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nota

SET UP OF FIELD EXPERIMENTS TO STUDY PHYSICAL AND CHEMICAL PROCESSES IN ACID SULFATE SOILS IN THE PULAU PETAK AREA, SOUTH-KALIMANTAN, INDONESIA

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CONTENTS

1. INTRODUCTION

In 1987, the joint LAWOO/AARD Research Project on Acid Sulfate Soils in the Humid Tropics was started. As part of this project, the Institute for Land and Water Management Research (ICW) is responsible for the modelling component, i.e. the modelling of physical and chemical processes in acid sulfate soils. Within the modelling component, ICW, CSR-Bogor and BARIF-Banjarbaru closely cooperate in laboratory and field experiments, and computer modelling.

The laboratory and field experiments are meant:

- to study physical and chemical processes in acid sulfate soils in detail;
- to collect input data for the model;
- to collect data to verify model results.

An additional important purpose of the field experiments is to promote the transferability of the information gathered from the column-experiment to field conditions.

Column experiments in Indonesia and the Netherlands, have been started up respectively in April and June 1988. The field experiments will start up in October 1988 during a mission of ir. J.J.B. Bronswijk, dr. A.L.M. van Wijk and ir. K. Nugroho to Indonesia.

The field experiments will be carried out on both actual and potential acid sulfate soils. On some sites different water management strategies will be applied. On other sites no changes in the, according to local practice, normal water management strategy will be applied.

2. EXPERIMENTAL SET UP

2.1. SELECTION OF FIELD SITES

The field plots play a central role in the modeling component research. Therefore great effort was put into the selection of the sites of the field plots. Discussions, both in Wageningen and Bajarbaru, yielded the following selection criteria:

- the selected sites should either have pyrite high in the profile, or have undergone acidification through pyrite oxidation in situ;
- the water management alternatives, as aplied in the column experiments: leaching, drainage and flooding, should also be studied in the field. Alternatives should include fresh, brackish and acid water;
- if possible, the field sites should be situated on the same soil type, so that differences between sites are mainly caused by water management strategies;
- 7 field sites is the maximum that can be handled by the Banjarbaru team;
- the field plots of the modeling component should be combined with the field experiments of the water management component.

On the basis of these criteria, the following sites were selected:

- Barambai I - Pyrite at 50 cm depth sorjan field;
  no tidal influence;
  two plots will be installed: one in cassave bed (1) and one in rice depression (2);
- Barambai II - pyrite at 30 cm depth;
  very acid top soil;
  rice field;
  no tidal influence.
  During wet season, the field is flooded continuously, in the dry season, groundwater levels may drop to 1 m depth (3).

At Barambai, the water management is not altered. Only the seasonal changes as a result of the actual management are monitored. At the other four sites, it is possible so alter the water management system:

Tabunganen - grey pyrite layer at 40 cm depth;
tidal influence;
brackish water;
pH higher than 5;
rice fields.

At Tabunganen, field plots of about 25 x 25 m are laid out. The following management will be applied:

- continuous flooding, high yielding variety rice, followed by local variety rice (4);
- daily flooding an drainage through tidal influence. Same crops as above (5);
- drainage down to 60 cm depth for about 14 days, alternated with one day flooding same crops as above (6);
- complete drainage down to 60 cm depth, no flooding. Crops: up land rice, maize (7).

2.2. EXPERIMENTS AND MEASUREMENTS

In order to determine the soil physical and chemical changes in the above mentioned field plots measurements will be carried out on incoming water, soil moisture and out flowing water.
First initial plot characteristics have to be determined. Soil sampling will be carried out to gain information about pyrite content, CEC, organic matter conten, (un)saturated hydraulic conductivity, pF etc. The amount of samples to be collected for this purpose depends strongly on the local spatial variability of the different soil properties. The influence of this phenomena has to be investigate prefereably beforehand.
During the experiments both the water quantity as well as the water quality of incoming water (precipitation, irrigation water, ponding water), out-

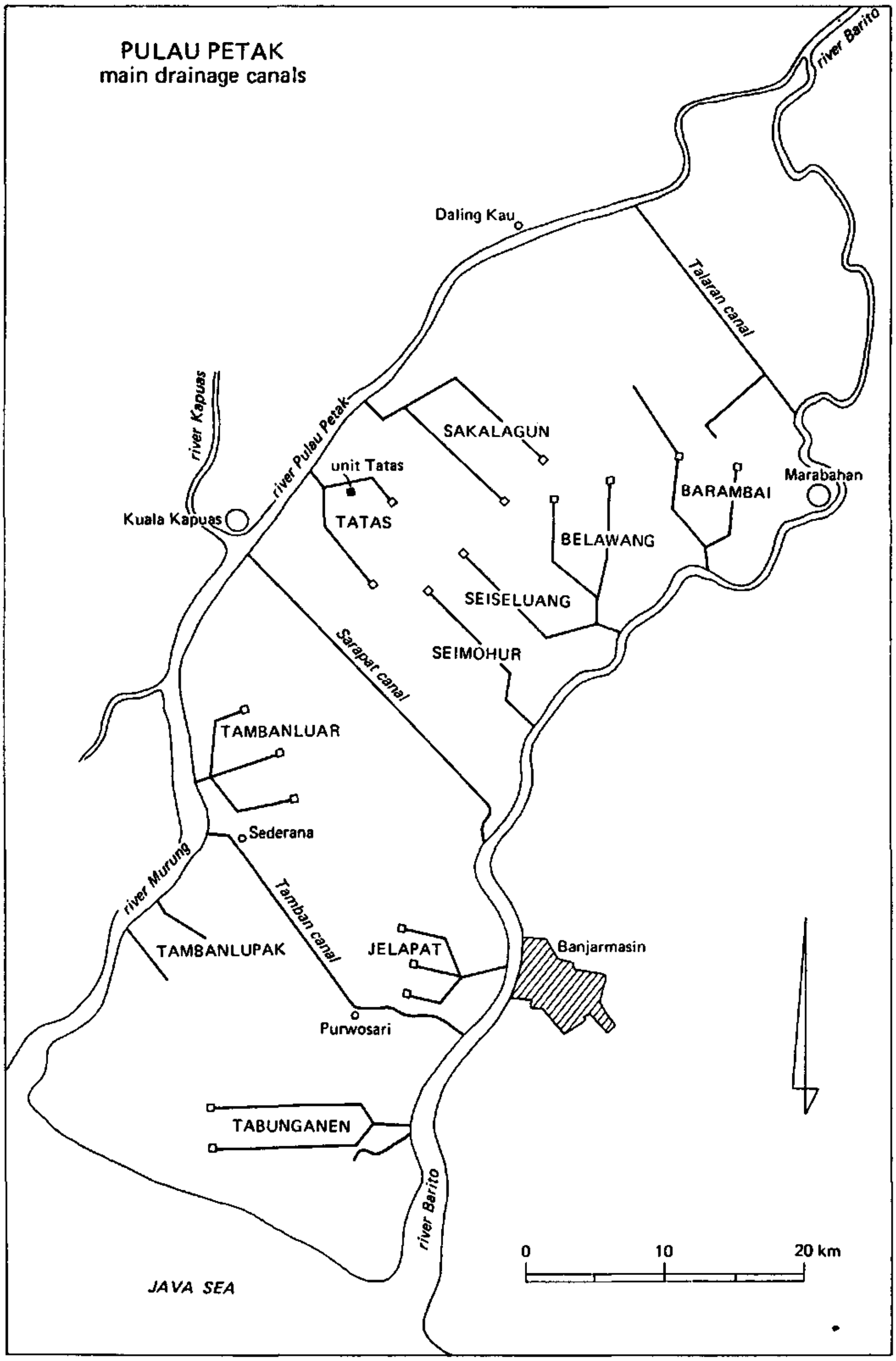

Fig. 1. Schematic map of Pulau Petak area

During the experiments both the water quantity as well as the water quality of incoming water (precipitation, irrigation water, ponding water), out-flowing water (drainage water, runoff, evaporation) and soil moisture should be monitored.
These data are necessary for calculating waterbalances as well as chemical changes in the soil profiles. Several measurements will be carried out in the soil profile a.o. soil moisture tensions, oxygen concentrations in soil air and redox potentials. Soil moisture will be extracted frequently at different depths varying from just below the soil surface up to at least the lowest (to be expected) groundwater level at the place of measurement. Groundwater levels and the quality of the water out of the saturated zone will be monitored on several locations in the experimental sites. A view from above of how each field site will be instrumentated is shown in Figure 2. Measured fielddata will be listed on forms as shown in Appendix B.

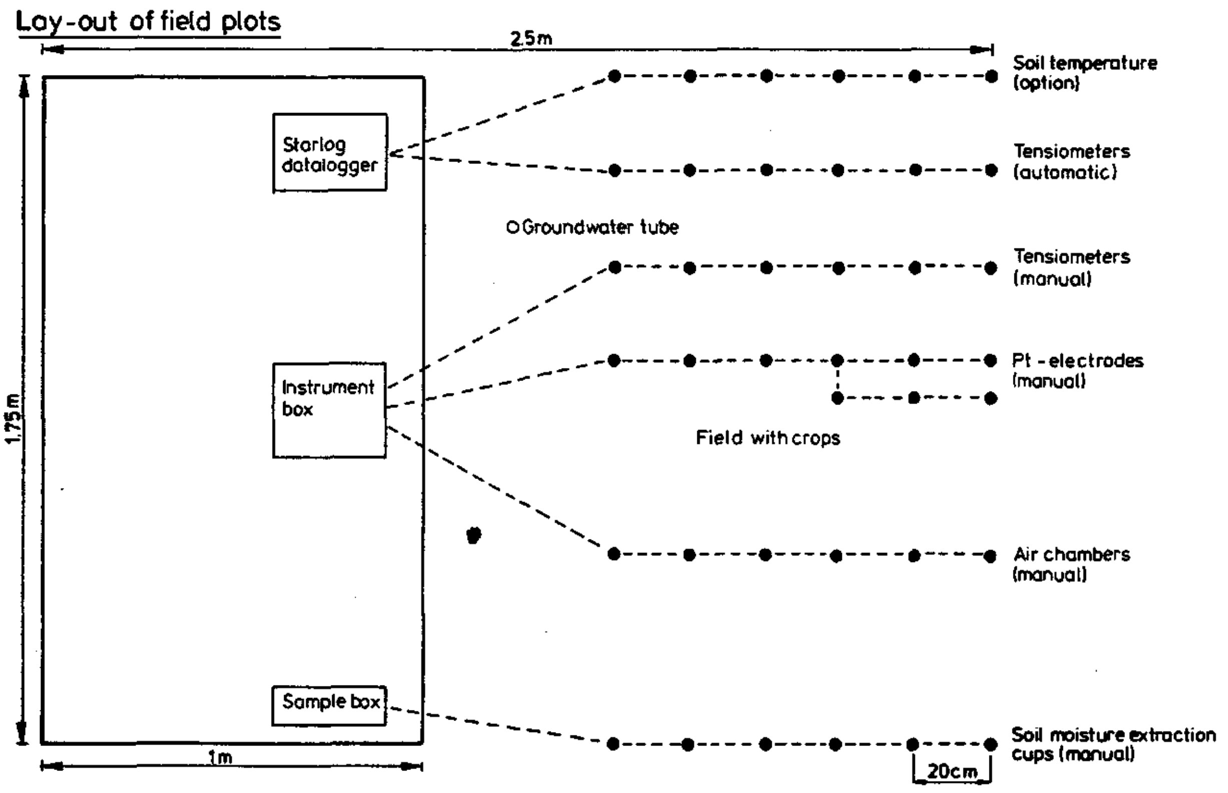

Fig. 2. Method of instrumentating the field sites

3. METHODS

3.1. METHOD FOR SURFACE WATER SAMPLING

Surface water (precipitation, irrigation water, ponding water, runoff, drainage water) will be sampled with small plastic bottles of 100 ml. each. Every two weeks this will be done. After measuring pH, dissolved O2 and EC these samples will be brought to the BARIF-laboratory where total analyses will be carried out.
Once every three or six months detailed sampling (for instance every hour) of all surface waters will be carried out to investigate short-term fluctuations in chemical composition during a consequetive low and high tide.

3.2. METHOD FOR GROUNDWATER LEVEL MEASUREMENT

Groundwater level tubes will be installed on every site. The exact amount depends on the local situation. The groundwater levels will be measured manually once every two weeks. Once every three or six months detailed measurements will be carried out to investigate groundwater level fluctuations during a consequetive low and high tide.

3.3. METHOD FOR SOIL MOISTURE TENSION MEASUREMENT

Soil moisture tension will be measured with tensiometers. The tensiometers will be installed at different depth as shown in Figure 3. Some of the tensiometers will be measured automatically with a STARLOG datalogger, while the others will be measured manually.
The interval of the measurements will be programmed beforehand.

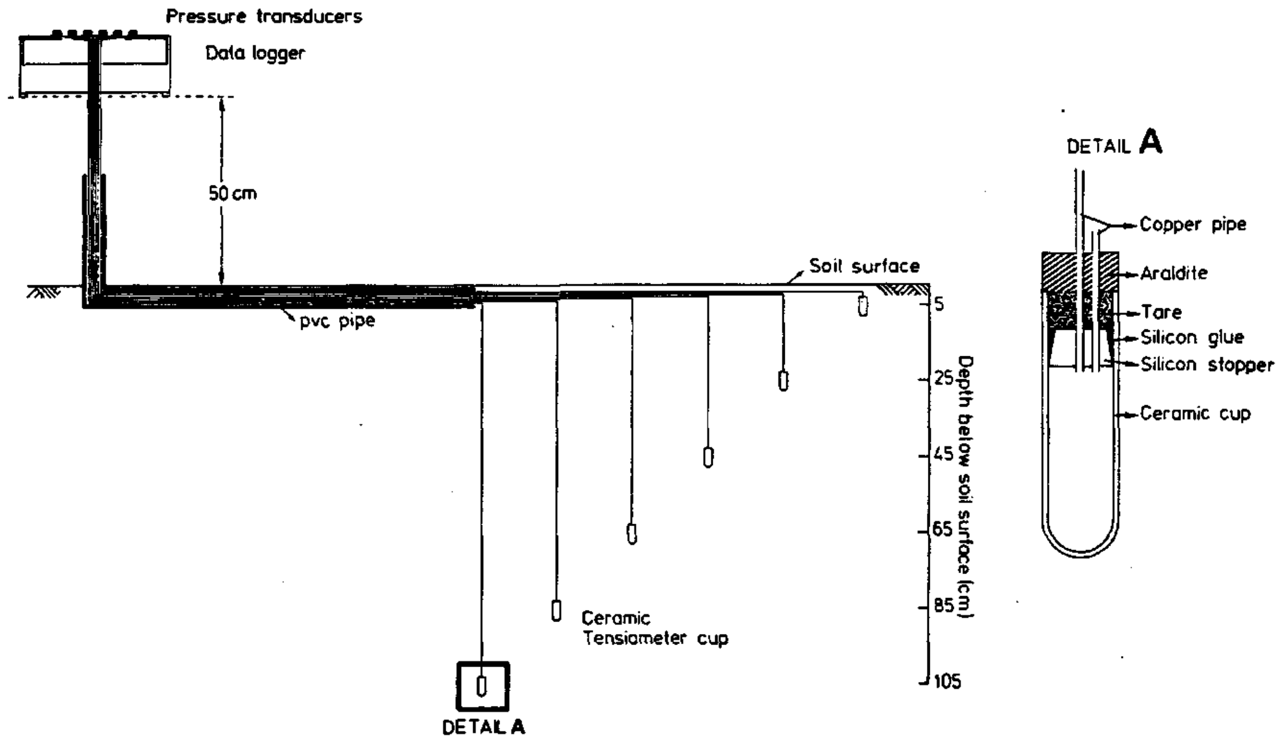

Fig. 3. Method of installing and measuring soil moisture tension at different depths in the soil

3.4. METHOD FOR SOIL MOISTURE EXTRACTION

There are two types of soil moisture extraction cups. The first type is made of polyethylene (VYON) with rather high porosity which can be used for soil moisture extraction out of wet soil layers. The second type is made of dense (low porosity) ceramic material (Soil Moisture INC. USA), which is useful for soil moisture extraction out of unsaturated soil layers. The polyethylene cups are chemically more inert than the with acid pre-washed ceramic cups. Up till this moment there exists no ready to use other alternative for these ceramic cups.
The soil moisture extraction cups will be installed in the field as been shown in Figure 4. Once every two weeks soil moisture will be extracted and brought to the BARIF-laboratory after measuring pH, dissolved O2 and EC in the field.

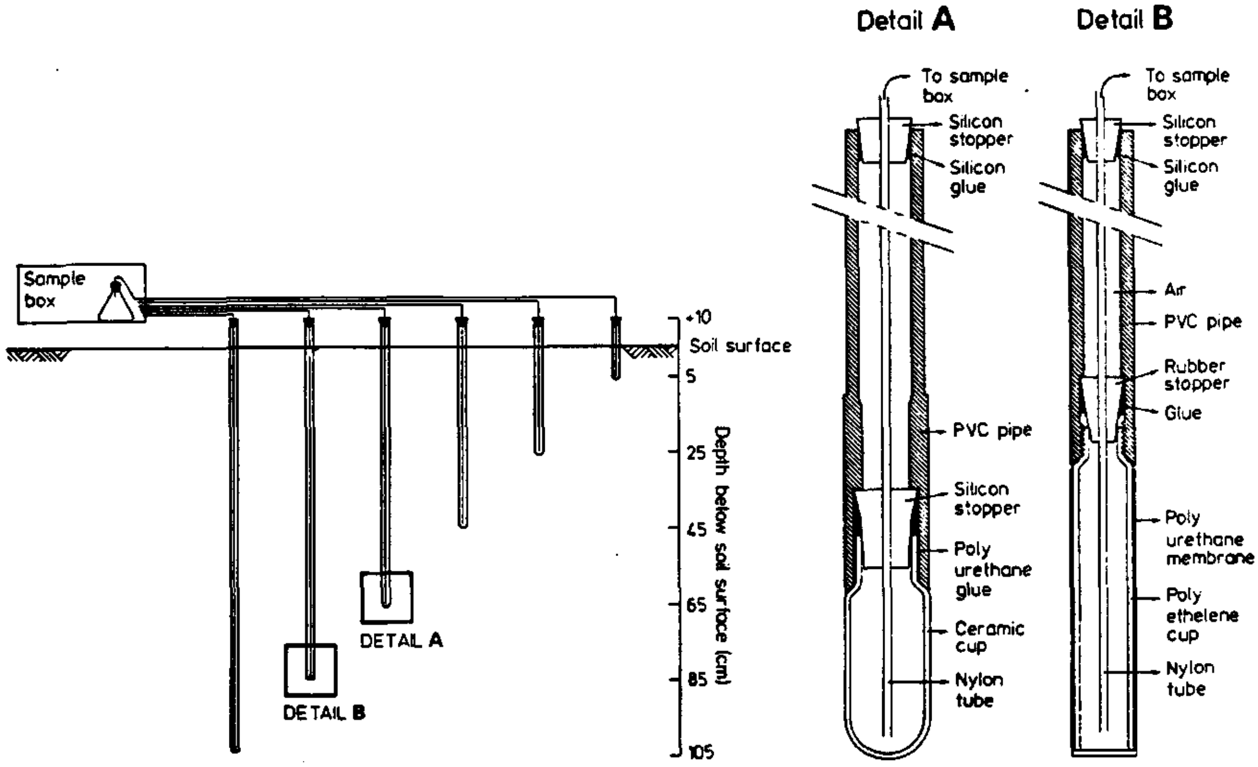

Fig. 4. Method of installing moisture extraction cups at different depths in the soil

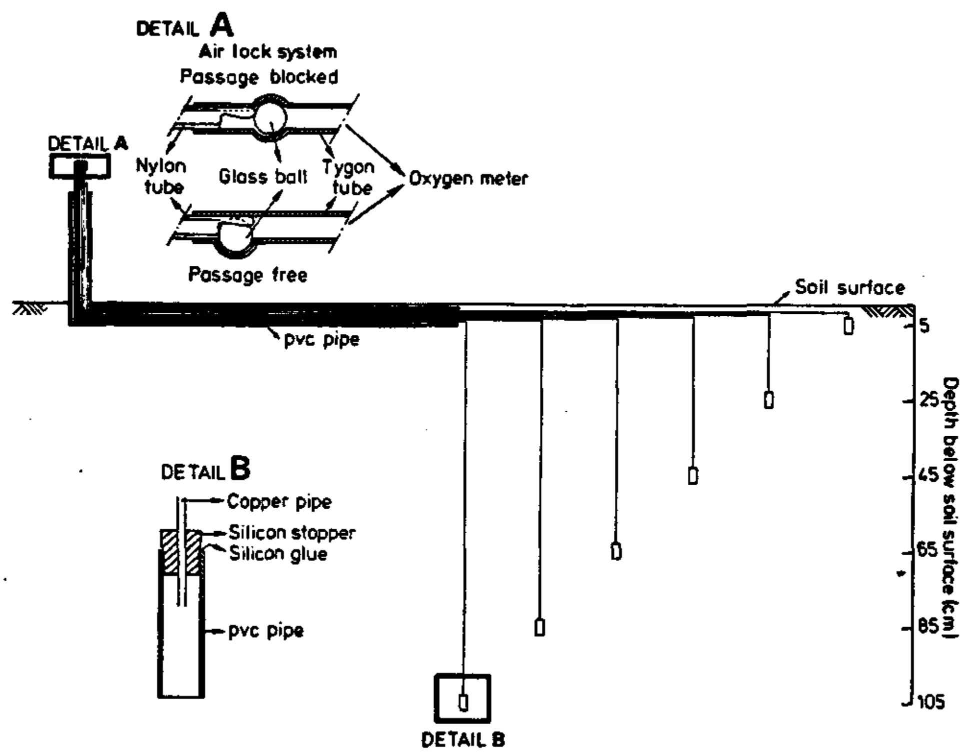

Fig. 5. Method of installing air chambers at different depths in the soil

3.5. METHOD FOR SOIL AIR EXTRACTION

The air chambers used for extraction air out of soil are made of hollow PVC-pipes. They will be installed at different depths as been shown in Figure 5.

3.6. METHOD FOR REDOXPOTENTIAL MEASUREMENT

The redoxpotential can be measured with a reference electrode (calomel electrode) in combination with a Pt-electrode. This system is used in the laboratory column experiments in Indonesia and the Netherlands. Pt-electrodes have been installed permanently in the soil column, while during measurements the calomel-electrode is brought into contact with soil water of the saturated zone.
This system should also be used during the forthcoming field measurements. Calomel-electrodes can be brought into contact with water of the saturated zone by lowering it in a groundwater tube which is placed in the direct neighbourhood of the Pt-electrodes. Installation in the field of the Pt- electrodes is shown in Figure 6.

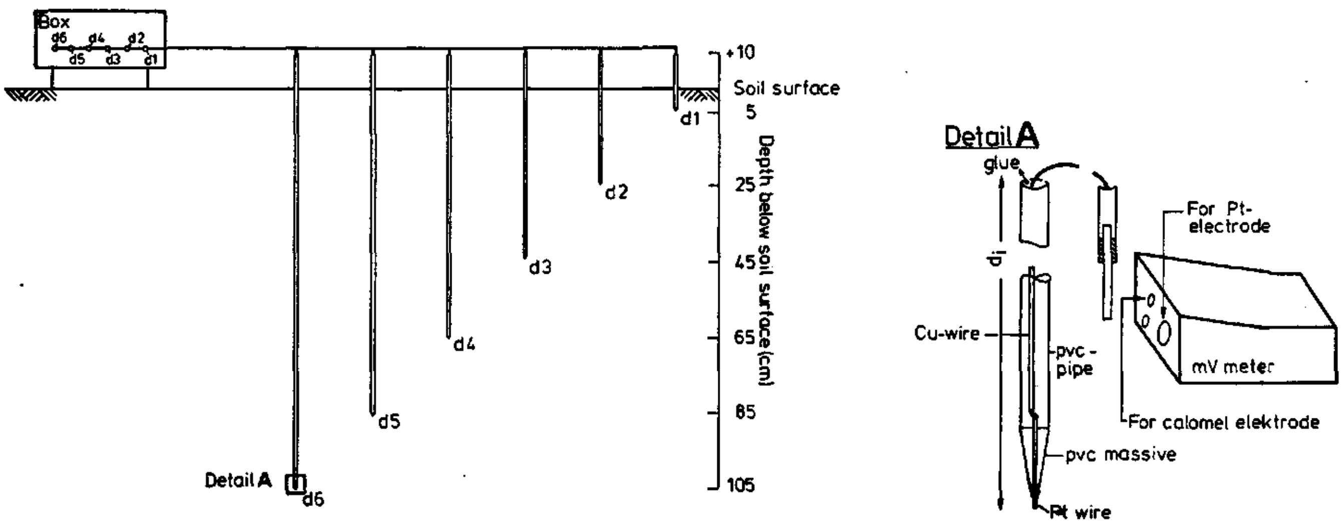

Fig. 6. Method of installing PT-electrodes at different depths in the soil

3.7. METHOD FOR pH MEASUREMENT

pH will be measured in the field with a portable pH-meter (WTW-pH 96) Measurements on soil moisture and surface waters will be carried out once every two weeks in the field. These measurements should be repeated in the BARIF-laboratory.
Once every three or six months detailed pH-measurements will be carried out to investigate short-term fluctuations during a consequetive low and high tide.

3.8. METHOD FOR DISSOLVED OXYGEN MEASUREMENT

Dissolved oxygen concentrations of soil moisture and surface waters will be measured in the field as well as in the laboratory with a portable oxygen meter (WTW-OXI 91).

3.9. METHOD FOR ELECTRIC CONDUCTIVITY MEASUREMENT

Electric conductivity of soil moisture and surface waters will be measured in the field as well as in the laboratory with a portable EC-meter (WTW-LF 91).

3.10. METHODS FOR CHEMICAL ANALYSIS

Water samples from the soil profiles and surface waters will be analysed according to the procedures which are used in the BARIF laboratory (Van den Toorn et al, 1988).

REFERENCES

BRONSWIJK, J.J.B. and C.J. RITSEMA (1988). Modelling of physical and chemical processes. Analysis of important parameters and first outline of simulation model. Research on acid sulphate soils in the humid tropics. ICW Note No. 1821.

RITSEMA, C.J., J.J.B. BRONSWIJK and K. NUGROHO (1988). Proposal for column experiments to study physical and chemical processes in acid sulphate soils at the BARIF-Institute, Banjarbaru, South Kalimantan, Indonesia. ICW Note No. 1835.

TOORN, A. VAN DEN, K. NUGROHO, and J. HARMSEN (1988). Methods for the determination of chemical composition of water samples from column experiments. (English and Indonesian edition). ICW Note No. 1863.

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INDONESIAN SUMMARY

Penelitian kolom di lapang agak berbeda dengan penelitian di laboratorium. Penelitian di lapang tidak menggunakan bidang terbatas seperti kolom di laboratorium. Oleh karenanya perubahan dari sifat yang diamati harus secara hati-hati diukur, seperti perubahan air tanah. Air yang masuk kedalam profil atau kolom akan diperhitungkan berdasarkan parameter lain yang dapat diukur seperti aliran air masuk dan keluar.
Aliran tersebut akan dihitung berdasarkan perubahan tinggi muka air tanah pada beberapa tempat di sekitar plot percobaan. Hal tersebut menentukan dalam pemasangan pengukur muka air tanah di plot percobaan.
Seperti juga percobaan kolom di laboratorium, yang diukur adalah redoks potensial, tegangan air tanah dengan tensiometer, kualitas air/larutan tanah, konsentrasi oksigen pada ruang udara tanah.
Alat dan metoda analisis laboratorium untuk contoh air yang digunakan hampir sama dengan percobaan di laboratorium, hanya untuk pengukuran dan pengambilan contoh air dibutuhkan penghubung/pipa yang lebih panjang.
Untuk menunjang pengamatan yang berkesinambungan, penggunaan alat-alat pengamat otomatis dilakukan. Dataloger/STARLOG yang digunakan mempunyai 8 saluran analog, yang digunakan untuk mengamati perubahan tegangan air tanah tanah (tensiometer).

APPENDIX A

LIST OF EQUIPMENT NEEDED FOR INSTALLATION OF ONE FIELD PLOT

GENERAL

20 m coloured tape for marking plots and sensors
2 measuring tapes
6 piketten
water resistant wire (for holding tubes etc. together)
4 pieces of 50 cm plastic tube (diam. approx. 4 cm)
hand saw
1 wooden measuring box where wires, tubes, etc. come together
2 knives
6 rolls of coloured tape to mark sensors at different depth
1 auger (approx. 4 cm diameter)
2 massive sticks (bottom diameter approx. 2 cm, length approx. 125 cm) to compact soil around sensors and tubes, etc.
spade
sign: please do not touch (Indonesian)

GROUNDWATER LEVEL TUBES

10 grwl tubes
4 liter coarse sand

MOISTURE EXTRACTION CUPS

1 special auger (diameter equal to ceramic cup)
1 special auger (diameter equal to vyon cup)
6 deaerated, HCl flushed m.extr. cups 5,25,45,65,85,105 cm length
box with 6 erlenmeyers, corks and tubes
bicycle pump

REDOX ELEKTRODES

6 redox elektrodes, 5,25,45,65,85,105 cm length
3 redox elektrodes, 5,25,45 cm length

TENSIOMETERS

special auger with diameter somewhat smaller than tensiometer cup
12 waterfilled de-aerated tensiometers
3 liter loss

OXYGEN CHAMBERS

4 liters washed gravel
6 oxygen chambers

STARLOGS

6 tensiometers (de-aerated and waterfilled)
1 Starlog box
1 wooden protection box

The above is the minimum required equipment, it is advised to take spare equipment, in case something breaks.
Spare equipment:
2 tensiometers
2 oxygen chambers
1 set of redox elektrodes
1 set of moisture extraction cups

On sites where a Starlog is not installed, the second serie of tensiometers will be measured manually. The tubes come together in the wooden measurement box.

APPENDIX B

Site	:	Author	:
Plot No.	:	Date	:
Time	:	Date of last meas	:
Temp(avg)	:	Temp(max)	:
		Temp(min)	:
Soil Temp.:		Depth of .... cm.	
		Depth of .....cm.	

Rainfall(mm) :
Evaporation (mm) Class A pan :
Wind speed m/sec. :
Radiation :

GROUNDWATER LEVEL (cm from the surface), dis. O_2, pH, EC:

No.	Distance from ex.p.	gwl	O_2	pH	EC	No.	Distance from plot	gwl	O_2	pH	EC
1						7					
2						8					
3						9					
4						10					
5						11					
6						12					

-TENSIOMETER (MANUAL, mbar); REDOX(in mV); SOIL AIR OXYGEN (in %)

DEPTH	-5.0 cm.	-25.0 cm	-45.0 cm	-65.0 cm	-85.0 cm	-105.0 cm
psh,mbar						
toh,mbar						
time						
redpot						
pe						
time						
O_2 (%)						
time						

-SOIL MOISTURE EXTRACTION

DEPTH	-5.0 cm.	-25.0 cm	-45.0 cm	-65.0 cm	-85.0 cm	-105.0 cm
Total ml						
Erlm. No						
time						
Diss.O_2						
pH						
EC						

WATER	RAIN	PONDING	IRRIGATION	DRAINAGE	CHANNEL	....
Erlm. No						
time						
Diss.O_2						
pH						
EC						

APPENDIX C

REGISTRATION OF PRESSURE HEADS IN FIELD PLOTS WITH THE STARLOG DATA LOGGER

1) INTRODUCTION

2) LAY OUT OF THE RECORDING SYSTEM

3) CALIBRATION OF THE PRESSURE TRANSDUCERS

4) USE OF THE DATA LOGGER

5) USE OF THE CANON PORTABLE COMPUTER (FTU)

1) INTRODUCTION

One of the important goals of the field plots in South Kalimantan is to study the actual water regime in Acid Sulfate soils. Because of the periodical flooding of the soil and because of the very high saturated hydraulic conductivity, it may be expected that for instance ground water levels and moisture content of the topsoils changes rapidly within short time periods.

In South Kalimantan field plots, pressure heads will be recorded by using an automatic system of Microswitch pressure transducers connected to a Starlog data logger.

The Microswitch pressure transducer gives a 0 to 6 Volt output, depending on the input voltage and the pressure difference between the two ports of the transducer. When the input voltage is constant (e.g. 8 Volt), the output voltage is lineair correlated with the pressure. By connecting a pressure transducer to a water filled tensiometer, the pressure head of the tensiometer can be monitored.

The starlog data loger is users friendly and well documented. Therefore, normally this extra manual would be superfluous. However, there are two reasons for extra explanation:

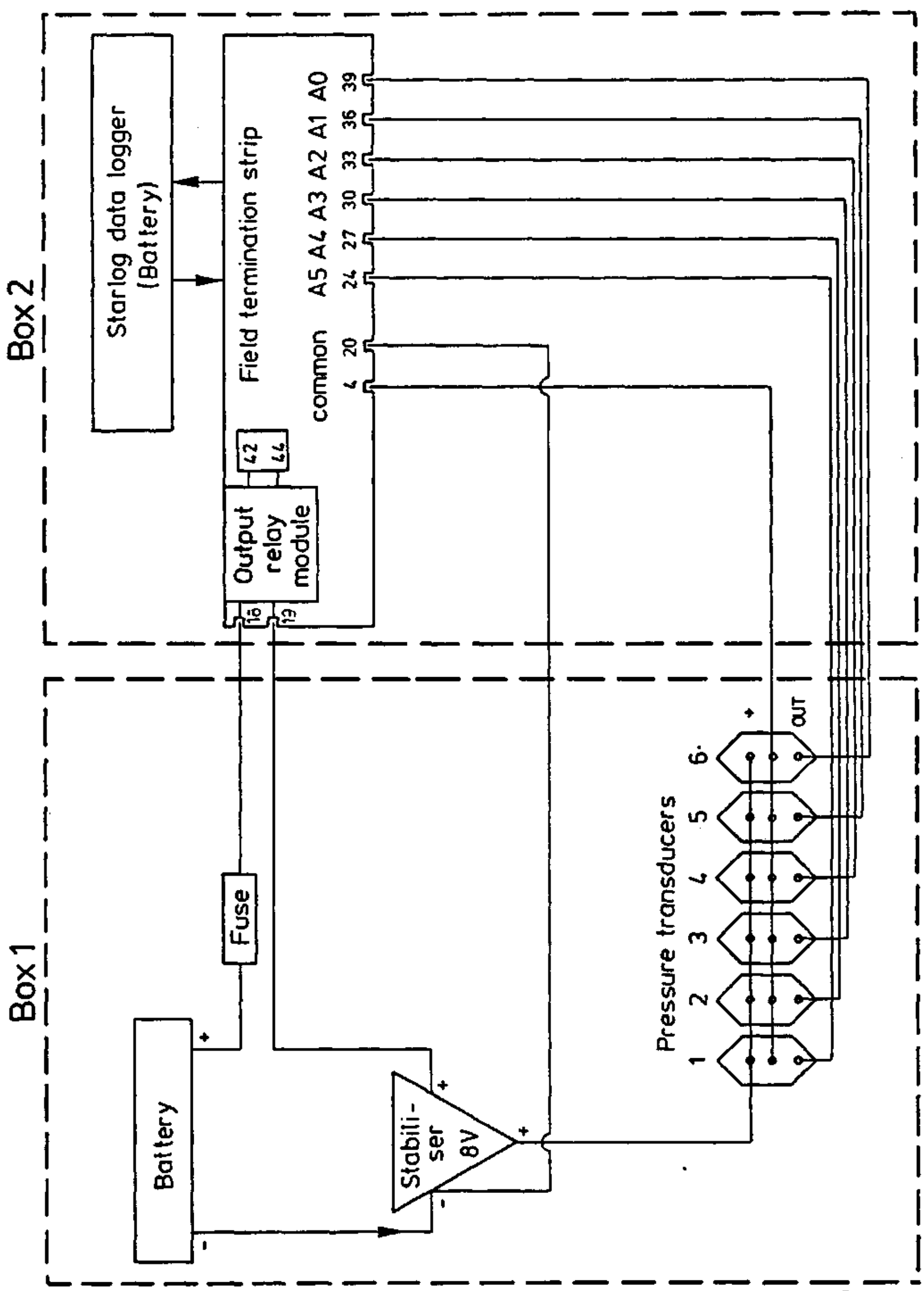
1) The starlog dataloger is able to provide a constant 5 Volt power supply to any external instrument that is attached. The Microswitch pressure transducers require a power supply of 8 to 12 volt. Therefore an external power supply is needed to feed the pressure transducer. This external power supply should be switched on before any measuremnt and switched off afterwards. Otherwise, the battery would be depleted rapidly. The Starlog datalogger can be programmed in such a way that it switches on and off the external power supply of the Microswitches. However, this requires additional explanation.
2) The use off the Canon portable computer (the Field Test Unit) is not well explained in the standard manuals.

2) LAY OUT OF THE RECORDING SYSTEM

All techical specifications of instruments is given in appendix 1. The complete recording system for pressure heads is pictured in fig 1. Each of 6 water filled tensiometers is connected to a Honeywell presuure transducer 141PC15G or 141PC05G. Each pressure transducer is connected to an battery of 13 volt for external power supply. In between the battery and the pressure transducers, an 8 volt stabilizer ensures a constant 8 volt power suplly for the pressure transducers. The output wires of each pressure transducer are connected to one of the analog channels of the data logger. The Data logger is connected to a so called output relay module. This module is nothing more than an switch in the connection between external power supply and Microswitch pressure transducer. This switch has two positions: "on" and "off". When this switch is on, the external power supply is connected to the pressure transducers. When the switch is off the connection is intermitted. The Datalogger manipulates the postion of the switch of the output relay module so the datalogger switches the external power supply for the pressure transducers on and off.

The Starlog Datalogger has 8 analog input channels. On these analog input channels, voltages between 0 and 2.5 Volt can be recorded. This means that any instrument output should be handled in such a way that the output lies within this range.

FIG 1. Lay out of the recording system



With an 8 volt power supply, the output of the 141PC15G pressure transducers at pressures of 0 and -15 psi is resectively 1 volt and 6 volt. (appendix). Because the input for the starlog should be between 0 and 2.5 Volt inputs larger then 2.5 Volt are recorded as 2.5. This means that any pressure lower than -6.25 psi is not recorded. With a 2:1 voltage divider, the 0 to 6 volt output range of the pressure transducer can be converted lineair to a 0 to 3 volt output range. In that case -15 psi corresponds with 3 volt, and 2.5 volt with -12.5 psi. For the 141PC05G, the maximum logger input of 2.5 Volt corresponds with 4.17 psi.

The field termination strip is the interface between the pressure transducers and the datalogger. All the output wires of the transducers are connected to the field termination strip. Both the voltage dividers and the output relay module mentioned above are placed on the field terminbation strip.

3) CALIBRATION OF THE PRESSURE TRANSDUCERS

Any pressure transducer has his own relationship between pressure input and Volyage output. In practice, the deflection of the individual calibration curves from the factory calibration is very small (See appendix). Therefore, in the field we will work with the factory calibration and program the Datalogger accordingly.

The 141PC15G gives a 6 Volt output at -15 psi pressure and a 1 Volt output at 0 psi (8 Volt excitation). 1 psi is equal to a pressure of 70.309 cm H20. Therefore (again at 8 Volt excitation):

0 cm — 1 V output
-1054.634 cm — 6 V output

which results in the following calibration line:

$V = -0.00474 * P + 1.0$

$P = -210.927 * V + 210.927$ (V in Volt, P in cm, 8 Volt excitation)

The output range for the Datalogger (0 to 5 Volt output of the pressure transducer, after voltage divider 0 to 2.5 Volt input for the logger):

0 Volt — P = 210.927 cm
5 Volt — P = -843.707 cm

For the 141PC05G:

0 cm — 1 V output
-351.545 cm — 6 V output

which results in the following calibration line:

$V = -0.01422 * P + 1.0$

$P = -70.309 * V + 70.309$ (V in Volt, P in cm, 8 Volt excitation)

The output range for the Datalogger (0 to 5 Volt output of the pressure transducer, after voltage divider 0 to 2.5 Volt input for the logger):

0 Volt — P = 70.309 cm
5 Volt — P = -281.236 cm

In this set up, the 141PC15G can record pressure heads between P = 210.927 cm and P = -843.707 cm which makes the instrument very suitable for topsoils with possible severe drying. The 141PC05G can record pressure heads between P = 70.309 cm and P = -281.236 cm which is suitable for the subsoil. In the fieldplots it is proposed to take the upper two tensiometers of the type 141PC15G and the lower 4 of the type 141PC05G. The factory calibration curves of the Microswitch pressure transducers are included in the instrument list. 141PC15G under number 7777 and 141PC05G under number 8888. The complete set of 2 141PC15G and 4 141PC05G Microswitch pressure transducers on respectively the analog channels a0-a5 are included in the instrument list under number 9999.

4) USE OF THE DATA LOGGER

Normally the Starlog datalogger can be programmed by running the computer program PDLGO on a PC and connecting the data logger to the PC. Below an example is given how to programm the Starlog data logger with PDLGO.

EXAMPLE 1

Logger program:

Every hour registration of 1 Microswitch 141PC15G pressure transducers connected to analog channel 0 of the Starlog. The pressure transducer is continuously connected to an external power supply of 8 volt. The output of the pressure transducer is reduce by 50%, using a voltage divider. This means that 0 volt output of the pressure transducer corresponds with 210.923 cm pressure head and 5 volt output with -843.707 cm. (see above) The Microswitch pressure transducer is not yet in the instrument list.

PDLGO

```
UNIDATA Portable Data Logger System Version 1.8

     Time: 09:25:34   Date: 29/09/88

   1  - GENERATE  a new scheme definition
   2  - REMOVE  an old scheme
   3  - LOAD  a logger for field operation (setup)
   4  - UNLOAD  data from logger
   5  - DISPLAY  print/plot data from a logger

   6  - CATALOG  of unloaded data files
   7  - QUIT  Return to DOS
   8  - TIME  Check & reset date/time
   9  - SHOW  list of available schemes
  10  - EXAMINE  a scheme definition

  Enter command number :- 1
```

```
                    Press F1 for Help (or ? <CA>)

               Section 1 - Scheme Identification

Enter scheme name (6 letters)
or <CA> to end :- BANJAR
Creating scheme
Scheme title: PRESSURE HEADS IN FIELD PLOTS
Are you using the model 61D3E Site Identification Option (Y/N) :- N
```

```
               Section 2 - Logger Communication

Default com port is 1 (COM1:)
Enter communication port number (1,2,*) :- 1

You have 3 types of logger access available:

        1       Direct connection (this is the default)
        2       Remote connection (via telephone dial-up)
        3       Canon X-07 FTU transfers

Enter logger access form: 1
```

Section 3 - Logger Definition

```
Logger sizes: 8K,16K,24K,32K etc, default 32K
Enter logger size: 32
Data buffer is 31232 bytes long.

Enter logger cycle rate (1-15) : 5
Enter Log Interval (in minutes):- 120
```

Section 4 - Log File Definition

```
Disk drive to store data files (a, b or c),
Default is current drive
Enter drive letter:-

Do you want put a comment on the data file (Y/N) :- y
```

Section 5 - Instrument Definition

```
Enter catalog code of instrument: LIST
```

```
The following transducers are defined:

Catalog number      Name
6504a               Wind speed/dirn
6504c               Wind speed & dirn,temp,radiation
6504d               Wind speed & dirn,temp,rad,humidity
6504e               Wind speed & dirn,temp,humidity
6505b               Ambient Temperature
6505c               Temp, Global Radiation
6505d               Temp,Radiation,Humidity
6505e               Temp,Humidity
6506a               Rainfall Gauge 0.2 mm
6506b               Rainfall Gauge 0.5 mm
6507a               Temperature (Red thermistor 15K ref)
6507b               Temperature (Yellow thermistor 15K ref)
6507c               Temperature (Violet thermistor 15K ref)
6508a               Water depth 1 m
6508c               Water depth 5 m
6508d               Water depth 10 m
6508e               Water depth 20 m
6509                Water level
6512M               Pressure Instrument - 10 kPa Gauge
6512M               Pressure Instrument - 10 kPa Gauge
6512A               Pressure Instrument - 50 kPa Gauge
6512B               Pressure Instrument - 100 kPa Gauge
6512C               Pressure Instrument - 200 kPa Gauge
6512J               Pressure Instrument - 500 kPa Gauge
6512K               Pressure Instrument - 1000 kPa Gauge
6512L               Pressure Instrument - 2000 kPa Gauge
6512D               Pressure Instrument - 10 kPa Differential
6512G               Pressure Instrument - 50 kPa Differential
6513A               Soil Moisture Probe (15k Reference)
6514A               DC Current Shunt - 2 Amp
6514B               DC Current Shunt - 20 Amp
6515A               Temperature Probe (AD590)
6521a               Capacitive depth 0.5 m
6521b               Capacitive depth 1.0 m
6521c               Capacitive depth 2.0 m

Enter catalog code of instrument: NEW
Do you want to save this as a standard type (Y/N) :- N
Number of transducers: 1
```

```
Transducer 1
Enter channel number: a0-7,c0-1,d1,s0-15,h0-15 A0
Transducer (short) Title: MICROSWITCH 141PC15G
Enter the conversion formula name: SCALE210.927TO-843.707
Units of result (Deg C,m/s etc): Cm
Using string - #= 1 digit, . = decimal place
USING string: ####.#

Check: MICROSWITCH 141PC15G
Channel a0, Name MICROSWITCH 141PC15G, Conversion scale210.927to-843.707, Units
Cm, using ####.#
Info OK (Y/N) :- Y
```

```
Operations on MICROSWITCH 141PC15G (a0)

Select 1 of the following: (default is 1)
 1        Log raw data
 2        Log average over whole log interval
 3        Log average over last N seconds of log interval
 4        Log accumulated total over log interval
 5        Log maximum (over log interval)
 6        Log minimum (over log interval)
 7        Do not log this channel

Enter option number: 1
Do you want to perform any other operations
on this channel (Y/N) :- N
Any more instruments attached (Y/N) :- N
```

Section 6 - Report Definition

```
Printout title:-
Scheme BANJA - PRESSURE HEADS IN FIELD PLOTS, Data from start to end
```

Section 6 - Report Definition

```
Printout title:-
Enter any new time format,ADS IN FIELD PLOTS, Data from start to end
or <CR> for default:- hh:mm dd/mo/yy
Do you want an ASCII file (Y/N) :- N
Do you want a LOTUS file (Y/N) :- N
Do a print-out on the screen (Y/N) :- Y
Do a print-out on the printer (Y/N) :- N
Print-out to any other disk file or device (Y/N) :- N
Do you want any plotting done (Y/N) :- N

Will you want to do your own data display
using PDLOUT (Y/N) :- N
```

```
Scheme BANJAR, Title: pressure heads in field plots
Communication port 1
Access form:  Direct
Logger size 32K
Logger cycle rate 5 seconds
Log interval 120 minutes
Log a0 as MICROSWITCH 141PC15G, being MICROSWITCH 141PC15G
Total 1 entries, 1 bytes logged, 31232 log entries
giving a max logging time of 2602 days, 16 hours.
```

In our case programming of the starlog is somewhat more complicated. This is caused by the fact that the external power supply of the pressure transducers should be turned on before logging and turned off afterwards. This cannot be done with the programm PDLGO. PDLGO is a tool to construct in a simple interactive way command files which the starlog datalogger can understand. We also can construct or adapt such a command file with any editor. For instance: With PDLGO we can add a new instrument to the instrument list which is placed in the file PDLTRANS.DAT. The same can be done directly by editing the file PDLTRANS.DAT and incorporating the new instrument. In some cases editing of the proper files is much quicker then running PDLGO. In other cases, editing files is the only way of creating the correct logger program, because PDLGO is not able to do what you want. This is the case when we want to turn on and off the external power supply of the pressure tranducers. The file that needs editing is the source file for the logger programm: xxxxx.SRC. When creating a logger program (scheme) named MICROS, the name of the file will be MICROS.SRC. Below, the file MICROS.SRC generated with PDLGO as in example 1 is printed. With the command PULSE, we can generate a pulse at bit 44 (see manual). We have to include PULSE before and after logging. Besides this we have to make sure that the circuit is open (external power off), before the first PULSE. In the second example below, the edited version is printed. So every time we create a scheme xxxxx with PDLGO, we have to edit the file xxxxx.SRC and then load the logger with it.

file MICROS.SRC created with PDLGO (last part):

```
; now accumulate for averages

fin     sadd    xacc,nb18
        sadd    yacc,nb19                   ; accum for av dirn and sigma t
        sadd    spacc,b29                   ; for av speed
        bjmpe   enable,2,199
        movbd   x,nb18
        smul    x,b29                       ; * c1 = wind speed
        dadd    xvacc,x
        movbd   x,nb19
        smul    x,b29
        dadd    yvacc,x                     ; accumulate for mean vector wi
199     jmp     1100                        ; continue with rest of stuff f

120     jmp     1200
149     jmp     150
1199    jmp     1198
1299    jmp     1298
;---------------------------------------
; logging and reset

130     jmpeq   enable,0,131                ; wind not enabled
        bjmpe   enable,2,132                ; don't need vector means
        ddiv    spacc,b55                   ; av wind speed
        ddiv    xvacc,b55
        ddiv    yvacc,b55
        movbd   spacc,spacc
        dmul    spacc,32640                 ; * 127.5 (*256)
        dsub    xvacc,spacc+1
        dsub    yvacc,spacc+1
        log     xvacc,0,2
        log     yvacc,0,2                   ; log vector mean wind
132     bjmpe   enable,4,131                ; don't need av wind
        ddiv    xacc,b55                    ; get av x
        ddiv    yacc,b55                    ; get av y
        log     xacc,0,1
        log     yacc,0,1
131     clear   xacc,20                     ; clean accumulators
        jmp     1300
;---------------------------------------
        .buffer 0,1536,32768,"stop"
        .set    b60,160
        .set    b61,5
        .set    b64,6

L100    jmp     1199

L200    jmp     1299

L300    log     b16,0,1
        log     b17,0,1
        log     b18,0,1
        log     b19,0,1
        log     b20,0,1
        log     b21,0,1

L50     clear   b53,4
        exit
```

file MICROS.SRC after editing and including PULSE command (last part):

```
.

120     jmp     1200
149     jmp     150
1199    jmp     1198
1299    jmp     1298
;----------------------------------------
; logging and reset

130     jmpeq   enable,0,131            ; wind not enabled
        bjmpe   enable,2,132            ; don't need vector means
        ddiv    spacc,bSS               ; av wind speed
        ddiv    xvacc,bSS
        ddiv    yvacc,bSS
        movbd   spacc,spacc
        dmul    spacc,32640             ; * 127.5 (*256)
        dsub    xvacc,spacc+1
        dsub    yvacc,spacc+1
        log     xvacc,0,2
        log     yvacc,0,2               ; log vector mean wind
132     bjmpe   enable,4,131            ; don't need av wind
        ddiv    xacc,bSS                ; get av x
        ddiv    yacc,bSS                ; get av y
        log     xacc,0,1
        log     yacc,0,1
131     clear   xacc,20                 ; clean accumulators
        jmp     1300
;----------------------------------------
        .buffer 0,1536,32768,"stop"
        .set    b60,160
        .set    b61,5
        .set    b64,6

L100    jmpeq   b52,5,1a
        jmp     1199

L200    jmp     1299

L300    log     b16,0,1
        log     b17,0,1
        log     b18,0,1
        log     b19,0,1
        log     b20,0,1
        log     b21,0,1
        pulse   100

L50     clear   b53,4
        exit
1a      jmpeq   b51,158,1b
        jmp     1199

1b      bjmpe   b32,2,1c
        pulse   100
        jmp     1199

1c      jmp     1199
```

ADAPTED PART OF MICROS.SRC

Below the adaptions are explained briefly. For more details, see the Starlog hardware reference manual and the listing of the complete source program. After L300, the logging commands are given. L300 is only excecuted at the programmed looging interval. The programmed logger interval is stored in bytes 60 and 61, expressed in logger cycli. When, as in our case, the cycle time of the datalogger is 5 seconds, b60=12 means a logger interval of 12*5 = 60 seconds. Because the datalogger has a resolution of 8 bits, the maximum value of each byte is 2**8=256. This means that the maximum value of b60 is 256 giving a logger interval of 1280 seconds. In b61, the number of times b60 is maximal is stored. For instance, b61=4, 60=56 corresponds with a logger interval of 4*1280 + 56*5 = 90 minutes. In the same way, the actual time is stored in byte 51 and byte 52. To determine if something should be logged, b51 and b52 are compared to b60-1 and b61. If we want to excitate the output relay module, the pulse command can be used. PULSE y (hardware reference manual, p22) generates a pulse of y*y*5 microseconds on pin 17 (connection 44 on the field termination strip). (Note: pulse is wrongly defined in the manual as pulse 0,y, it took some time to find that out) Because the pressure transducers take a little time to start up, it is advised to switch on the external power 5 seconds before measuring. We then have to pulse when b51 = b60-2. (and b52 = b61). y is taken as 100, which gives a pulse of 100*100*5 microseconds = 0.05 s. After logging, another pulse intermits the external power supply for the pressure transducers. One final thing that needs to be arranged is the control of the relay position. When, due to some unforeseen circumstances, the relay is not turned of after logging, then next time 5 seconds before logging, the relay is turned off, etc., etc. Therefore, we have to check the position of the relay before giving the pulse. When b32=2, then the relay is closed and the external power already on, so no pulse should be given.

The adapted scheme should now be included into the data logger scheme. This is done by:

PDLASEM BANJAR

After creating a scheme, the scheme is stored. Now we can load a datalogger with the scheme (running PDLGO). The datalogger is taken into the field and connected with the field termination strip. At the moment of connection, the datalogger starts working automatically. Every now and then, the timesetting of the Starlog should be checked (PDLGO, option nr 8).

5) USE OF THE CANON PORTABLE COMPUTER

The Canon portable computer (Field Test Unit) can be used to check the last recorded data in the field. The FTU should be connected to the starlog with the proper cable. With the command L we can vieuw different Adresses of the Loggers memory. Every cycle time in our case 5 sec.), the contents of the adresses are changed. Every log cycle (e.g.2 hours, the contents of the adresses are stored in the buffer. The analog channels 0 to 5 are placed in logger adress 16 to 21 (see FTU reference card). To check the last reading of analog channel 0 (pressure transucer 1), give the command:

A
16

On the screen appears something like:

255 210 106 230
002 235 098 001

The numbers represent the current contents of adress 16 to adress 23:

a16 a17 a18 a19
a20 a21 a22 a23

The numbers indicate the value of the byte and need to be scaled to have any physical meaning. The value ranges from 0 to 255.

Scaling and conversion in Physical units (for instance mbar) is possible in the following way:

1) connect FTU and turn on

2) SHIFT-CLEAR to wipe screen

3) A16 to read current recordings

4) E

5) select offset (0 for adress 16, 1 for adress 17, 2 for adress 18, etc.)

6) 1 byte

7) Formula: F

8) Enter min. and max values. (for 141PC15G, min (0V) = 210.927, max (5V) = -843.707, for 141PC05G, min (0V) = 70.309, max (5V) = -281,236)

9) using ##### cm

10)Save this screen set up by pressing W

11)Enter File name (e.g. banjar)

Now this screen set up is stored and can be used in the field:

1) connect FTU and turn on

2) Go to last stored data by pressing J0

3) go to current recording

4) press R , file banjar (restore screen set up)

4) By setting step size to six (i.e. the number of adresses stored at each logging cycle) and using the and you can trough the recorded data

5) By pressing SHIFT-D the time of the recording will be displayed on the bottom line)

6) WHEN THE PROGRAM IS LOST FROM THE MEMORY OF THE CANON

When batteries of the Canon Field test unit are removed, the FTU program is wiped from the memory. The FTU program can simply be loaded in the memory again by giving the command:

> RUN"FTU

The Canon will switch off automatically. Next time when it is turned on, the program FTU is executed.

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a Honeywell Division

Installation instructions for 140PC pressure sensors

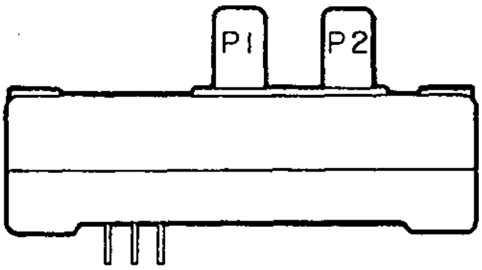
PK 8763 8

GENERAL INFORMATION

140PC pressure sensors provide output voltage proportional to pressure applied. They operate from a single, positive supply voltage ranging from 7 to 16VDC. Signal conditioning results in directly usable outputs; temperature compensation results in predictable performance over specified temperature ranges.

MEASURAND COMPATIBILITY

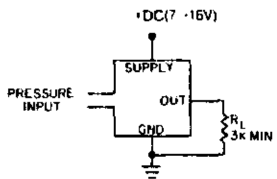
P1: Dry gases only. (Active side of IC)	P2: Materials in contact with media are polyester, epoxy adhesive and silicon bonded to borosilicate glass with an electrostatic bond (passive side of IC).



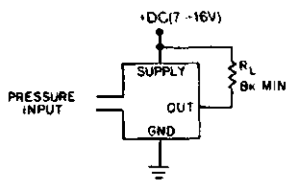
Type	Measurand Applied to Port
Absolute (A)	P1 only
Differential (D)	P1 and P2
Gage (G)	P2 only

ELECTRICAL AND PRESSURE CONNECTIONS

Current Source



Current Sink



WARNING
Damage may result from reversal of supply and ground connections.

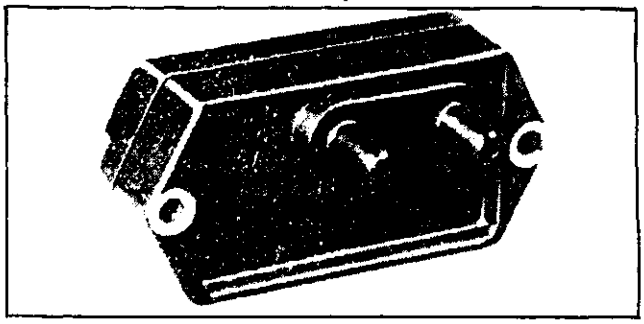
SOLDERING

Limit soldering to 315°C (600°F) maximum, with 10 seconds maximum duration.

CLEANING

Proper cleaning fluids should be selected, based on the type of contaminant to be removed. MICRO SWITCH recommends use of the following:

- Alcohols
- Fluorinated solvents



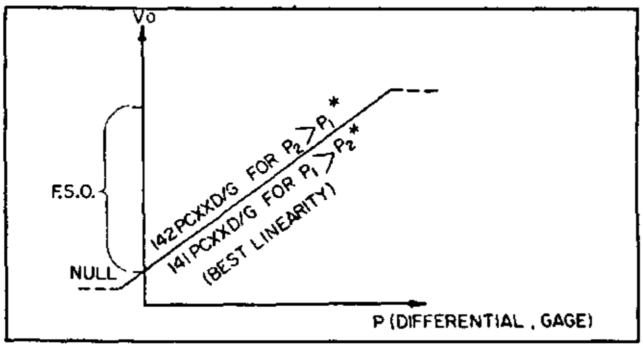
PRESSURE REFERENCE

Absolute pressure is measured with respect to a vacuum reference.

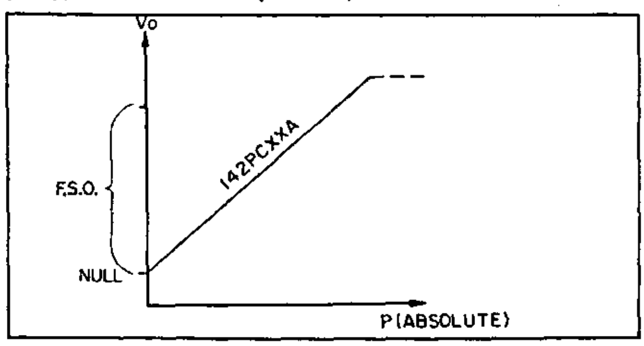
Differential pressure transducers apply P1 to the active (connection) side of the chip, and P2 to the passive side.

Gage pressure is measured with respect to atmospheric (room) pressure reference.

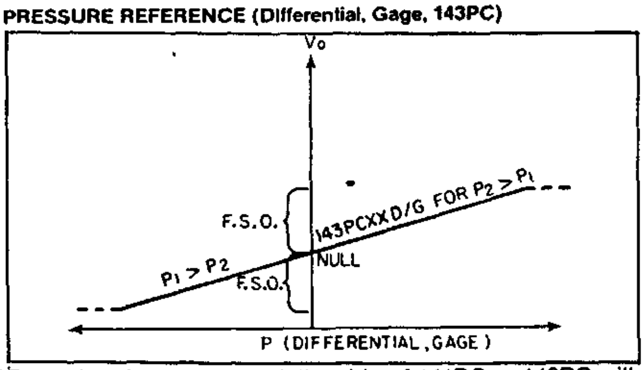
PRESSURE REFERENCE (Differential, Gage)



PRESSURE REFERENCE (Absolute)



PRESSURE REFERENCE (Differential, Gage, 143PC)



*Reversing the pressure relationship of 141PC or 142PC will cause the output to saturate below null.

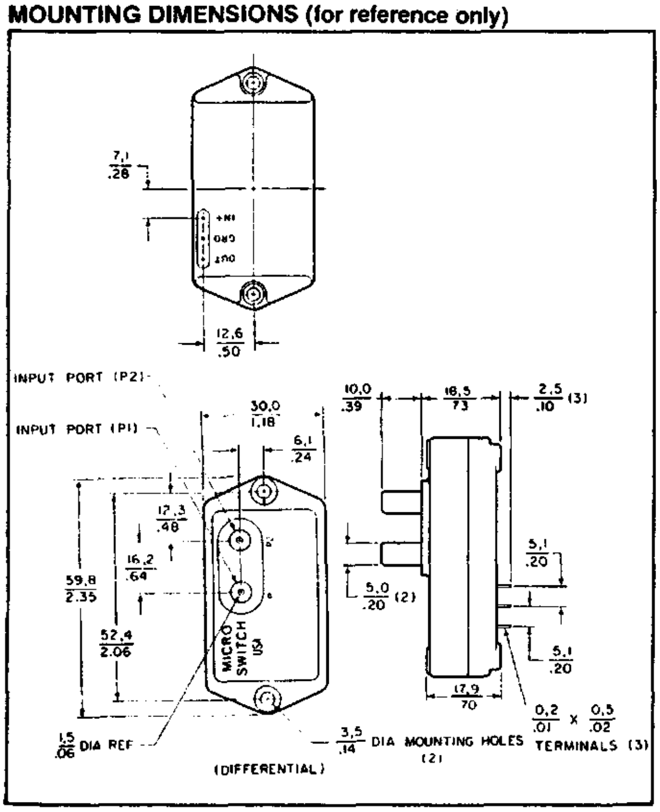
141/142/143PC SPECIFICATIONS at 8.0 ± 0.01VDC Excitation, 25°C

PARAMETER	140PC TYPE	PRESSURE RANGE	Min.	Typ.	Max.	UNITS
F.S.O. (Full Scale Output)*	141/2 143	All All	4.85	5.00 ±2.50	5.15	V
Null Offset	141/2 143	All All	0.95 3.45	1.00 3.50	1.05 3.55	V
Output at Full Pressure	141/2 143	All All, P2 > P1 P2 < P1	5.80 5.80	6.00 6.00 1.00	6.20 6.20	V
Excitation	All	All **	7.0	8.0	16	VDC
Output Current Source Sink	All	All	 10 5			 mA
Supply Current, 10K ohm load	All	All		8.0	20.0	mA
Overpressure	141/2 143	0-1, 0-5 0-15 0-15(L), 0-30 ±1, ±2.5 ±5 ±15			20 45 60 20 20 45	psi
Operating Temperature	All	All	-40°C to +85°C (-40°F to +185°F)			
Storage Temperature	All	All	-55°C to +125°C (-65°F to +257°F)			

*F.S.O. is the algebraic difference between end points (output at null and full pressure).

**8.0 VDC is recommended with 1 psi devices

MOUNTING DIMENSIONS (for reference only)



WARRANTY/REMEDY - Seller warrants its products to be free from defects in design, material and workmanship under normal use and service. Seller will repair or replace without charge any such product it finds to be so defective on its return to Seller within 18 months after date of shipment by Seller. **The foregoing is in lieu of all other expressed or implied warranties (except of title), including those of merchantability and fitness for a particular purpose.** The foregoing is also purchaser's sole remedy and is in lieu of all other guarantees, obligations, or liabilities or any consequential, incidental, or punitive damages attributable to negligence or strict liability, all by way of example.

While we provide application assistance on MICRO SWITCH products, personally and through our literature, it is up to the customer to determine the suitability of the product in the application.

Together, we can find the answers.

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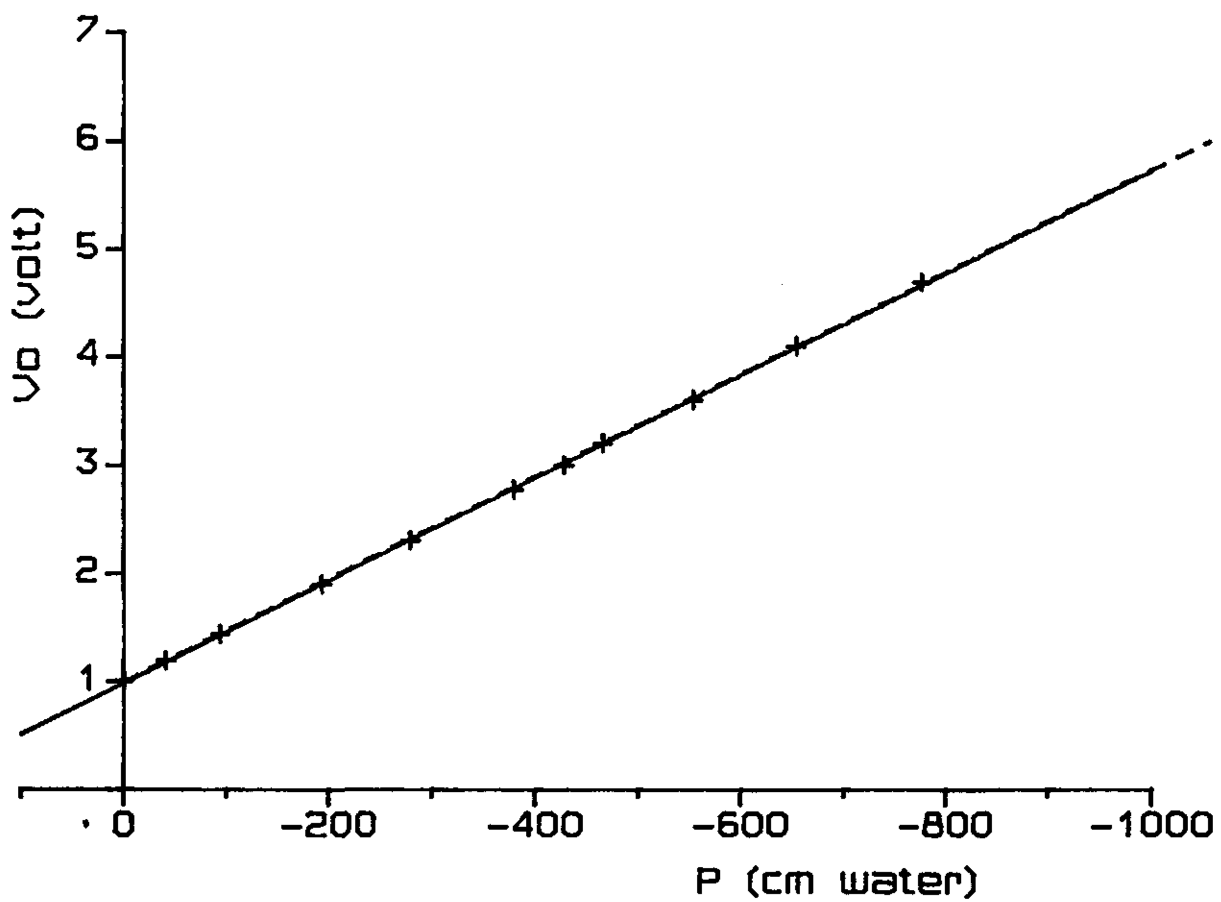

P.Transd. 03990012,Vin = 8 V

P (cm H2O)	Vo (Volt)
0.0	1.005
-41.0	1.193
-94.0	1.436
-194.0	1.900
-280.0	2.304
-380.0	2.772
-429.0	3.000
-777.0	4.700
-654.0	4.100
-554.0	3.600
-466.0	3.200

$$Vo = -0.0047 * P + 0.9864$$
$$P = -210.7344 * Vo + 207.8685$$

F FREE. Display list of screen setups (and remaining free space for new setups)

@ Jump to the address pointed to by the1st 2 bytes on the screen (INDIRECT)

s Set FTU to direct communication mode. Keyboard and display are connected to COM (RS-232) channel. (Press s again to exit)
Note: use b command to set baud rate.

The following commands may only be used with loggers programmed using the IBM software package V#1.8 or greater.

x TRANSFER programs between an IBM and the X-07 (USE ONLY WITH PDLFTU)

j JUMP to a specific data log entry
Enter log number (or RETURN for latest)

a Toggle the ADDRESS display (bottom line) to the Time of the current log entry

d Display information on
Cycle time of the logger.
Log size (number of bytes used per log).
Log interval in minutes and seconds.
Time of the first log, the number of logs made and the number of full days the logger has been recording.

r RESET the logger ready for another recording session.
*** ALL RECORDED DATA WILL BE LOST ***

INSTRUMENT LIST

Catalog	Description
6504A	Weather Instrument – Windspeed & Direction
6504C	as above – plus Temperature & G. Radiation
6504D	as above – plus Humidity
6504E	Weather Instrument – Wind/Dir/Temp/Hum
6505B	Weather Instrument – Temperature
6505C	as above – plus Global Radiation
6505D	as above – plus Humidity
6505E	Weather Instrument – Temp & Humidity
6506A	Rainfall 0.2mm tipping bucket gauge
6507A	RED Thermistor probe
6507B	YELLOW Thermistor probe
6507C	VIOLET Thermistor probe
6508A	1 metre Water Depth probe
6508C	5 metre Water Depth probe
6508D	10 metre Water Depth probe
6508C	20 metre Water Depth probe
6509B	65 metre Water Level Instrument
6513A	Soil Moisture block
6521A	0.5 metre Capacitive depth probe
6521B	1.0 metre Capacitive depth probe
6521C	2.0 metre Capacitive depth probe

FIELD TEST UNIT

REFERENCE CARD

MODEL 6401B FTU

UNIDATA AUSTRALIA

INITIALISATION

To initialise the ROM based FTU system Version 1.0

1. Turn the FTU off
2. Insert the 27C64 into the chip socket in the rear of the FTU (Be sure the notch in the chip matches the notch in the socket)
3. Set the RAM/ROM switch DOWN to RAM
4. Turn the FTU on
5. Type in RUN "FTU"
   (The FTU will switch itself off again)
6. Initialisation is complete.

The FTU will now operate automatically whenever it is turned on. (Step 5 must be repeated whenever the FTU is reset).

Use STARTS and KEYS() functions to customise the FTU operation for your application. (see BASIC referance manual)

(Sets FTU to Address 100 on startup)
STARTS="RUN"+CHRS(34)+"FTU"+CHRS(13)+"A16"+CHRS(13)

(Display start of Buffer 0 when F1 key is pressed)
KEYS(1)="bfØJØ"+CHRS(13)+CHRS(13)

INSTRUCTIONS

KEY	FUNCTION
▶	Step forward 1 byte of logger memory
◀	Step backward 1 byte of logger memory
▼	Step forward STEPSIZE bytes of logger memory
▲	Step backward STEPSIZE bytes of logger memory
T	Display and set the logger TIME and DATE
t	Set FTU time and date
S/bar	Reset the FTU screen to initial state
S	Set the value of STEPSIZE
HOME	Clear and redraw the current screen
Q	QUIT the FTU program and exit to BASIC
A	Move to a new ADDRESS of logger memory
B	Move to a new BLOCK of logger memory
L	Move to a LOCATION within the current block
b	Alter the FTU communication baud rate
H	HELP – Display this list of commands.
P	PUT data into logger memory Up to 8 values separated by commas or RETURN'S may be entered. Data entry is ended by 2 consecutive RETURN'S or the 8th value. A nul entry (2 consecutive commas eg. , ,) causes no alteration to that section of logger memory.
CLR	CLEAR (SHIFT/HOME) the current screen of all ENTRIES and INSTRUMENTS.
I	Add an INSTRUMENT (or transducer) to the current display screen.

Enter the catalog number of the instrument.
(see Instrument List)
Enter the input channel of each transducer on the instrument.

Input channels are:—

AO-7 analog channels 0 to 7
(logger address 16 to 23)
CO-1 counter inputs 0 to 1
(logger address 25 or 29)
LO-7 water level inputs 0 to 7
(logger address 200 to 216)

E — Define an ENTRY in the current display screen.

Enter the OFFSET of the first byte of the entry.

Enter the number of BYTES the entry will contain
(Each entry may contain 1 to 4 bytes)

Enter the FORMULA required for the entry

Valid Formulas are:—

		Do not display this entry	
N	NONE	Do not use any formula on this entry	
R	RED	Red thermistor formula	(6507A)
Y	YELLOW	Yellow thermistor formula	(6507B)
V	VIOLET	Violet thermistor formula	(6507C)
D	DIRECTION	Use the wind direction formula	
S	SOIL	Use the soil moisture formula	(6513A)
F	FULLSCALE	User defined full scale the entry	
H	HI–RES	Entry is a 2's compliment 13 bit value	
T	TIME	Decode the entry as a date and time	

For formulas RYVS:—
Enter the value of the reference resistor in kohms.

For formulas FH:—
Enter the minimum value
Enter the maximum value

Enter the USING display string for the entry
≠ for a digit or a leading space
. for a decimal place
(Formala T returns 2 strings time & date
a USING string & & must be used)
For more information see PRINT USING on page 92 of the X-07 reference manual.

W — WRITE (save) the current screen setup.
Enter the name of the file

(If the name FTU is used this screen setup becomes the default screen when the FTU unit is next turned on) 350 bytes of ram file are required for each screen setup.

R — READ a previously saved screen setup.
Enter the name of the file

D — DISPLAY current data buffer pointers
Enter the buffer number (0 to 7)

J — JUMP to the address pointed to by the (S)tart, (E)nd or (C)urrent pointer

Enter the buffer number (0 to 7)

APPENDIX D

SOME PRACTICAL REMARKS ABOUT INSTALATION OF FIELD PLOTS

1) GENERAL

Important: The field plots should resemble the surrounding field. Therefore try to avoid disturbing the site while placing instruments. Work with few people on one site. Don't destroy the crop. Mark the place were tubes or wires are laying in the field so that farmers can avoid them.
When taking measurements, try not to damage the crops. Be careful.

2) INSTALATION OF STARLOG DATA LOGGER

-De-aerating the system in the laboratory
The whole system between tensiometer in the soil and pressure transducers in the Starlog box should be completely filled with water. This is always hard to achieve, especially when you have to bring everything from the lab out into the field. Therefore it is necessary to fill the pressure transducers and the tensiometers seperately with de-aerated water and connect them in the field. First connect the pressure transducers with the perspex valves through the lid of the Starlog box. A small piece of tygon tubing (no 1) should be placed in the bottom hole of the valve, whereafter the tube of the pressure transducer (a little greased) can be pushed into the tygon tubing. This connection can whithstand a pressure of -1000 mbar. De-aerating this system can be done by using one perspex valve inlet to suck all the air out of the system after which de-aerated water is applied trough the other inlet. The upper inlet should be connected to the vacuum pump. The lower inlet is connected with a bottle of de-aerated water. All connections should be air tight at -1000 mbar. Vacuum should be applied for about 15 minutes, then the vacuum connection should be closed. (Vacuum can be checked by conecting a barometer or a pressure transducer box to the bottle with water. Reading should be preferably -950 mbar or higher). Immediately, the water bottle should be turned so that water can flow into the pespex valve. After that the vacuum in the water bottle should be released and the water will fill the whole system, even the very hard to reach inner part of the pressure transducer. See drawing for illustration of the above priniciple. Note: ALWAYS BE VERY CAREFUL WHEN SHIFTING GLASSBEADS IN A CLOSED SYSTEM FILLED WITH WATER. PRESSURES MAY RISE TO HEIGHTS THAT DESTROY THE MEMBRANE IN THE PRESSURE TRANSDUCER!
Now the two inlets of the perspex can be closed temporarily for transport through the field. The tensiometers can be de-aerated by submerging them (all tubes open) in reservoirs connected to the vacuum pump. Wait for at least one day. After that the tensiometers can be closed and brought into the field.

- Instalation, measurement and flushing in the field
Transport tensiometers in moist surroundings and place them quickly in the soil.
After the tensiometers have been placed and the Starlog has been installed, one tensiometer tube can be conected to the bottom inlet of the perspex valve. The upper inlet of the valve can be used for hand measurements of the tensiometers and for flushing the system with new da. water. In that case the second tube of the tensiometer is used for applying the suction. Visible air bubbles can mostly be removed by flushing. When air bubbles approach the pressure transducer, eventually they may enter the final channel which cannot be flushed. In that case, one could try with a field pump to de-aerate again, the same way as described above. Otherwise, close the tensiometers, take the data logger in the lab and de-aerate.

3) PLACING OF TENSIOMETERS.

-Placing of top two tensiometers.
In the topsoil, pressure gradients will be highest. Therefore, the top two tensiometers are placed horizontally. A small pit is dug with a spade to approx. 35 cm. With the special auger, the right hole is made in the walls of this pit. This horizontal hole should be as deep as possible so as not to have any influence from the pit at the place of the tensiometers. The waterfilled tensiometer can be pushed slowly into the hole. Make sure contact between tensiometer and hole is tight. Afterwards fill the hole with correct soil material and finally fill the pit.

-Placing of bottom four tensiometers.
These tensiometers are placed vertically. With the big auger (approx. 4 cm) a hole is made to the desired depth. (the centre of the tensiometer should be the reference point). A little Loss soil is poured into the hole, water is added untill oversaturation, the tensiometer is lowered in the hole, Loss is added again together with water. The Loss should be compacted slightly by using a long stick. When the whole tensiometers is embedded in Loss, the auger hole may be filled with original soil material. During filling, the soil material should be compacted to prevent direct flow of water from soil surface to tensiometers.

4) PLACING OF OXYGEN CHAMBERS

Oxygen chambers are placed vertically. To avoid clogging they are embedded in gravel. A 4 cm can be used for the holes. 1 cm of gravel should be poured into the hole. Thereafter the oxygen chamber is lowered. Gravel is poured in again till the o.c. is covered. Then the auger hole can be refilled.

5) PLACING OF REDOX ELEKTRODES

Because of thinness of the elektrodes, no auger is needed. After removing the protection lid, the elektrodes of the correct length can be pushed slowly into the soil. However the tip is very delicate. So be careful with hard soil layers, wood, etc.

6) PLACING OF MOISTURE EXTRACTION CUPS

Moisture extraction cups are placed vertically. With the special auger hole to the desired depth can be made. The cups can be pushed to the bottom of the hole. The soil around the pvc pipe should be compacted strongly to prevent water transport from soil surface to cup. The tubing should be led to the observation area and be closed. When extraction of moisture should take place, a box with erlenmeyers will be taken from the lab and connected to the tubes.

7) PLACING OF GROUNDWATERLEVEL TUBES

The bottom of the groundwaterlevel tubes (gwlt) should be placed at one meter depth. This means that the top of the gwlt will be 50 cm above the soil surface, so they can be measured in the wet season.Because of the risk of smearing the gwlt filter to impermeability, the filters of the groundwaterlevel tubes in the soil should be surrounded by a highly permeable medium, in this case sand. Auger holes (approx. 3 cm diam.) should be made. Pour 1 cm sand in the hole, place the gwlt, pour sand around the tube untill one cm above the filter. Then refill the hole with original soil. During this, try to puddle and compact the refilled soil with a round stick to make sure that no water will flow from soil surface alongside the gwlt to the filter.