b) Drums with horizontal axis (Fig. 4) of which two serve to wind and unwind the bobbin carrying the mareograph chart and a third whose axis is connected to the clockwork mechanism comprise the essential features of the recording apparatus. Its two extremities are bordered with short needles spaced equidistantly at 24 mm. which serve to pierce the paper roll (mareogram) at intervals of every two hours (1 mm. along the time axis is equivalent to 5 minutes).

3) The clock mechanism (Fig. 1 and 2) coupled to the axis of the recording drum is actuated by a pendulum and fitted with a wheel with 60 teeth corresponding to the minutes; the clock is wound once a week.

4) Control Apparatus (Fig. 1) used to check the instantaneous height of the water referred to the fundamental datum of the station by direct soundings obtained with a metal console. The measurements taken thus once or twice a week serve to connect the points on the mareogram (its zero) with a fixed level whose position with respect to external bench marks is known.

For the approximate determination of the position of the water level use is made of the counter-poise suspended from the float wire and of a permanent graduated scale on the opposite wall of the building. The check measurements are made with the aid of a bronze tape divided into semi-decimetric divisions (Fig. 5) unwinding from a pulley with horizontal axis and provided with a metallic pendulum bob (Fig. 3) at its lower end which acts on the control paper. The above paper has a fixed shape and dimensions, and is specially imbrued (**), being steeped in water, and the paper band thus delineates the height of the water by means of a darkened line.

NOTE. — For further details of this device see the article by Dr. H. Renqvist: *Der Wasserstandsdienst in Finnland* published in *Annalen der Hydrographie und Maritimen Meteorologie*, Vol. I, 1923.

(**) After having been steeped in a solution of iron chloride and dried, the paper is then treated with coat of powdered tanin.

A BATHYTHERMOGRAPH

by

Athelstan F. SPILHAUS, New York University.

(Reprint from: *Sears Foundation: Journal of Marine Research*, Vol. I, N° 2, 9th April 1938. PP-95).

In the study of the homogeneous layer in the ocean, Rossby (1) found it desirable to have an instrument which would provide a continuous record of temperature against pressure in the surface layers of the ocean. A preliminary instrument named an "oceanograph" was constructed and used during the summer of 1934. The manifold uses to which such an instrument could be put presaged a widespread employment of the apparatus. This, however, did not come about because of certain inherent difficulties in Rossby's design. The record was made on a large smoked foil, and thus entailed the attachment of multiplying linkages to the actuating elements for pressure and temperature. Such multiplying linkages are uncertain in action in sea water, and, furthermore, the size of the instrument to accommodate them must necessarily be fairly great. At Prof. Rossby's suggestion, the author attempted to modify the oceanograph so that it would be more suitable for routine use. The modifications were made with the following aims in view:

(*a*) The instrument should if possible be small enough so that it can be lowered on an ordinary log line by hand if necessary, thus enabling it to be utilized on vessels not equipped with a hydrographic winch.

(*b*) The instrument should be sufficiently rapid in its response such that regardless of the rate at which it passes through the water no errors due to the lag of the thermometric element will be apparent.

(*c*) Care should be taken to eliminate hysteresis of the pressure element.

(*d*) The plates on which the record traces are made should be easily inserted and removed and easily evaluated.

(1) C. G. Rossby and R. B. Montgomery. «The Layer of Frictional Influence in Wind and Ocean Currents». Papers in Phys. Oceanography and Meteorology of the Mass. Inst. of Tech. & Woods Hole Oceanographic Inst., Vol., III, N° 3, p. 73.

DESCRIPTION OF THE INSTRUMENT.

The instrument finally evolved consists essentially of a pressure element comprising an hermetically sealed syphon inside of which is a guide and compression spring to give the requisite pressure range. Mounted on the movable end of the pressure element is a straight bi-metal strip, and thus motion with pressure is at right angles to the deflection of the strip with temperature. At the end of the bi-metal strip a fine needle point is arranged to inscribe a trace on a small glass slide. The slide is prepared for the record by coating it with a thin layer of oil and then smoking the glass to slightly blacken it. The function of the oil is to prevent the smoked film being washed off by the sea water. In view of the fact that the motion of the inscribing point is in two dimensions, the plate which receives the record is held perfectly rigidly in the body of the instrument, and thus insertion and extraction of the plates are

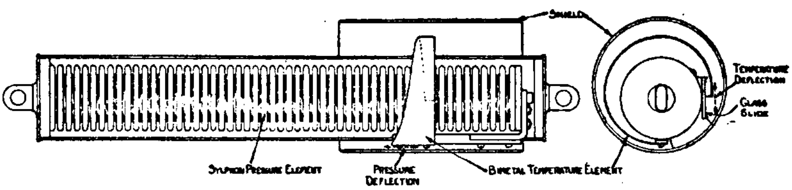

Fig. 1.
The Bathythermograph.

entirely independent of the sensitive actuating elements. Figure 1 shows the complete instrument in the lower photograph and indicates the method of insertion of the glass slide to take the trace, while the upper part of the illustration gives a view of the instrument partly disassembled to show the simplicity of the actuating elements.

Figure 3 is a photographic enlargement of an original record from the small slide, and the accompanying key diagram shows the trace superimposed on a calibration grid. It can be seen that the record consists of two lines — one made during the descent of the instrument, and the other during the ascent. It can be easily shown that hysteresis of the pressure element and lag of the temperature element both act in such a way as to separate the ascent and descent traces; so that if either pressure hysteresis or thermal lag are present to a marked degree, two distinct traces would have been recorded. The coincidence of the two curves, however, insures that the instrument is functioning correctly. From the standpoint of thermal lag the record is particularly remarkable when it is realized that in the case of the particular test in the photograph the instrument was sent down and brought up through the water at a rate of 100 meters per minute. Thus the whole test down to a depth of 150 meters was completed in 3 minutes. Evaluation of the record obtained is simply accomplished by projecting it by means of a miniature camera projector on to a calibrated screen. Tests were made by lowering the bathythermograph on the end of a log line and it was found that good records could be obtained by an ordinary seaman.

....

....

FURTHER DEVELOPMENT.

Though the result shown may be considered as very satisfactory, it is proposed to improve the instrument further by an attempt to utilize a design such as indicated in Figure 2. The improvement which such a design would incur is that the temperature element would be exposed directly to the flow of water and that all thermal lag by it would be eliminated. Furthermore, the size of the instrument, if constructed according to the design in Figure 2 will be cut down considerably and, though in the first design the coordinates are very nearly rectangular (because the length of the bi-metal strip is great compared to the deflection of its end), in the second design the coordinates will be perfectly rectangular. Finally, it is thought that vibration will be entirely eliminated by the second design, and that, therefore, a finer trace and greater accuracy will be obtained.

It is hoped that this instrument can be produced, if demand is sufficient, cheaply enough to obtain its widespread application, not only by biologists and oceanographers, but also in the fishing industry — the apparatus being such that it can be handled by entirely untrained personnel.

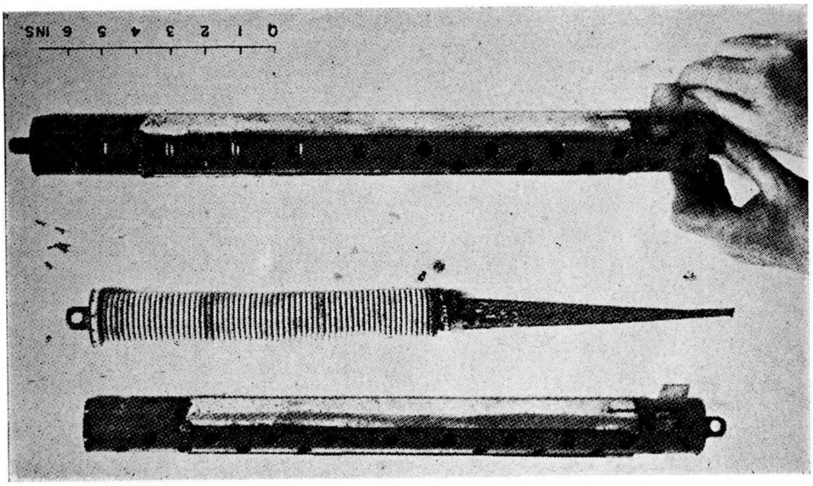

Fig. 2

Modèle No 2 relatif au Bathythermographe perfectionné

The Bathythermograph.
Model No. 2. Improved instrument.

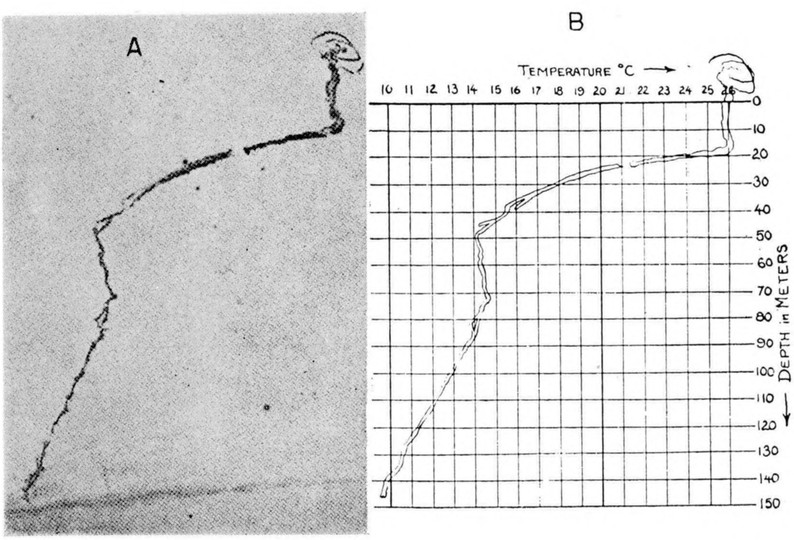

Fig. 3

Agrandissement photographique (A) *d'un enregistrement original du Bathythermographe, avec abaque-clef* (B) *montrant le tracé superposé à la feuille de calibrage.*

Photographic enlargement (A) from an original record of the bathythermograph, with key diagram (B) showing trace superimposed upon calibration chart.