RESEARCH FOR THE MANAGEMENT
OF THE FISHERIES ON LAKE
TANGANYIKA GCP/RAF/271/FIN-FM/02 (En)

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FIELD MANUAL FOR HYDRODYNAMIC MEASUREMENTS ON LAKE TANGANYIKA

by
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PREFACE

The Research for the Management of the Fisheries on Lake Tanganyika project (Lake Tanganyika Research) became fully operational in January 1992. It is executed by the Food and Agriculture Organization of the United Nations (FAO) and funded by the Finnish International Development Agency (FINNIDA) and the Arab Gulf Programme for United Nations Development Organizations (AGFUND).

This project aims at the determination of the biological basis for fish production on Lake Tanganyika, in order to permit the formulation of a coherent lake–wide fisheries management policy for the four riparian States (Burundi, Tanzania, Zaïre and Zambia).

Particular attention will be also given to the reinforcement of the skills and physical facilities of the fisheries research units in all four beneficiary countries as well as to the buildup of effective coordination mechanisms to ensure full collaboration between the Governments concerned.

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* Series of **technical documents (GCP/RAF/271/FIN-TD)** related to meetings, missions and research organized by the project.

* Series of **manuals and field guides (GCP/RAF/271/FIN-FM)** related to training and field work activity conducted in the framework of the project.

For both series, reference is further made to the document number **(01)**, and the language in which the document is issued: English **(En)** and/or French **(Fr)**.

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1. INTRODUCTION

In the Project ‘Research for the Management of the Fisheries on Lake Tanganyika’ (LTR), the hydrodynainical data are collected by both automatic recording devices and manual measurements. The data collection is organized in the different research stations around the lake. The locations of recording instruments are given in Table 1. This paper includes a short description of all instruments and provides measuring principles. Its purpose is to assist LTR personnel who are conducting the manual measurements as well as to provide information to those who are involved in other research programme’s subcomponents and who need the hydrodynamic data for the interpretation of their results.

2. METEOROLOGY

2.1 Automatic data collection

LTR has two fully automatic weather stations. One is situated on a pier in Bujumbura harbour (Figure 1) and the other at the southern end of the lake near Mpulungu (Figure 2).

- Automatic weather station 2700 (Figure 1) consists of a set of hardware, up to 11 sensors for air and ground data, a sensor scanning unit, a data storing unit and a solar cell power module.

The hardware of the station includes a ground based housing for the sensor scanning unit, data storing unit, acessories and tools (1). The housing is equipped with a mast (2) that supports a sensor arm for the atmospheric sensors (3). A solar cell power module (4) is installed as an integrated part of the mast. One of the guy wires (5) and the winch are used for raising and lowering the mast during installation and service.

The station on the lake near Mpulungu is a combined meteorological station with a 300 mthermistor string (Figure 2). The station has an inflateable buoy (1) with a superstructure carrying sensors for wind and air temperature (2), a sensor scanning unit (3), a solar cell power module (4) and a data storing unit (5). The eleven point temperature string (6) is fastened to the superstructure inside the buoy. A ballast chain (7) ensures vertical positioning of the string and stabilization of the buoy. The buoy scans 16 channels in sequence every 65 seconds.

The sensors installed for the two stations are:

Station	**Sensor level above lake surface**	**Sensors type**
Bujumbura	4 m	Wind speed Air temperature
	13 m	Relative humidity Wind speed Wind gust Wind direction Air pressure Air temperature Relative humidity Rainfall Solar radiation
Mpulungu	2.6 m	Wind speed Air temperature

Wind speed is the average of the wind speed during the recording interval. Gust is the maximum instantenous wind speed during the interval.

To ensure a proper functioning the following checks should be done weekly (W) or monthly (N) for Bujumbura weather station:

- wires should be tight (W);
- the mast and sensors should be straight and vertical, if not, the mast can be straightened by guy wires and winch (W);
- the numbers in the DSU (data storing unit) display should increase in 24 hours with a value = 12*(86400/recording interval in seconds) (W); and
- the sensors should be clean. In order to check this, the mast should be turned in horizontal position with the winch (N, see Appendix 1).

Following checks should be done for Mpulungu lake station:

- the exact location of the station (W);
- the numbers in the DSU should increase in the display in 24 hours with a value = 16* (86400/recording interval in seconds) (W); and
- all the sensors should be clean (W).

The specifications for each sensor type are given in Appendices 2–8. The calibration coefficients of each sensor are specific and during data processing care should be taken in using the right values.

Recording of data is done to data storing units (DSU) with 10 minutes intervals in Bujuinbura and 30 minutes intervals in Mpulungu. The DSU capacity is enough with these intervals for about 30 days recording period in Bujumbura and 80 days in

Mpulungu.

Data is unloaded and calibrated to engineering units with the Aanderaa program P3059. The manual of this software is provided to each research station. After calibration data can be listed with the same program. Graphical presentation of these ASCII data can be done by using Harvard Graphics (HG), Lotus, Graftool or similar graphical software. In Figure 3 (a, b, c, d, e) there are examples of air temperature, wind speed and water temperature data collected at the lake station outside Mpulungu. The graphs are produced with HG.

The calculation of periodic means (i.e. hourly, daily mean values) is done with software, which will be provided by the consultants later. This software is coded in FORTRAN and a MS-FORTRAN compiler is needed for using it.

2.2 Manual wind measurements on the lake

Each station has been provided with a hand anemometer, which is used in measuring wind fields over the lake (Figure 4). This is important in order to find out the areas where hills are sheltering the lake surface from winds. The measurements are to be conducted together with flow cylinder measurements in the lines, which were determined with technical personel at each station.

The measurement in each location is done as follows:

- position is read and recorded from GPS;
- the heading of the boat is turned against the wind;
- boat is driven with a steady speed for about 100 **in;**
- wind speed wl (= true wind speed **+** boat speed) is read and recorded;
- the heading of the boat is turned 180 degrees;
- boat is driven with a steady speed for about 100 **in;**
- wind speed w2 (= true wind speed — boat speed) is read and recorded; and
- the true wind speed w = 0.5 (wl+w2) is calculated and recorded;

The results are recorded on the Lake Wind Data Sheet (see Appendix 9).

2.3 Wind measurements with anemometers in land stations

Research stations in Kigoina and Mpulungu have wind anemometers (property of NBWE, Finland) and wind direction pointers. These are used for measuring average wind speeds in the morning, afternoon and nights. The readings are taken three times/day. In the future, in connection with other data sampling; more frequent readings can be taken. The readings are taken at the following time (= local times):

	In Kigoma	In Mpulungu
Morning	9:00	8:00
Afternoon	15:00	14:00
Evening	20:00	19:00

Wind direction is read from the direction pointer and recorded during these readings. The results are recorded on the data sheet (see Appendix 10).

3. WATER TEMPERATURE MEASUREMENTS BY THERMISTOR STRINGS

Apart from the thermistor string which is attached to the ineteo buoy, there are two other subsurface thermistor strings which are installed in the lake (Table 1). These instruments consist of a 12 channel recording unit with D~U and a thermistor string, which employs 11 temperature sensors embedded in a polyurethane cable which is 300 **in** long (Figure 5). The instrument is installed between noncoinpressible viny/floats and a heavy anchor. In the upper end of the instrument is mounted an acoustic release system. The releaser can be activated from the surface with an acoustic signal and as a result a marking buoy comes to the surface. Thus the instrument can be lifted and a new DSU fitted. An acoustic pinger is also attached to the string.This pinger sends an acoustic signal each second and with a receiver a diver can find the instrument in case the acoustic releaser should not function.

The two LTR thermistor strings have a specific temperature range, from +15.5 to +35.1°C with an accuracy of 0.02 °C.

In data recording channel number one the station identification number is located. The locations of the 11 temperature sensors in the cable are:

Channel number	Distance from recording unit (m)
2	5
3	55
4	105
5	155
6	175
7	195
8	215

9	235
10	255
11	275
12	300

The exact depth of each temperature sensors has to be calculated during each installation. In March 1993 the highest sensor (number 12) was 7 m under the lake surface. The recording units are programmed to store temperature data with 30 minutes intervals. This makes it possible to deploy the instruments for 113 days.

The thermistor string which is attached to the metec buoy outside Mpulungu has a wider temperature range and a lower accuracy than the two subsurface thermistor strings. Its temperature range aries between –8 °C and +41 °C and with an accuracy of 0.05 °C. In the buoy station the first 5 channels are used for station identification and meteorology. The channellocations of the thermistor strings are as follows:

Channel number	Distance from surface (m)
6	1
7	5
8	30
9	50
10	70
11	90
12	110
13	150
14	200
15	250
16	300

Data from DSUs are unloaded and calibrated using the Aanderaa P3059 program. During calibration, specific calibration coefficients are needed for each sensor. They are found in the Aanderaa manuals '<u>Specific information on thermistor strings 2862. Serial No 2019</u>' and '<u>Specific information on thermistor strings 2862, Serial No 2020'</u>. After data calibration, the data processing can be continued like in the case of the meteo buoy (see 2.1)

4. SURFACE WATER TEMPERATURE BY MANUAL MEASUREMENTS

The lake surface temperature measurements are conducted in a 1 km^2 grid which is located near each research station. The measurements are done for ground calibration of satellite images. The timing of measurements is determined according to the time of passage of the satellites and a special program for that is presented later. In each grid the measurements are conducted in five locations and an areal mean value of measured temperatures are used for image calibration. A data sheet (see Appendix 11) is used. Each station will be provided with a manual thermometer for lake surface temperature measurements.

5. FLOW CYLINDER MEASUREMENTS

Flow cylinder measurements are used to:

- determine the surface flow pattern near each stations along the lake;
- find out how winds (direction and speed) affect the flow pattern;
- find the areas of strong currents;
- determine the horizontal diffusion rate; and to
- provide information about currents for installation of recording current meters in the future.

The measurement is based on flow cylinders which are submerged at the desired depth with a thin rope and a small buoy. The cylinder will travel with the water flow and from the movements of the buoy the flow is detected.

The method is:

- easy to apply;
- gives quickly some results;
- easy to modify;
- not costly;
- Lagrangian, and does not give much information of variations of currents in time;
- there will be five cylinders available for each station;
- the time of travel to the measuring sites is maximum 2 hours;
- the minimum time for measuring is <u>one hour</u>, in order to get good accuracy of travel distance by GPS;
- the maximum depth of measurement is 50 m, since the currents affecting a long rope may distort the measuring. A thin rope is recommended;
- in rough weather cylinders are difficult to detect; and
- if only one boat is available measurements should be done in a fairly restricted area 2 km^2.

There are several ways of spacing the cylinders:

1 - To put cylinders at the same depth over the whole line (e.g. 2 m). Spacing is 300-500 metres between the cylinders. When

you extend the line, remember to use one site as reference from the previous measurement.

2 - To put 3 cylinders on surface at 2 m level and 2 at 40 m level in the two locations together with 2 m cylinders.

3 - To put 5 cylinders in the same site (levels 2 , 10, 20, 30, 40 m)

4 - To vary the spacing of cylinders in horizontal and vertical direction according the results from 1—3.

5 - After 1—3/4, to follow cylinders on the area of strong currents for an extended period (i.e. 6 hours) and to take positions each hour.

In the first phase (1993) measurements should be conducted as follows:

— lines from the shore towards the open lake. The measurements will be done once/week line by line. About five lines near each station should be covered during the period at least with methods 1 and 2;

- lake wind measurements are done at each startpoint and stoppoint during each flow measurement; and

— the data will be processed in each research station according to the instructions given earlier (see Appendix 12). This calculation is based on the determination of travel time and travel distance. The travel distance is calculated on the basis of difference between startpostion and stopposition.

6. CTD MEASUREMENTS

Conductivity Temperature Depth profiler (CTD) model STD12 Plus used by LTR is manufactured by Applied Microsystems Inc., Canada (Figure 6). It is equipped with an oxygen sensor. The instrument is selfcontained and has a solid state memory (500 kB). The instrument is powered with standard alkaline batteries. The CTD is operated with a PC software and the instrument can be used for several succesive measurements without constant programming. The sensors attached to the instrument have the following technical specifications:

Sensor	Range	Accuracy	Response time
Pressure	0 - 200 bar	0.01 %	
Temperature	- 2 - 32°C	0.01°C	250 ms
Conductivity	0.2 - 40 ppt	1 µSiemens/cm	0 (ms)
Oxygen	0 - 15 mg/l	1 mg/l	

The response time of the conductivity cell is dependent on the flushing of the sensor. If the flushing speed is 0.5 in/s the response time is 50 ins. The response time of the oxygen sensor is the lowest of all. If the oxygen sensor is used it is best to lower the instrument with increments and not with high speed. For futher information the reader is referred to 'Model STD-12 no 622 User' Manual'.

There are basically two ways to program this instrument. A communication package (like Procomm) or by using AMLsoftware by Applied Microsystems. Right now AML is still under development and the user must be able to use both softwares.

The instrument can be programmed and data unloaded according to the following instructions:

1. Connecting the STD-12 plus to a computer:

- connect the RS-232 connector to the COMl port of your computer (you can also choose port COM2 but then you have to change the software) (see STD-12 PLUS Preliminary User Manual for more details);

— once the connections have been made and the communications software has been loaded, the red shorting plug can be inserted into the hole connector on the instrument, press Enter, this will initiate the autobauding sequence.

2. Use of Procomin as a communications package (MS—DOS~:

- the simplest method of communicating with the STD-PLUS is to use a terminal program;

— copy Procomm—program to your computer's hard disk;

— to run Procomm, type procomm and press Enter;

- assuming that the STD-PLUS is connected to the computer and is powered up, one only has to press Enter again and the STD-PLUS autobauding feature will automatically sense the communication baud rate and will send back the main menu;

- the STD-PLUS is now communicating with the computer and one can program it by using its own commands (see STD—12 PLUS Preliminary User Manual for more details). Use Procomm for instance to

1) set the correct date and time;
2) to set the baud rate;
3) to change the parameters for a specific sensor;
4) to see variables or sensor information.

3. AML total system software

- the AML consists of two parts: the DOS interface and the system software, the DOS interface is a program which allows the computer to talk directly to the STD-12 Plus. Once the device driver DOS-INT.SYS in the "config.sys" file has been installed, one can directly access the instrument as if it was another disk drive (e.g. d:);

- first install the total system software to the hard disk, place the Total System Software disk in the disk drive, log to that drive and type INSTALL C:

- installation requires the alteration of the "config.sys" file; before changing it, make a backup copy of that file, install the device driver by inserting the following command: DEVICE = C:\AML\DOS-INT.SYS COMl 19200 (for instrument operation on COM2, write DEVICE = C:\AML\DOS-INT.SYS COM2 19200)

— after these changes were made, restart the computer, If everything is correct, the following message is seen:

Dos Interface Oct 92
Drive D:

- D is the drive letter that is used for accessing the instrument

— in order to use the Total System Software, one must first connect the STD-12 to the computer and then start the program by writing

C:
CD AML
AML

— the title page now showing in your screen allows one to access the following menus : FILE, DATA and OPTIONS. Choose menus by typing the first letter of the word in conjunction with the ALT key or a function key or click on any portion of a menu with the mouse (for more information, see 'Total System Software manual');

— use the escape key (ESC) to return to a previous menu or window;

— you choose funtions by using cursor keys to move the menu bar up and down and pressing enter or by clicking on the word with the mouse cursor:

A. FILE submenu:

— one can copy data from the instrument to the computer's hard disk or floppy disk, and one can also erase and rename files.

B. DATA submenu:

- to configure the instrument for logging by using the function SETUP CAST, to choose sample time unit,sampling interval, depth logging interval and to give name to the log file;

- function VIEW/EDIT DATA: allows to view and edit data logged by the instrument;

- function REALTIME DATA: allows to view and edit data in real time;

- function COEFFICIENTS: allows to view and alter calibration coefficients and display parameters.

C. OPTIONS submenu:

– function DIRECTORIES: allows to alter the location of where the software will store and retrieve specific files; and

– function HARDWARE allows to configure the software for the computer's hardware options.

4. Calibration of the oxygen sensor

- STD-PLUS has a model 64 dissolved oxygen sensor, which produces an e m f directly proportional to the concentration of oxygen dissolved in the solution in which the sensor is immersed;

- for information of the functioning and calibration of the sensor, see 'Model 64 Dissolved Oxygen Sensor: Operation Manual.'

In LTR the instrument should be programmed to take readings by depth increment (2 m). After the programming of the instrument, the communication cable is taken of f and replaced with a dummy plug. When the instrument is lowered in the water and the conductivity cell immersed it will automatically trigger the data logging.

7. WATER LEVEL RECORDING

Water level recording gives information of seasonal fluctuations of water level and short term periodical oscillations of the surface (seiching and tides). LTR installed three automatic water level recorders along the lake (Table 1). The Druck pressure sensor is used for water level measuring and a Telog data recording unit is used for data collection and calibration (Figure 7). The sensor is installed in a plastic tube in a blank of a pier. The tube protects the sensor and dampens the effect of waves. The sensor has a measuring range between 0 and 70 cm, with an accuracy of 0.1 %. Since the instrument records relative water level values, it is essential to combine the daily readings of existing water level staff on gauges in Bujumbura and Mpulungu with Telog observations. Because of the seasonal water level fluctuations the water level in the tube has to be checked weekly and, if required, a new level of the sensor has to be selected. The pressure sensor collects water level data once per second and the data recording units are programmed to store hourly mean values. With these settings the memory capacity is enough for nine months recording.

With the following instructions one can program the Telog recorder with appropriate interval and measuring range and also unload and scale the data:

1. **Starting the program and saving the data**

- configure the serial port in the PC, set baud rate=9600, parity=n, data bits=8, stop bits=l

- start the Telog-program from the floppy disk or from the hard disk by writing 2100 If one starts the program from the hard disk, remember to put the data disk in the disk drive;

— set date but notice the order : month, day, year;

- set time;

- press FlO to get the main menu;

- press F4 (change baud rate) to check the baud rate

(should be 9600);

- press F6 (utilities) in order to get to the next menu;

— press Fl (configure disk drive) to choose disk drive

for the data disk,usually it is a:, press Enter a:

- press FlO (abort this function);

— press F3 (set default com port), to choose serial port coml or coin 2;

- press FlO (abort this function);

— press FlO (return to main menu);

— press F3 (process next recorder or DTU);

— press Fl (2100 recorder) and connect the recorder to the computers serial port with the Telog cabel, then press Enter. One must have the data disk in the disk drive. Now the main menu should be seen on the computer screen (recorder status);

— press Fl (analyze recorder data);

- press Fl (display hi-resolution graph) and wait until the data have been read into the PC (read recorder data —please wait);

— press Fl (auto—scale graph), now one can see the stored data, max 271 days (Telog records water level once each second and it is programmed to calculate one hour mean values);

— press FlO (analyze recorder menu);

— press F4 (save recorder data to disk);

— give name to the file, press Enter;

— you can use F5 (read recorder data from disk) to get the recorder data from the disk;

— press FlO (return to the main menu);

— press FlO (exit to operating system).

2. Scaling of the recorder

- start the program, set date and time;

— press Fl (2100 recorder) and connect the recorder to the computer’s serial port with the Telog—cabel, press Enter;

- put the data disk in the disk drive;

— press F6 (utilities);

- press F2 (define recorder scaling);

— give first the unit, m (meter), press Enter, give values to point 1, first 0 %, press Enter, and then 0 meters, press Enter, then give values to point 2, first 100 %, press Enter and then 0.7 meters, press Enter;

— answer Y if the program asks to erase the stored data;

— press FlO (return to the main menu);

— press FlO (exit to operating system)

3. Scaling of the data on the disk drive

- start the program, put the data disk in the disk drive;

- set date and time;

- press FlO (go to the main menu);

— press Fl (analyze recorder data);

- press F5 (read recorder data from the disk), move with arrows to the desired file and press Enter;

- press FlO (return to main menu);

- press F6 (utilities);

- press F2 (define recorder scaling), do the scaling same way as earlier your did in the scaling of the recorder.

4. Programing the recorder

- start the program (2100), set date and time, notice the order: month, day, year;

- choose Fl (2100 recorder);

- connect the recorder to the computer's serial port, press Enter

- wait until the settings of the recorder (recorder status) are seen;

- press F2 (program recorder);

- press Fl (change recorder status);

- use arrows to choose the name of the recorder (recorder ID);

- the time of the recorder will always be the time when one starts the program;

- with the space bar one can choose between three choices OK, RESET, SYNC. Choose SYNC. so that the recorder will record data every hour (if one has chosen one hour to be the recording interval);

- in the next field one chooses minimum, maximum or mean recording (averages);

- alarm status must be OFF;

- in the next field one chooses the recording interval 00:00:00 (hh:mm:ss);

- use the space bar to choose the storage capacity=6512;

- when the recorder has been programed, press Fl (re—program recorder using displayed status);

- reset the recorder, press Y;

- wait until the PC has moved the new status to the recorder;
- press FlO (return to the main menu);
- press FlO (exit to operating system).

TABLE 1: Recording instruments in Lake Tanganyika

Instrument type	Location	Levels of measurement under/above lake surface	Recording interval
Water level station Water level station Water level station	Bujumbura, harbour Kigoma, harbour Mpulungu, fish company	0.6 m under 0.6 m under 0.6 m under	1 hour 1 hour 1 hour
Weather station Wind meter Wind meter	Bujumbura, harbour Kigoma, guest house Mpulungu, Fisheries	4 and 13 m above	10 minutes 3 times/day 3 times/day
Thermistor chain	Near Kigoma 5° 00′ 45" S 29°33′ 31" E Water depth: 460 m	7 - 307 m under	30 min
Thermistor chain	Near Kirandoo 7° 03′59" S 30° 20′06" E Water depth: 608 m	18 - 318 m under	30 min
Weather station + Thermistor chain	Near Mpulungu 8° 30′06" S 30° 53′58" E Water depth: 320 m	2.6 m above 1 - 300 m under	30 min 30 min

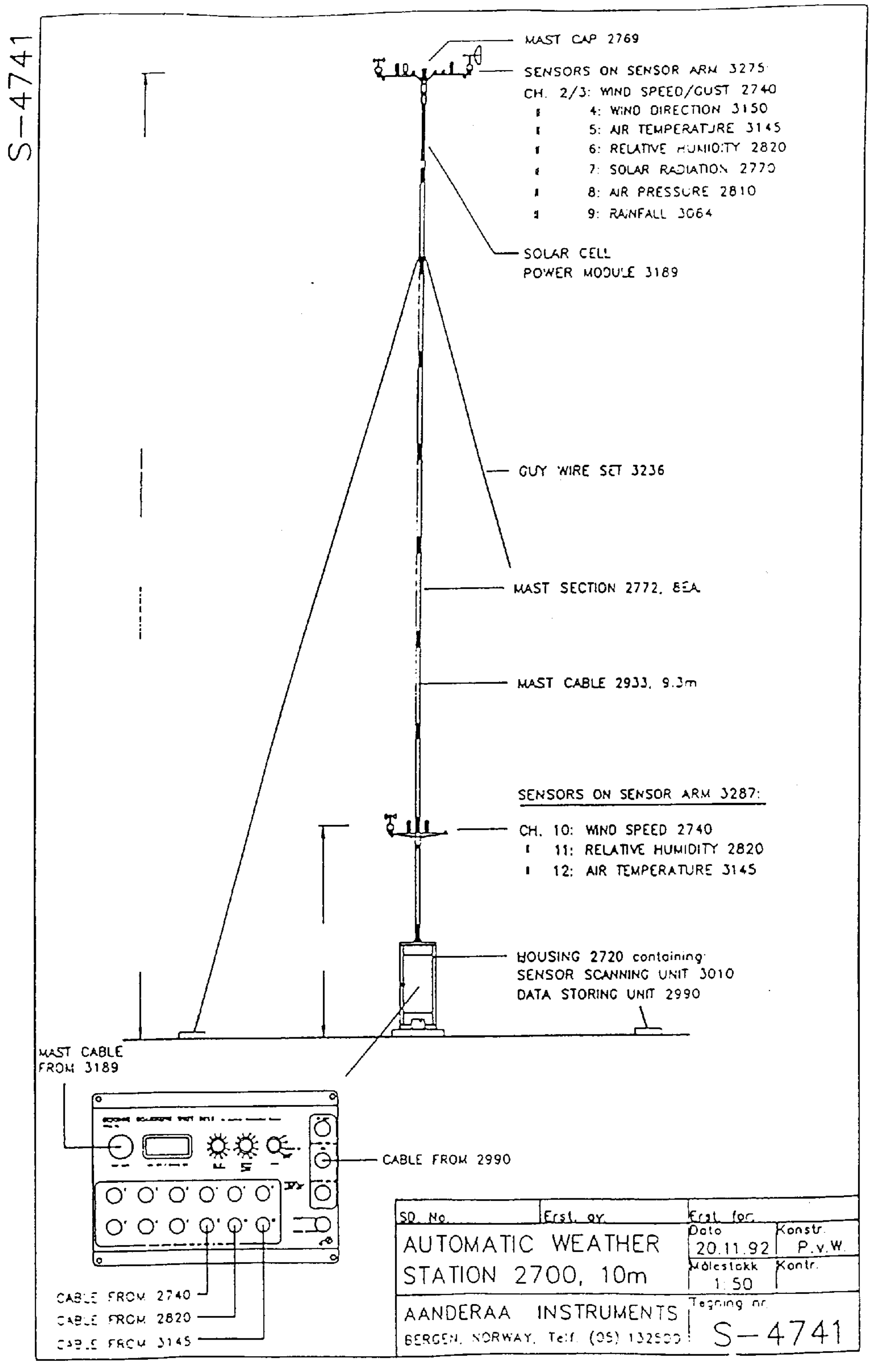


Fig. 1 : Aanderaa weather station in Bujumbura harbour

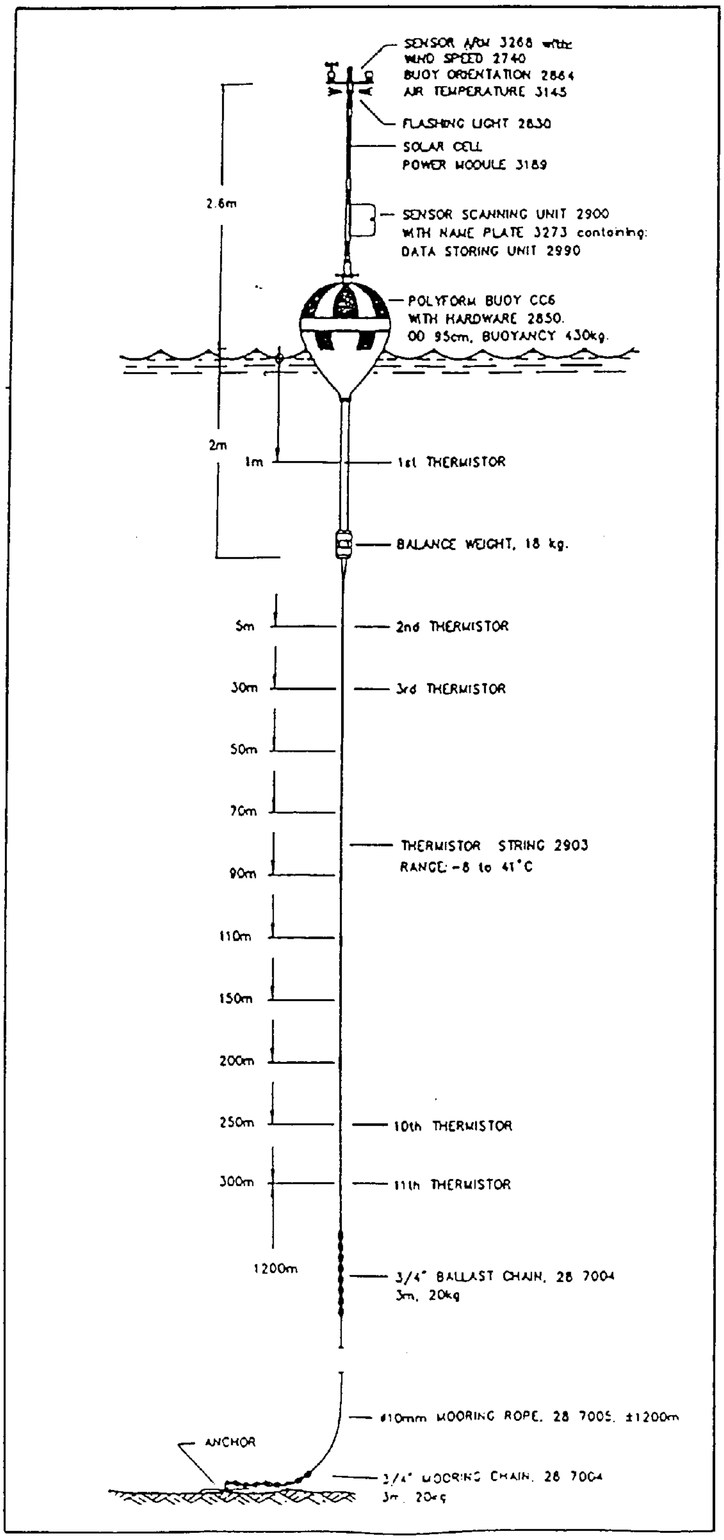


Fig. 2 : Meteorological buoy and thermistor chain in Mpulungu

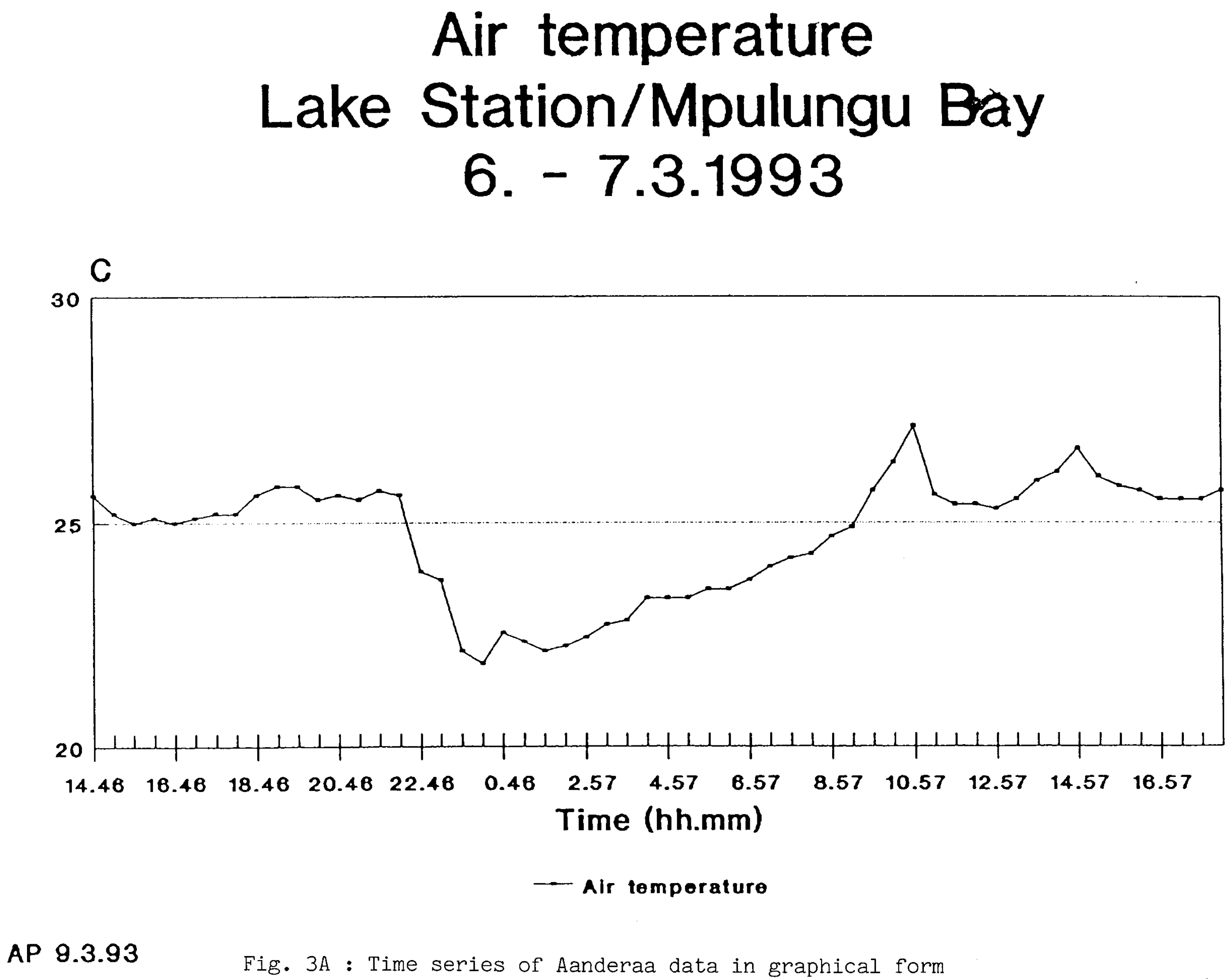
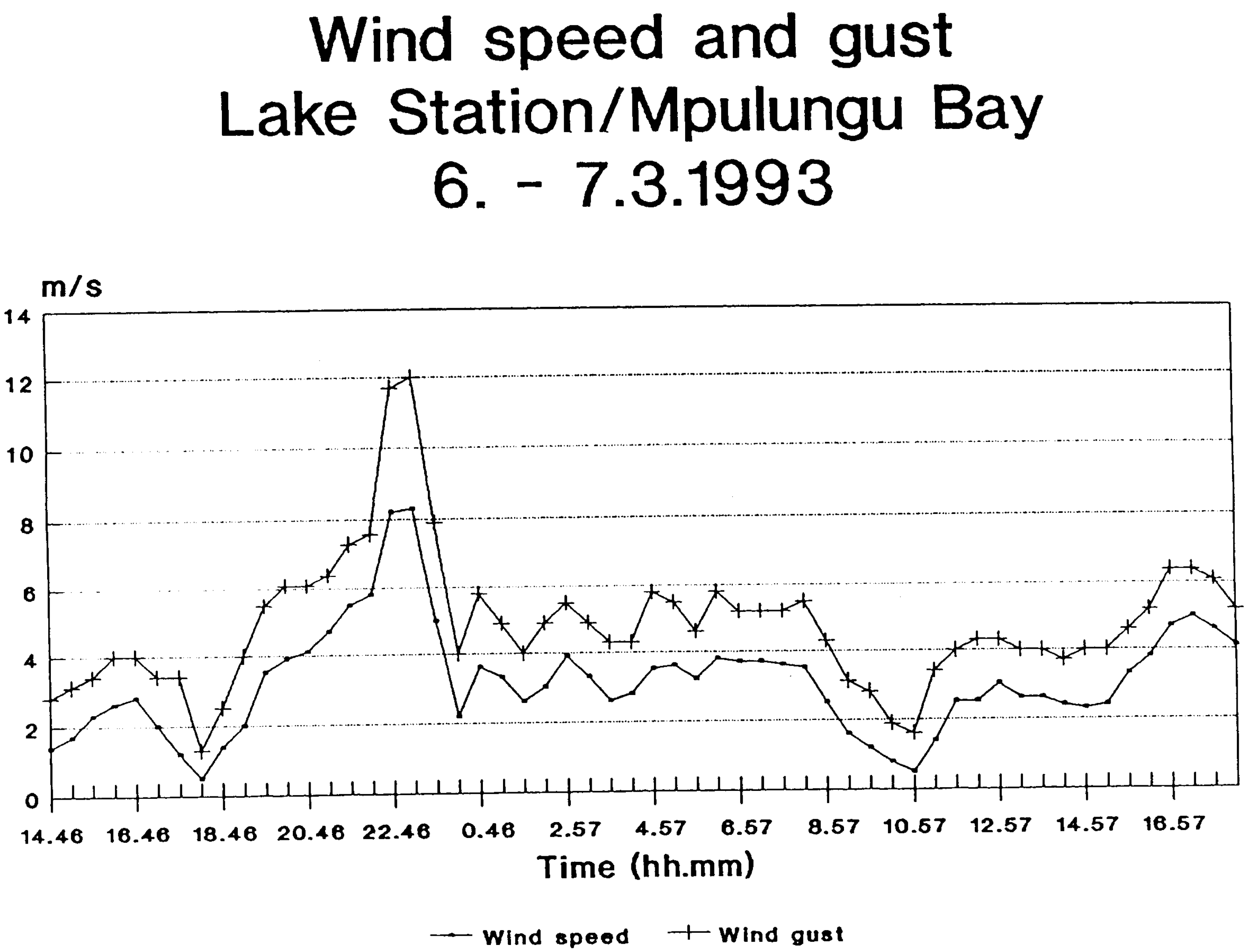


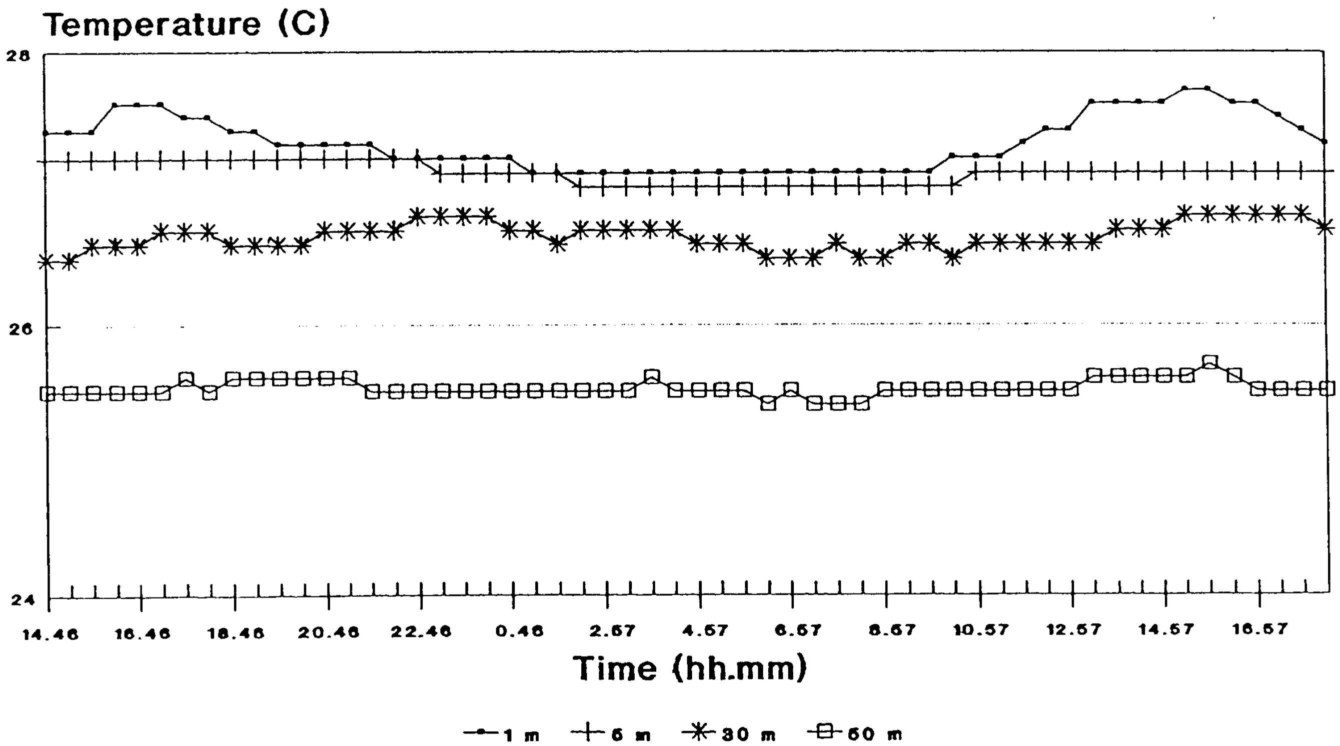
Fig. 3A : Time series of Aanderaa data in graphical form



AP 9.3.93

Fig. 3B : Time series of Aanderaa data in graphical form

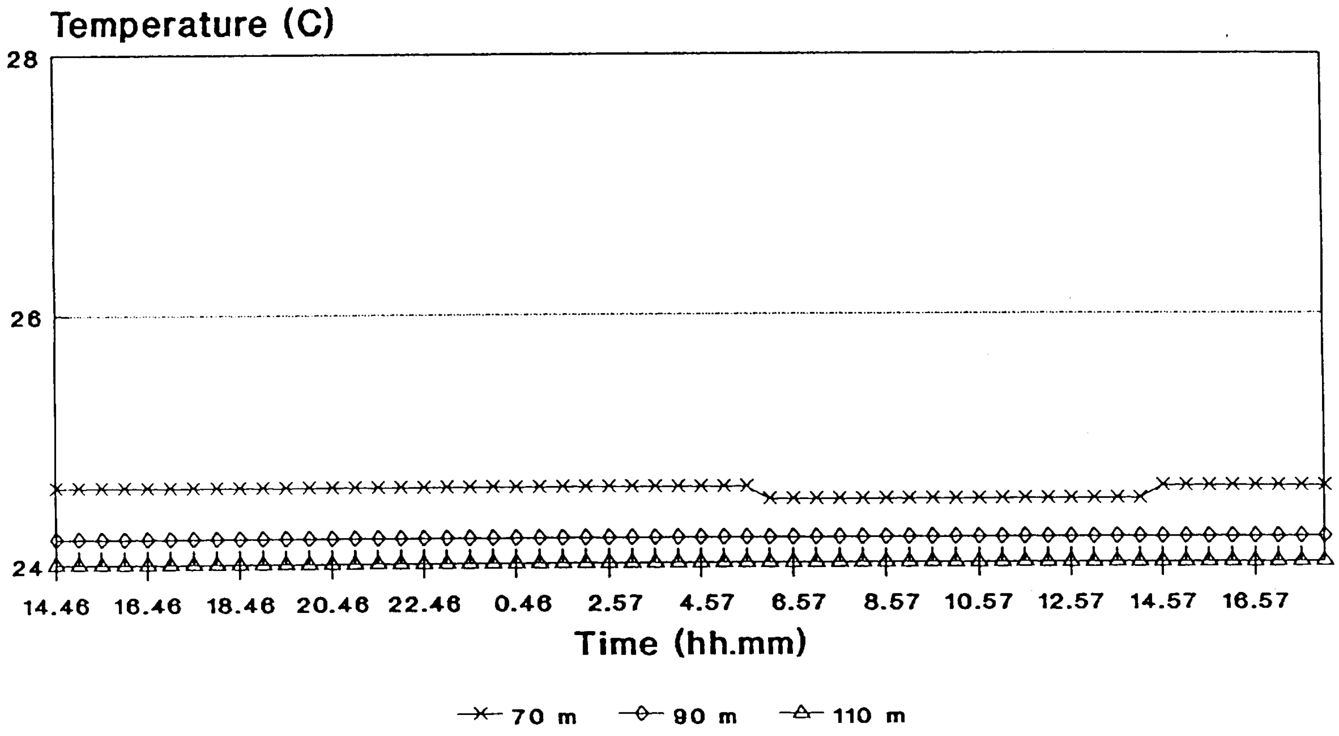
Water temperature
Lake Station/Mpulungu Bay
6. - 7.3.1993



AP 9.3.93

Fig. 3C : Time series of Aanderaa data in graphical form

Water temperature
Lake Station/Mpulungu Bay
6. - 7.3.1993



AP 9.3.93

Fig. 3D : Time series of Aanderaa data in graphical form

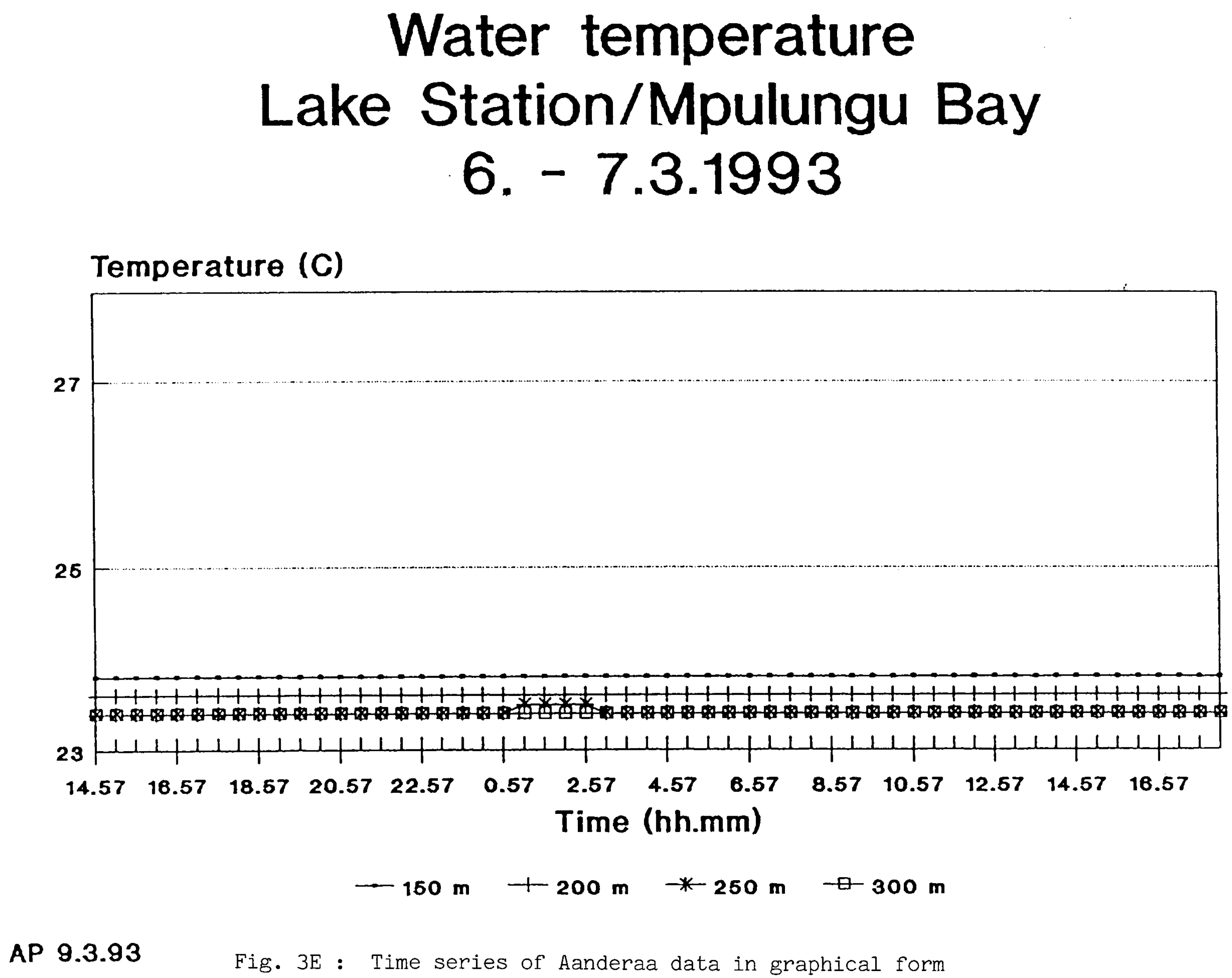
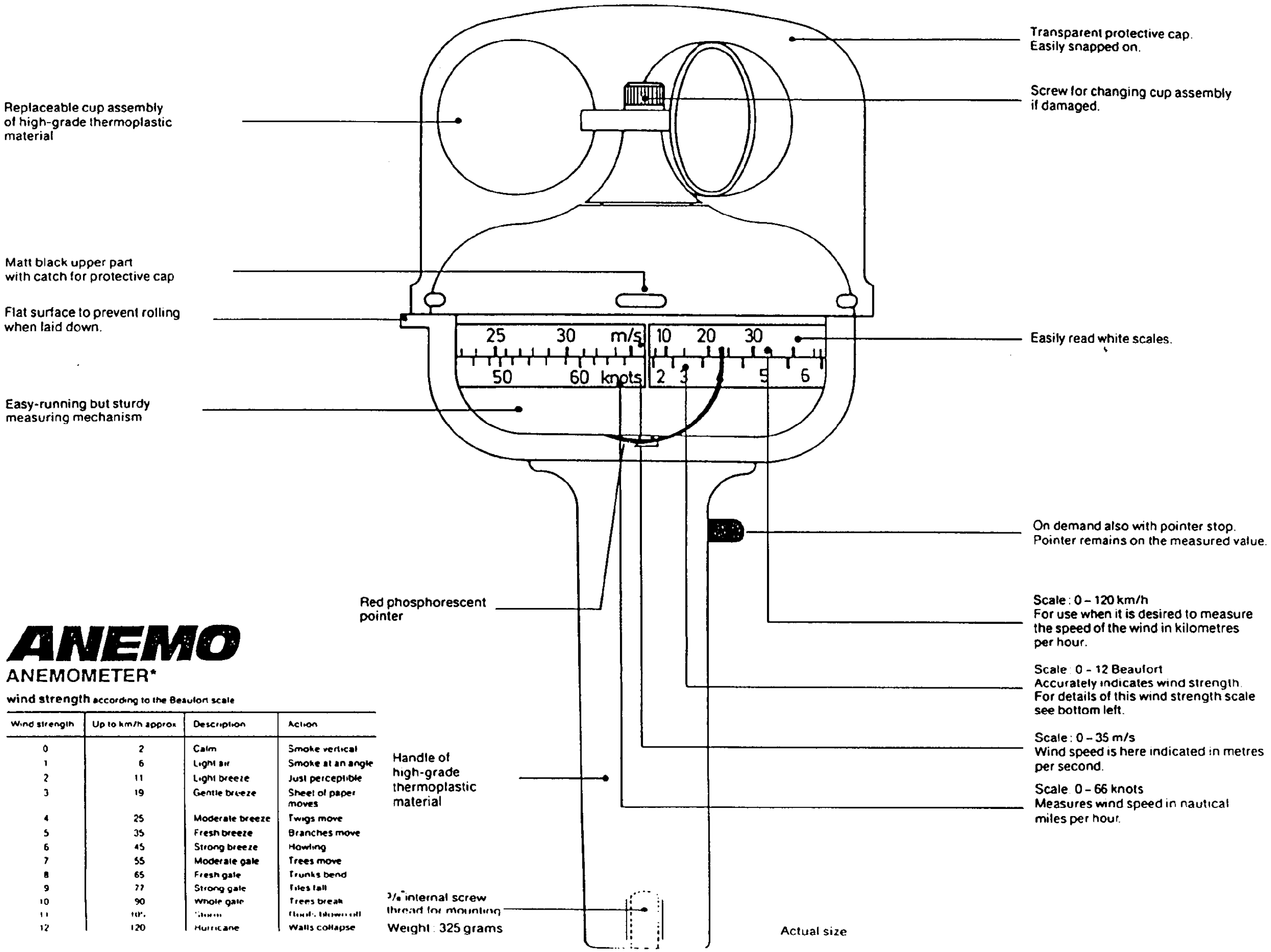


Fig. 3E : Time series of Aanderaa data in graphical form



Wind strength	Up to km/h approx	Description	Action
0	2	Calm	Smoke vertical
1	6	Light air	Smoke at an angle
2	11	Light breeze	Just perceptible
3	19	Gentle breeze	Sheet of paper moves
4	25	Moderate breeze	Twigs move
5	35	Fresh breeze	Branches move
6	45	Strong breeze	Howling
7	55	Moderate gale	Trees move
8	65	Fresh gale	Trunks bend
9	77	Strong gale	Tiles fall
10	90	Whole gale	Trees break
11	[illegible]	[illegible]	[illegible]
12	120	Hurricane	Walls collapse

Fig. 4 : Wind anemometer used on the lake

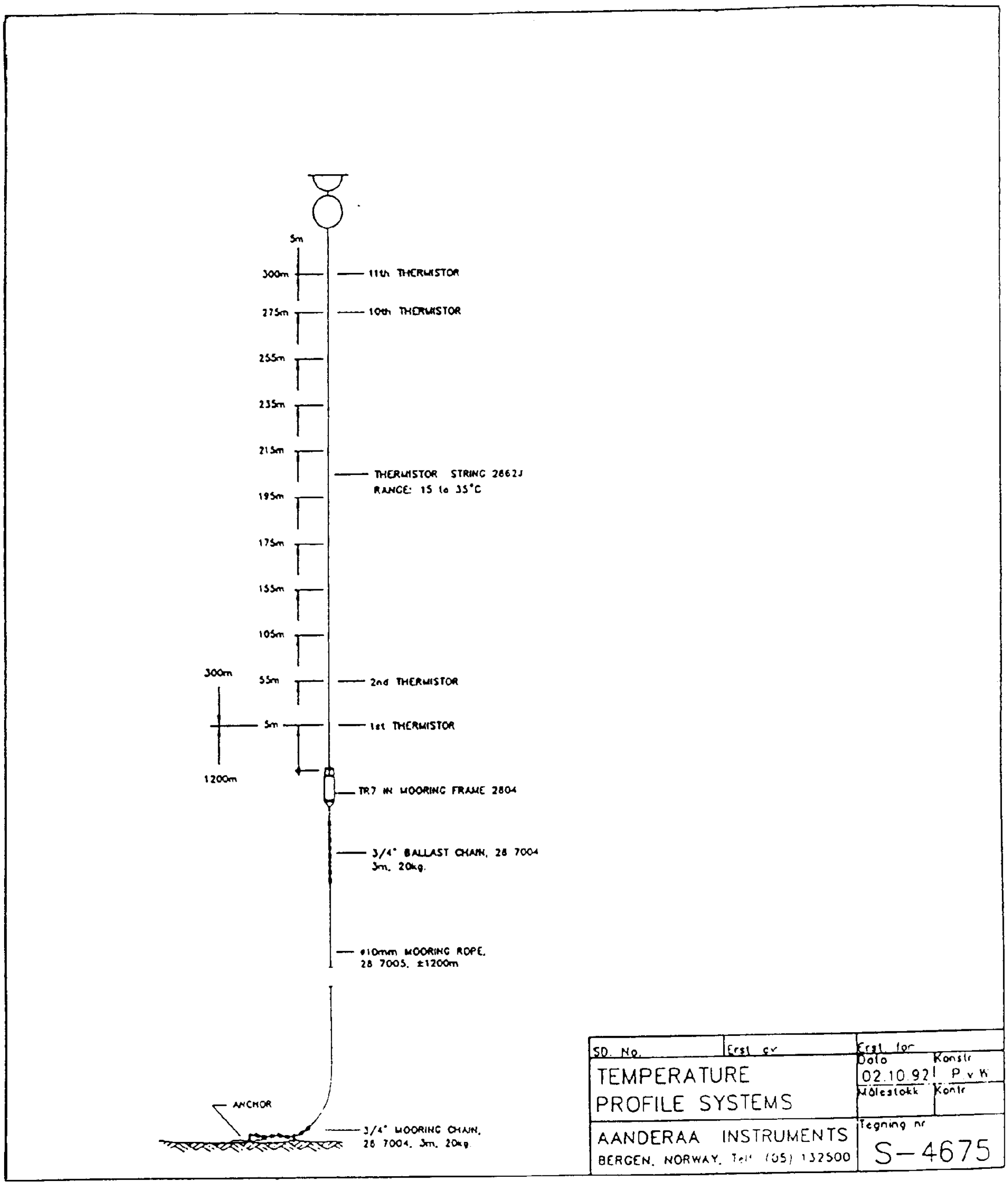


Fig. 5 : Installation of thermistor chain

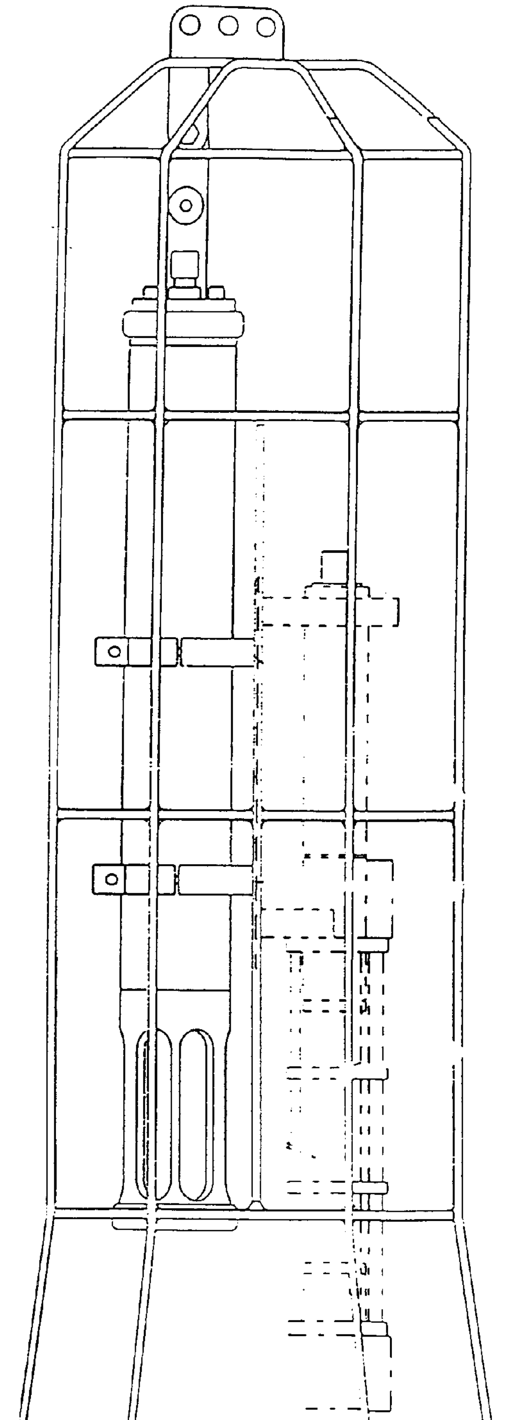


Fig. 6 : CTD profiler model STD-12 Plus

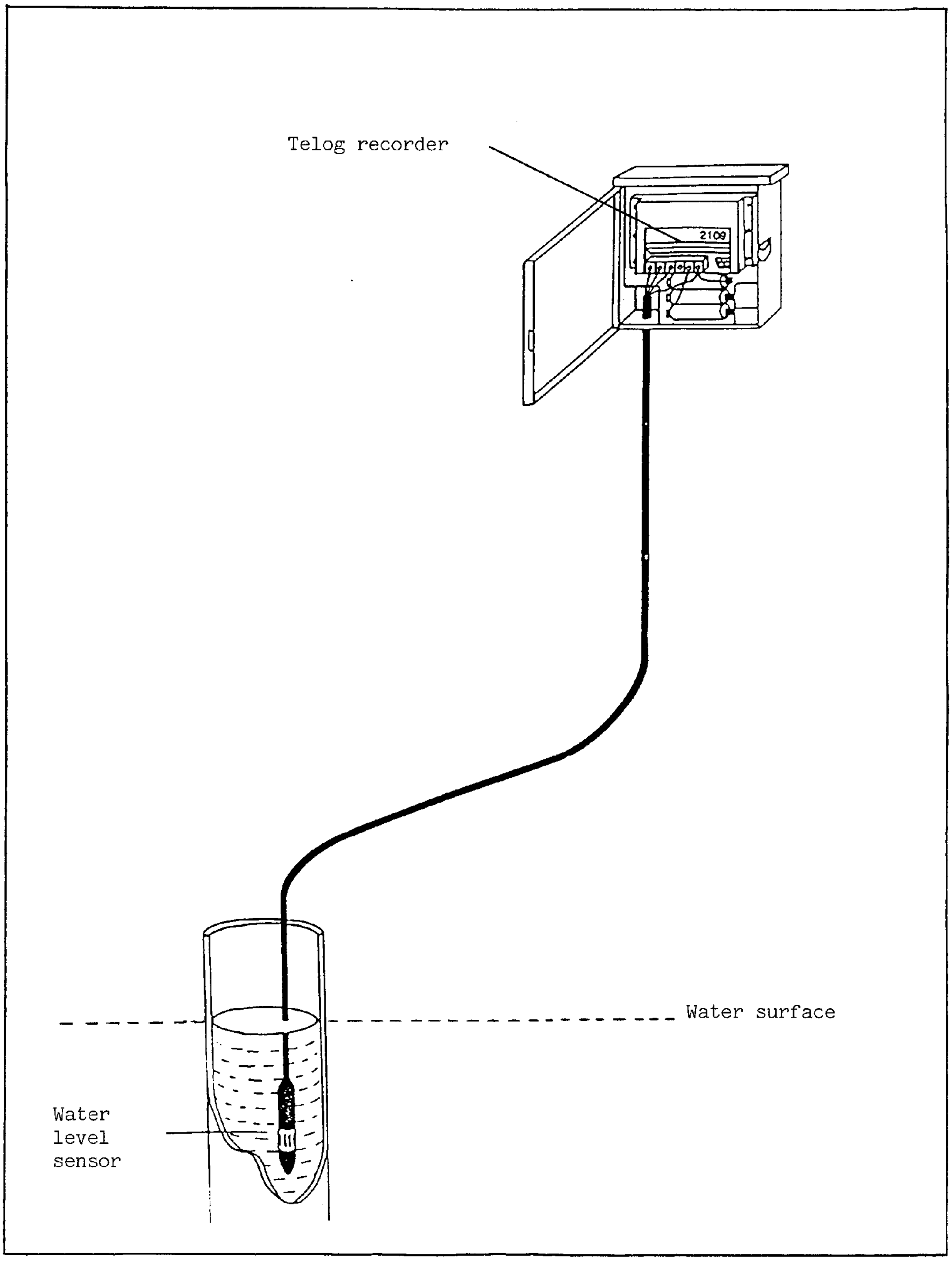
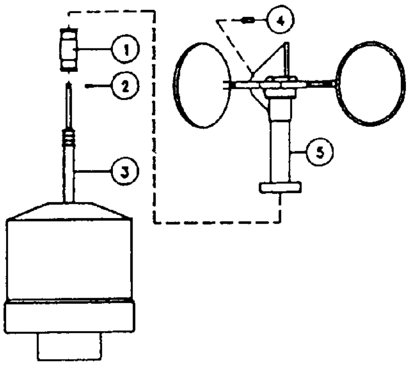


Fig. 7 : Telog recorder with water level sensor

Maintenance hints for meteorological sensors.

2740 Wind Speed Sensor:

All sensors have identical rotors and bearings. Type calibration is valid for all sensors. The individual sensors are tested for performance only. Calibration not required. Bearings should be replaced annually.

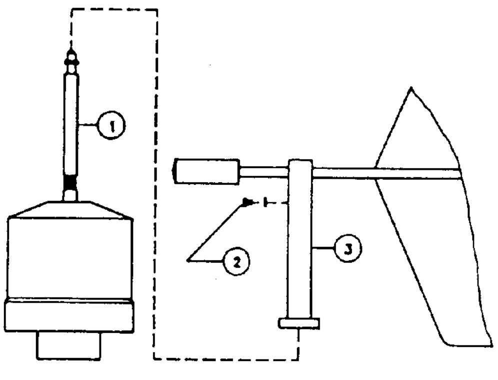


To change the Bearing Assembly 2620B (1) proceed as follows:

- Loosen set screw (4) and pull Rotor with skirts and magnet(5) off the shaft (3).
- Remove the clip ring (2) and replace the Bearing Assembly.
- Install clip ring and Rotor (5) and install set screw (4).

2750/3150 Wind Direction Sensor:

Positioning of internal compass is done during calibration. Recalibration not required unless compass is changed. Annual renewal of damping fluid for the wind vane is recommended.



Refill damping fluid as follows:

- Remove screw (2) and pull Vane Assembly (3) off shaft (1).
- Turn the Vane upside down and fill damping oil, Silicone 60000 sct. into the bore (3).
- Place Vane on shaft (1) and let Vane slide downunder its own weight when turning, until only clear oil escapes through the screw hole (no air bubbles).
- Install screw (2) and tighten up
- Dry off excess oil.

3145 Air Temperature Sensor:

Sensor is based on platinum sensing element. Seven point calibration is performed in water bath at factory. As the sensor does not age, recalibration is not required.

2810 Air Pressure Sensor:

Calibrated at 10 points against a reference mercury precision barometer. The sensor has a linear characteristic. For check of calibration we recommend annual single-point comparison, e.g. against a precision barometer reference (to disclose possible seal discrepancies). Any deviation in value should be added to or subtracted from original A-coefficient value.

2820 Relative Humidity Sensor:

Dry dust and deposits off the radiation screen to maintain full efficiency. In the field the calibration of the sensor is best checked by comparison with a psyckrometer.

2770 Solar Radiation Sensor:

Cover the glass dome and check that the zero reading is 0 ± 0.02 W/m^2. Clean the dome with soap solution and dry off with a soft cloth.

3064 Rainfall Sensor:

Check that the funnel is free of obstacles such as leaves and dirt. Clean the orifice/filter once a year.

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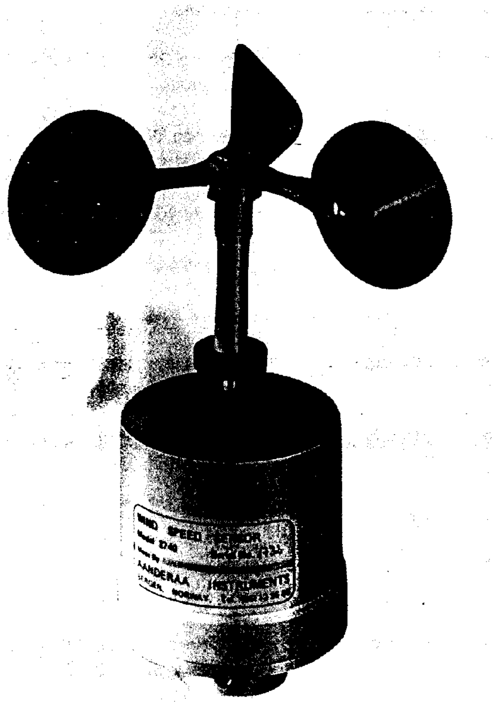


WIND SPEED SENSOR 2740

This sensor will measure the average and maximum wind speed (gust) during the sampling interval. It is designed for use with the Aanderaa Automatic Weather Stations, Sensor Scanning Unit 3010 or Display Units 3315/3017.

The Wind Speed Sensor 2740 consists of a three cup rotor on top of an aluminum housing. The sensor can be fitted directly onto the sensor arm of Aanderaa Automatic Weather Stations or used separately if a connecting cable is used. The sensor will fit onto a 25 mm vertical tube.

The rotor bearings consist of 2 stainless steel ball bearings protected by a surrounding skirt. The lower end of the skirt is furnished with a magnet. The magnet's rotation is sensed by a reed switch located inside the housing. The sensor has 2 output signals; average and maximum wind speed (gust).

A new principle is employed ensuring that the arithmetic mean of the wind speed is always obtained regardless of sampling interval, providing that the sampling interval is between 4 seconds and 36 hours.

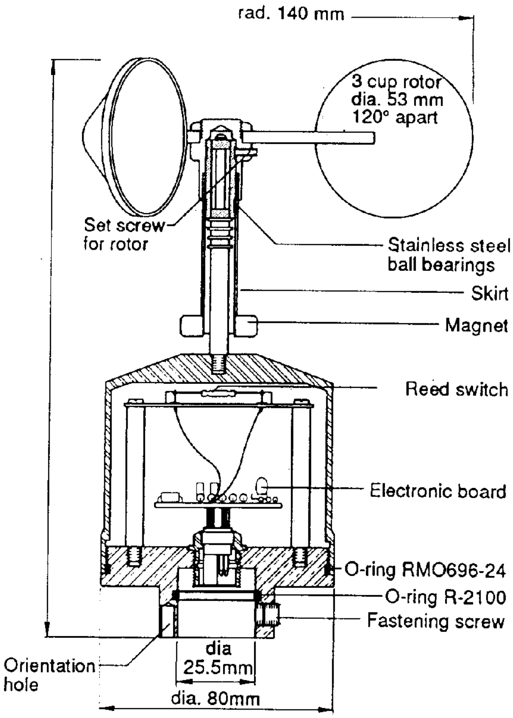
The maximum wind speed is the highest speed occurring over a 2 second period at any time during the sampling interval.

A micro controller reads pulses from the reed switch and calculates the average and the wind gust. It also provides the Aanderaa SR-10 output. Both average and gust will have the same conversion factor for calculation of speed in meters per second. This factor is independent of the sampling interval used.

The sensor requires a continuous voltage supply to operate. This supply is obtained from the datalogging system's main battery (9V). Current consumption is less than 100 microamperes. During the reading process the current consumption will increase to 300 microamperes.

DATA SHEET D 151, OCTOBER 1991

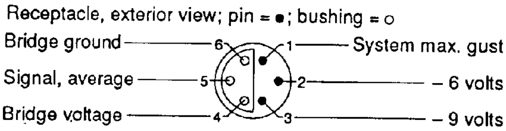
SPECIFICATIONS FOR WIND SPEED SENSOR 2740



Threshold Speed:	30 – 50 cm/s
Range:	Up to 76 m/s
Distance Constant:	1.5 meters
Accuracy:	± 2% or ± 20 cm/s, whichever is the greater
Output Signals:	1. Average Wind, SR-10 2. Wind Gust, SR-10
Calibration Factor:	1.194 m wind way for each revolution. Two counts each rotor revolution.
Operating Temperature:	– 40 to + 50°C
Electrical Connection:	Receptacle 2843 mating Watertight Plug 2828
Material Housing:	Aluminum 6061T6 anodized 20μ
Net Weight:	500 grams
Packing:	Plywood case 360 x 280 x 105 mm
Gross Weight:	4.1 kilograms (add 0.7 kg for Connecting Cable 2842)

PIN CONFIGURATION

Receptacle, exterior view; pin = •; bushing = o



Connecting Cable 2842 (10 meter cable with watertight plugs) with Gust Adapter Cable 2911 is available for connecting this sensor to the Aanderaa datalogging systems. Other lengths, or separate plugs and cables, are available on request.

CALIBRATION

The calibration of this type of Wind Speed Sensor was carried out in a wind tunnel at the FFF laboratory in Stockholm, Sweden in 1979. The measurements were taken in 12 steps from 5 to 60 m/s. Three sensors were calibrated at the same time, all giving the same coefficients.

The converting of raw data to engineering units both for average and wind gust is given by the formula:

$$V = A + B \times N$$

where N is the raw data reading and A and B are the calibration coefficients. Coefficient A is equal to zero.

Coefficient B is equal to 7.46E–2 for wind speed in meters per second and 1.449–1 for wind speed in knots.

Wind speed(V), . m/s = 7.46E–2 x N
Wind speed(V), knots = 1.449E–1 x N

D 151, OCT 91

AANDERAA INSTRUMENTS

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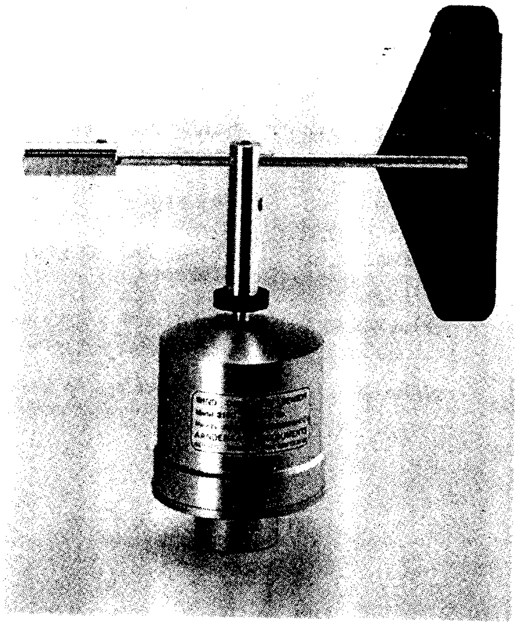
WIND DIRECTION SENSOR 3150

A sensor for measuring wind direction. It is designed for use with the Aanderaa Automatic Weather Station 2700.



This sensor consists of a light wind vane pivoted on top of a housing. Inside the housing a compass with a potentiometer is magnetically coupled to the vane. It is designed to be used in channel 4 of the Sensor Scanning Unit 3010 only.

To ensure minimum current consumption when used on the sensor arm of the Automatic Weather Station 2700, a special electronic circuit will allow the sensor to be clamped in channel 4 only.

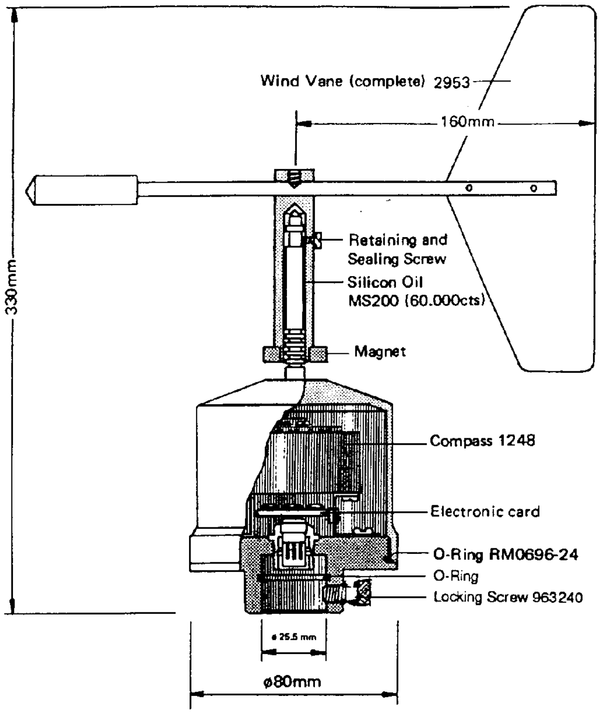
When direction is to be read, the compass is clamped by applying current to a clamping coil located inside it. In this way, the wind direction is given as a potentiometer setting. A set of resistors is connected to the compass to make the signal compatible with the datalogging system. For the purpose of damping the vane movements, the space between the pivot and the surrounding skirt is filled with silicon oil. The oil damping permits the vane to line up even in very light wind.

The sensor is furnished with an orientation mark that must be lined up with magnetic North to give correct magnetic bearings. When properly orientated this sensor will cause the datalogging system to read 0 for wind coming from the North, 256 from East, 512 from South and 768 for wind blowing from the West.

Do not fasten this sensor to structures other than those of aluminum or plastic to avoid galvanic corrosion.

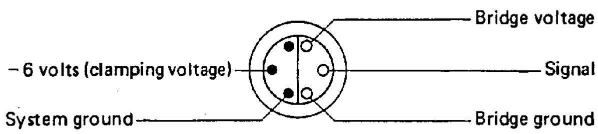
DATASHEET D 203, JULY 1991

SPECIFICATIONS FOR WIND DIRECTION SENSOR 3150



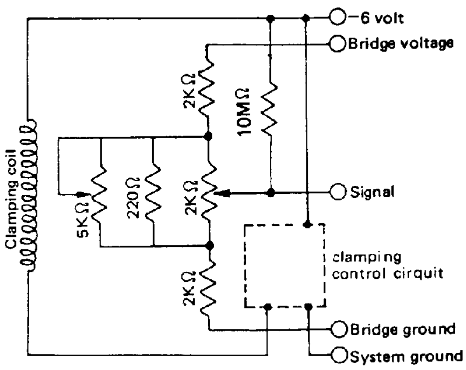
Threshold Speed:	Less than 30 cm/s
Accuracy:	Better than ± 5°
Operating Temp.:	– 40 to + 50°C
Electrical Connection:	Receptacle 2843 mating Watertight Plug 2828 (or Lemo Plug F306)
Mounting:	On Automatic Weather Station Sensor Arm 3275, channel 4
Material Housing:	Aluminum 6061T6, anodized 20 µ
Weight:	0.575 kg
Packing:	Plywoodcase 360 x 280 x 105 mm
Gross Weight:	4 kg (add 0.7 kg for connecting Cable 2842)
Warranty:	One year against faulty materials or workmanship

PIN CONFIGURATION



Receptacle 2843 seen from plug side
(• = pin; o = bushing)

Electronic circuit:



CALIBRATION

Provided that the orientation mark on this sensor is orientated towards North, the standard calibration formular is:

Direction, degrees = 1.5 + 0.349 · N is valid. (N = datalogger reading).

D 203, JUL 91

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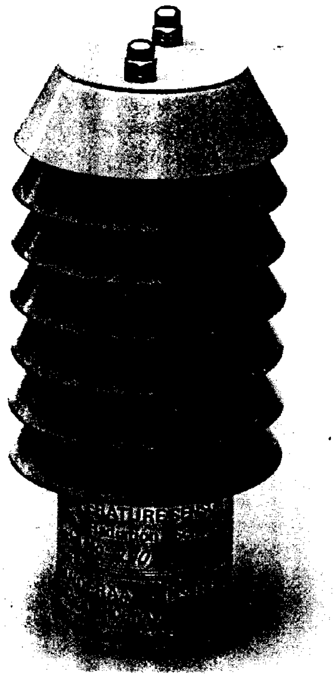


TEMPERATURE SENSOR 3145

A platinum sensor for air, water and soil temperature measurements.

The sensor is based on the ohmic half-bridge principle (VR-22) and employs a 2000Ω film-type platinum resistor as the sensing element.

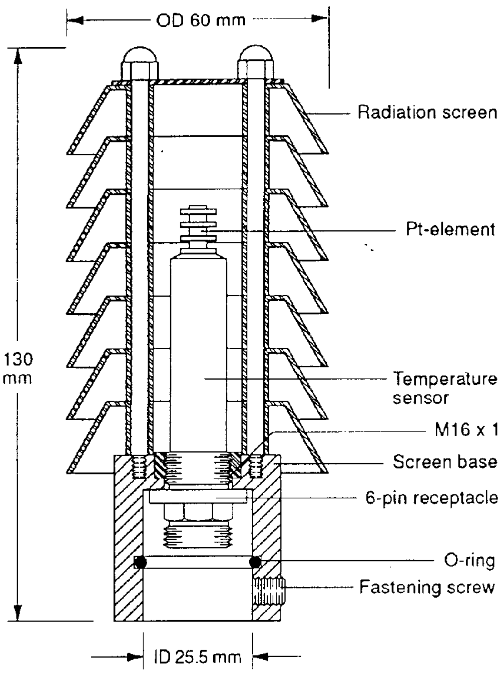
The Temperature Sensor exists in 2 versions, one with a temperature range of – 44 to + 49°C, designated 3145, and the other with a range of – 8 to + 41°C, designated 3145A

For air temperature measurements the sensor is equipped with Radiation Screen 2922, which protects the sensor from heating caused by solar radiation in wind velocities as low as 0,5 m/s. Installed in the screen the sensor will plug directly to the Sensor Arm of the Automatic Weather Station 2700 or to a vertical aluminum tube 25 mm in diameter. For water and soil temperature measurements the sensor must be used with separate cables. Up to 500 m long cables can be used. However, when using cables longer than 75 m the cable resistance must be corrected for (see overleaf).

When cables exceed 10 m lengths, avoid free air stretch of the cable, as free air causes the cable to be susceptible to picking up atmospheric electricity. The cable should either follow the ground or be supported by a grounded steel wire.

DATA SHEET D 205, AUGUST 1992

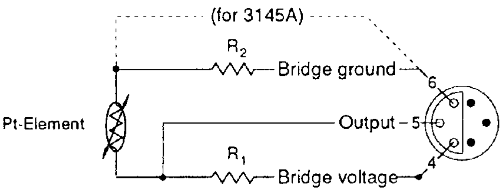
SPECIFICATIONS FOR TEMPERATURE SENSOR 3145/3145A



TYPE	3145	3145A
Sensing Element:	Pt 2000.	Pt 2000.
Resistor, R_1:	4000 Ω.	2120 Ω.
Resistor, R_2:	2000 Ω.	0.0 Ω.
Measuring Range:	– 44 to + 49°C.	–8 to + 41°C.
Resolution:	0.1°C.	0.05°C.
Sensor Output	Aanderaa half-bridge (VR-22)	
Time Constant (63%):	In air: approx. 6 minutes; in water: approx. 3 seconds.	
Electrical Connection:	Watertight Plug 2828.	Watertight Plug 2828A.
Material and Finish:	Aluminum 6061T anodized 20μ and polyurethane.	Stainless steel SIS 2343 and polyurethane.
Nett Weight:	135 grams.	150 grams.
Gross Weight:	500 grams.	500 grams.
Packing:	Cardboard box, 300x200x210mm.	
Warranty:	One year against faulty materials and workmanship .	

Circuit Diagram

Receptacle, exterior view; bushing = o ; pin = •



Connecting Cable 2842 (a 10 meter cable with Watertight Plugs), is available for connecting this sensor to Aanderaa datalogging systems. Other lengths, or separate plugs and cables, are available on request. If a connecting cable longer than 75 meters for the 3145A sensor or 150 meters for the 3145 sensor is used, the reading N should be corrected for due to the cable resistance. Add a correction factor for each 10 meters of cable as follows: (N – 512) x 0.00011 for the 3145 sensor or (N – 512) x 0.00023 for the 3145A sensor.

CALIBRATION SENSOR TYPE: 3145 SERIAL NO. 1274

Temp. °C	-39,75	-25,93	-11,52	2,65	17,22	32,35	47,21
Reading, N	52	216	382	541	699	856	1007

These calibration points give the following coefficients: Temperature °C = A + B x N + C x N^2 + DN^3

Coefficients:

A	-4,394E1
B	8,115E-2
C	9,288E-6
D	0

Date 2/11-92 Sign: Rou Aagunes

DATA SHEET D 205, AUG 1992

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RELATIVE HUMIDITY 2820

A sensor for measuring relative humidity, designed to be used with Aanderaa Automatic Weather Station 2700, Sensor Scanning Unit 3010 and other sensor read-out units.

Relative Humidity is one of the basic parameters in meteorology and a Relative Humidity (RH) Sensor will normally be included in a weather station. Sensor 2820 is designed to fit Aanderaa Automatic Weather Station 2700, but can also be used as a separate unit.

The 2820 sensor consists of an RH probe with a receptacle for a watertight plug and a radiation screen to protect it from solar radiation and rain.

Sensor 2820 utilizes a bundle of hygroscopic hair and a silicon beam which detects the variations in length of the hair as humidity changes. The hair bundle is tensioned by a spring which transfers the deflection to the beam. Two resistors diffused onto each side of the beam are parts of a temperature controlled half-bridge. In this way the variation in length of hair is converted to an electrical signal.

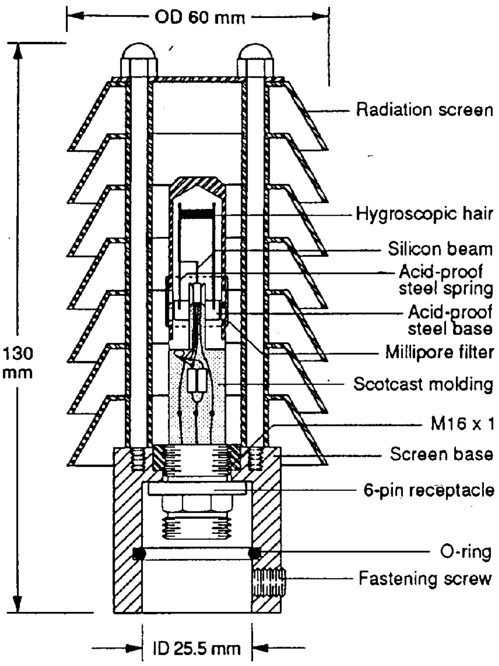
The hair bundle of this sensor has been impregnated with silver chloride. This treatment improves the performance of the hair bundle considerably. Hair bundles treated this way show:

1. Larger percentile change.
2. Good repeatability (low hysteresis).
3. The ability to be cycled repeatedly between 0 and 100% RH without significant change in calibration.

The time constant of this sensor for reaching 63% of a step change in humidity is about 5 minutes at room temperature.

DATA SHEET D 160, SEPTEMBER 1992

SPECIFICATIONS FOR RELATIVE HUMIDITY SENSOR 2820

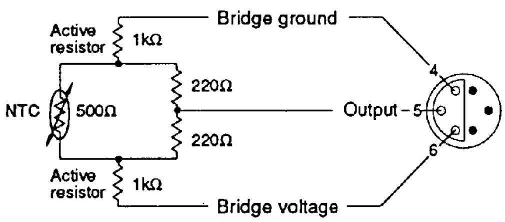


Range:	5 to 100% Relative Humidity (RH).
Accuracy:	± 3% RH.
Resolution:	0.3% RH.
Output Impedance:	500Ω.
Sensor Output:	Aanderaa half-bridge VR-22.
Operating Temperature:	– 30 to + 50°C.
Electrical Connection:	Watertight Plug 2828, or Lemo Plug F2306.
Material and Finish	
Probe:	Scotchcast molding and aluminum 6061T, anodized 20μ.
Radiation Screen:	White nylon.
Dimensions:	Radiation screen, Ø60x127.5mm.
Net Weight:	140 grams.
Gross Weight:	500 grams.
Packing:	Cardboard box, 300x200x210mm.
Warranty:	One year against faulty materials and workmanship.

Connecting Cable 2842 (10 meter cable with watertight plugs), is available for connecting this sensor to the Aanderaa Datalogging Systems. Other lengths, or separate plugs and cables are available on request.

Circuit Diagram

Receptacle, exterior view; bushing = o ; pin = •



CALIBRATION

Calibration (20°C): SERIAL NO. 1784

% RH	10	25	40	50	60	70	80	90	95	100
Reading, N	90	170	240	300	355	430	510	620	680	820

These calibration points give the following coefficients: Humidity (%RH) = A + B x N + C x N^2 + DN^3 (formula is valid from 10 to 100%)

Coefficients:

A	-1,098 · E 1
B	2,360 · E -1
C	-9,685 · E -5
D	-3,165 · E -8

Date 7-10-92 Sign: H. Knudsen

DATA SHEET D 160, SEP 1992

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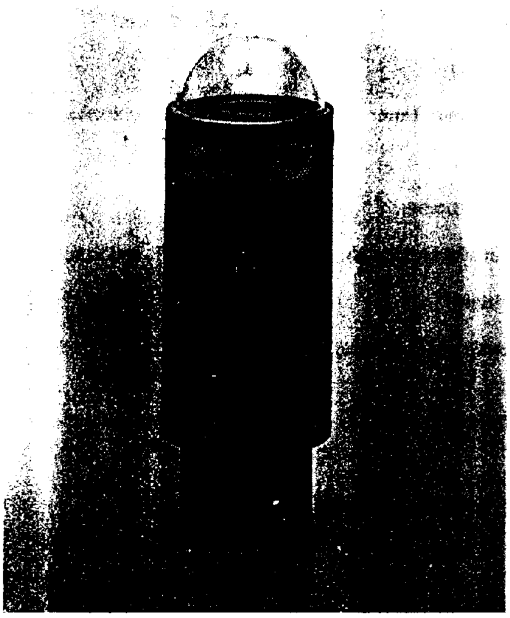


SOLAR RADIATION SENSOR 2770

A sensor for incoming solar and sky radiation, specially designed for use with Aanderaa Automatic Weather Station 2700 and Sensor Scanning Unit 3010.

Incoming solar and sky radiation is one of the basic meteorological parameters. It enables meteorologists to prepare more accurate weather forecasts. For climatological studies and studies of plant growth, knowledge of radiation is also of great importance.

Solar Radiation Sensor 2770 has been developed to measure solar and sky radiation under all weather conditions. The sensor employs a high sensitivity thermistor bridge which measures the temperature rise of a black surface under a glass dome.

To obtain full reading, only a temperature rise of about 4°C is needed due to the high sensitivity of the thermistor bridge. This eliminates the need for double domes, frequently used for radiation sensors.

The reading of the sensor is, because of the symmetrical design, only affected by radiation and not by changes in the ambient temperature. Therefore no radiation screen is needed around the sensor.

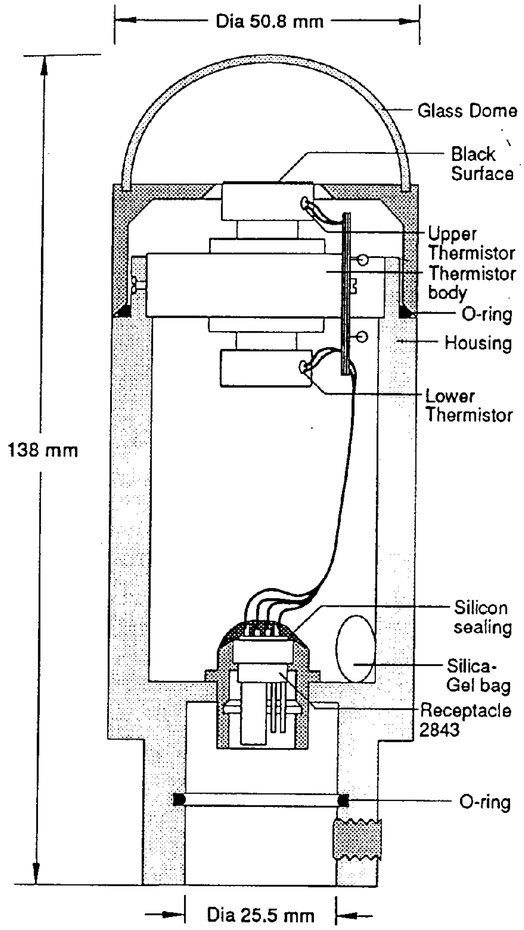
The solar Radiation Sensor 2770 is designed to be placed on the sensor arm of the Aanderaa Automatic Weather Station 2700. Although it gives momentary readings, it will give a sensible average of incoming radiation during each 10 minute period of operation.

Solar Radiation Sensor 2770 can be used with Sensor Scanning Unit 3010 together with other sensors to build a climatological recording station. In that case, a watertight cable is available for connecting the sensor to the Sensor Scanning Unit. All sensors will fit a 25 mm aluminum tube.

A special version of the sensor, Net Radiation Sensor 2811 (Pyrradiometer) is available. This sensor is equipped with a lupolene dome and is sensitive in the range 0.3 to 60 microns.

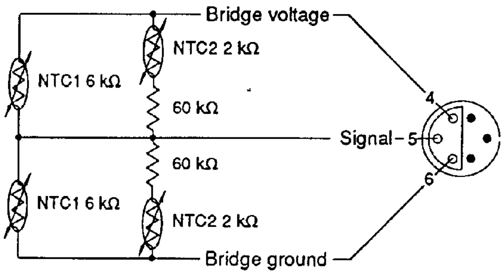
DATA SHEET D 159, JANUARY 1992

SPECIFICATIONS FOR SOLAR RADIATION SENSOR 2770



Wavelength	0.3 to 2.5 micron
Resolution:	4 W/m²
Output:	VR-22, halfbridge
Output Impedance:	2.5 kΩ at 20°C
Accuracy:	Better than ± 20 W/m²
Linearity:	> ± 1%
Response Time:	63% of final value in 60 seconds
Range:	0 – 2000 W/m²
Glass Dome:	Borosilicate
Material and Finish:	Aluminum 6061T, anodized 20µ
Weight:	250 grams
Electrical Connection:	AWS Sensor Arm 3275 or Connecting Cable 2842
Warranty:	One year against faulty materials or workmanship

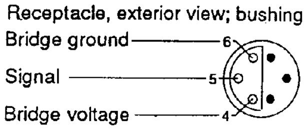
Electronic Circuit:
Receptacle, exterior view; bushing = o ; pin = •



NTC1: Thermistor Unicurve 6 kΩ at 20°C
NTC2: Thermistor Unicurve 2 kΩ at 20°C

PIN CONFIGURATION

Receptacle, exterior view; bushing = o ; pin = •



CALIBRATION

Radiation, W/m²	Reading, N
0	511
1000	736

Serial No: 427

Gives the following coefficients:
A: -2,271:E3 B: 4,444:E0
Radiation (W/m²) is obtained by the formula:
R = A + B x N (where N is the raw data reading)

Date: 6/5-92 Sign: A. Tvedt

D 159, JAN 92

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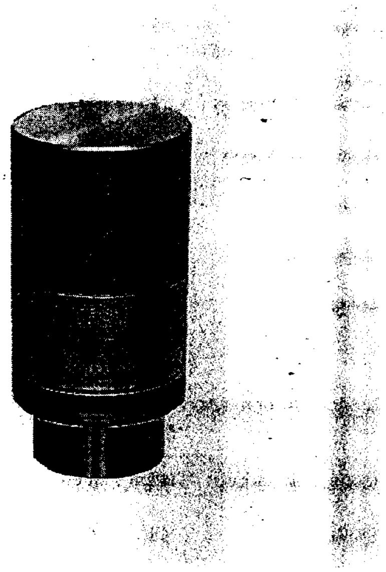


AIR PRESSURE SENSOR 2810

A barometric pressure sensor for Aanderaa Automatic Weather Station and for use together with Sensor Scanning Units 3010/3110 or Display Units 3017/3315.

The monolithic technology used in modern electronic devices may also be used for making small pressure sensors. Sensors made using this method have very small hysteresis and a very low rate of ageing.

To eliminate error due to ambient temperature changes the small sensing element can be heated to a specific temperature before the measurement is taken.

Air Pressure Sensor 2810 utilizes a 4 x 4 mm small silicon chip as a sensing element. In the central area of this chip is a thin membrane that is exposed to atmospheric pressure on one side and to a vacuum on the other. The membrane is furnished with 4 diffused resistors that form a Wheatstone bridge. The output signal is proportional to the atmospheric pressure. The chip thus acts as an absolute pressure-sensing device.

A temperature sensing resistor and 4 heating resistors are also diffused onto the chip. In conjunction with an external control circuit, these resistors allow the chip to be held at a constant temperature of 47°C during the measurement.

DATA SHEET D 161, OCTOBER 1991

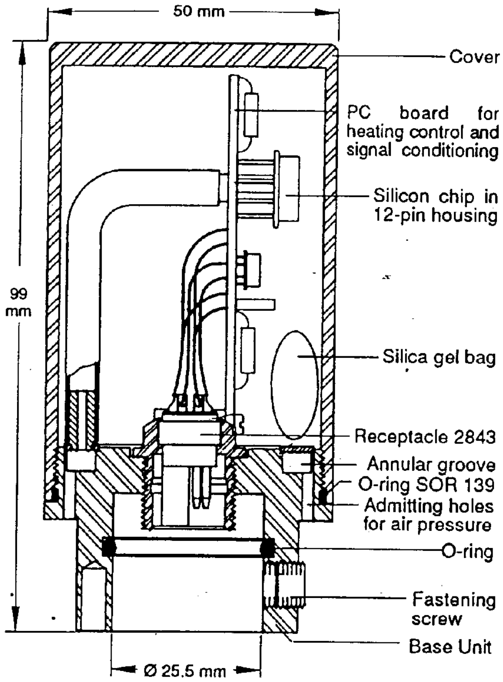
The sensor consists of a PG-board with components fastened to the sensor base and protected by a cylindrical cover. The cover is screwed onto the base and sealed with an o-ring. Six holes in the base provide atmospheric pressure to the sensing element inside the sensor.

The sensor shows outstanding performance as it has practically no hysteresis, no temperature drift and no ageing. It is also insensitive to mechanical acceleration and can be operated in any position. The sensor is waterproof.

Before measurement the sensor is heated to 47°C and to allow enough time for temperature stabalization the sensor should be connected to one of the last channels in the measuring system.

Current consumption for silicon chip heating varies with ambient temperature. At 47°C the heating current is zero. This increases linearly as temperature decreases. A maximum of 60 mA for heating is reached at – 40°C. The heating current is normally switched off between readings.

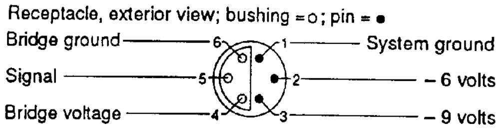
SPECIFICATIONS FOR AIR PRESSURE SENSOR 2810



Measuring Range:	920 – 1080 mb (other ranges on request)
Accuracy:	± 0.2 mb
Resolution:	0.2 mb
Operation Temperature Range:	– 40 to + 47°C
Output Impedance:	45 Ω
Sensor Output:	Aanderaa ~~half~~-bridge
Supply Voltage:	– 6 and – 9 volts
Heating Current:	(47 – T) 0.75 mA T is ambient temperature in degrees Centigrade
Electrical Connection:	AWS Sensor Arm or Sensor Cable 2842
Material and Finish:	Aluminum 6061-T6, anodized 20μ
Weight:	200 grams
Packing:	Cardboard box
Gross Weight:	600 grams
Warranty:	One year against faulty materials or workmanship

PIN CONFIGURATION

Receptacle, exterior view; bushing = o; pin = ●



CALIBRATION. Range: 920 - 1080 mb **Serial No:** 762

The calibration is performed at room temperature. Reference: Dr. A Müllen, Berlin Hg Barometer Type IIi. Read-out unit 3010.

Calibration points

Pressure mb	920.14	937.79	955.94	972.99	991.34	1008.80	1027.65	1042.71	1062.55	1081.20
Raw data	47	144	244	340	441	538	642	725	836	938

Resulting in the following coefficients:

A = 9.117·E2 B = 1.806 E-1

The general formula is:

Pressure, mb = A + B x N

Date 29.10 19 92 Sign. KM Klepsvik

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AANDERAA INSTRUMENTS

DATA COLLECTING INSTRUMENTS FOR LAND, SEA AND AIR

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RAINFALL SENSOR 3064

A water precipitation sensor designed for use with Automatic Weather Station 2700.

Monitoring rainfall is of great interest to meteorologists and climatologists as well as the public in general. The Rainfall Sensor 3064 is designed to measure this important parameter with great accuracy and reliability.

It is a small, lightweight and rugged sensor with no moving parts especially intended to be mounted on the sensor arm of the Automatic Weather Station 2700. The sensor housing is made of anodized aluminum. The funnel with a diameter of 76.5 mm, is an integral part of the housing. The electronics are embedded in Scotchcast and connected to a 6-pin output receptacle.

The rainfall is collected in a funnel and shaped into equally sized droplets by a special filter and orifice. As the droplets fall each one is counted by a pulse counter. Each droplet signifies a fixed amount of water and by multiplying this amount with the number of droplets counted, the total rainfall between samplings is measured by the Sensor Scanning Unit 3010.

The sensor plugs directly on to the sensor arm of the Automatic Weather Station 2700 or if used separately, to a 25 mm vertical tube. In the latter case the sensor is connected to the monitoring system with Cable 2842.

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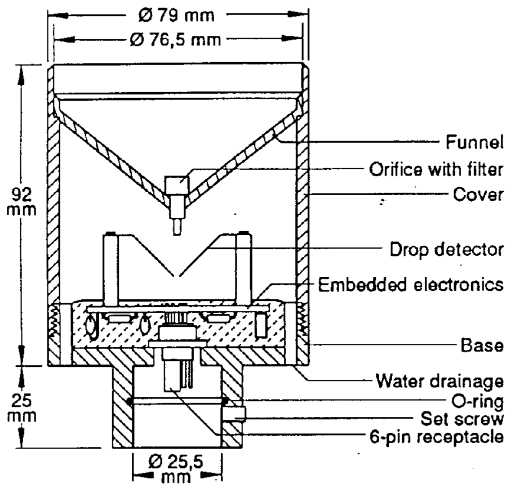
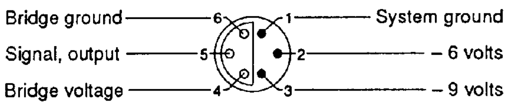
SPECIFICATIONS FOR RAINFALL SENSOR 3064



Resolution:	0.02 mm
Range:	20.5 mm/interval 8 mm maximum/minute
Output Signal:	SR10
Electrical Connection:	Receptacle 2843 mating Water-tight Plug 2828
Operating Temperature:	0 to + 60°C
Material:	Aluminum 6061-T6
Finish:	Anodized, 20µ
Net Weight:	380 grams
Packing:	Cardboard box
Gross Weight:	500 grams
Warranty;:	One year against faulty materials or workmanship

PIN CONFIGURATION

Receptacle, exterior view; bushing = o ; pin = •



CALIBRATION

Serial No: 200

The sensor calibration is performed with the sensor connected to Sensor Scanning Unit 3010. The general formula for converting the raw data reading measured by the Sensor Scanner to engineering units is:

Rainfall, mm = A + B x N

where A and B are the calibrating coefficients and N is the raw data reading.

The coefficients A and B are fixed and the same for all 3064 sensors.
A = 0 and B = 0,021 or 2.1E-2

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APPENDIX 9

RESEARCH FOR THE MANAGEMENT OF THE FISHERIES OF LAKE TANGANYIKA

WIND MEASUREMENTS ON THE LAKE							
Number	Position		Time	Wind direction	Wind Speed	Measurer	Station
of measurement	Latitude	Longitude	HHMMSS	m/s	deg		
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
Number	Position		Time	Wind direction	Wind Speed	Measurer	Station
of measurement	Latitude	Longitude	HHMMSS	m/s	deg		
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Data sheet for wind measurements on the lake

APPENDIX 10

RESEARCH FOR THE MANAGEMENT OF THE FISHERIES OF LAKE TANGANYIKA

WIND MEASUREMENTS/ANEMOMETER STATIONS										
Station		Number of anemometer								
	Time of reading			Time of reading			Time of reading			
Date	Morning	Anemometer value	Wind direction	Afternoon	Anemometer value	Wind direction	Evening	Anemometer value	Wind direction	Measurer

Data sheet for wind measurements by hand anemometers

APPENDIX 11

RESEARCH FOR THE MANAGEMENT OF THE FISHERIES OF LAKE TANGANYIKA

SURFACE TEMPERATURE MEASUREMENTS							
	Number	Position		Time	Temperature	Measurer	Station
	of measurement	Latitude	Longitude	HHMMSS			
	1						
	2						
	3						
	4						
	5						
Mean temperature							
	Number	Position		Time	Temperature	Measurer	Station
	of measurement	Latitude	Longitude	HHMMSS			
	1						
	2						
	3						
	4						
	5						
Mean temperature							
	Number	Position		Time	Temperature	Measurer	Station
	of measurement	Latitude	Longitude	HHMMSS			
	1						
	2						
	3						
	4						
	5						
Mean temperature							

Data sheet for lake surface temperature measurements

APPENDIX 12

RESEARCH FOR THE MANAGEMENT OF THE FISHERIES OF LAKE TANGANYIKA

Water current measurements with drogues				
Depth (m)				
Startpos:				
Latitude				
Longitude				
Starttime				
Stoppos:				
Latitude				
Longitude				
Stoptime				
Traveltime (s)				
Travellength (m)				
Average speed (cm/s)				
Average direction (deg)				
Depth (m)				
Startpos:				
Latitude				
Longitude				
Starttime				
Stoppos:				
Latitude				
Longitude				
Stoptime				
Traveltime (s)				
Travellength (m)				
Average speed (cm/s)				
Average direction (deg)				
Depth (m)				
Startpos:				
Latitude				
Longitude				
Starttime				
Stoppos:				
Latitude				
Longitude				
Stoptime				
Traveltime (s)				
Travellength (m)				
Average speed (cm/s)				
Average direction (deg)				

Data sheet for flow cylinder measurements