are recorded with microten--siometers [VII.2].

So, potentials can only be measured till about -800 cm. In that way, an experiment is carried on about 2 days (heavy soils) till about 20 days (sandy soils).

2 - HYPOTHESES

*** Some classical assumptions are done:

A1 - validity of fluxes theory
A2 - unidimensionnal transfers (vertical)

B1 - no swelling and no shrinking
B2 - air pressure in the soil equal to atmospheric pressure
B3 - osmotic potential is negligeable
B4 - isothermic conditions
B5 - vapour flows into the soil are negligeable

C - sample homogeneous for its hydraulic properties

D - measurements are reliable; according to Boels and co-workers (1978), response time at 1% precision of the microtensiometers used here is lower than 450 s and should not be a problem (since potentials do not vary very quickly with time).

** Soil hydraulic properties determined here correspond only to desorption.

3 - DETERMINATION OF WATER RETENTION CHARACTERISTIC

* This method can be classified as an instantaneous profile method (Klute and co-workers, 1986) developed for laboratory.

* One advantage of this method is that measurements of water content at different depths of the sample (which is quite laborious nowdays, eg. gamma technique) are not required, neither the determination a priori of the water retention characteristic.

The sample is divided in different layers defined by the positions of microtensiometers (in general, the depth of one tensiometer is defined as the middle of one layer). Each layer is assumed to have an uniform profile of water content.

First, an a priori water retention characteristic is calcu--lated from the mean water contents of the sample, and the average pressure heads measured with the tensiometers.

Then, the "correct" characteristic is determined by an iterative prodedure, where mean water contents of the sample (calculated with load cell data) are fitted with the means of water contents estimated for the different layers (estimated with potential measurements and the expected characteristic) [III.3,VII.3].

4 - DETERMINATION OF UNSATURATED HYDRAULIC CONDUCTIVITIES

* Unsaturated conductivities are calculated for the mean depths between two tensiometers with Darcy's law, mass conservation's law, and by doing linear interpolations [III.4,VII.4].

5 - ADVANTAGES OF THE METHOD:

* A review of instantaneous profile techniques, used at the laboratory or in the field, has been done by Klute (1972). He considers that the precision of these techniques is "good". As a matter of fact, these techniques are based only on classical hypotheses .

  But for laboratory, Klute (1972) also recommands to use not too little samples (the size of samples must take into account the size of structural elements), and to measure on the same sample both potentials and water contents.

* Compared to other instantaneous profile methods, the method proposed by Wind (1966) has the main advantage that it is not necessary to measure water contents at different depths of the sample (see before).

6 - DISADVANTAGES OF THE METHOD:

* A priori, the method has some disadvantages:

61 - a limited range for the measurements:

Measurements cannot be done for pressure heads superior to tensiometer´s air entry value.

62 - close to saturation:

Gradients of sorption potential are very small, and difficult to measure. Incertitudes on those gradients will affect the precision of calculating hydraulic conductivities (Wind,1966).

63 - when the soil is drying:

Calculation of potential gradient with linear interpolation is less reliable, and it will affect the precision of the calculation of conductivity (Boels and co-workers, 1978).

64 - because the water retention curve is fitted on data:

All the incertitudes on this fitting procedure will be forced into the calculation of conductivities.

65 - biases due to calculation of fluxes:

They are a priori cumulative from the depth at which flux is used as boundary condition. So, far from this depth, calculation of conductivities are less reliable (Wind,1966; Boels and co-workers,1978).

The boundary condition used now at FYSLAB is the bottom of the sample (no fluxcondition).

COMPUTATION - MINIMUM PROCEDURE

1 - *GET RAW DATA FOR ONE EXPERIMENT ON THE COMPUTER* ... [part VI]

11. RECORD EXPERIMENTAL DATA WITH THE DATA LOGGER .... [VI.1]

12. GET RAW DATA FILE ON THE PDP RSX-11M-PLUS ... [VI.2,VI.3]

    action: copy data files on PDP RSX-11M-PLUS
    input: magnetic cassettes
    output: you get ICWW00.yyy file

2 - *TREATMENT OF RAW DATA FILE* .... [part II]

21. GET RAW DATA FILES FOR EACH SAMPLE .... [II.1]

    action: run program KHSORT
    input: ICWW00.yyy file
    output: KHRAWxx.DAT files

22. PLOT RAW DATA FILES FOR EACH SAMPLE .... [II.2]

    action: run program KHPLOT
    input: KHRAWxx.DAT files
    output: KHRAWxx.DAT files

    -- correct data for each KHRAWxx.DAT
    -- set the "major time events"

23. COMPRESS OR DELETE DATA OF RAW DATA FILES .... [II.3]

    action: run program KHCMPR
    input: KHRAWxx.DAT files
    output: KHRAWxx.DAT files

    -- if necessary

3 - *CREATE PARAMETERS FILES FOR COMPUTATION* .... [part V]

31. PARAMETER FILE FOR DESCRIPTION OF EACH SAMPLE ..... [V.3]

    action: with text editor
    output: create files KHPARxx.DAT

32. PARAMETER FILE FOR COMPUTATION .... [V.4]

    action: with text editor
    output: create file KHCNTR.DAT

4 - *COMPUTATION OF SOIL HYDRAULIC PROPERTIES* .... [part III]

41. connect the PRINTER to the terminal .... [VIII.1]

    -- if you want to make HARD COPIES

42. run program KHCNTR .... [III.6]

    action: run KHCNTR (= run a group of FORTRAN programs)
    input: KHRAWxx.DAT,KHPARxx.DAT,KHCNTR.DAT
    output: KHRAWxx.yyy,KHPARxx.yyy,KHFYSxx.yyy

    -- an alternative is to run individual programs

5 - *SAVE THE RESULTS ON MAGNETIC TAPE* .... [VI.4]

action: use .BCK mode
input: KHRAWxx.yyy,KHPARxx.yyy,KHFYSxx.yyy
output: KH.yyy file on magnetic tape KHDATA

- PART II -

TREATMENT OF RAW DATA FILES

PROGRAM KHSORT
GET RAW DATA FOR EACH SAMPLE

1 - TIME AND ACTION:

*** RUN KHSORT (about 30 min for 10 samples)

2 - PURPOSE:

*** PROGRAM TO SORT DATA OF THE DIFFERENT LOAD CELLS AND PRESSURE TRANSDUCERS FOR EACH SAMPLE SEPARATELY

* Unknown values are interpolated (linear interpolations).

3 - INPUT:

31. FILE:

*** ICWW00.yyy [V.1,VI.2,VI.3]

32. ON SCREEN:

** EXAMPLE:

```
Clear data in all KHRAWxx.DAT (1) or not (2) ?  1
Give file # of ICWW00.yyy data file:  40
Sort data from load cell #, to load cell #?  1,19
```

* If you have still some KHRAWxx.DAT files you want to keep, and you want to use KHSORT only for some samples, you must be careful not to clear data in all KHRAWxx.DAT files.

4 - OUTPUT:

41. FILE:

*** KHRAWxx.DAT [V.2]

42. ON SCREEN:

* Error messages (tests made on timing and scanivalve data)

```
IERR  - error number:
-2 - NO CLASSIFIED ERROR
-1 - SCANIVALVE ERROR
 0 - NO ERRORS
 1 - SCANIVALVE ERROR            + DATA LOST
 2 - TIMING ERROR                + NEW TIMING INTERVAL
 3 - TIMING AND SCANIVALVE ERROR + NEW TIMING INTERVAL,DATA LOST
 4 - SCANIVALVE ERROR            + BLOCK OF DATA LOST
 5 - DISTORTED DATA IN SCANIVALVE
```

5 - PROBLEMS:

51. WHEN PROGRAM KHSORT SENDS ERROR MESSAGE:

* The records of ICWW00.yyy file for which an error is detected are given by the program.

  For errors -2,-1, check the data.
  For errors 1,2,3,4,5, the program corrects the data.

52. IF PROGRAM KHSORT DOES NOT RUN PROPERLY:

** Sometimes, the program stops, because of a "FORTRAN input conversion error".

  There may be odd characters in ICWW00.yyy file; they must be deleted, otherwise the program KHSORT will not run.

```
> HEL KH/KH
$ ED ICWW00.yyy
. delete odd characters
. save the new file ( CTL^Z then EXIT; wait about 5 min )
```

* Examples of odd characters are: <CR>, CTL^A ; there may be also a record with no data.
  - Error 64 Strange character. check data!
  - Error 73 Floating zero divide at PC= 056152 in "KHSORT" at or after xx

  These odd characters often correspond to little problems with the data logger used for experiments: a magnetic cassette is replaced by another one, the data logger is stopped for a while.

* It is also possible to "cut" ICWW00.yyy file in different parts, and to look for wich parts the program KHSORT does not run; as a matter of fact, ICWW00.yyy may be a big file.

PROGRAM KHPLOT
PLOT RAW DATA FILES FOR EACH SAMPLE

1 - TIME AND ACTION:

*** SET TERM FORMFEED / NOWRAP

*** RUN KHPLOT (about one day for 10 samples)

2 - PURPOSE:

*** PLOT RAW DATA FOR EACH SAMPLE

*** PLOT DATA FROM PRESSURE TRANSDUCERS OR FROM LOAD CELLS
SET "THE MAJOR TIME EVENTS"
CORRECT DATA

3 - INPUT:

31. FILE:

*** KHRAWxx.DAT [V.2]

32. ON SCREEN:

** EXAMPLE 1:
```
Display data from KHRAWxx.DAT (give file #): 11
Stop(0),plot pressure transducer(1) or load cell data(2):2
```

** EXAMPLE 2:
```
Display data from KHRAWxx.DAT (give file #): 3
Stop(0),plot pressure transducer(1) or load cell data(2): 1
Plot 1 or more chan.(1) or difference between 2 chan.(2): 1
Give pressure transducer channel # (1-12,max.6):1,2,3,4,5,6
```

** EXAMPLE 3:
```
Display data from KHRAWxx.DAT (give file #): 17
Stop(0),plot pressure transducer(1) or load cell data(2): 1
Plot 1 or more chan.(1) or difference between 2 chan.(2): 2
Give the 2 channel # (chan.[1]-chan.[2]): 6,1
```

4 - OUTPUT:

41. FILE:

*** KHRAWxx.DAT [V.2]

** Old data in KHRAWxx.DAT are overwritten.
To get the old data of one sample, run KHSORT again with ICWW00.yyy file for that particular sample [II.1].

42. ON SCREEN:

** The curves are plotted, with maximum 93 records each time.

X-axis: record number
Y-axis: raw data from transducers or load cell ("data logger units")

*** DISPLAY CURSOR AND OPTIONS:
C - CONTINUE
D - CORRECT DATA
S - SET MAJOR TIME EVENTS
Y - RESCALE Y-AXIS

C - CONTINUE

When you press the C-key, the program plot the next 93 records of KHRAWxx.DAT file. You cannot go back into this file, and you cannot stop the program KHPLOT till all the KHRAWxx.DAT file has been plotted.

D - CORRECTION FOR PRESSURE TRANSDUCER OR LOAD CELL DATA

When you press the D-key, you can correct data. Pressure transducer data can be corrected only if you are plotting data of ONE pressure transducer.

CORRECT DATA:
C - CONTINUE
S - START DELETE
E - END DELETE

To correct one or more point(s), put Y-axis at the level of the first data you want to correct (you can move Y-axis with → and ← key). Press the S-key; then put the Y-axis at the level of the last data you want to correct and press E-key.

A linear interpolation is done between the first and the last records (both included).

To correct a group of data that you cannot see completely on the screen, use C-key (continue) between "start" and "end delete".

If you have made a mistake by pressing S-key (start delete), you can escape by pressing C-key (continue) till the end of the file.

You cannot correct the first or the last data of a file.

S - SET THE MAJOR TIME EVENTS

You must define "the major time events":

a) NRES: "start of experiment"
b) NRTL: "last good tensiometer reading"
c) NREE: "end of experiment"

In general, the last good tensiometer reading is choosen as the first record, where data of a pressure transducer (corresponding to a tensiometer) seems to have reached a maximum value (and after, the pressure transducer data often decrease very quickly).

When you press the S-key, you will see on the screen:

```
NRES, NRTL AND NREE:
CONTINUE WITH EVENT SETTING (YES OR NO) OR
DELETE EVENTS (D) ?

SET TIME EVENTS:
C - CONTINUE
S - START OF EXPERIMENT
T - LAST GOOD TENSIOMETER READING
E - END OF EXPERIMENT
```

Put the Y-axis on the selected point, then press S, T or E-key.

Y - RESCALE Y-AXIS

When you press the Y-key you will see on the screen:

```
GIVE YMIN AND YMAX
```

The scale values YMAX and YMIN are written on the screen; you can enter two new values (separated by a comma).

5 - ANALYSIS OF PROBLEMS AND DIAGNOSTIC: [VII.5,VII.6]

** For each sample, you can follow this procedure:

a) plot load cell data and correct odd data;

b) plot all transducer pressure channels, note the problems that are the same for all channels and set major time events;

c) plot the difference between reference channels to check if this difference is constant;

d) plot one by one the transducer pressure channels and correct data.

51. ISOLATED ODD POINTS:

* It seems better to eliminate them; they may appear for instance when someone walks in the laboratory, because of the sensitivity of instruments to vibrations.

52. OSCILLATIONS OF CURVE(S):

* This can be due to instrumental problems (vibrations,...) Correction is possible.

53. SLOPE MODIFICATION OF SOME CURVE(S)

* This can be due to installation of ventillator (evaporation suddently increases).
No correction is possible, but it may be a little problem when load cell data will be fitted with a polynom [III.1].

54. TRANSLATION OF ALL PRESSURE TRANSDUCER CURVES:

* This may be due to a bad working of scanivalve.
No correction is possible. In theory, this should not be a problem for the determination of soil hydraulic properties, because the gradients of potential with depth are unchanged; but for the calculations, mean values of reference levels are kept: so there will be an error on the determination of potential values [III.2].

55. TRANSLATION OF TENSIOMETRIC CURVES:

* The sample may have been moved or data have been lost (if we assume that the data of reference channels are constant).
No correction is possible. If the sample has been moved, there will be an error on the determination of potential values.

56. TRANSLATION OF REFERENCE CHANNEL CURVE(S):

* The reference level(s) may have been moved.
No correction is possible. Because the mean values of reference level are kept for further calculations, the determination of potential values will be always wrong [III.2].

6 - REMARKS:

* When choosing the major time events, it seems better to keep only the part of the data for wich all tensiometric data seems to be reliable. Start the experiment when h1 - h4 < 0 [IV.2]. Otherwise, some problems may append with program KHWRC, when the water retention characteristic is determined by a fitting procedure [III.3].

* If data corresponding to one tensiometer do not seem to be realistic, you can choose to keep only data for the other tensiometers, when defining KHPARxx.DAT file (but using less than four tensiometer data leads a priori to less reliable linear interpolations for potential gradients versus depth) [V.3].

* If you have problems to plot the data with your terminal, it may be neccessary to change the set-up of this terminal (ask some help).

* You can make hard-copies [VIII.1].

PROGRAM KHCMPR
COMPRESS OR DELETE DATA OF RAW DATA FILE

1 - TIME AND ACTION:

*** RUN KHCMPR (about 20 min for 10 samples)

2 - PURPOSE:

*** PROGRAM TO COMPRESS OR DELETE DATA FROM KHRAWxx.DAT FILES
COMPRESSED OR DELETED DATA ARE REWRITTEN INTO THE SAME FILE

** The maximum number of records allowed for output file is 300 [III.1].

3 - INPUT:

31. FILE:

*** KHRAWxx.DAT [V.2]

32. ON THE SCREEN:

** EXAMPLE 1 (compress data):
```
Compress or delete data from KHRAWxx.DAT (give #)
or stop (0): 13
Give first and last record to compress or delete: 2,557
Give compress rate N (N:1) or delete (N<0): 2
```

** EXAMPLE 2 (delete data):
```
Compress or delete data from KHRAWxx.DAT (give #)
or stop (0): 13
Give first and last record to compress or delete: 395,654
Give compress rate N (N:1) or delete (N<0): -1
```

4 - OUTPUT:

*** KHRAWxx.DAT [V.2]

* Old data in KHRAWxx.DAT are overwritten.
  To get the old data, run KHSORT and KHPLOT again [II.1,II.2].

5 - PROBLEM:

* If you want to compress or delete a group of data, you must note the first and the last records corresponding to this group, when you are using the program KHPLOT [II.2].

* "Major time events" must have been defined with program KHPLOT [II.2].

6 - REMARK:

When you compress data, and then plot them with program KHOPLOT, do not forget that abscissas correspond to record numbers, and not to real time [II.2].

- PART III -

COMPUTATION OF SOIL HYDRAULIC PROPERTIES

PROGRAM KHILCD
CALCULATION OF EVAPORATION RATE

1 - TIME AND ACTION:

*** (a) automatic mode: RUN KHCNTR [III.6]
* (b) manual mode : RUN KHILCD (few minutes)

2 - PURPOSE:

*** PROGRAM TO IMPROVE THE LOAD CELL DATA

* A fourth order regression curve is fitted through the load cell data; load cell data are then changed in KHRAWXX.DAT file according to the calculated curve [VII.1].

3 - INPUT:

*** KHRAWxx.DAT [V.2]

* All the KHRAWxx.DAT files are processed. If a file has been yet processed, this is not done anymore.

4 - OUTPUT:

*** KHRAWxx.DAT [V.2]

5 - PROBLEMS:

* Major time events must have been defined with KHPLOT program [II.2].

* If one KHRAWxx.DAT file contains more than 300 records, you must compress this file with KHCMPR program [II.3].

* If the slope of the fitted curve is positive in the range of measured data, a new regression is made with a polynom of smaller order (3,2,1).

  This problem may appear if evaporation rate has changed very much during the experiment (installation of a ventilator).

PROGRAM KHFYS
CONVERT RAW DATA INTO PHYSICAL MEANINGFULL DATA

1 - TIME AND ACTION:

```
*** (a) automatic mode: RUN KHCNTR          [III.6]
  * (b) manual mode    : RUN KHFYS           (few minutes)
```

2 - PURPOSE:

*** PROGRAM TO CONVERT THE MEASURED DATA INTO PHYSICAL MEANINGFULL DATA

* From the load cell data and from the mean water content determined at the end of the experiment, the mean water contents (versus time) are calculated.

* From the pressure transducer data and with regard to the mean values (over all the experiment) of each reference level, pressure heads are calculated.

* Data are converted by linear interpolation as if all data were sampled at the same time.

3 - INPUT:

*** KHRAWxx.DAT, KHPARxx.DAT and KHCNTR.DAT [V.2,V.3,V.4]

** All informations of KHCNTR.DAT are read. The way of doing polynomial regressions ("normal or half-log") and "hard copy control" are stored in output file, for program KHWRC [III.3].

** From KHPARxx.DAT file are read the "load cell conversion factor", the correspondences between pressure transducer channels and tensiometer numbers, the "sample data" (to get its dimension) and the mean water content of the sample determined at the end of experiment.

4 - OUTPUT:

*** KHFYS.DAT file [V.5].
This file corresponds to only one sample.

5 - PROBLEMS:

* KHRAWxx.DAT file must have been processed by programs KHPLOT, KHCMPR and KHILCD [II.1,II.2,II.3].

PROGRAM KHWRC
CALCULATION OF THE WATER RETENTION CURVE

1 - TIME AND ACTION:

*** (a) automatic mode: RUN KHCNTR [III.6]
** (b) manual mode: RUN KHWRC (about 3 hours for 10 samples)

2 - PURPOSE:

*** PROGRAM TO CALCULATE THE WATER RETENTION CURVE

The method of Wind (1966) is used [I.2,VII.3].

** The water retention curve is fitted with polynomials. (pressure head versus water content).

The initial iteration is calculated with the mean water contents of the sample and the means of pressure heads.

** The water retention curve can also be fitted with a half-log curve (Log h instead of h). This option must have been selected in KHCNTR.DAT [V.4], before running program KHFYS [III.2].

3 - INPUT:

*** KHFYS.DAT and KHPARxx.DAT [V.3,V.5]

** From KHPARxx.DAT are read the "layer data" (= thickness of the layers) in order to calculate their water content.

4 - OUTPUT:

41. FILE:

*** KHFYS.DAT [V.5]

* Coefficients of the polynomial that are stored correspond to pressure heads given in cm.

* Water contents corresponding to the different layers are calculated with the polynomial and are also stored.

42. ON SCREEN:

*** The curve and data points are drawn [VII.7]

** To make hard copy, connect the printer to the terminal [III.2,VIII.1].

* When you have run the program KHFYS [III.2], if the "hard copy control" was 0 in file KHCNTR.DAT [V.4], the program KHWRC waits after one plot that you enter any character before going on.

5 - PROBLEMS:

* Polynomials are maximum 6-th order. Some tests are done on the slope of the polynomial and on the magnitude of the coefficients obtained.

  If those tests are not satisfactory, a new fit is made with a lower order polynomial (6,5,...,1).

** It may be useful to make a half-log regression instead of a normal regression, when the water retention characteristic seems difficult to fit (because of its slope), for instance with sandy soils.

* If you abort the program, do not forget to leave the Tektronic mode and to unlock files (an example is given at [III.6]).

PROGRAM KHTH
CALCULATION OF UNSATURATED HYDRAULIC CONDUCTIVITY

1 - TIME AND ACTION:

*** (a) automatic mode: RUN KHCNTR [III.6]
** (b) manual mode: RUN KHTH (about 1 hour for 10 samples)

2 - PURPOSE:

*** PROGRAM TO CALCULATE THE UNSATURATED HYDRAULIC CONDUCTIVITY AS A FUNCTION OF h AND THETA.

The method of Wind (1966) is used [I.2,VII.4].

3 - INPUT:

*** KHFYS.DAT, KHPARxx.DAT and KHCNTR.DAT [V.3,V.4,V.5]

** From KHCNTR.DAT file is read the "hard copy control" (for this program).

** From KHPARxx.DAT file are read the "tensiometer data", the "layer data" and the "sample data".

4 - OUTPUT:

41. FILE:

*** KHFYS.DAT [V.5]

* The k-theta and the k-h relationships are fitted with a 2-nd order polynomial. Those results are stored.

42. ON SCREEN:

*** The log h -theta, the logk-theta and the logk-log h curves are plotted [VII.8].

*** To make hard copy, connect the printer to the terminal and set a positive value for "hard copy control" in KHCNTR.DAT file [VIII.1].

** If "hard copy control" is 0 in KHCNTR.DAT file, it is possible to fit k-theta and k-h relationships:

a) with a polynomial:
Its order (maximum 6) is choosen by the operator: when a curve is plotted on the screen, press RETURN key; the program asks a response to continue: if you enter a positive integer, a new polynomial will be fitted on data, whose order is equal to the number given.

b) with a polygon:
When a curve is plotted, use the X-axis and Y-axis to select a node of the polygon, then press "-" key. Continue till the polygon is defined, then press the "1" key: the polygon will be plotted.

Those results are stored in KHFYS.DAT

** If "hard copy control" is set negative in KHCNTR.DAT, no hard copy is done and the program does not wait after each plot.

5 - PROBLEMS:

** Hydraulic conductivities are determined using a finite - difference form of Darcy's law [I.2,VII.4].

But two situations may appear, where conductivities are not calculated by program KHTH:

a) unrealistic calculated flux:

If the calculated flux through the layer is not positive (with regard to a positive direction from the bottom to the top of the sample).

b) very small gradient of potential:

If the calculated gradient of pressure head plus a "noise region" is not inferior to -1 (this "noise region" is defined as 2 times the standard deviation of tensiometric measurements = 0,6 cm) [VII.1].

6 - DIAGNOSTIC FOR THE RESULTS:

** With the iterative procedure used by program KHWRC [III.3], aN unique water retention curve is found; but when this curve is used for the calculation of conductivities, all incertitudes on the determination of this characteristic will be forced on to the calculation of conductivities [I.2].

Sometimes, it seems that 2 or 3 unsaturated conductivity curves may be distinguished: these curves are likely to correspond to the different couples of tensiometers.

This problem may be due to many reasons:

a) There is a bias on measurements (microtensiometers were not in equilibrium, or were not horizontal);

b) There is a numerical problem (linear interpolations done are not reliable);

c) The sample is not homogeneous for its hydraulic properties.

In any case, results are not reliable in theory [I.2].

** It may be interesting to compare the actual number of conductivity points calculated by the program KHTH to the theoritical number of points that could have been calculated.

This theoritical number is equal to the number of time steps multiplied by the number of tensiometer's couples.

PROGRAM KHSAV
SAVE THE DATA

1 - TIME AND ACTION:

```
*** (a) automatic mode: RUN KHCNTR          [III.6]
  * (b) manual mode    : RUN KHSAV           (few minutes)
```

2 - PURPOSE:

*** PROGRAM TO SAVE THE CURRENT CONTENT OF THE FILES

3 - INPUT:

*** KHFYS.DAT, KHRAWxx.DAT and KHPARxx.DAT [V.2,V.3,V.5]

4 - OUTPUT:

*** DATA are stored in files KHFYSxx.yyy, KHRAWxx.yyy and KHPARxx.yyy respectively, where xx is the load cell number and yyy is the experiment number [V.2,V.3,V.5].

PROGRAM KHCNTR
COMPUTE SOIL HYDRAULIC PROPERTIES

1 - TIME AND ACTION:

*** RUN KHCNTR (about 5 hours for 10 samples)

2 - PURPOSE:

*** THIS PROGRAM RUNS AUTOMATICALLY THE PROGRAMS KHILCD, KHFYS, KHWRC, KHTH, KHATAB AND KHSAV [III.1, III.2, III.3, III.4, IV.3, III.5].

3 - INPUT:

*** KHCNTR.DAT, KHRAWxx.DAT, KHPARxx.DAT [V.2,V.3,V.4]

*** From KHCNTR.DAT are read which KHRAWxx.DAT files must be processed by the FORTRAN programs.

*** KHRAWxx.DAT files of the list are processed one after the other.

** The "data file to be processed" in KHCNTR.DAT is the list of KHRAWxx.DAT files that should be processed. If the values of this list are set negative, "half log" polynomial regressions will be done by KHWRC [III.3].

** The "last data file processed" in KHCNTR.DAT corresponds to the first KHRAWxx.DAT file in the list, where the process starts indeed:

a) if this number (xx) is positive, KHCNTR starts the process with this file.

b) if this number (xx) is negative, KHCNTR starts the process with the next file of the list.

This number (xx) is automatically reset by KHCNTR program.

** The "hard copy control" in KHCNTR.DAT file indicates if you want to have hard copies with KHWRC [III.3] and KHTH [III.4] programs:

a) if this number is positive, hard copies will be obtained with both programs.

b) if this number is negative, no hard copies are done.

c) if this number is equal to 0, the program waits after each plot, that you enter any character before going on.

4 - OUTPUT:

41. FILES:

*** KHFYSxx.yyy, KHRAWxx.yyy, KHPARxx.yyy [V.2,V.3,V.4]

42. PRINTER:

*** When making hard copies ("hard copy control" is positive in KHCNTR.DAT file), connect the printer to the terminal [VIII.1].

5 - PROBLEMS:

** See the problems reported for each programs called by KHCNTR.

*** Do not forget that the input files used by KHCNTR (and all the programs it calls) are KHRAWxx.DAT and KHPARxx.DAT.

Only when calculations are ended, these files are copied with a new name: KHRAWxx.yyy and KHPARxx.yyy where yyy is the number of the experiment (program KHSAV, see [III.5]).

*** If you want to abort the program, check that all the data files are not locked before running this program again:

```
...   CTL^C          <- call for DCL mode
DCL>  ABO            <- abort the program
$     UNLOCK *.*     <- unlock all the files
```

** If you are making hard copies, do not forget to connect the printer to the terminal [VIII.1].

PROGRAM KHRES
RESTORE THE CONTENT OF FILES FOR ONE EXPERIMENT

1 - TIME AND ACTION:

*** RUN KHRES (few minutes)

2 - PURPOSE:

*** PROGRAM TO RESTORE THE CONTENT OF FILES KHFYSxx.yyy, KHRAWxx.yyy AND KHPARxx.yyy INTO FILES KHFYS.DAT, KHRAWxx.DAT AND KHPARxx.DAT RESPECTIVELY [V.2,V.3,V.5].

3 - INPUT ON THE SCREEN:

** EXAMPLE 1:

```
Restore all raw data and parameter files (0) or one
parameter and data files (1) ? 0
Give the experiment # : 41
```

** EXAMPLE 2:

```
Restore all raw data and parameter files (0) or one
parameter and data files (1) ? 1
Give load cell # and experiment # : 15,41
```

4 - OUTPUT ON THE SCREEN:

* Some error messages are sent (if mismatch of load cell # and experiment # or if error during reading).

- PART IV -

PROGRAMS TO DISPLAY DATA

PROGRAM KHPRAW
PRINT THE RAW DATA OF ONE EXPERIMENT

1 - TIME AND ACTION:

*** RUN KHPRAW

** This program is available on the VAX-VMS (because it is too long to run this program with the PDP RSX-11M-PLUS).

2 - PURPOSE:

*** PRINT THE RAW DATA OF ONE EXPERIMENT

3 - INPUT:

31. FILE:

*** ICWW00.yyy [V.1]

32. ON SCREEN:

** EXAMPLE:

```
Data output to terminal (1) or to line printer (2): 1
Print data from file: ICWW00.040
Improve lay out (1) or print scale data (2): 2
Print data from scale #, to scale #? : 1,19
```

4 - OUTPUT:

*** ON SCREEN

There are two printing modes:

(1) Improve the lay-out of the raw data file (add space)
(2) Print the data of the scanivalves separately

* Checks are made on timing data and the scanivalve number (and messages are sent).

PROGRAM KHDISP
DIPLAY DATA (INPUT OR RESULTS)

1 - TIME AND ACTION:

*** RUN KHDISP (few minutes)

2 - PURPOSE:

*** PROGRAM TO DISPLAY DATA FROM KHRAWxx.DAT OR FROM KHFYS.DAT

3 - INPUT:

31. FILES:

*** KHRAWxx.DAT or KHFYS.DAT [V.2,V.5]

32. ON SCREEN:

** EXAMPLE 1:

```
Display data from KHRAWxx.DAT (give file#) or from
KHFYS.DAT (0)? 13
Display from channel, to channel (...)? 1,6
Continue (1), stop (2) or print and stop (3)? 2
```

** EXAMPLE 2:

```
Display data from KHRAWxx.DAT (give file#) or from
KHFYS.DAT(0)? 0
Display from tensiometer, to tensiometer (...)? 1,6
Continue (1), stop (2) or print and stop (3)? 2
```

4 - OUTPUT:

*** Results are displayed on the terminal and a print can be obtained.

5 - PROBLEM:

* For an automatic print, check that the printer is connected with the terminal.

PROGRAM KHATAB
DISPLAY THE RESULTS

1 - TIME AND ACTION:

*** (a) automatic mode: RUN KHCNTR [III.6]
  * (b) manual mode : RUN KHATAB (few minutes)

2 - PURPOSE:

*** PROGRAM TO DISPLAY THE ANALYSED DATA AS A TABLE OF theta-h-k AND h-k VALUES.

3 - INPUT:

*** KHFYS.DAT [V.5]

4 - OUTPUT:

*** Results are displayed on the terminal and an automatic print can be obtained (if printer is connected to the terminal).

PROGRAM KHDIFF
COMPARE THE MEAN MEASURED WEIGHT OF THE SAMPLE AND THE SUM OF CALCULATED WEIGHTS OF LAYERS

1 - TIME AND ACTION:

** RUN KHDIFF (few minutes)

2 - PURPOSE:

** PROGRAM TO CALCULATE THE DIFFERENCE BETWEEN THE MEASURED WEIGHT OF THE SAMPLE AND THE SUM OF THE CALCULATED WEIGHTS OF ALL LAYERS.

3 - INPUT:

** KHFYS.DAT [V.5]

4 - OUTPUT:

** On the screen

PROGRAM KHEVAL
EVALUATE THE ANALYSED DATA

1 - TIME AND ACTION:

** RUN KHEVAL (few minutes)

2 - PURPOSE:

** PROGRAM TO EVALUATE THE ANALYSED DATA.

* The h-theta, k-theta or k-h relationships are evaluated for given theta or h.

3 - INPUT:

31. FILE:

** KHFYS.DAT [V.5]

32. ON SCREEN:

** EXAMPLE:

Evaluate h-theta(1),k-theta(2) or k-h(3) relationship or stop(0)? ...

Then the program ask for a numerical value.

4 - OUTPUT:

** On the screen

- PART V -

STRUCTURE OF DATA FILES

STRUCTURE OF THE ICWW00.yyy DATA FILE

*** This file contains raw data for one experiment.

*** You can edit this file (sequential ASCII file, variable record length).

*** RECORD STRUCTURE:

```
POSITION

1 - 3    EXPERIMENT #
4 - 6    DAY
7 - 8    HOUR
9 -10    MINUTE

11       SCANNIVALVE POSITION (OR CHANNEL #) (1,2...6)

12 -13   PRESSURE TRANSDUCER # (E.G.=00)
14 -17   PRESSURE TRANSDUCER DATA

18 -19   LOAD CELL # (E.G.=01)
20 -23   LOAD CELL DATA

24 -25   PRESSURE TRANSDUCER # (E.G.=02)
.
.
MAXIMUM 5 GROUPS OF OF PRESSURE AND LOAD CELL DATA
.
.
66 -67   LOAD CELL # (E.G.=09)
68 -71   LOAD CELL DATA
```

* Usually one record contains data from pressure transducers 00 to 08 (load cell 01 to 09), or from pressure transducers 10 to 18 (load cell 11 to 19).

*** REFERENCES:

a) experimental set-up : [VII.1,VII.2]
b) how to get the file : [VI.2,VI.3]
c) calculation   : [II.1]
d) print the file   : [IV.1]

EXAMPLE OF ICWW00.yyy FILE

* Spaces and apostrophes have been added.

```
041 068 1622  1    00 0083   01 0419   02 0033   03 0363   ...
041 068 1642  2    00 0117   01 0419   02 0067   03 0363   ...
041 068 1702  3    00 0119   01 0419   02 0073   03 0363   ... B
041 068 1722  4    00 0126   01 0419   02 0082   03 0363   ... L
041 068 1742  5    00 0134   01 0419   02 0089   03 0363   ... O
041 068 1802  6    00 0316   01 0419   02 0333   03 0363   ... C
041 068 1822  1'   10 0083   11 0370   12 0033   13 0380   ... K
041 068 1842  2'   10 0111   11 0369   12 0147   13 0380   ...
041 068 1902  3'   10 0114   11 0370   12 0156   13 0380   ... 1
041 068 1922  4'   10 0117   11 0369   12 0167   13 0380   ...
041 068 1942  5'   10 0119   11 0369   12 0180   13 0380   ...
041 068 2002  6'   10 0317   11 0369   12 0333   13 0380   ...

041 068 2022  1    00 0084   01 0418   02 0033   03 0362   ...
041 068 2042  2    00 0200   01 0419   02 0169   03 0362   ...
041 068 2102  3    00 0202   01 0418   02 0178   03 0362   ... B
041 068 2122  4    00 0207   01 0419   02 0190   03 0362   ... L
041 068 2142  5    00 0215   01 0418   02 0200   03 0362   ... O
041 068 2202  6    00 0317   01 0418   02 0333   03 0362   ... C
041 068 2222  1'   10 0085   11 0369   12 0032   13 0380   ... K
041 068 2242  2'   10 0131   11 0369   12 0242   13 0380   ...
041 068 2302  3'   10 0133   11 0369   12 0250   13 0380   ... 2
041 068 2322  4'   10 0137   11 0369   12 0255   13 0380   ...
041 068 2342  5'   10 0140   11 0369   12 0261   13 0380   ...
041 069 0002  6'   10 0316   11 0369   12 0335   13 0380   ...
 ^   ^    ^   ^     ^          ^         ^         ^
'EXP' DAY TIME SCAN'TRANSDU LOAD CELL TRANSDU LOAD CELL ...
```

STRUCTURE OF THE KHRAWxx.DAT DATA FILES

*** These files contains raw data for one sample of soil.

*** These files cannot be edited (direct access files, with a fixed record lenghth of 144 bytes).

* RECORD STRUCTURE:

RECORD 1:   72 (2 BYTE) INTEGER WORDS

```
           1       : NLAST
     W     2       : NCHAN
     O     3       : NRES
     R     4       : NRTL
     D     5       : NREE
     S     6       : IKHILCD
     .     7-10    : RESERVED
     .     11      : IFN
     .     12      : IDAY
           13      : IHOUR
           14      : IMIN
           15      : MINLOAD
           16      : MAXLOAD
           17      : MINCHAN # 1
           18      : MAXCHAN # 1
           .                 .
           .                 .
           39      : MINCHAN # 12
           40      : MAXCHAN # 12
           41-72   : NOT USED
```

RECORD 2,3...n: 36 (4 BYTE) REAL WORDS (12 GROUPS OF 3 WORDS)

```
           1       : TIME    # 1
     W     2       : DATPRES # 1
     O     3       : DATLOAD # 1
     R     4       : TIME    # 2
     D     5       : DATPRES # 2
     S     6       : DATLOAD # 2
     .     .                 .
     .     .                 .
     .     34      : TIME    # 12
           35      : DATPRES # 12
           36      : DATLOAD # 12
```

```
* VARIABLES:
  ---------

NLASTT       : LAST RECORD IN FILE CONTAINING DATA
                (=0 IF NO DATA IN FILE)

NCHAN        : NUMBER OF CHANNELS (= PRESSURE TRANSDUCER
                CHANNELS OR SCANNIVALVE POSITIONS) IN ICWW00.yyy

NRES         : RECORD # WHERE THE EXPERIMENT STARTS
NRTL         : RECORD # OF THE LAST GOOD TENSIOMETER DATA
NREE         : RECORD # WHERE THE EXPERIMENT ENDS
                (NRES, NRTL AND NREE ARE SET BY PROGRAM KHPLOT)

IKHILCD      : KHILCD STATUS  - 0 LOAD CELL DATA NOT PROCESSED
                              - 1 LOAD CELL DATA PROCESSED

IFN          : EXPERIMENT NUMBER

IDAY         : DAY    |
IHOUR        : HOUR   | OF FIRST SCAN (IN RECORD 2)
IMIN         : MINUTE |

MINLOAD      : MINIMUM VALUE OF LOAD CELL DATA
MAXLOAD      : MAXIMUM VALUE OF LOAD CELL DATA
MINCHAN #    : MINIMUM VALUE OF CHANNEL # OF PRESSURE TRANSDUCER
MAXCHAN #    : MAXIMUM VALUE OF CHANNEL # OF PRESSURE TRANSDUCER
                (CHANNELS # : 1,2,3,... 12)

TIME    #    : TIME ELAPSED SINCE 1ST SCAN (MN) |
DATPRES #    : PRESSURE TRANSDUCER DATA         | FOR CHANNEL #
DATLOAD #    : LOAD CELL DATA                   |
                (CHANNELS # : 1,2,3,... 12)

*** REFERENCES:
    ----------

     a) how to get the file : [II.1]
     b) calculation         : [II.2,II.3,III.1,III.2]
     c) print the file      : [II.2,IV.2]
```

STRUCTURE OF THE KHPARxx.DAT FILES

*** These files contain the description of the experimental set-up for the samples of soil. They also contain the water contents of the samples measured at the end of the experiment.

*** THESE FILES MUST BE CREATED, USING EDIT MODE.

Different groups of data must be given in free format (separated by a comma or a space) immediately after each record corresponding to the description of the same group of data.

When these files are read, there is a special subroutine to find the string corresponding to the description of a group of data.

*** FILE STRUCTURE:

```
;LOAD CELL CONVERSION FACTOR
FLOAD
;PRESSURE TRANSDUCER CONVERSION FACTOR AND LEVEL
FPRES, HPRES

;HIGH REFERENCE
HHIGH, NHIGH
;LOW REFERNCE
HLOW, NLOW

;TENSIOMETER                          <- First tensiometer
PTENS, HTENS, NTENS                      .
    .                                    .
    .                                    .
;TENSIOMETER                          <- Last tensiometer
PTENS, HTENS, NTENS                      (Maximum 10)

;SAMPLE DATA
DIAM, HEIGHT, HSAM, VSAM
DESCSAM                               <- Maximum 4 records

;LAYER DATA                           <- First layer
NLAY, HLAY                               .
    .                                    .
    .                                    .
;LAYER DATA                           <- Last layer
NLAY, HLAY                               (Maximum 10)

;RESEARCHER DATA
DESCPROJ                              <- Maximum 3 records

;MOISTURE CONTENT
WATER
```

*** VARIABLES:

FLOA	:	FACTOR NEEDED TO OBTAIN THE MASS (kg) OF THE SAMPLE, (MULTIPLY FACTOR WITH LOAD CELL DATA)
FPRES	:	FACTOR NEEDED TO OBTAIN THE PRESSURE (mm WATER COLUMN AT T=20 C,1mm WATER COLUMN= 9,80655 Pa AT T=3,98 C AND 9,78929 Pa AT T=20 C)
HPRES	:	LEVEL OF THE PRESSURE TRANSDUCER WITH REGARD TO THE ZERO LEVEL (mm)
HHIGH,HLOW	:	LEVEL OF HIGH / LOW REFERENCE WITH REGARD TO ZERO LEVEL (mm)
NHIGH,NLOW	:	CHANNEL # OF HIGH / LOW REFERENCE (1,2...,12)
PTENS	:	TENSIOMETER # (1,2...,10; COUNT FROM TOP TO BOTTOM)
HTENS	:	LEVEL (mm) OF TENSIOMETER #
NTENS	:	CHANNEL # (1,2...,12) OF TENSIOMETER # (= SCANIVALVE POSITION)
DIAM	:	DIAMETER (mm) OF THE SAMPLE
HEIGHT	:	HEIGHT (mm) OF THE SAMPLE
HSAM	:	LEVEL OF THE TOP OF THE SAMPLE (mm)
VSAM	:	VOLUME OF SAMPLE WITHOUT TENSIOMETERS (mm**3)
DESCSAM	:	TEXT FOR DESCRIPTION OF SAMPLE (MAXIMUM 4 RECORDS)
NLAY	:	LAYER # (1,2...,10; COUNT FROM TOP TO BOTTOM)
HLAY	:	THICKNESS OF LAYER # (mm)
DESCPROJ	:	TEXT FOR PROJECT DESCRIPTION (MAXIMUM 3 RECORDS)
WATER	:	MOISTURE CONTENT (m**3/m**3) OF SAMPLE MEASURED AT THE END OF EXPERIMENT.

*** REMARKS:

a) The correspondence between PTENS and NTENS depends on how the microtensiometers have been connected to scanivalve.

b) The sum of HLAY must be equal to HEIGHT. Try also to define HLAY so that the depth of each microtensiometer corresponds to the middle of one layer.

c) FPRES is a dummy variable (not used at this moment).

*** REFERENCES:

a) how to create these files : [VII.1,VII.2]
b) programs using these files : [part III]

EXAMPLE OF KHPARxx.DAT FILE
===========================

```
;LOAD CELL CONVERSION FACTOR
 0.005
;PRESSURE TRANSDUCER CONVERSION FACTOR AND LEVEL
 0.00123 (*), 225.0
;HIGH REFERENCE
 130.0, 1
;LOW REFERENCE
 -870.0, 6
;TENSIOMETER
 1, 166.0, 5
;TENSIOMETER
 2, 146.0, 4
;TENSIOMETER
 3, 126.0, 3
;TENSIOMETER
 4, 106.0, 2
;SAMPLE DATA
 103.0, 80.0, 176.0, 656200.0
 -60 CM  -  1304 B
 VELD C, PAGV LELYSTAD
 COORDINATEN:
 DATUM MONSTERNAME: 16-2-´84
;LAYER DATA
 1, 20.
;LAYER DATA
 2, 20.
;LAYER DATA
 3, 20.
;LAYER DATA
 4, 20.
;RESEARCHER DATA
 JUNT HALBERTSMA
 HAL
 PROJECT 421.2
;MOISTURE CONTENT
 0.221
```

(*) : dummy variable.

STRUCTURE OF THE KHCNTR.DAT FILE

*** This file contains some parameters used by KHCNTR, KHFYS, KHWRC and KHTH programs [III.2,III.3,III.4, III.6].

The data in this file determine the way how these programs are executed, and which data files must be processed.

*** THIS FILE MUST BE CREATED USING EDIT MODE.

Different groups of data must be given in free format (separated by a comma) immediately after each record corresponding to the description of the group of data.

When this file is read, there is a special subroutine to find a string corresponding to the description of a group of data.

*** FILE STRUCTURE:

```
;HARD COPY CONTROL
 ICOP

;DATA FILES TO BE PROCESSED
 NFIL

;LAST DATA FILE PROCESSED
 NLAST
```

*** VARIABLES:

ICOP : Controls whether KHWRC or KHTH generates hard copies or not.

<0 - no hard copy, no wait after plot
=0 - no hard copy, wait after plot
>0 - hard copy, no wait

NFIL : List of numbers of KHRAWxx.DAT data files to be processed (=1, 3,...,19) by KHCNTR.

Negative values indicate that KHWRC fits the water retention curve with a half-log curve. Zero values are skipped by KHCNTR.

NLAST : Corresponds to the first KHRAWxx.DAT file that must be processed by KHCNTR or KHFYS.

=0 - start with first data file from list.
>0 - start with the corresponding KHRAWxx.DAT file (xx = NLAST).
<0 - start with the next KHRAWxx.DAT file of the list.

Program KHCNTR sets this number. Its negative value is set before the execution of the first program (KHFYS) and its positive value is set after the last program (KHSAV).

REMARK : This record should be the last one of the file!

*** REFERENCES: file used for calculations: [part III]

EXAMPLES OF KHCNTR.DAT FILE

** EXAMPLE 1: $ RUN KHCNTR with:

```
;HARD COPY CONTROL
 1                                = hard-copies
;DATA FILES TO BE PROCESSED
 ,1,3,5,7,9,11,13,15,17,19        = KHWRC fits h(theta)
;LAST DATA FILE PROCESSED
 0                                = start with file # 1
```

** EXAMPLE 2: $ RUN KHTH with:

```
;HARD COPY CONTROL
 0                                = no hard-copy and wait
;DATA FILES TO BE PROCESSED
 , , , , , , , ,15, ,             = KHWRC fits h(theta)
;LAST DATA FILE PROCESSED
 0                                = start with file # 15
```

** EXAMPLE 3: $ RUN KHCNTR with:

```
;HARD COPY CONTROL
 -1                               = no hard-copy, no wait
;DATA FILES TO BE PROCESSED
 ,-1,-3, , ,-9,-11,-13,-15, ,     = KHWRC fits logh(theta)
;LAST DATA FILE PROCESSED
 3                                = start with file # 9
```

STRUCTURE OF THE KHFYS.DAT DATA FILE

*** This file contains the results of the computation for one sample of soil.

*** This file cannot be edited (direct access file, fixed record length of 88 bytes; 1 integer word is 2 bytes).

* RECORD STRUCTURE:

```
RECORD 1:
                   1      NRF
        W          2      NTENS
        O          3      NOT USED
        R          4      IFN
        D          5      IEXPN
        S          6      DAY
        .          7      HOUR
        .          8      MIN
        .          9      IHRDC
                   10     LINLOG
                   11     NOT USED
                   12     NORDHT
                   13     THETLO
                   14     THETHI
                   15-22  COEFHT

RECORD 2:
                   1      NORDKH
        W          2      HLO
        O          3      HHI
        R          4-11   COEFKH
        D          12     NORDKT
        S          13     THTLO
        .          14     THTHI
        .          15-22  COEFKT

REC 3,4,...NRF:
                   1      TIME
        W          2      THETAM
        O          3      HTENS # 1
        R          .
        D          .
        S          12     HTENS # 10
        .          13     WTENS # 1
        .          .
        .          .
                   22     WTENS # 10
```

* VARIABLES:

```
NRF            : LAST RECORD IN FILE CONTAINING DATA
NTENS          : NUMBER OF TENSIOMETERS USED IN THE
                 EXPERIMENT (MAXIMUM 10)

IFN            : DATA FILE NUMBER (=LOAD CELL NUMBER)
IEXPN          : EXPERIMENT NUMBER

DAY            : DAY    ¦
HOUR           : HOUR   ¦ OFFSET OF FIRST SCAN (IN RECORD 2)
MIN            : MINUTE ¦

IHRDC          : HARD COPY CONTROL (USED BY KHWRC)
LINLOG    - 0  : linear fit of water retention curve
          - 1  : half-log fit of water retention curve
                 (used by KHWRC)

NORDHT         : ORDER OF POLYNOMIAL DESCRIBING THE WATER
                 RETENTION CURVE
THETLO         : LOW BORDER OF THIS CURVE
THETHI         : HIGH BORDER OF THIS CURVE
COEFHT         : COEFFICIENTS OF POLYNOMIAL DESCRIBING WATER
                 RETENTION CURVE

NORDKH    > 0  : ORDER OF POLYNOMIAL DESCRIBING THE k-h CURVE
          < 0  : NUMBER OF COORDINATE PAIRS DEFINING THE POLYGON
                 THAT DESCRIBES THE k-h CURVE
HLO            : LOW BORDER OF CURVE
HHI            : HIGH BORDER OF CURVE
COEFKH    > 0  : COEFFICIENTS OF CURVE DESCRIBING THE k-h CURVE
          < 0  : NODES OF POLYGON (log(h1),log(k1),log(h2),..)

NORDKT    > 0  : ORDER OF POLYNOMIAL DESCRIBING THE k-THETA CURVE
          < 0  : NUMBER OF COORDINATE PAIRS DEFINING THE POLYGON
                 THAT DESCRIBES THE k-THETA CURVE
THTLO          : LOW BORDER OF CURVE
THTHI          : HIGH BORDER OF CURVE
COEFKT    > 0  : COEFFICIENTS OF CURVE DESCRIBING k-THETA CURVE
          < 0  : NODES OF POLYGON (THETA1, log(k1), THETA2,..)


TIME           : TIME ELAPSED SINCE FIRST SCAN (MINUTES)
THETAM         : MEAN WATER CONTENTS OF SAMPLE (m**3/m**3)
HT#1,HT#10     : PRESSURE OF TENSIOMETERS #1 / #10
                 (IN mm WATER, T=20 deg C)
WT#1,WT#10     : WATER CONTENTS OF THE LAYER SURROUNDING
                 TENSIOMETERS #1 / #10
```

*** REFERENCES:

```
a) how to get this file : [III.2]
b) calculations         : [part III]
c) print this file      : [IV.2,IV.3]
```

- PART VI -

USING MAGNETIC TAPE, MAGNETIC CASSETTES

OR FLOPPY DISC

USING THE DATA LOGGER FOR ONE EXPERIMENT

1 - PURPOSE:

** RECORD EXPERIMENTAL DATA WITH THE DATA LOGGER OF FYSLAB

THE PRINCIPLE OF THIS AUTOMATIC SYSTEM HAS BEEN DESCRIBED BY BOELS AND CO-WORKERS [I.2,VII.2]

2 - START ONE EXPERIMENT:

21. HOW TO PREPARE SAMPLES:

** This important problem will not be discussed here: you have to ask some help.

Samples must be saturated, microtensiometers must be installed and filled with deareated water, the good working of scanivalves must be checked (in manual mode)...

22. INITIALIZE A MAGNETIC CASSETTE:

** On the data logger:

+ select the experiment number ("PROEF NO")

+ if necessary, select the time (you have to remove the panel of the data logger, ask some help)

+ select the time step (in min) and press PRESET-key

  - for sandy soils, you can choose about 10 min
  - for heavy soils, you can choose about 2 min

(It is also possible to change the time step during the experiment)

** With the unit TU58 of the data logger:

+ install a magnetic cassette (on unit 0)

+ press about 6 times CONTROL-button: an error code appears

error code = 000 : no problem
= 011 : check the cassette's protection
= 245 : cassette with no free blocks

for other codes : look at the manual from TFDL

+ press START-button: you will get the number of free blocks of the cassette

+ press CONTROL-button and START-button at the same time: the cassette is initialized (old data on this cassette will be overwritten); normally an empty cassette contains 504 blocks

+ press EJECT-button, if you want to take off the cassette

+ the unit TU58 of the data logger will always create a file called ICWW00.zzz (often zzz = 001)

23. RUN THE DATA LOGGER:

** On the data logger:

+ select the canals to be recorded with the data logger:

- pair numbers: scanivalves
- odd numbers: load cells

+ press RESET-button
+ press START-button

+ select AUTOMATIC-mode: the data logger is running

3 - CHANGE MAGNETIC CASSETTE DURING ONE EXPERIMENT:

** With 10 soil samples, 1 block corresponds to about 7 reading (or 7 time steps): in these conditions, a cassette can be used over about 70 time steps.

+ select HAND-mode
+ press EJECT-button
+ take off the old magnetic cassette (from unit 0)

+ install a new magnetic cassette (also unit 0)
+ initialize the new cassette as before
+ select AUTOMATIC-mode

4 - CHECK THE DATA LOGGER WORKING DURING ONE EXPERIMENT:

** On the data logger:

+ between two reading, select the MANUAL-mode
+ press RESET-button

+ by pressing the START-button, you will see the values that are read for the different canals (=different soil samples), when scanivalves are in a certain position. If scanivalve position corresponds to a tensiometric reading, and if the scanivalve have just moved, you may have to wait few seconds , so that you get a stablization of the read values.

+ select the AUTOMATIC-mode before in order to record other data. If you were still in MANUAL-mode when scanivalve positions have changed, you will lost recorded data.

+ proceed in the same way for all scanivalve positions.

* If you are using a quite long time step (more than 10 min), you can check recorded data in another way: ask some help at FYSLAB.

5 - STOP ONE EXPERIMENT:

** On the data logger:

+ select HAND-mode

+ press EJECT-button

+ take off the last magnetic cassette
(normally, the data logger is always switched on)

6 - PROBLEMS:

*** Never forget to select AUTOMATIC-mode when recording the data !

*** If you are working with less than 10 soil samples, be careful when you select the canals recorded with the data logger !

*** If some lights corresponding to scanivalves are on, this indicates that some scanivalves are disconnected from the data logger or that they do not work well (press RESET-button to check this last point). If you have still any problem, ask some help !

** If you cannot initialize a magnetic cassette, ask some help.

*** The main problems are not coming from the data logger, but from the measuring instruments:

- Never remove soil samples or reference levels !
- Avoid to touch scanivalves during an experiment !
- Check that there is no air in capillairs connected to scanivalves.
- Check that the reference levels remain constant.

*** Finally, when doing an experiment:

- Do not forget to determine the mean water content of the samples at the end of experiment !
- Do not forget that an experiment may last few weeks.

GET RAW DATA ON PDP RSX-11M-PLUS (VIA PDP RT-11)

A - COPY MAGNETIC CASSETTES ON A FLOPPY DISC (PDP RT-11)

1 - TIME:

* about 30 min

2 - PURPOSE:

** COPY THE DATA FILE OF ONE EXPERIMENT ON A FLOPPY DISC.

THIS FLOPPY DISC WILL BE READ THEREAFTER ON THE PDP RSX-11M-PLUS [VI.2(B)].

3 - ACTION:

** Read the magnetic cassettes on the PDP RT-11 and copy the data files on a floppy disc:

+ switch on the PDP RT-11

+ select mode "NORMAL" and press the button "EXECUTE MODE SELECTION" (if necessary)

\# enter date [dd-mmm-yy]
\# enter time [hh:mm:ss]
\# press RETURN-key
(when "startup file [filnam.typ]?" appears)

+ install the floppy disc
+ install the first magnetic cassette (in unit 0)

\# DIR DD0: (directory for magnetic cassette)
\# DIR DY: (directory for floppy disc)

+ check that there are enough free blocks on the flopy disc, to copy the content of the cassette

COPY DD0:ICWW00.001 DY:*.* (wait about 5 min)

+ remove the magnetic cassette

+ copy the others cassettes on the floppy disc in
  the same way.
  (check that ICWW00.zzz files have different names
  for each cassette, or change their names when they
  are copied on floppy disc)

+ remove the floppy disc

+ you can switch off the PDP RT-11

4 - INPUT:

** Magnetique cassettes containing data of experiment [VI.1].

5 - OUTPUT:

** Floppy disc containing data of experiment.

6 - PROBLEMS:
----

* If you must initialize the floppy disc:

  + select mode "FORMAT" and press the button
    "EXECUTE MODE SELECTION"
    (wait about 30 s)

  + select mode "NORMAL" and press the button
    "EXECUTE MODE SELECTION"
    (the floppy disc is initialized)

  # INIT DY:

*** For other problems, ask some help !

B - COPY THE FLOPPY DISC ON THE PDP RSX-11M-PLUS

1 - TIME:

* about 30 min

2 - PURPOSE:

** GET THE RAW DATA FILE OF ONE EXPERIMENT ON THE KH/KH DIRECTORY.

3 - ACTION:

** The floppy disc containing raw experimental data must be read on the PDP RSX-11M-PLUS:

```
> HEL KH/KH

+ install the floppy disc on the disc unit

$ MOUNT /FOR DY:

$ .FLX DY: /LI/RT  (directory of the floppy disc)

$ .FLX
FLX>=DY:*.*/RT  (wait about 15 min)

+ take off the floppy disc

$ APPEND ICWW00.002 ICWW00.001  |
$ APPEND ICWW00.003 ICWW00.001  | if you have many files
  ...                           |

$ RENAME ICWW00.001 ICWW00.yyy
  (yyy: experiment number)
```

* If you have to exit FLX-mode, enter CTL^Z

4 - INPUT:

** floppy disc with data of experiment [VI.2(A)]

5 - OUTPUT:

** ICWW00.yyy file on KH/KH directory [V.1]

6 - PROBLEM:

*** If problems, ask some help !

GET RAW DATA ON THE PDP RSX-11M-PLUS (VIA VAX-VMS)

*** WARNING : THIS IS AN OBSOLETE POSSIBILITY !!!

As a matter of fact, FYSLAB does not have an account anymore on ADMVAX.

A - COPY MAGNETIC CASSETTES ON A MAGNETIC TAPE (VAX-VMS)

1 - TIME:

* about 30 min.

2 - PURPOSE:

* COPY THE DATA FILE OF ONE EXPERIMENT ON A MAGNETIC TAPE. THIS TAPE WILL BE READ THEREAFTER ON THE PDP RSX-11M-PLUS [VI.3(B)].

3 - ACTION:

* Read the magnetic cassettes on the VAX-VMS:

```
# Local>    C ADMVAX
# Username: ........  (no account anymore !)
# Password: ...

# ALLOC CSA1:
+ bring one magnetic cassette to the computer centrum
# MOUNT /FOR CSA1:
# EXC
EXC> COPY  CSA1:*.* *.*
EXC> EXIT
# DISM  CSA1:
# DEALL CSA1:

+ copy in the same way the content of other cassettes

+ append all the ICWW00.zzz files, so that you
  will get the ICWW00.yyy file (where yyy is the
  experiment number)

# LO
```

* Then copy the experimental data file on a magnetic tape:

```
# Local>    C LUCTOR
# Username: CHAL_0200700
# Password: ...

# ALLOC MUB0:
+ bring the magnetic tape to the computer centrum
# MOUNT MUB0:label
# COPY  ICWW00.yyy MUB0:*.*
# DISM  MUB0:
# DEALL MUB0:

# LO
```

* If the magnetic tape has been initialised on the PDP RSX-11M-PLUS, this tape must be mounted on the VAX-VMS with the option:

```
# MOUNT/OVERRIDE=OWNER_ID MUB0:label label
```

4 - INPUT:
----

* Magnetic cassettes containing data of experiment [VI.1]

5 - OUTPUT:
----

* Magnetic tape containing data of experiment

6 - PROBLEMS:
----

* If problem, ask some help.

B - COPY THE MAGNETIC TAPE ON THE PDP RSX-11M-PLUS

1 - TIME:

* about 30 min

2 - PURPOSE:

* GET RAW DATA FILE OF ONE EXPERIMENT ON KH/KH DIRECTORY.

3 - ACTION:

* The magnetic tape containing load cell and tensiometric data is read on the PDP RSX-11M-PLUS of FYSLAB.

```
> HEL KH/KH

+ SWITCH ON the tape unit of the PDP
+ place the magnetic tape into the tape unit
+ press buttons LOAD REWIND and ON_LINE (wait for
  the end of blinkering)

$ MOUNT MS:label
$ COPY  MS:ICWW00.yyy *.*
$ DISM  MS:

+ wait for the end of blinkering, take the tape
+ SWITCH OFF the tape unit of the PDP
```

4 - INPUT:

* Tape records with data of experiment [VI.2(A)]

5 - OUTPUT:

* ICWW00.yyy file on KH/KH directory [V.1]

6 - PROBLEM:

* If problem, ask some help.

SAVE THE DATA ON A MAGNETIC TAPE

1 - TIME:

* about 15 min

2 - PURPOSE:

** SAVE DATA ON A MAGNETIC TAPE.

3 - ACTION:

** Copy the data files on a magnetic tape

```
> HEL KH/KH

+ SWITCH ON the tape unit of the PDP
+ place the magnetic tape KHDATA into the tape unit
+ press buttons LOAD REWIND and ON_LINE (wait for the
  end of blinkering)

$ MOUNT MS:KHDATA
$ .BCK  MS:KH.yyy = *.yyy/SL
$ DISM  MS:

+ wait for the end of blinkering, take the tape
+ SWITCH OFF the tape unit of the PDP
```

4 - INPUT:

** KHFYSxx.yyy, KHPARxx.yyy and KHRAWxx.yyy [V.2,V.3,V.5]

5 - OUTPUT:

** KH.yyy file

6 - PROBLEMS:

** Direct access files can only be copied by using the BCK-mode.

* To exit BCK-mode, enter CTL^Z

RESTORE DATA FROM MAGNETIC TAPE KHDATA

1 - TIME:

* about 15 min

2 - PURPOSE:

** Restore data stored in the magnetic tape KHDATA

3 - ACTION:

** Copy the data of the tape KHDATA (those data are stored with a special format in order to use the minimum space)

```
> HEL KH/KH

+ SWITCH ON the tape unit of the PDP
+ place the magnetic tape KHDATA in the tape unit
+ press buttons LOAD REWIND and ON_LINE (wait for
  the end of blinkering)

$ MOUNT MS:KHDATA
$ .RST   *.* = MS:KH.yyy/SL
$ DISM   MS:

+ wait for the end of the blinkering, take the tape
+ SWITCH OFF the tape unit of the PDP
```

* To copy only one special file, you must specify:

```
$ .RST *.* = MS:KH.yyy / SE:KHPARxx.yyy
```

4 - INPUT:

** KH.yyy file [VI.5]

5 - OUTPUT:

** KHFYSxx.yyy, KHPARxx.yyy and KHRAWxx.yyy [V.2,V.3,V.5]

6 - PROBLEMS:

** Direct access files can only be restored using the RST-mode.

* To exit RST-mode, enter CTL^Z

** After restoring, the file will be still on tape. Saving the data on tape again,the file is twice on tape with the same version and a different date.

- PART VII -

FIGURES AND TABLES

```
-----------------------------------------------------------
    *** WARNING : The numerical values given in this
        part correspond to the experimental set-up
        used now at FYSLAB.
        If you change this set-up, you must be careful
        when editing parameter files KHPARxx.DAT [V.2].
-----------------------------------------------------------
```

DIMENSION OF SOIL SAMPLE

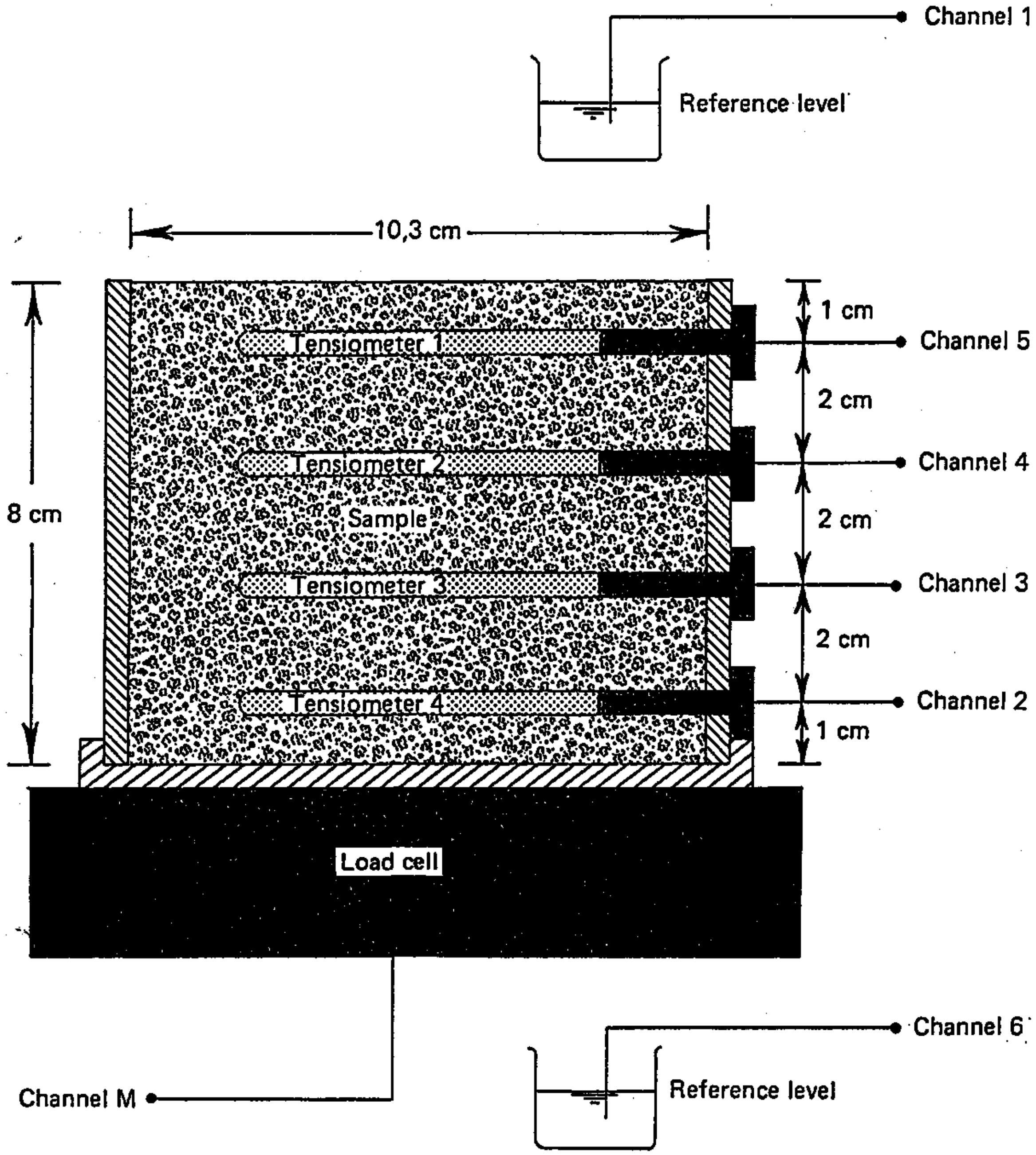


Fig. - Set-up used now at FYSLAB for the determination of soil hydraulic properties (schema).

* DIMENSIONS OF SAMPLE:

- height = 80 mm
- diameter = 103 mm
- total volume = 666 584 mm3

- volume of 1 tensiometer # 2 597 mm3
  (diameter # 6 mm)

- volume (sample - 4 tensiometers) # 656 200 mm3

* DEPTH OF MICROTENSIOMETERS BELOW THE TOP OF THE SAMPLE:

- tensiometer 1 = - 10 mm
- tensiometer 2 = - 30 mm
- tensiometer 3 = - 50 mm
- tensiometer 4 = - 70 mm

* PRECISION ON THE MEASUREMENTS:

- microtensiometers: it is possible to assume that the incertitudes on the measurements are normally distributed, with a standard deviation of 0.3 cm (this result has been obtained with the reference levels data).

- load cell: the data are digitized, and the smallest difference between two recorded values is 5 g. Compared to this step of 5 g, the incertitudes on the measurements are much smaller.

- VII.2.1 -

DESCRIPTION OF THE AUTOMATIC SYSTEM

DETERMINATION OF $k - \psi$ AND $\psi - \theta$ RELATIONSHIPS

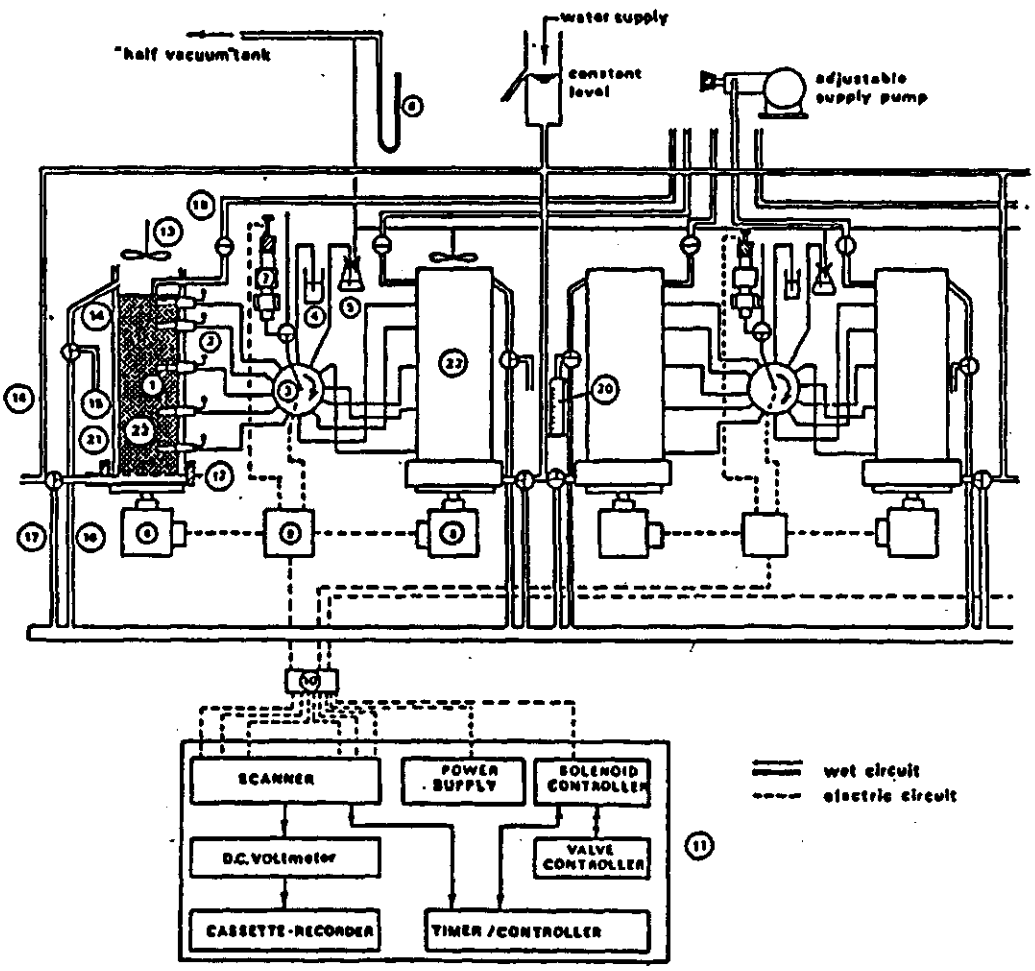


FIG. Setup of measuring and controlling devices: 1, tensiometer; 2, air outlet; 3, scannivalve; 4, "zero" reference pressure; 5, "half-vacuum" reference pressure; 6, mercury manometer; 7, pressure transducer; 8, load cell; 9, connector; 10, connector; 11, data-logger; 12, base cap with watertight sealing; 13, airvane; 14, overflow tube; 15, overflow outlet to 20; 16, overflow drain; 17, drain; 18, water supply for wetting and measuring saturated conductivity; 19, water supply in adjustable flow rates; 20, calibrated measuring vessel; 21, sample ring; 22, soil core.

(Boels and co-workers,1978)

* These indications are valid for all the load cells #
(they are coming from KHPAR01.040 file).

** CORRESPONDANCE LOAD CELL # AND PRESSURE TRANSDUCERS # :

transducer #	load cells #
# (00/10)	01 , 11
# (02/12)	03 , 13
# (04/14)	05 , 15
# (06/16)	07 , 17
# (08/18)	09 , 19

** CONVERSION FACTORS:

load cell : 0.005 (kg)

pressure transducers : not used (dummy value)

** LEVELS:

high reference : 130.0 (mm)
low reference :-870.0 (mm)

tensiometer # 1 : 166.0 (mm)
tensiometer # 2 : 146.0 (mm)
tensiometer # 3 : 126.0 (mm)
tensiometer # 4 : 106.0 (mm)

top of sample : 176.0 (mm)

** CORRESPONDANCE TENSIOMETERS - SCANIVALVE # :

tensiometer	channel of scanivalve
high reference	# 1
low reference	# 6
tensiometer 1	# 5
tensiometer 2	# 4
tensiometer 3	# 3
tensiometer 4	# 2

* Used for: KHPARxx.DAT files [V.3]

DETERMINATION OF THE WATER RETENTION CHARACTERISTIC

REITERATION PROCEDURE

Generally the moisture contents determined by weighing do not fully agree with those calculated from the tension readings. As the first are fairly exact, the errors are in the tension readings and in the pF-curve used. Making the assumption that the tension readings are accurate, the pF-curve is corrected in the following way. Every moisture content determined from the tension readings is multiplied by the quotient of the real and the calculated total moisture content. These corrected moisture contents are plotted against the tension; through these points a new line is drawn: the first correction of the pF-curve. The moisture contents are again calculated, now with the aid of the new pF-curve. For every date they are added and their sum is divided by the real total moisture content. They are multiplied by this quotient and again plotted against the tension. Through those points the second corrected pF-curve is drawn. One can repeat these corrections and each time the deviations of the points will be less.

An example of this iteration procedure is given in table 1 and fig. 1. For the sake of demonstration this is a fictitious example where the real pF-curve was known and the used pF-curve was made to differ extensively from the real curve.

Table 1 shows that the corrected moisture contents at every step come nearer to the true moisture contents. In fig. 1 the difference between the true and the corrected curve becomes smaller after every iteration.

In reality the true curve of course is not known; the iterations should be continued until the deviations of the points from the smooth line through them are not greater than one per cent of moisture. Generally this is achieved in 4 or 5 iterations. Only curves of sandy soils, which have a very flat part, need some more, as fig. 1 shows.

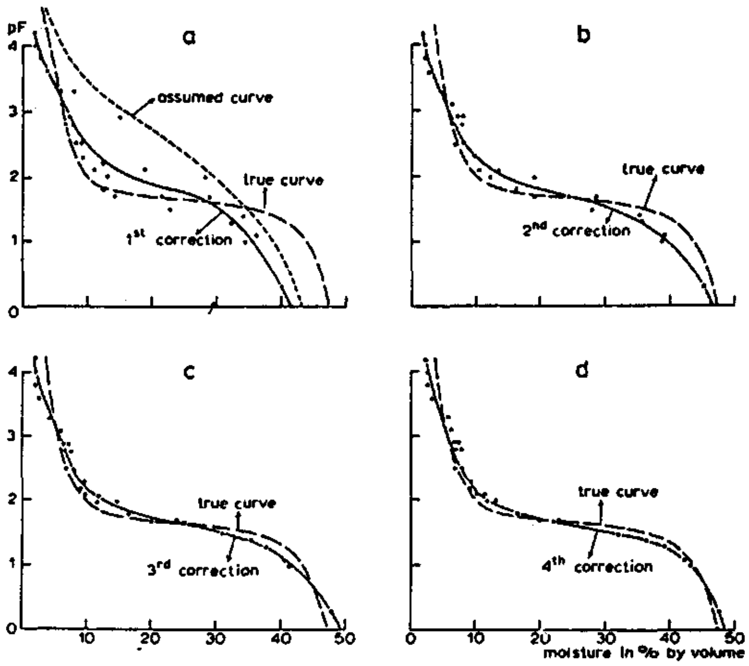


FIGURE 1. *Example of the reiteration method. The crosses are corrected values obtained from the former curve, assumed curve 1a first correction in 1b etc. Through the crosses a new line is drawn, which approach the true curve more and more. The true curve is given in every figure; in reality it is of course not known*

(Wind, 1966)

Instantaneous profile method : theoritical equations and discretization for the calculation of the unsaturated conductivity

a. Theoretical equations

(1)	$\frac{\partial \theta}{\partial t} = - \frac{\partial q}{\partial z}$	(mass conservation law)
(2)	$q = - K \left(\frac{\partial h}{\partial z} - 1 \right)$	(Darcy's law)
(1)+(2) → (3)	$\frac{\partial \theta}{\partial t} = \frac{\partial}{\partial z} \left[K \left(\frac{\partial h}{\partial z} - 1 \right) \right]$	(Richard's equation)
(3) → (4)	$\int_{Z_r}^{Z} \frac{\partial \theta}{\partial t} dz = K \left(\frac{\partial h}{\partial z} - 1 \right)$	(integration of (3))

z: depth

t: time

θ: volumetric water content

h: sorption potential

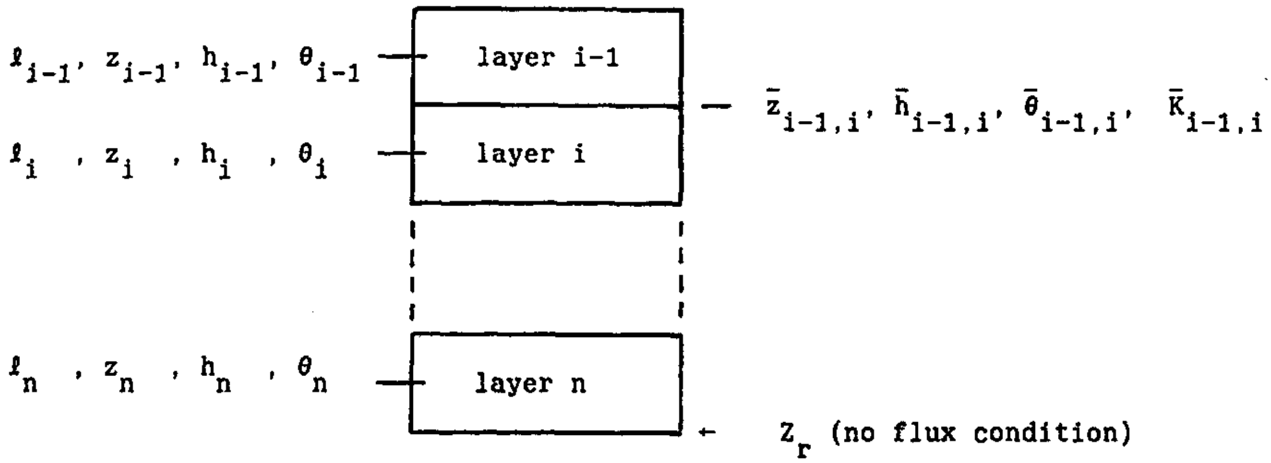
Z_r: reference level (no flux)

Z : depth at which K is calculated

K : unsaturated conductivity (at depth Z)

q : flux (at depth Z)

b. Discretization of the system



(4) → (5) $$\sum_{j=n}^{i} \left(\frac{\Delta\theta_j}{\Delta t}\right) . \ell_j = \bar{K}_{i-1,i} . \left(\frac{\Delta h_{i-1,i}}{\Delta z_{i-1,i}} - 1 \right)$$

(6) $$\bar{z}_{i-1,i} = \frac{1}{2} (z_{i-1}+z_i)$$

(7) $$\bar{h}_{i-1,i} = \frac{1}{2} (h_{i-1}+h_i)$$

(8) $$\bar{\theta}_{i-1,i} = \frac{1}{2} (\theta_{i-1}+\theta_i)$$

i : layer number (1,2,3,4)

n = 4 (in this case)

z_i: depth of the middle of layer i

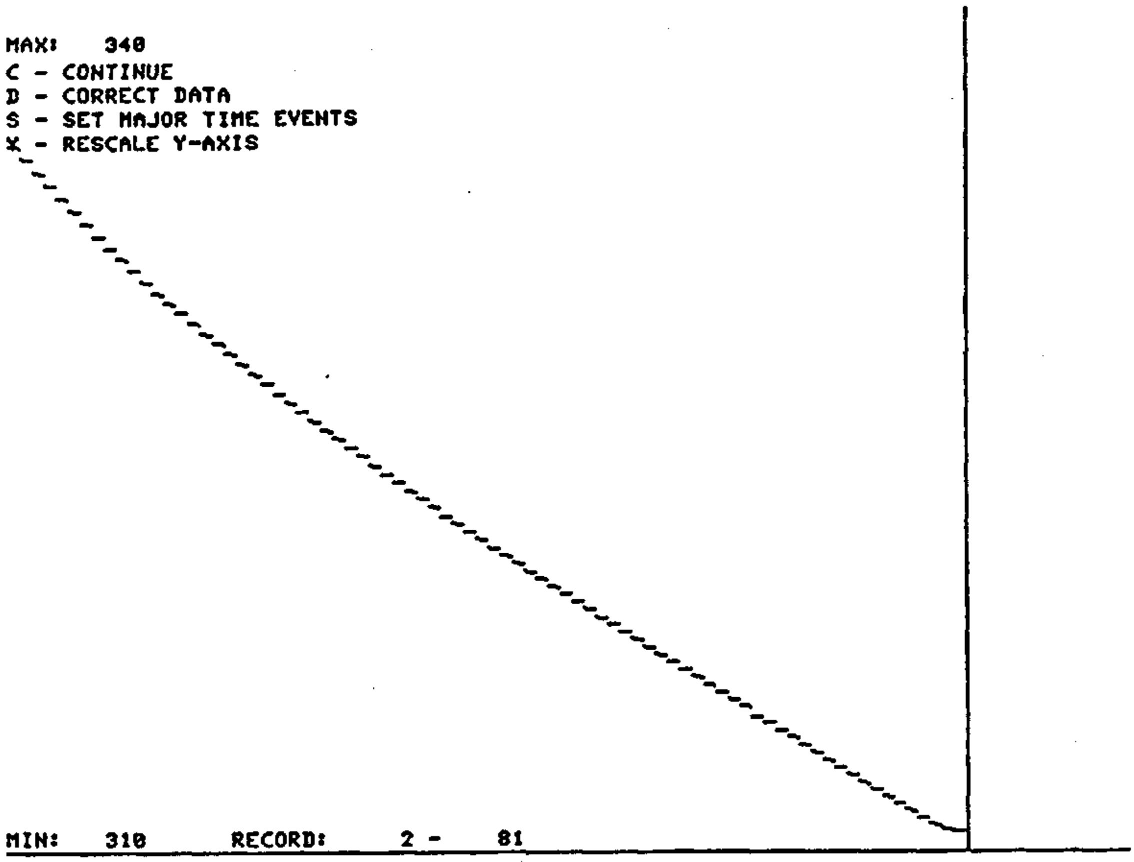
ℓ_i: thickness of layer i

θ_i: volumetric water content of layer i

h_i: sorption potential of layer i ; mean value over the time step Δt

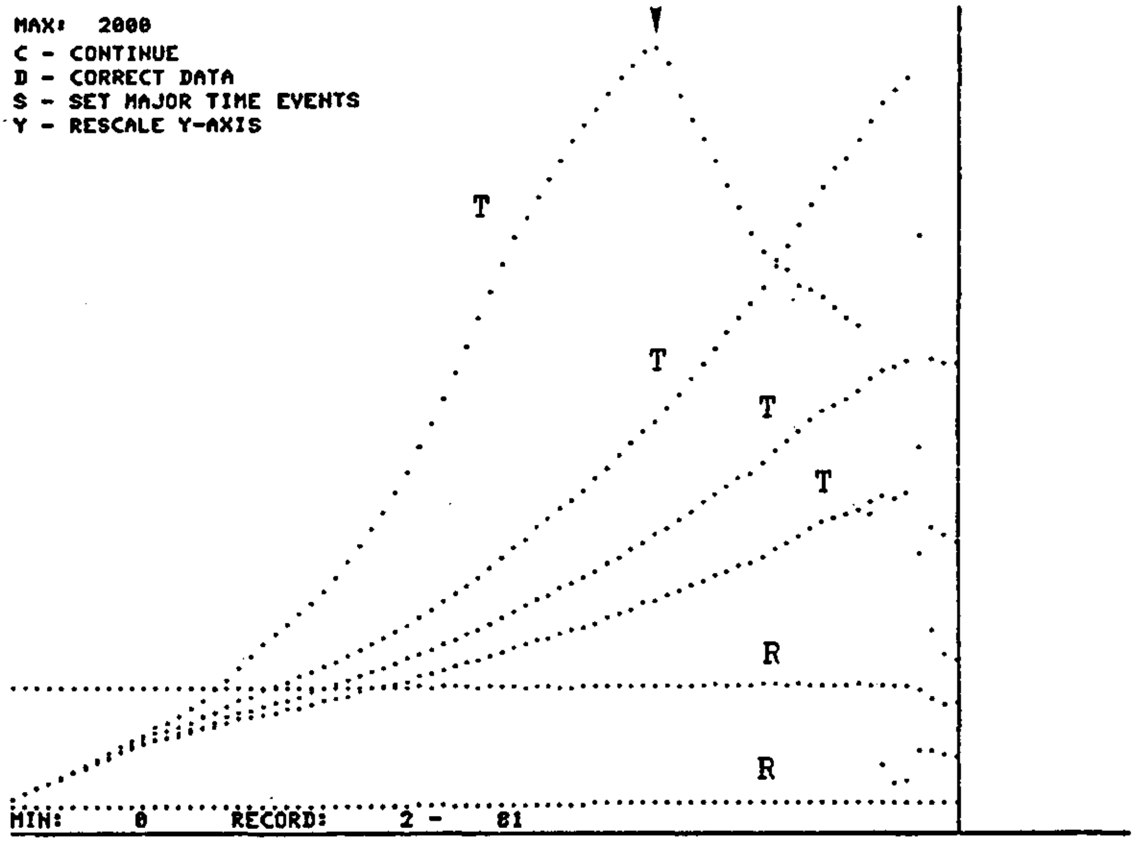
$\bar{K}_{i-1,i}$ corresponds to $\bar{z}_{i-1,i}$, $\bar{h}_{i-1,i}$, $\bar{\theta}_{i-1,i}$

OUTPUT OF KHPLOT : 1 - LOAD CELL DATA



* This file has been processed with KHPLOT and compressed with KHCMPR three times more than necessary.

OUTPUT OF KHPLOT : 2 - TENSIOMETRIC DATA

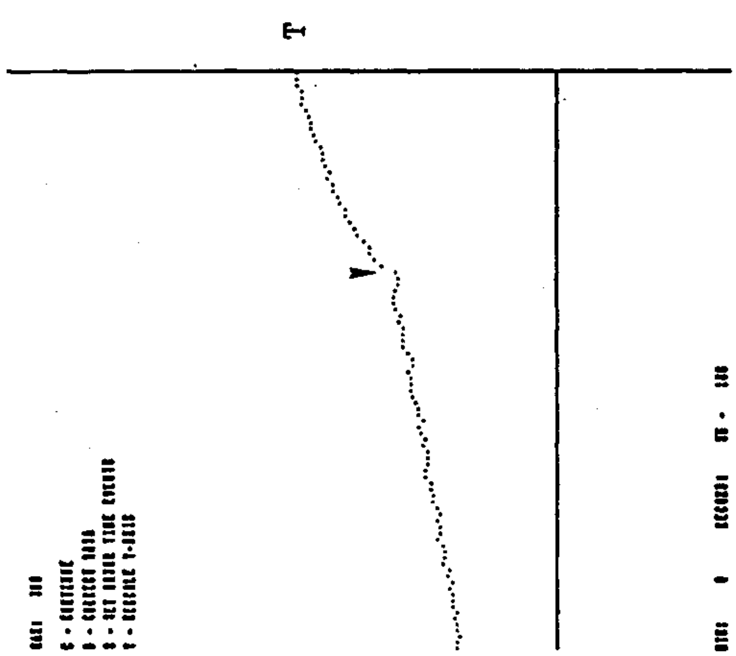


T : channel for tensiometric data
R : channel for reference level

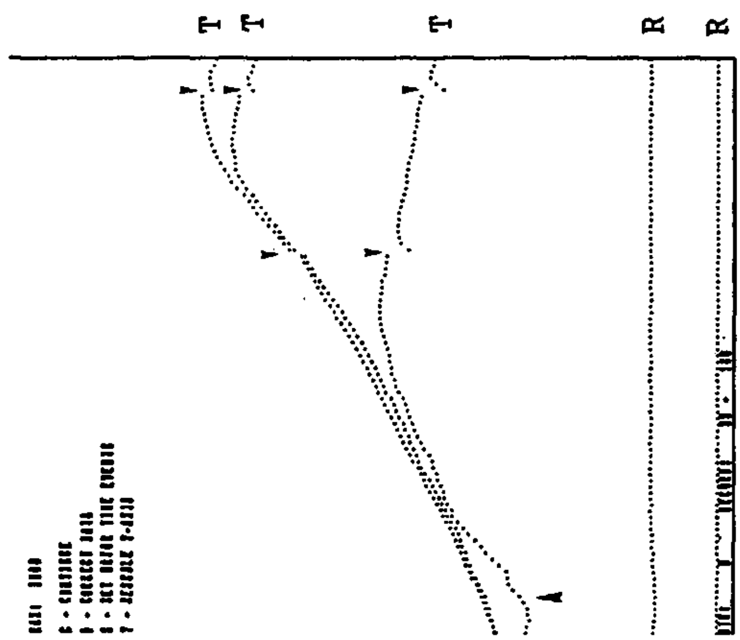
➤ : this arrow should correspond to the "last good tensiometer reading"

* This file has been processed with KHPLOT and compressed with KHCMPR three times more than necessary.

OUTPUT OF KHPLOT : 2 - TENSIOMETRIC DATA

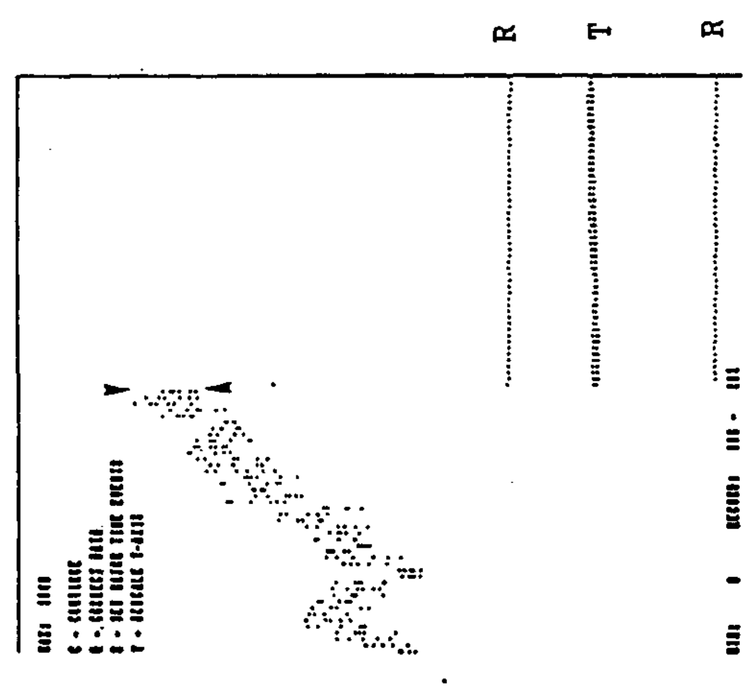


(1) SLOPE MODIFICATION OF CURVE

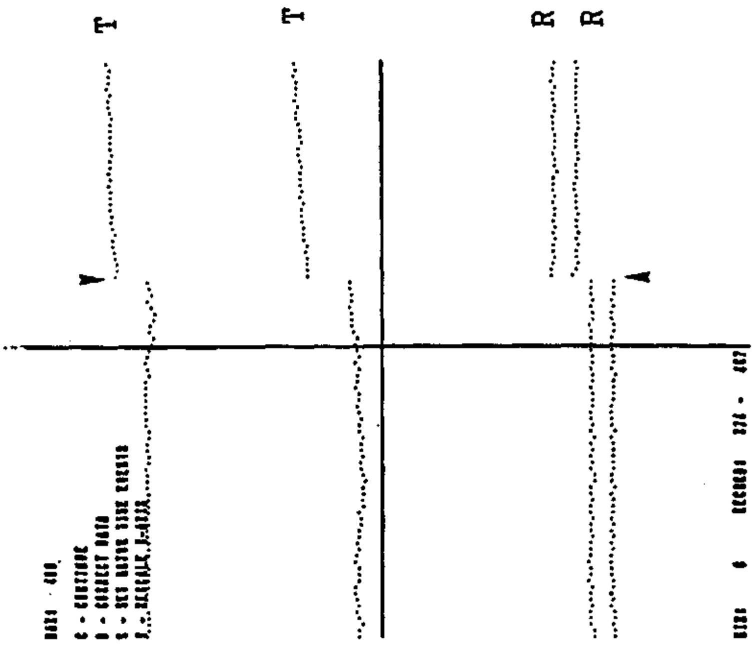


(2) LITTLE OSCILLATIONS OF CURVES

OUTPUT OF KHPLOT : 2 - TENSIOMETRIC DATA

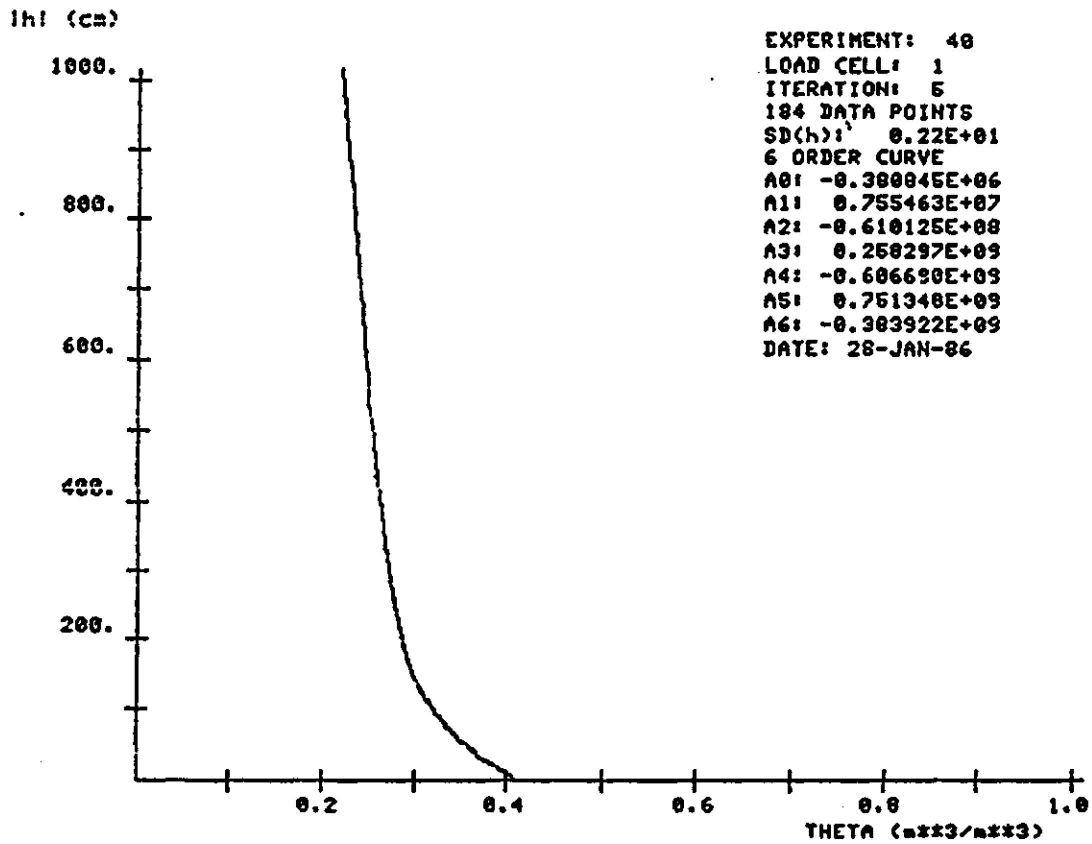


(3) IMPORTANT OSCILLATIONS OF ALL CURVES



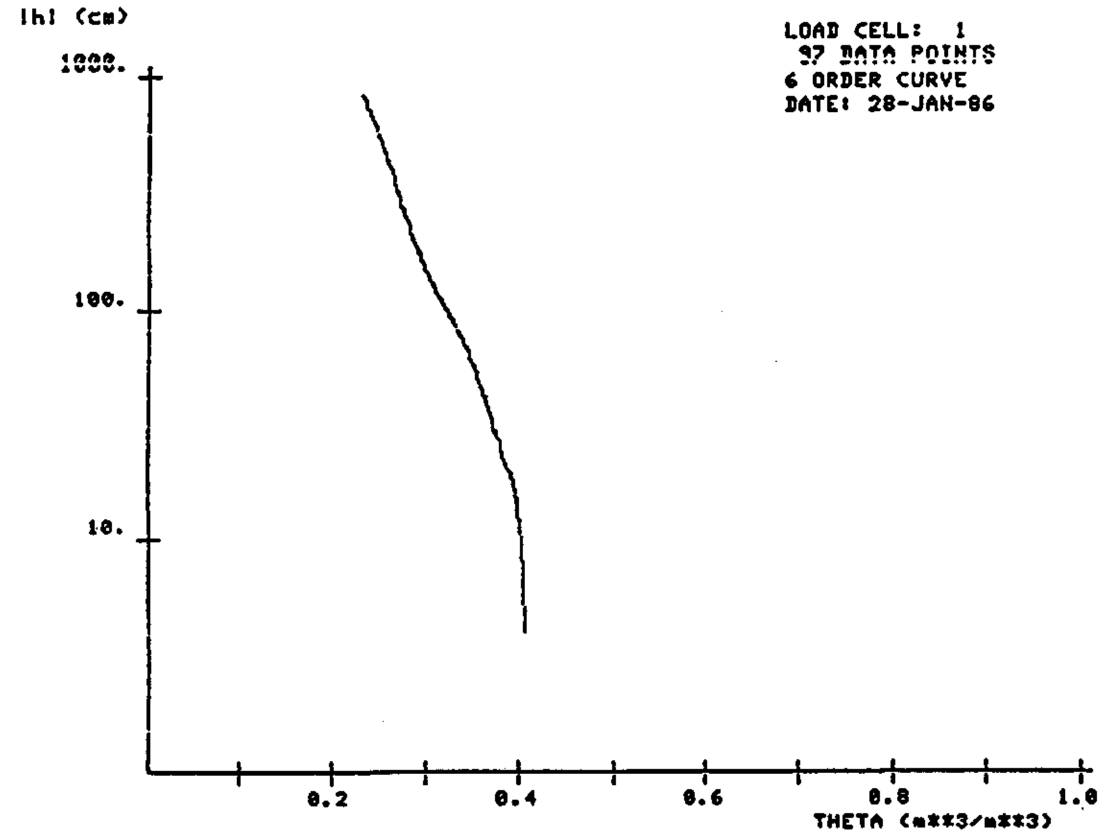
(4) TRANSLATION OF ALL CURVES

OUTPUT OF KHWRC



OUTPUT OF KHTH

(WATER RETENTION CURVE)

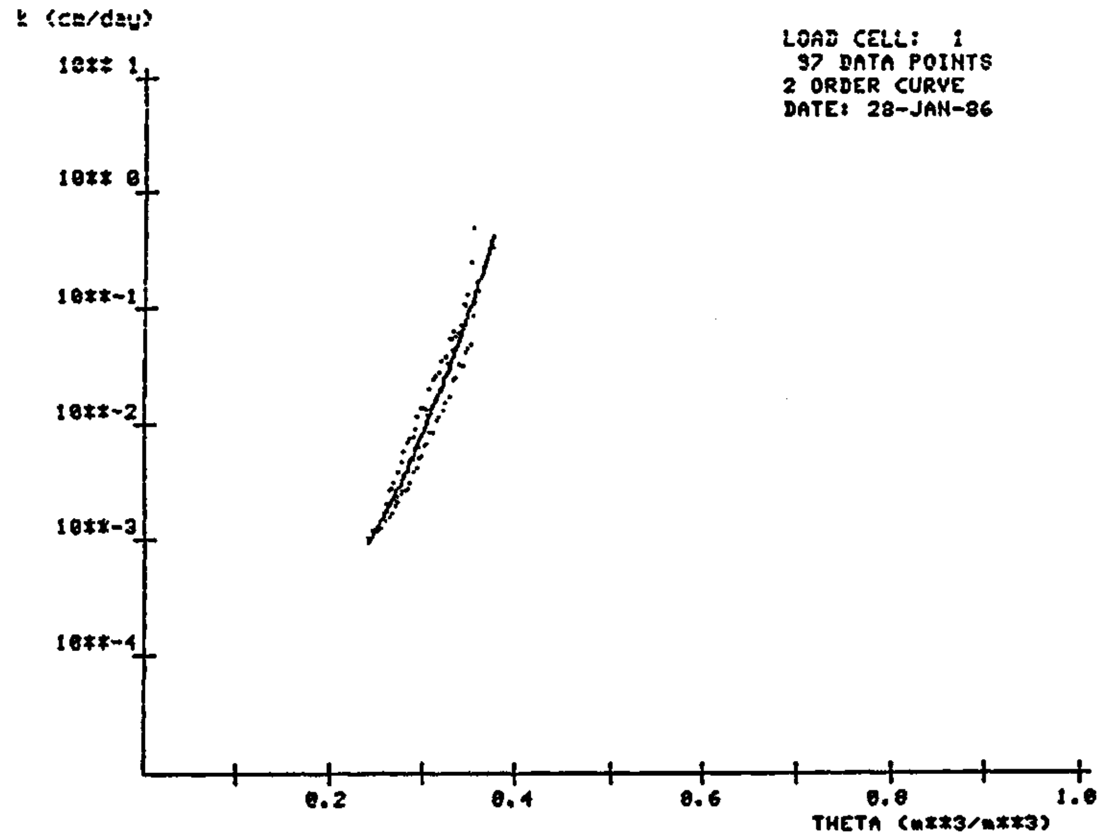


The water retention (h-THETA) curve was fitted with:
|h|=a0 + a1*THETA + ... + aN*THETA**N
(h in cm and THETA in m**3/m**3)
Permitted THETA range from 0.232 to 0.405
a0 = -0.3808449E+06
a1 = 0.7554627E+07
a2 = -0.6101246E+08
a3 = 0.2582969E+09
a4 = -0.6066902E+09
a5 = 0.7313483E+09
a6 = -0.3839217E+09

EXPERIMENT: 40
-5 CM - 1201A
VELD C, PAGV LELYSTAD
COORDINATEN:
DATUM MONSTERNAME: 16-2-'84

OUTPUT OF KHTH

(UNSATURATED HYDRAULIC CONDUCTIVITY CURVE)

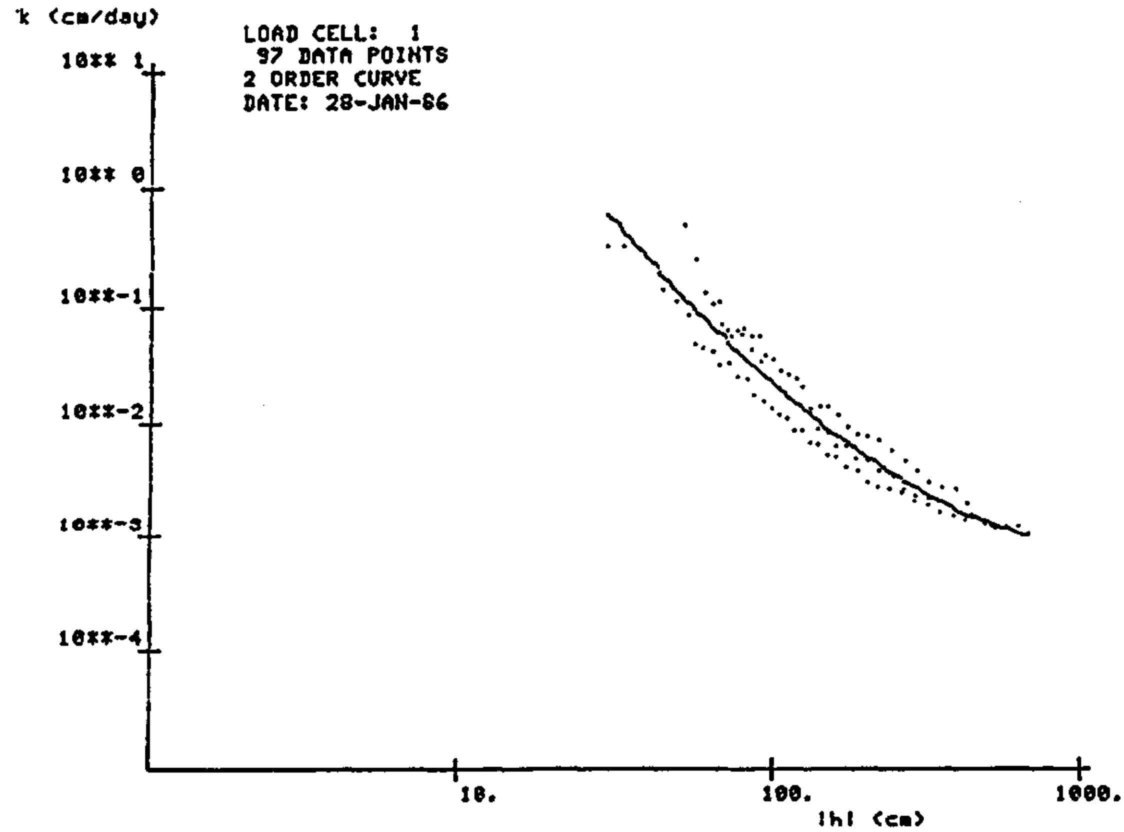


The k-THETA relation was fitted with:
log(k) = c0 + c1*THETA + ... + cN*THETA**N
(k in cm/day and THETA in m**3/m**3)
Permitted THETA range from 0.240 to 0.376
c0 = -0.3809291E+01
c1 = -0.7221989E+01
c2 = 0.4344091E+02

EXPERIMENT: 40
-5 CM - 1201A
VELD C, PAGV LELYSTAD
COORDINATEN:
DATUM MONSTERNAME: 16-2-'84

OUTPUT OF KHTH

(UNSATURATED HYDRAULIC CONDUCTIVITY CURVE)



The k-h relation was fitted with:
log(k) = b0 + b1*log(|h|) + ... + bN*[log(|h|)]**N
(k in cm/day and h in cm)
Permitted |h| range from 30. to 690.
b0 = 0.6342980E+01
b1 = -0.5690300E+01
b2 = 0.8450347E+00

EXPERIMENT: 40
-5 CM - 1201A
VELD C, PAGV LELYSTAD
COORDINATEN:
DATUM MONSTERNAME: 16-2-'84

- PART VIII -

SOME REMARKS ABOUT TERMINALS AND FORTRAN

MAKE HARD COPY

** Connect the printer directely to the terminal

** Automatic mode with program KHCNTR [III.6]

** Manual mode: press the terminal-key "HARDCOPY"

FORTRAN PROGRAMS, COMPILATION AND LINK

** Do not change original programs !

** Programs are written in FORTRAN-77

** Often programs are linked with different options (for instance "MAXBUF = 144"): see the listing of the programs (ask at FYSLAB).

** Often programs are linked with different librairies (see the listing of the programs):

a) RMS	
b) SSP	(Scientific Subroutine Package)
c) PLOT10	(Plot subroutine package)
d) Specific library	(that must be created)

** When a program must be linked with different libraries, it is necessary to write a SPECIFIC command file that cannot be done easily: see for instance the command files for KHTH.FTN and KHWRC.FTN (ask the listing at FYSLAB).

* Every program can be compiled and linked on the VAX-VMS, since the libraries called by this program have been installed on the VAX-VMS.

SOME GENERAL PROBLEMS

*** You may have the following problems:

a) NO COMMUNICATION WITH THE COMPUTER:

Check the set up of the terminal and the connection with the computer.

b) A PROGRAM DOES NOT RUN:

Check that all the input files required exist (for instance all KHPARxx.DAT files and KHCNTR.DAT). Check that all the input and output files used are not locked.

c) THE TERMINAL CANNOT PLOT GRAPHICS ON THE SCREEN:

Check that the terminal is a graphic terminal and check the set up of the terminal.

d) IT IS NOT POSSIBLE TO MAKE HARD COPIES:

Check that the printer is connected to the terminal and "on line".

Also, the way of doing hard copies depends of the printer set-up.

e) IT IS NOT POSSIBLE TO FIND SOME DIRECTORIES:

The accounts (for users or for tape and cassettes units) may have been changed.

For the PDP : ask at FYSLAB
For the VAX : ask at COMPUTER CENTRUM

** If you cannot solve these problems, ask some help !!!