Preface

This data report deals with the hydrographical and fluorometric data which were taken during the Antarctic cruise ANT I No. 56 of "Meteor" from November 13th to December 18th 1980. The data were measured by means of the "Optik Sonde" (OS) of the SFB 95.

The presentation of the data is given in form of tables - every 50th set of data is printed - and in form of plotted profiles to give a survey of the vertical structure of the measured oceanographic parameters.

This report contains the temperature and salinity profiles, the profiles of attenuation (extinction) coefficient at 670 nm wavelength and the fluorescence of chlorophyll expressed as chlorophyll a concentration values (see "calibration").

The optical data such as irradiance profiles and spectra will be published in a second report.

Introduction

Former investigations in Antarctic waters have shown a very high spatial variability of phytoplancton standing stock. Since in the whole area nutrients can be assumed to be non limiting factors in plancktonic growth, the main factor influencing the phytoplanctonic production and distribution would be the hydrographic environment.

The objective of our work was to investigate the spatial distribution of particulate matter in relationship to the hydrographical structure of the surface layer down to 200 m depth, further to determine the thickness of the euphotic layer, the attenuation of the underwater light and the variation of underwater spectra. These themes were in close relation to the investigations of the biologists, who were investigating the production and structure of the phytoplancton.

Locations of the OS-stations

The locations of the OS-stations during leg ANT I are listed in Table I. The positions given are the actual ship positions during profiling with the OS.

The cruise track of "Meteor" is shown in Fig. 1, Some additional information to the stations (see also Zeitzschel & Zenk (1981)) are given below.

No. 19 to No. 23 and No. 25 to No. 26 are located on a transect from north to the first most southern position at No. 26
No. 26 to No. 40 are situated near the ice border region I.
No. 40 to No. 67 is a transect, separated by a space of 2,5 miles, from the ice border to the north. No. 40 to No. 51 is a linear transect, No. 51 to No. 67 detours due to pack-ice.
No. 68 is a long-term station in a plancton-bloom.
No. 71 to No. 78 are stations in the Bransfield strait while drifting.

No. 86 most northern station west of Elephant island.

No. 92 Bransfield strait south east of King George island.

No. 95 - No. 100 second stay at the ice border, region II. No. 95 and 96 most southern stations.

No. 102 to No. 107 drifting stations.

No. 104 Jo-Jo-profiling between 40 m and 140 m depth, time interval 2,5 minutes, with the ship oriented to the position of a drifter.

No. 110 to No. 117 drifting stations east of Etna island.

No. 111 Jo-Jo-profiling between 50 m and 200 m depth, time interval 3 min.

No. 119 to No. 133 grid with 15 stations, eastern outlet of the Bransfield strait.

No. 137 western outlet of the Bransfield strait.

No. 139 Strait of Palmer Archipelago.

No. 144 in the west of Smith Island.

No. 148 and No. 150 Drake passage.

This data report includes one representative lowering profile of each OS-station.

Instrumentation

The instrumentation used at this cruise consisted of four underwater units, a microcomputer-controlled data acquisition system, a recording system for the global irradiance and a two path photometer mounting for measuring the optical attenuation coefficients of water samples (Diehl & Haardt (1980), Haardt et al. (1979), Diehl & Pischke (1981)).

One underwater rack was used for the 24 channel spectroradiometer (Fig. 4), a second one was mounted in a sea-water pumped system for continous registration of fluorescence (F1), temperature (T1) and electrical conductivity (L1) of the surface water (Fig. 3).

For the profiling measurements we used two sensor racks, the first one being limited to depths of max. 200 m, the second one to depths of max. 500 m. A winch with 8 wire cable, 450 m length, was available on board of the vessel.

Rack I (Fig. 2a) contained:

P2 pressure up to 10 bar

T2 temperature -2^{o} to 23^{o} C, τ = 300 ms

L2 electrical conductivity 10 $mScm^{-1}$ to 60 $mScm^{-1}$

FS chlorophyll-fluorescence, calibrated in Chla units

D 670 selective optical density at 670 nm

ED scalar irradiance (downwelling) Eod, 10^{0} to 10^{-5} kw/m^2

EU scalar irradiance (upwelling) Eou, 10^{0} to 10^{-5} kw/m^2

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Rack II (Fig. 2b) contained

P3 pressure up to 50 bar

T3 temperature -2^{0} to 23^{0} C, τ = 30 ms

L3 electrical conductivity 10 mS cm^{-1} to 60 mS cm^{-1}

F2 chlorophyll-fluorescence, calibrated in Chl. a units

ER downwelling irradiance Ed or diffuse reflectance R = Eu/Ed

CR light attenuation coefficient c at λ = 670 nm

Because of possible selfshading of optical probes the number of probes mounted in one rack is limited. On the other side it is rather pointless to construct the light sensors for depths deeper than 200 m, so it was reasonable to use two racks for two depth ranges, which easily could be exchanged. Fig. 2 shows the two racks. The physical dimensions of the racks are (diameter x height) 65 cm x 35 cm.

In this configuration the measured data - each probe is provided with a frequency output - directly could be transmitted via the 8 wire cable. The board unit includes frequency to voltage converters, digital instruments for the indication of the 8 parameters in physical dimensions and the power supply. During profiling, up to five selectable parameters were plotted versus depth by means of a six channel XY-recorder. So quick looks of the actual vertical structures were available directly at the moment of the measurements. Parallel to this form of registration, the data are stored with selectable sampling rate as 12 bit integers on a magnetic cassette. Standard sampling intervall was 0,1 sec between each set of 8 parameters. The organization of sampling, data transfer and computation to physical dimensions is done by a microcomputer. The data acquisition program is written in assembler language (4KByte) and enables the microcomputer to display every 7^{th} set of data at standard sampling rate, salinity computation included.

The data sets displayed on the terminal can be transferred to a printer, so a record of the station can be kept.

The whole set up of the "Optik-Sonde" profiling measuring system is given in Fig. 5. The sensor labeled with Ead is an additional sensor which measure the downwelling irradiance above the sea surface. This sensor was installed 10 meters above sea surface.

Furtheron there was a sensor installed for the global irradiance Eglob with data registration on a separate plotter and separate 0,5 h integrator with printer.

Calibration and technical data of the sensors

The probes used in the "Optik-Sonde" are minimized in their mechanical dimension, power consumption and necessary connection requirements. The channel coding of the analog outputs of the sensors is done by relaxation oscillators. The output is a frequency variation in the standard 1000 Hz to 2000 Hz range, which is modulated on the supply current of the probes. The resolution is limited by noise only, the overall time constants are the time constants of the sensors

Depth sensors

Conversion of pressure into an electrical signal is performed with a KISTLER piezoresistive quartz sensor. The sensor is DC driven with constant current, resolution is limited by noise to $2 \cdot 10^{-5}$ at 100 ms averaging time. Accuracy is 0.2 %, repeatability better than 0.1 %. Two pressure ranges with 10 bar (P_2) and 50 bar (P_3) were in use. The calibration is performed by means of pressure balance within an error of less than 0.2 %.

Temperature

The variation of the electrical resistance of a platinum thermometer is converted to an analogous frequency variation by using a relaxation oscillator. The three sensors T_1, T_2, T_3 differ in their time constants. For T_1 and T_2 the time constant is 0,3 sec. for T_3 about 30 ms (according to the data of the manufacturer). The thermometers are calibrated against a set of standard thermometers with an accuracy of $2 \cdot 10^{-2}$ degrees, the resolution amounts to 10^{-3} degree.

Conductivity

The probe for the determination of the electrical conductivity is equipped with a cylindrical cell of quartz glass with five inner electrodes (Ginzky (1977)), the inner diameter is 8 mm, the length is 60 mm. The conductivity is transformed linearly into a frequency shift.

Calibration was performed within 0.01 mS cm^{-1} with standard seawater using the Unesco salinity-conductivity relations. The sensor L3 was damaged by freezing seawater at station 21, which resulted in unrealistic high L3 salinity readings. The incorrect data are removed from the tables.

Fluorescence

The in vivo chlorophyll a fluorescence is measured with two different probes, F_s is manufactured by EOS (Hamburg), the other one F_2 is a Variosens III type from Impulsphysik (Hamburg) (Früngel & Koch (1976)). Both excite the fluorescence of chlorophyll a by means of a broad band Xenon arc flash with a spectrum up to 500 nm or 550 nm respectively of less than 10 μs duration and 100 ms repetition-rate. Both probes markedly differ in their methods of signal processing. The first one is equipped with a sychronous detector, the second one with a peak detector with an averager following. The measuring volumes are about .1 ml or about one ml respectively. Both probes were calibrated in a culture of phytoplancton in terms of photometrically determined chl a. This calibration is not necessarily valid for in situ environments, because the fluorescence yield is influenced by several factors such as physiological state, composition of species and the illumination history. Furtheron at high irradiance levels there exists a quenching effect in the profiles of fluorescence. The given chlorophyll values therefore should be read only as equivalents to chlorophyll a concentrations of the phytoplancton calibration culture (Astheimer & Haardt (1983)).

Irradiances

The irradiance sensors are constructed with PN planar silicon photodiodes, the spectral sensitivity of which are corrected to a flat spectral response by means of colour filters. The spectral ranges of the sensors are limited to 400 nm - 750 nm corresponding to the active range of photosynthesis. In case of the ER probe, which measures the downwelling irradiance E_d or the diffuse irradiance reflectance $R = E_u/E_d$ respectively, the angular response is a cosine characteristic, in case of ED and EU the angular response is constant. By means of horizontally positioned screens, the downwelling (Eod) and the upwelling scalar irradiance (Eou) are measured. The output frequency of the probes is logarithmic relating to the input irradiance within an 1 % error band in the range between 1 Kw m^{-2} and 10 mW m^{-2}. The absolut accuracy is better than 10 %. The calibration is done in simulated daylight against an Hilger Schwarz thermopile.

Selective optical density D 670

Another probe, which is sensitive only to the content of chlorophyll in the watercolumn, is the D 670 probe. The selective optical density is measured at 670 nm and halfwidth of 8 nm. The irradiances at 650, 670 and 690 nm are measured and the optical density related to the baseline between 650 and 690 is calculated by means of an analogous computing circuitry built in the probe. This probe was development in 1978 (Haardt (1979)) and tested since at various expeditions. It measures cumulatively the amount of Chl. a. of the watercolumn above the sensor.
The probe is calibrated with optical neutral filters, the optical density of which are previously determined by means of a precise photometer mounting (Haardt et al. (1979)).

Attenuation CR

The extinction (attenuation) of light in seawater is determined by means of the CR-probe. It operates with a monochromatic light source of λ = 670 nm wavelength, halfwidth of 30 nm and an optical pathlength of 30 cm. The diameter of the beam is about 1 cm, the aperture angle about 3 degrees and the measuring range is 0,2 m^{-1} to 2,5 m^{-1}. Since the beam is folded, the measuring volume amounts to 10 ml. The output frequency linearly depends on the coefficient of the attenuation.
A detailed description of the optics and electronics may be found in Diehl (1971) and Kroebel & Diehl (1974)). A discussion of the properties of the particles influencing the attenuation is given in Diehl & Haardt (1980) and Haardt et al. (1979). Since the attenuation in seawater is caused mainly by scattering, the accuracy of the measurements depends on the aperture angle and the particle sizes. The calibration of the probe is realised with an electrical attenuator, which simulates the optical attenuation.

Spectroradiometer

The underwater spectra of the downwelling and the upwelling irradiance are measured by means of a filter radiometer with 24 spectral channels in the spectral range from 390 nm to 710 nm (Haardt (1978)). The filter separating the different spectral channels is a linear variable interference filter, manufactured by Schott u. Gen./Mainz.

The receiving unit consists of an array of 24 PN silicon photodiodes (Siemens).

The half power band width of each channel amounts to about 20 nm.

The currents generated by each diode are integrated parallely. The individual values are stored and afterwards transmitted serially. The spectra can be plotted directly on an XY-recorder as calibrated and normalized spectra.

The calibration of the spectroradiometer is performed using a tungsten filament lamp (Osram WI 41) of 2800^{0} K.

Literature cited

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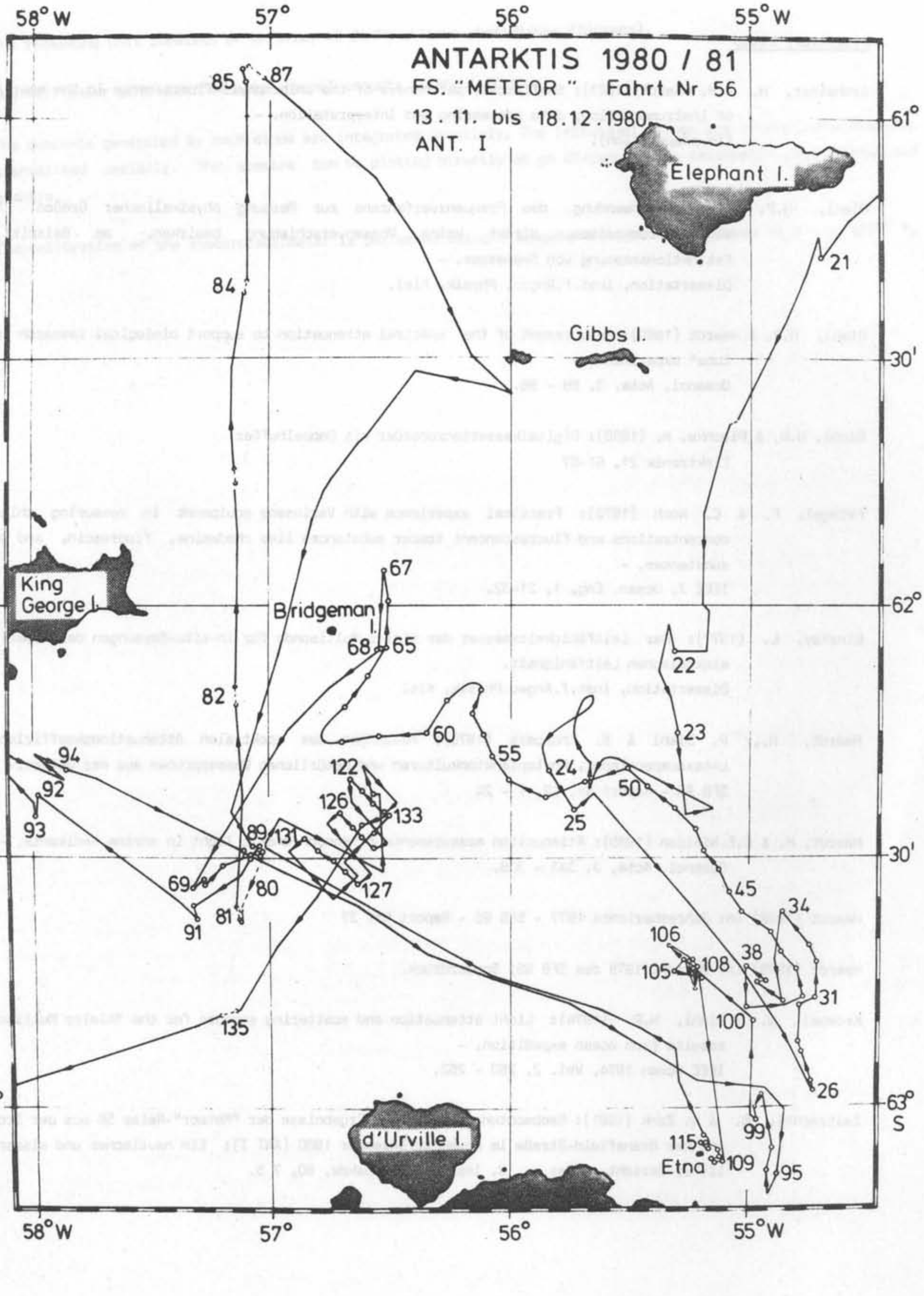

Fig. 1: Cruise-track of "Meteor"

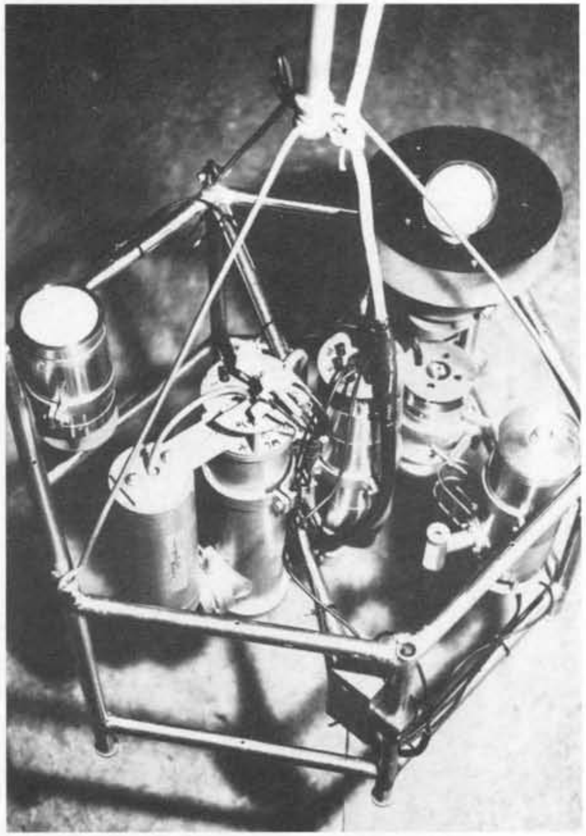

Fig. 2a) Rack I with sensors measuring the selective optical density (D 670) and the fluorescence of Chl.a (FS), the central underwater unit, sensors measuring the downwelling scalar irradiance (Eod), the upwelling scalar irradiance (Eou) and depth (P2), temperature (T2), conductivity (L2) (from left to right).

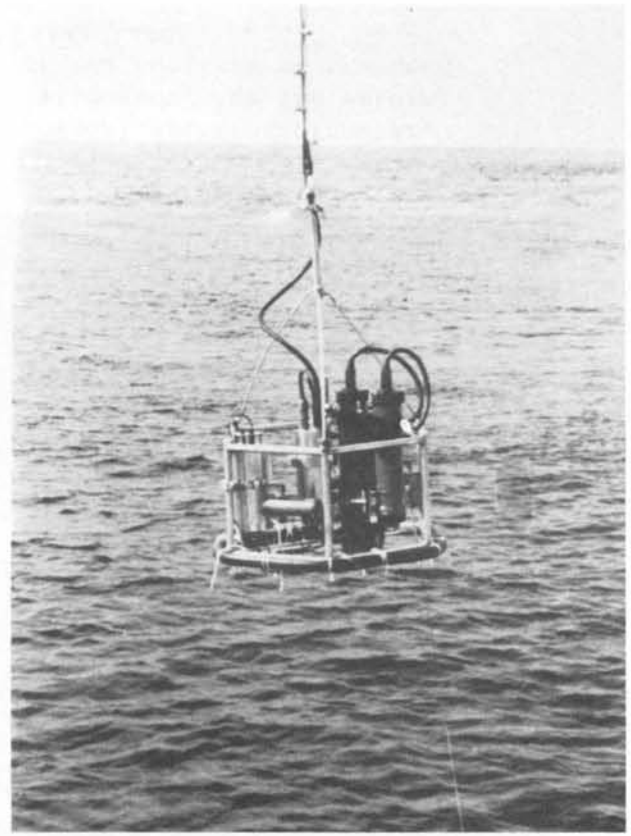

Fig. 2b) Rack II with sensors measuring the attenuation coefficient of light (CR), the downwelling irradiance (Ed), the diffuse reflectance (R), the fluorescence of Chl.a (F2) and depth (P3), temperature (T3), conductivity (L3).

Fig. 3: Flow-through chamber of the continous recording system. Sensors mounted inside the chamber are: temperature-sensor (T1), conductivity (L1), fluorescence of Chl.a (F1) and pressure (P1) (physical dimensions of the sensors are similar to those shown in Fig. 2).

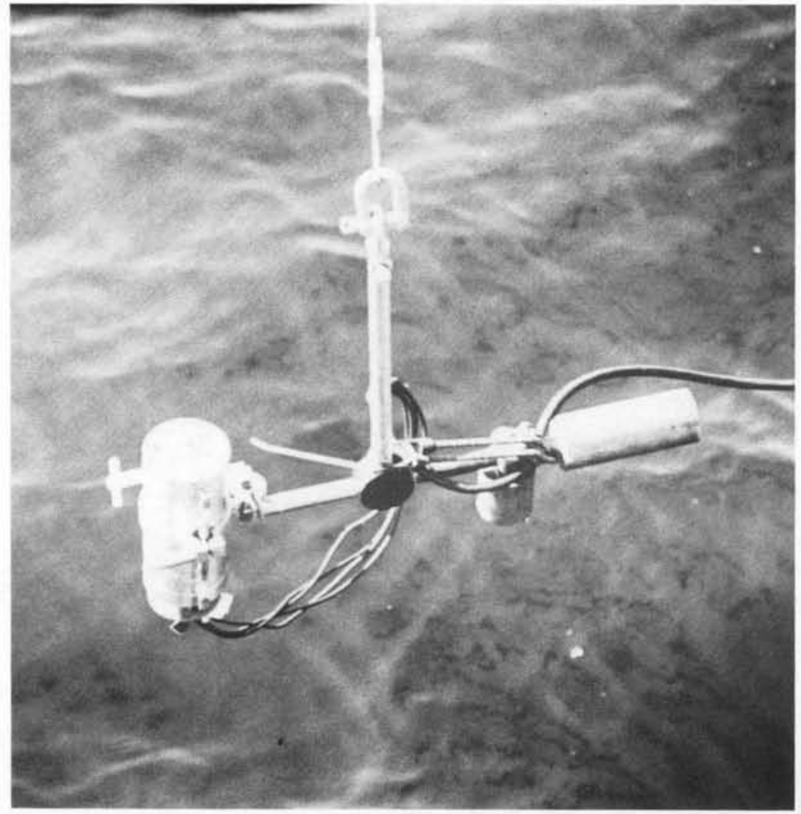

Fig. 4: The 24-channel spectroradiometer, in this alignment, for the determination of the spectrum of the downwelling irradiance

List of symbols

P 2, P 3	pressure in decibar	
T 2, T 3	temperature in degree celsius	
	time constants are T 2 : τ 2 = 300 ms	
	T 3 : τ 3 = 30 ms	
L 2, L 3	electrical conductivity in mmhos/cm	
S 2, S 3	computed salinity in ppt	
CR	attenuation (extinction) coefficient at λ = 670 nm in 1/m	
F2	concentration of chlorophyll a in mg/m^3 (fluorometric equivalent units of Chlor. a.)	
FS	concentration of clorophyll a in 10 mg/m^3 (fluorometric equivalent units of Chlor. a)	
DD	selective optical density at λ = 670 nm	
ER	logarithm of downwelling irradiance in KW/m^2	
EU	upwelling scalar irradiance (units as above)	
ED	downwelling scalar irradiance (")	
EA	downwelling irradiance above sea-surface	

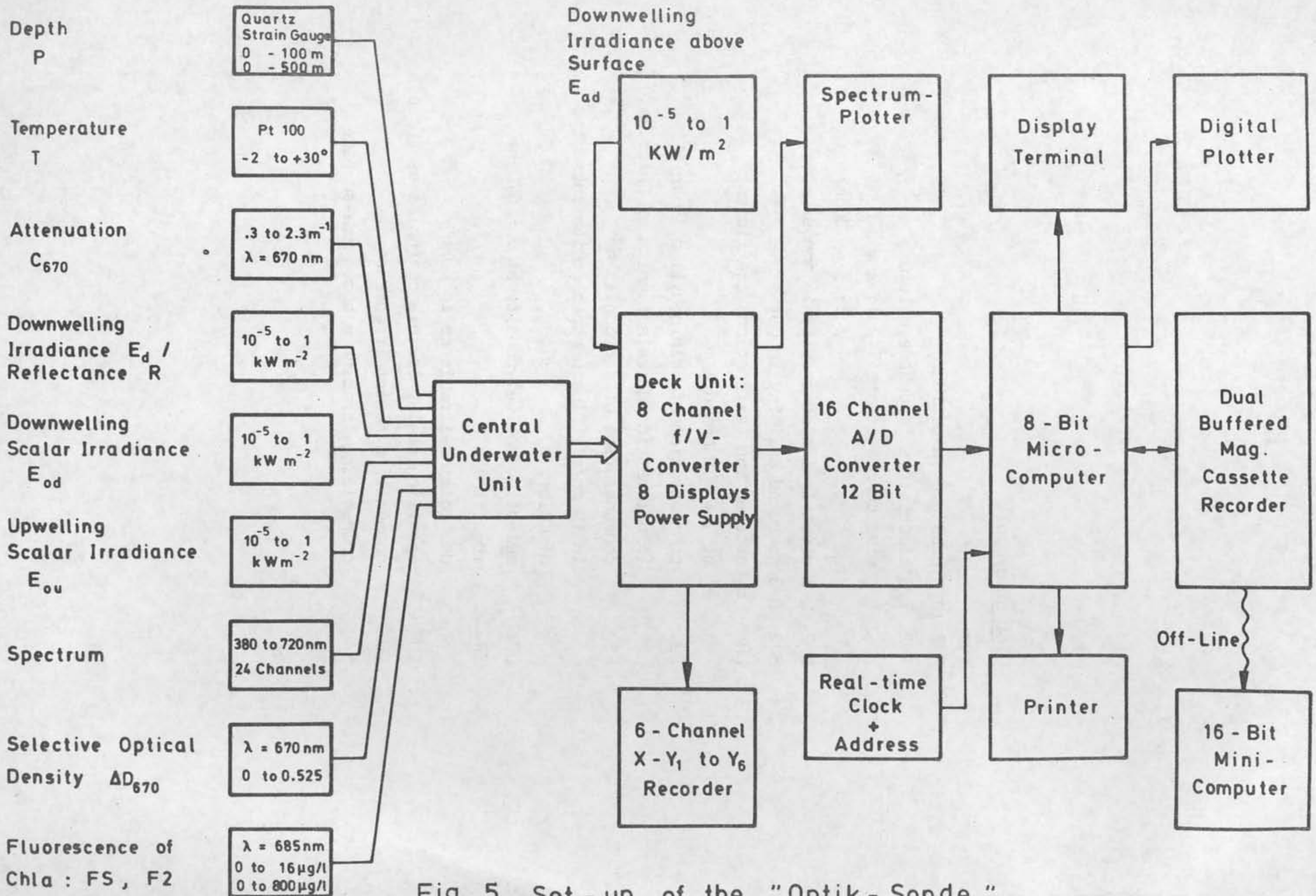

Fig. 5 Set-up of the "Optik-Sonde" profiling measuring system