SVENSKA HYDROGRAFISK-BIOLOGISKA KOMMISSIONENS SKRIFTER

Ny serie: Hydrografi. II.

N:o 2. *VILHELM I. PETTERSSON:* Improvements in the Hydrographic Technique

I. A registering Photothermograph

II. A new Plancton-catcher

With the author's compliments

13614

IMPROVEMENTS IN THE HYDROGRAPHIC TECHNIQUE. I

A REGISTERING PHOTOTHERMOGRAPH

BY V. I. PETTERSSON

Wezäta
WALD. ZACHRISSONS BOKTRYCKERI A.-B.
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PRINCIPLES OF THE PHOTOTHERMOGRAPH

METEOROLOGY owes its present technical standpoint and significance mainly to the facility with which observations of pressure, temperature, moisture, etc., can be automatically made at any height in the atmosphere. The prompt issue of yearly and monthly dates with curves and synoptic charts accompanied by daily and half-daily reports, built on a system of quick, though accurate, observations of the atmospheric conditions, has become a standard institution all over the world.

Oceanography has not developed any corresponding methods for actual reports on the momentary hydrographical conditions, although it is recognized that the heat stored up in the surface-water exercises a predominating influence on the actual state of the temperature and the humidity of the air and its movements.

In point of exactitude the very considerable number of surface observations collected on board steamers is inferior to the corresponding meteorological material because the possibility of committing errors is at least tripled on a rapidly moving vessel, water-samples having to be brought on board and tested in different ways in the shortest time possible.

Like meteorology, hydrography is tending towards methods of accurate automatic registration which, to begin with, should concern temperature, the determination of density and salinity of the water requiring more complicated technical arrangements.

The instrument, that I wish to describe here, is in the first place meant to be fitted on board vessels, where no scientifically trained observer is answerable for the observations taken. It can be characterized as a photothermometer, and is at the time so arranged as to give on the same film a photographic record of the ship's position by means of a number referring to the ship's journal.

The film containing the record of observations is always at hand in case of future requests for information.

The photothermograph may be said to be the first of its kind where the transparency of the thermometer-glass is used for directly copying in full size the scala and the meniscus of the thermometer on a film. The proceeding will easily be understood by studying Fig. 1 which represents a horizontal section of the thermometer together with the lamp, film and other fixtures in about $1^{1}/_{2}$ the natural size.

The source of light is an electric linear-fibre-lamp L of the same length as the thermometer-scale. The light is thrown through the glass-stem of the thermometer T on the film-ribbon F. The channel which contains the mercury-column is impenetrable for the light-rays up to the point reached by the mercury; but in order to get sharp readings of the stand of the meniscus it is necessary to neutralize the effect of reflection and parallax. The light is screened off on all sides by the covering S except in the direction of the thermometer. Between the lamp and the thermometer a cylindrical lens in the shape of a glass-staff Gl. is inserted immediately before the stem of the thermometer which is cut and polished into a trapezoidal shape as shown in the figure. On the back-side of this stem the scale is etched and the recording film F is made to pass by in close contact with the glass-scale which is calibrated in centigrades divided in half degrees.

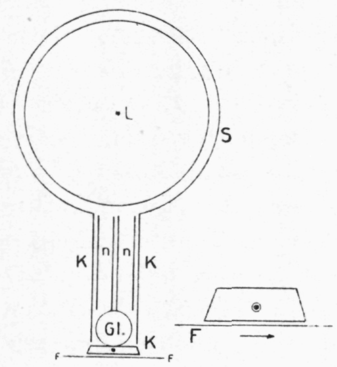


Fig. 1.
L Lamp, S Covering, KK Glassplates, Gl Glasstaff, nn Glasstubes, F Film.

Between the lamp and the glass-staff there is an interspace about 2 cm. wide which contains a system of two rows of small glass-tubes of 3 mm. outward diameter packed closely together horizontally with a slight inclination towards the thermometer. The whole aggregate of tubes is enclosed between two glass-plates, KK each tube nn being coated on its outside with opaque varnish which, when solidified, keeps the whole system together and prevents the reflection of the lamp-rays which pass inside and between the tubes.

Every flash of the lamp sends a bundle of paralleled light-rays through the stem of the thermometer to a photographic film F which is unrolled from a magazine-cylinder in the usual way. By means of ordinary cinema films with the devices ordinarily employed in the photographic technique, and guided by an expert of the Hasselblad Co. in Gothenburg, I have succeeded in constructing a handy and relatively cheap recording instrument, the details of which will be understood from Fig. 2, without any lengthy description. The envelope of thin, enamelled brass-plate is divided into two compartments of which the upper one contains the optical arrangement and the photographic camera with the usual device for the unrolling and exposition of a cinema-film worked by a spring which is set in action and brings a fresh portion of the film behind the scale of the thermometer when the engineer, on duty in the machine-room of the ship, receives a signal from the bridge, given when the ship has passed 100 miles from the last place of observation. He then turns the handle of a screw and presses a knob which at the same time sends a flash from the lamp L through the thermometer T and another from the little lamp through a window to the film. This device serves for control which excludes any possibility of a mistake. Between the window and the film an opaque glass-plate can be inserted on which the engineer writes with a lead-pencil the number of the exposure and the position of the ship, which then appears at the head of the graphic as can be seen from p. 5.

The cinema-film used on board the Swedish steamer Drottningholm is 18 meters and has room for 60 graphics for the voyage between Pentland Firth to New-York and return.[1]) After the arrival in Gothenburg the little camera-box, without being opened, is taken out of the apparatus and sent to the photographic office where it is exchanged for a new one.

On p. 5 we find the positive reproduction of 29 exposures covering the distance, 100 miles to the East, of Pentland Firth—Halifax in November 1925. Positive-film and relatively long exposures — 15 seconds — were used, some 9 meters of film being stored on the storeroller. The film-roll, containing also about 9 meters more, used on the way back to Europe, was taken out in Gothenburg and developed there, whereupon the minute reading down to 1/20th part of a degree was possible by means of a transparent scale of milk-glass applied beneath the film over an electric lamp. For every reading the photographic registering of the number of film referring to the ship's journal below the image of the scala was noted.

The temperatures shown on p. 5 will have to be reduced by — 0°,70 C, the quite new type of thermometer, specially fabricated for the purpose, suffering from a somewhat high correction.

The under compartment is made of thicker materiel because it will have to sustain the pressure of a strong water-current which arrives directly from the intake of one of the large circulationpumps in use both on steam- and motor-ships which sends an incessant stream of sea-water from 7½ meters below the surface through the under-compartment which is water-tight and separated from the upper one.

The inflow and exit tubes must be wide in order to ensure a strong flow of sea-water around the thermometer which is inserted in the under-compartment by means of a tight rubber packing. In the under-compartment there is room also for the bulb of another thermometer with a free scale, which can be read off by the staff in the engine-room. This will be of use in icefilled regions.

In order to control the efficiency of the lamp two windows with red glass are placed in the casement. The inner mechanism of the camera is the same as used in a cinema-apparatus and needs no description. The few extra devices employed which do not appear in the figure are well known to everybody familiar with the photographic technique.

On board the s/s Drottningholm of the Swedish-American line it has been possible by the courtesy of the Captain, Mr. Ellsén and the first engineer, Mr. Pherson, at the recommendation of the Inspector, Mr. Björkström, to make a most favourable installation of the new Photothermograph in combination with the circulation-pump. Moreover, it was agreed that for every hundred mile logged distance the position of the ship should be signalled from the bridge down to the engine-room.

In this manner the records of sea-temperatures will be free from mistakes, always easy to make, and strictly comparable with records obtained on board of other ships that use apparatus of the same construction. The ordinary water-sampling by means of buckets hauled on deck of steamers running with a speed of 18—21 knots ought to be abolished.

No place on board a ship is better situated for the installation of a recording instrument than the engine-room next to the intake of water for the circulation-pump, and it seems to be preferable henceforth to record the temperature of the sea at a depth of 7—8 meters than at the surface which is more liable to temporary variations. I have alluded to these principles in a newly published paper: Étude de la Statistique Hydrographique[1]) etc. p. 12:

»Nous avons besoin d'un matériel d'observations minutieuses et exactes pendant des périodes suffisantes. Mais les observations doivent être indépendantes de l'observateur et devenir pour ainsi dire une méthode mécanique. L'instrument doit être installé à bord des navires d'observations et les filmes, après chaque voyage, seraient expédiés directement au Bureau pour y être développés et les résultats publiés.

Il est nécessaire de continuer les observations du Bulletin et les rendre encore plus complètes en leur faisant embrasser encore d'autres régions, résultat qu'on ne peut atteindre que par une coopération internationale centralisée comme celle établie par le Bureau de Copenhague.»

Before the organisation of that Bureau, in 1898—1899, a trial was made by the Swedish hydrographic Commission in order to obtain records during a year from all parts of the Atlantic.

If steamers, provided with recording instruments made regular observations on such lines and sent in the films to the Bureau it would be possible for the Bureau to issue monthly charts representing the thermic state of the Atlantic. Professor Bjerknes has pointed out the desirability of accurate records of sea-temperature at least up to 1/10 of a degree. It is very easy to obtain twice that degree of accuracy by the photothermometric method. The film is placed above a transparent scale of white enamelled glass and the temperature read off with a lens moved by a micrometer screw.[2])

[1]) As the magazine-cylinder can contain 30 meters of film, the same instrument could be used for a far longer distance.

[1]) Svenska Hydrografisk-Biologiska Kommissionens Skrifter 1926.

[2]) Requests of further information as to the photothermograph, its construction and use as well as its fabrication may be directed to »Service Hydrographie», Bureau International pour l'Exploration de la Mer, Strandvej 34, Copenhague.

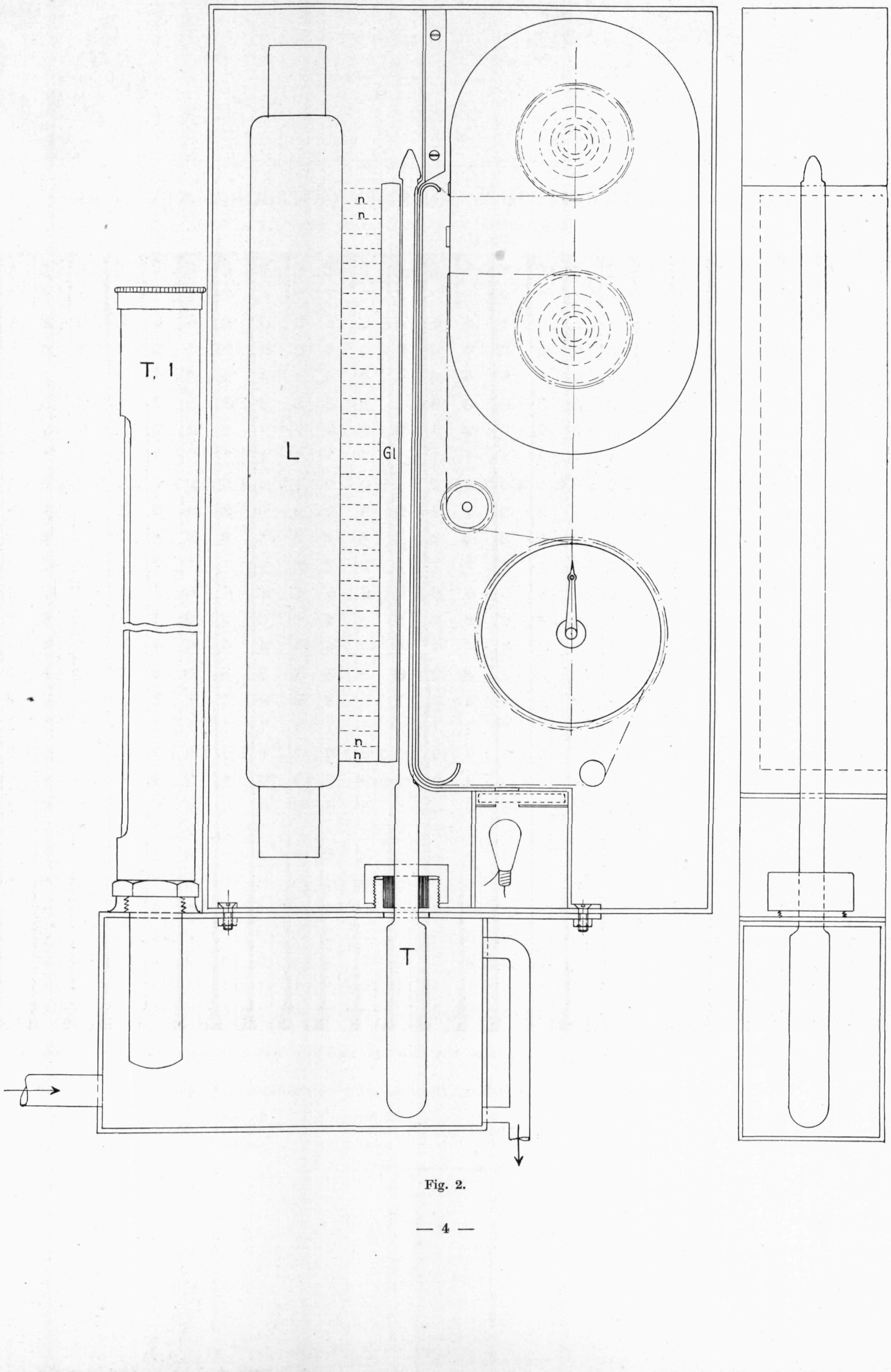
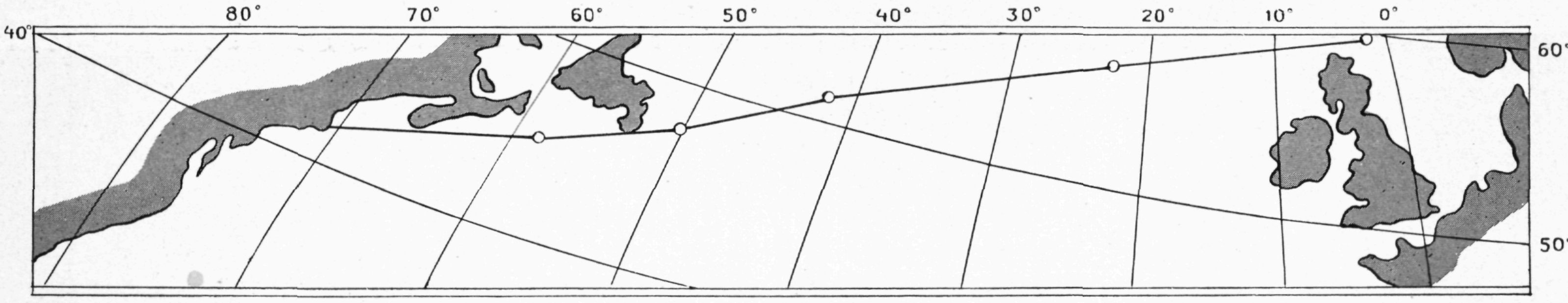
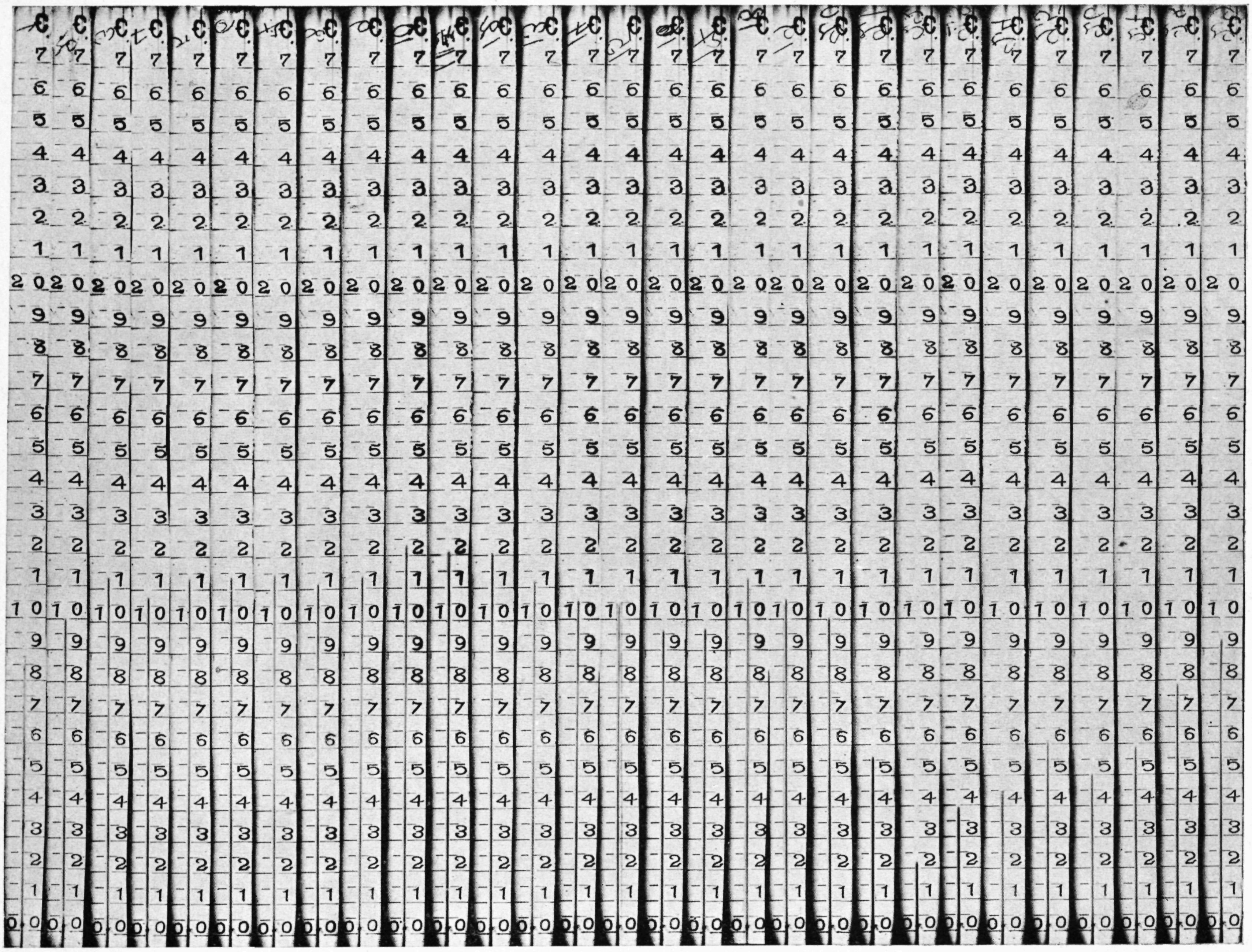


Fig. 2.



S/S »DROTTNINGHOLM» 53:d A. JOURNEY GÖTEBORG–NEWYORK

Photothermogram of watertemperatures from intake of the water 7,5 m. below surface



300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400 2500 2600 2700 2800 2900 3000 3100

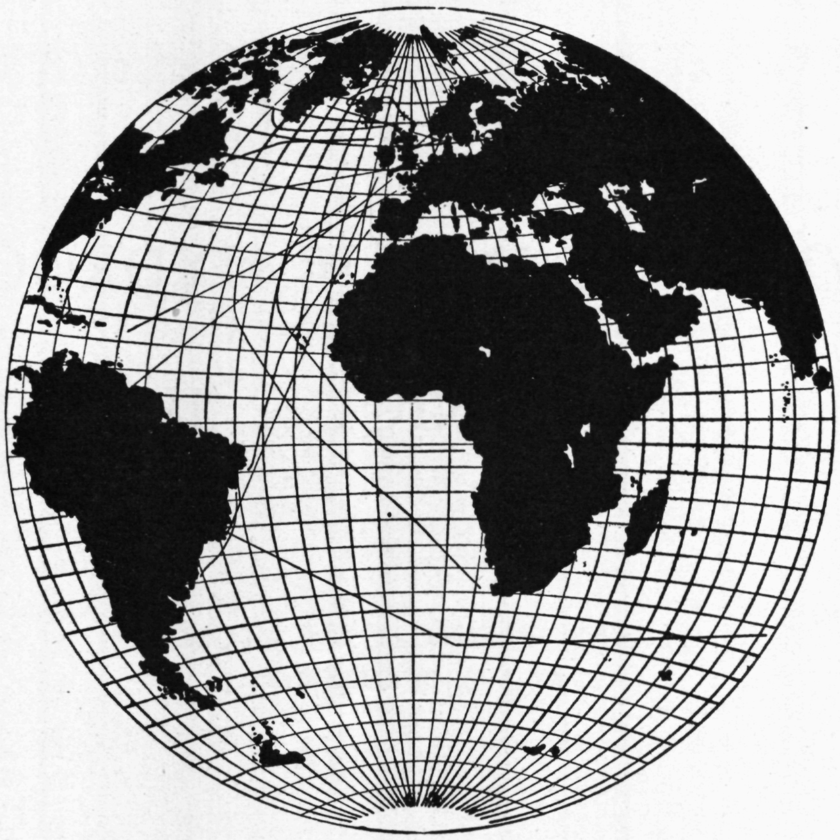
miles logged distance from Göteborg; Positions after observations every noon

15 Nov.	17 Nov.	19 Nov.	20 Nov.	21 Nov.	22 Nov.
N 58°30′	57°02′	52°03′	48°18′	45°17′	(Halifax)
W 0°20′	22°33′	42°04′	50°29′	58°34′	

E ➜ W

From Göteborg 14/11 1925 — 1925 — In New York 23/11 1925

LINES OF RESEARCH IN 1898—99



From Les Variations annuelles de l'eau de surface de l'océan Atlantique 1898—1899, par P. T. Cleve, G. Ekman, O. Pettersson

IMPROVEMENTS IN THE HYDROGRAPHIC TECHNIQUE. II

A NEW PLANCTON-CATCHER

BY V. I. PETTERSSON

INTRODUCTION

HYDROGRAPHY has for a long time possessed methods of investigating sea-water as to its salinity and temperature, its contents of gases as O_2, CO_2, etc., at any depth between the surface and the bottom. For such purposes only small quantities of water are necessary, the samples being brought on board the vessel by means of insulating water-bottles, the temperature usually measured »*in situ*» with reversible thermometers.

For the biologists who have to deal with the small organisms which form the plantonic contents of the different water-layers, bound to follow the motion of the water, the question is of a more complicated nature. A real quantitative as well as qualitative test of the plancton at a certain depth first of all requires the filtering of a measured amount of water, and further that this water be taken exactly from the water-layer in the sea which is to be investigated.

The methods until now in use to effect a rational investigation have in principle been of three kinds:

1. The method of water-sampling (actually in use by the German hydrographical expedition in the South Atlantic).

2. The method of hauling nets vertically or horizontally through the water, (Hensen, Nansen, Petersen & others).

3. The pumping-method, (introduced by Lohmann).

In 1. and 3. the water is brought on board the ship and either filtered or centrifugated there. In 2. the filtering is effected during the hauling of the net through the water over a certain distance.

1. The method of water-sampling will always be of a special significance for testing the amount of nannoplancton by the centrifugal system.

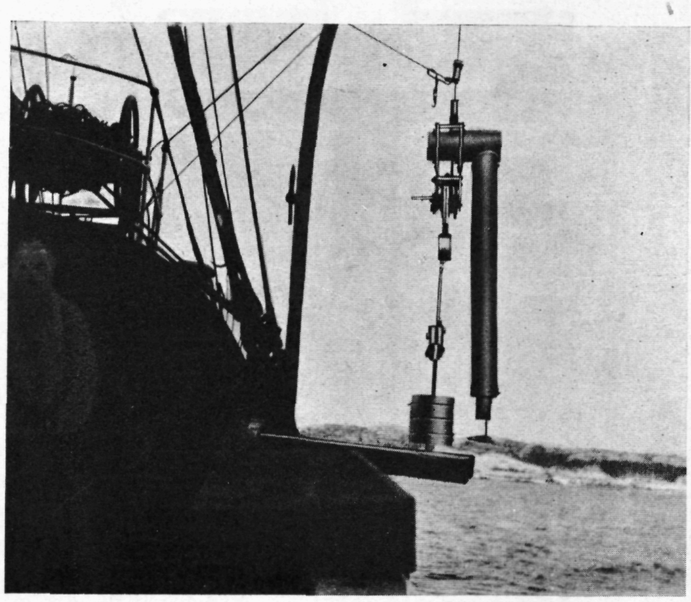
2. The net hauling method is considered as essentially necessary for a quick determination of the amount of plancton, where great quantities are desired, although the results will have to be regarded as more or less uncertain, because the bigger organisms can escape at the approach of the slowly moving net. As to horizontal hauls the impossibility to decide at every moment the exact depth from where the plancton was caught makes the results to some degree uncertain.

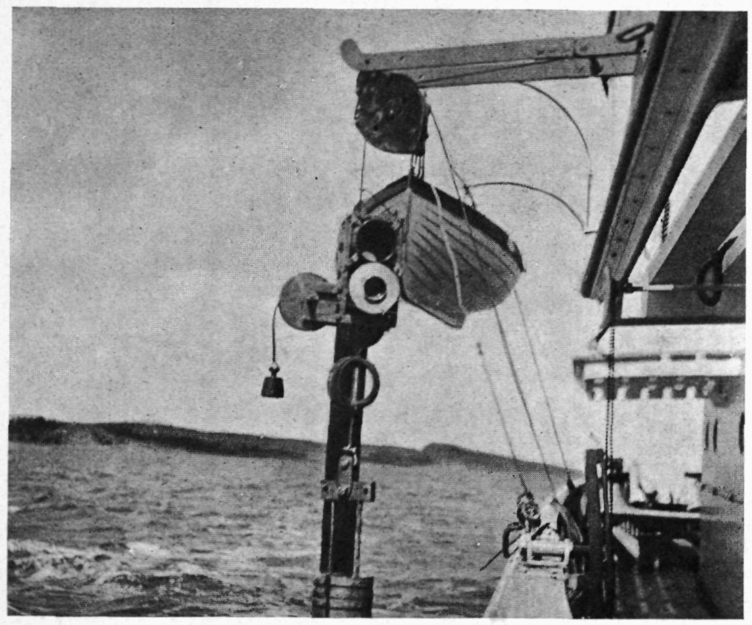
3. The pumping-method may be divided into two classes:

a) The water is pumped up on board the vessel and filtered there. This is the course Professor Lohmann has followed by lowering a rubber-tube to the depth desired and sucking up the water by means of a pump on the deck of the vessel. The weight of the tube however prevents the use of great dimensions of same and also the taking of samples at considerable depths.

b) The water is filtered »*in situ*», the filtering nets being lowered down to various depths together with the pumping-machinery. This is a new principle which has led me to the construction of the instrument described in the following article, which instrument was demonstrated in the course of a lecture held at the last meeting of the International Council in Copenhagen, September 1925.

DESCRIPTION OF THE APPARATUS





The apparatus contains a rapidly rotating »Archimedean» screw worked by a sinking weight which is set in action by a running messenger when the apparatus has attained the depth desired.

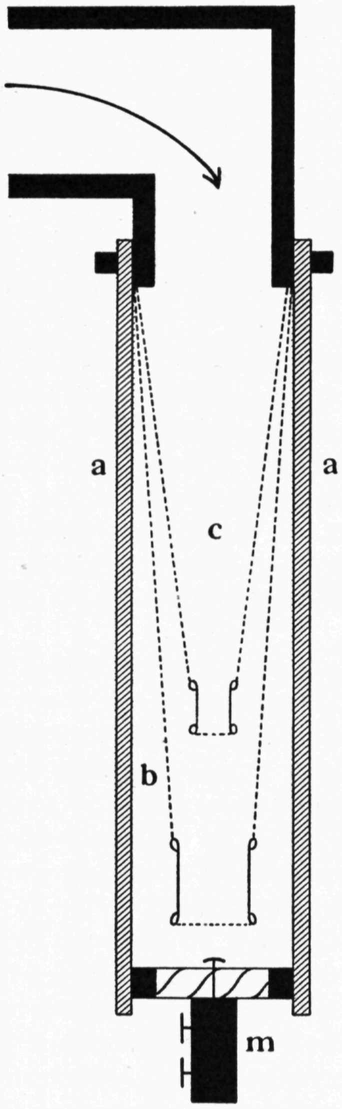


fig. 1.

III. The line with the weight. The line is wound on a wheel, that is retarded in its movement by a brass-ribbon trailing on the line itself. From there, the line passes 3—4 times around the pulley. Its length usually is from 40 to 60 meters (when run down) but it is generally used doubled once or twice by the application of one or more blocks in which way samples can be taken at a depth of only 10 meters from the bottom. The weight is adjustable — usually about 30 kilograms — and is wound up together with the line when run down, by means of a crank-handle which can be attached to the magazine-wheel.

IV. The filtering-tube with the nets c and b attached to it, through which the screw drives the water to be filtered. The nets are usually two of different mesh-sizes — for inst. No. 6 and No. 13, or No. 3 and No. 25 — the inner one to be passed first by the water, thus mainly keeping the copepods and other zoo-plancton back, and letting the phytoplancton pass through to the second net.

V. The rubber-tube a fastened on to the apparatus together with the nets enclosing them altogether and preventing the water taking any other way out than trough the opening in its opposite end where

VI. The volume- or current-meter m is attached.

It will be observed that the rubber-tube together with the filters can be put on and fastened to the apparatus as well as removed from it by simply opening and shutting the lock to a brass-belt.

As to the material used for the construction of the apparatus only brass or bronze can of course stand the corrosion of the sea-water. The former metal is employed for all parts not especially exposed to twistings or friction, where the latter (bronze) is necessary. The line should likewise be of bronze, a steel-line soon damaging the metal of the pulley.

To the vertical part of the apparatus a wide rubber-tube, a, is attached (see fig. 1) inside of which there are two plancton nets, c and b. The amount of filtered seawater (usually 200 liters) which passes through the apparatus is measured by the gauge m.[1]) There are many important details of construction which can be ascertained by specialists, interested in researches of this kind, by application to the Hydrographic department of the Central Bureau of the international Study of the Sea in Copenhagen.

For the present, it will be sufficient to direct the attention to the photographs on p. 2 which represent the apparatus ready for use.

The main parts are:

I. The metallic frame consisting of two parts kept together partly by riveted bolts and partly by the shafts themselves.

II. The screw and the transmissions — cog-wheels — down to a pulley around which the line carrying the weight is wound. For every rotation of the pulley the screw rotates four times, that is 1200 times to the minute.

[1]) Which makes 1870 turns when 200 Liters of water pass through the tube a and the nets c and b.

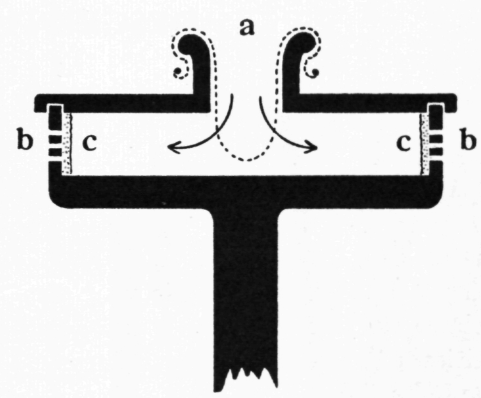


fig. 2.

At the suggestion of Professor Pettersson I have introduced a device for filtering the smallest plancton organisms, the socalled Nanno-plancton, by a centrifugal machine consisting of a cylindric box with perforated wall (fig. 2) mounted on the fastest rotating shaft of the apparatus. (1200 rotations to the minute.)

The water enters the centrifuge through the mouth-piece a and escapes through the holes in the wall having passed through the pores of a strip of filtering-paper c placed inside the wall. As the intention is to separate from each other the different kinds of plancton, a piece of finely-meshed silk gauze is tied over the opening of the mouth-piece as shown in Fig. 2. Fig. 3 is a section of the centrifuge.

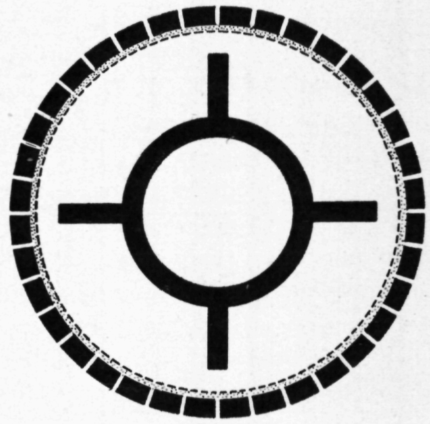


Fig. 3.

The above described plancton-catcher has already been submitted to several practical tests on board the Swedish research-ship »Skagerak». In the summer 1925 several hydrographic deep soundings, including the taking of plancton-samples at different depths down to 500 meters below the surface were made in the Skagerak, on a line Koster-Risør-Skagen. Very good results were obtained also in the open sea and with no greater disturbances from rough weather than those to be reckoned with when using a water-bottle or a Nansen plancton-net. The catches brought mainly copepods, sagitta and phytoplancton, the latter fairly well sorted from the former ones by aid of the two filters b and c of different mesh-size.

After the conference in Copenhagen, in September, a short expedition was made in the Southern Baltic, where a series of plancton-hauls was taken off Bornholm under the control of Magister Jespersen of the Danish Commission who had been invited on board the Skagerak to follow the operations.

As seen from the following tables, for the calculation of which I am indebted to Mr. Jespersen, the hydrographic conditions in that part of the Baltic were just then of an interesting character, because a heavy storm had driven in great quantities of salt-water from without through the Sund and the Belts. The original salt-water in the Bornholm depth and elsewhere had been lifted by the inflow of this still salter water creeping in along the bottom of the southern Baltic. This will be seen from the following tables giving at the same time an idea about the distribution of organic life in the different water-layers represented by the plancton taken in such depths as seemed to be of special hydrographic interest.

It is evident from the above tables, that the zoo- as well as the phytoplancton may change considerably in quality and still more in quantity from one water-layer to another in less than 10 meters vertically reckoned, such fluctuations being, at least in this case, expressively due to changes in the hydrographical conditions chiefly of thermical nature. The only secure way of recording similar variations in quantity and quality of organic substance, not only of the phytoplancton but also of the copepods, which possess a considerable agility and quickness in their movements, is an apparatus filtering a measurable amount of water at any depth between the surface and the bottom. For this purpose the only accurate method has hitherto been the Lohmann plancton-pump, the use of which is restricted to rather narrow limits by the technical circumstances already alluded to. It will appear that these difficulties have to a certain extent been overcome in this new type of plancton-catcher, at any rate when investigating waters of more considerable depth, where samples taken close to the bottom are of less significance. For the deepest waterlayer 10 meters from the bottom, it will be necessary to use an ordinary plancton-net, either in vertical hauls or worked horizontally along the bottom over a measured distance.

The strong point of the pumping-method lies in the possibility of obtaining plancton-samples in any exact depth between the surface and the bottom. This condition must be fulfilled in order to establish a closer connection between Hydrography and Biology. In this respect, as seen from the table, quite a new perspective is open.

The quantitative measurements are also worthy of attention. They are obtained by decanting each sample down to 10 ccm. either in fresh or salt-water only, or mixed with Formol or Alcohol — and afterwards centrifuging for a certain time in calibrated glass tubes. Every sample being sifted by the filters in copepods and phytoplancton, the volumes in cbmm of both kinds of plancton will automatically be obtained for every depth.[1])

This way of proceeding is mainly of practical nature and, if standardized, will allow a quick comparison on the spot with other catches, provided all figures — by means of the current-meter attached to the apparatus — are reduced to 100 liters of water. A small centrifuge with the capacity of two glasses at one time will be sufficient and can easily be carried on board for the purpose. It will of course be for planctonists to decide on such particulars.

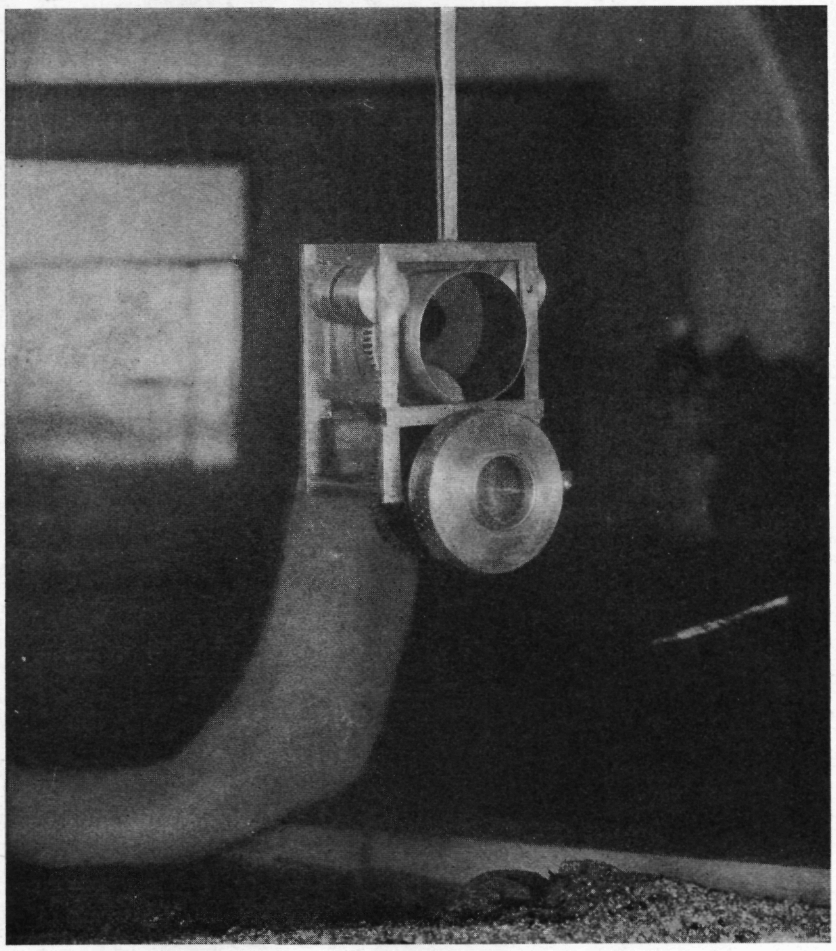
[1]) The apparatus has during an expedition to the Middle of the Baltic this summer been used with success for a qualitative purpose for which it is specially adapted, viz. to study the vertical distribution and movements of certain plancton-forms from a higher to a lower niveau and *vice versa* at different times of the day.

PLANCTON SAMPLES

TAKEN E. OF BORNHOLM 7/9 1925, 55° 16′ LAT. N; 14° 54′ LONG. E. 10 A. M.

	Surface	10 m	15 m	20 m	25 m	30 m	35 m	40 m	45 m	57 m
Salinity ‰ [1]	7,38	7,38	—	7,39	—	7,48	7,94	9,11	12,39	13,19
Temperature C° [1]	14,20	14,20	—	14,13	—	10,52	5,30	6,91	11,61	12,51
Contents of plancton: [2]										
in cbmm/100 Lit. w.										
Mill gaze nr. 6:	6	9	9	—	3	—	9	—	3,5	—
» » » 13:	7	8	11	—	5	—	3,5	—	6	—
Together	13	17	20	—	8	—	12,5	—	9,5	—
Crustaceæ:										
A. Number of copep. to 100 Lit. w.										
1. Pseudocal. elong.	2	1	2	—	—	—	68	—	19	—
2. Temora longicorn.	2	13	29	—	13	—	277	—	24	—
3. Enrytemora sp.	4	8	6	—	—	—	6	—	—	—
4. Centrop. hamatus	—	12	39	—	4	—	12	—	2	—
5. Acartia sp.	111	148	112	—	10	—	125	—	50	—
6. Harpacticide	—	—	—	—	—	—	—	—	—	—
7. Oithona sp.	—	—	—	—	—	—	2	—	17	—
8. Naupliæ	2	—	1	—	—	—	1	—	—	—
Together	121	182	189	—	27	—	491	—	112	—
Cladoceræ:										
1. Evadne sp.	43	16	42	—	—	—	—	—	—	—
2. Podon sp.	1	2	1	—	—	—	—	—	—	—
3. Bosmina duarit.	35	211	509	—	18	—	7	—	2	—
Together	79	229	552	—	18	—	7	—	2	—
All crustaceæ	200	411	740	—	45	—	498	—	114	—

[1]) By Dr. Erik Martens, H. B. K. Sweden.
[2]) By Dr. Jespersen, Komm. f. Havunders, Denmark.



The plancton-catcher photographed during a trial in the aquarium
by Mr. S. Pettersson.

Nezāta