Reprinted from the *Indian Journal of Marine Sciences*, Vol. 7, No. 3, September 1978, pp. 205-20

Transparency Meter to Study the Underwater Light Penetration in the Sea

M. N. VISHNUDATTA & A. V. S. MURTY
C.M.F.R. Institute, Cochin 682020

Received 2 *December* 1977; *revised received* 12 *June* 1978

An electronic device using a selenium photocell has been designed and fabricated to measure irradiance of light at various levels of the water column to relate irradiance with biological productivity. The instrument is portable and easy to operate at sea. Its performance at sea is found satisfactory.

ABSORPTION and scattering of sunlight in sea water play a very important role in determining the vertical distribution of particulate matter[1] and marine organisms. From the physical point of view also, it is a useful phenomenon to determine the characteristic properties of water masses especially with reference to suspended particles, if any, so as to relate the dynamics of the euphotic zone.

The Secchi disc is still popular for determining the sunlight penetration in sea water. The basic limitation of the Secchi disc, which gives only the total extinction depth of the water column measured from the surface, is that it cannot give the fractional penetration of sunlight. Techniques have been developed to measure the absorption including scattering of sunlight at various levels in the sea using photosensitive elements[2-4], like photomultiplier tubes, cadmium cells and selenium photocells. None of the photocells behaves linearly to incident light. However, their response is improved towards linearity depending on photosensitive elements used. The photosensitive elements in general and the photomultiplier tubes in particular are dependent in their response on the ambient temperatures. A third limitation of their response is with the non-uniformity of their output for the visible range of wavelengths of the spectrum.

The selenium photocell is superior over others because of improved linearity of response and relatively uniform performance in the visible range[2,5]. In addition, its output (current) is least affected by the ambient temperatures in the sea water.

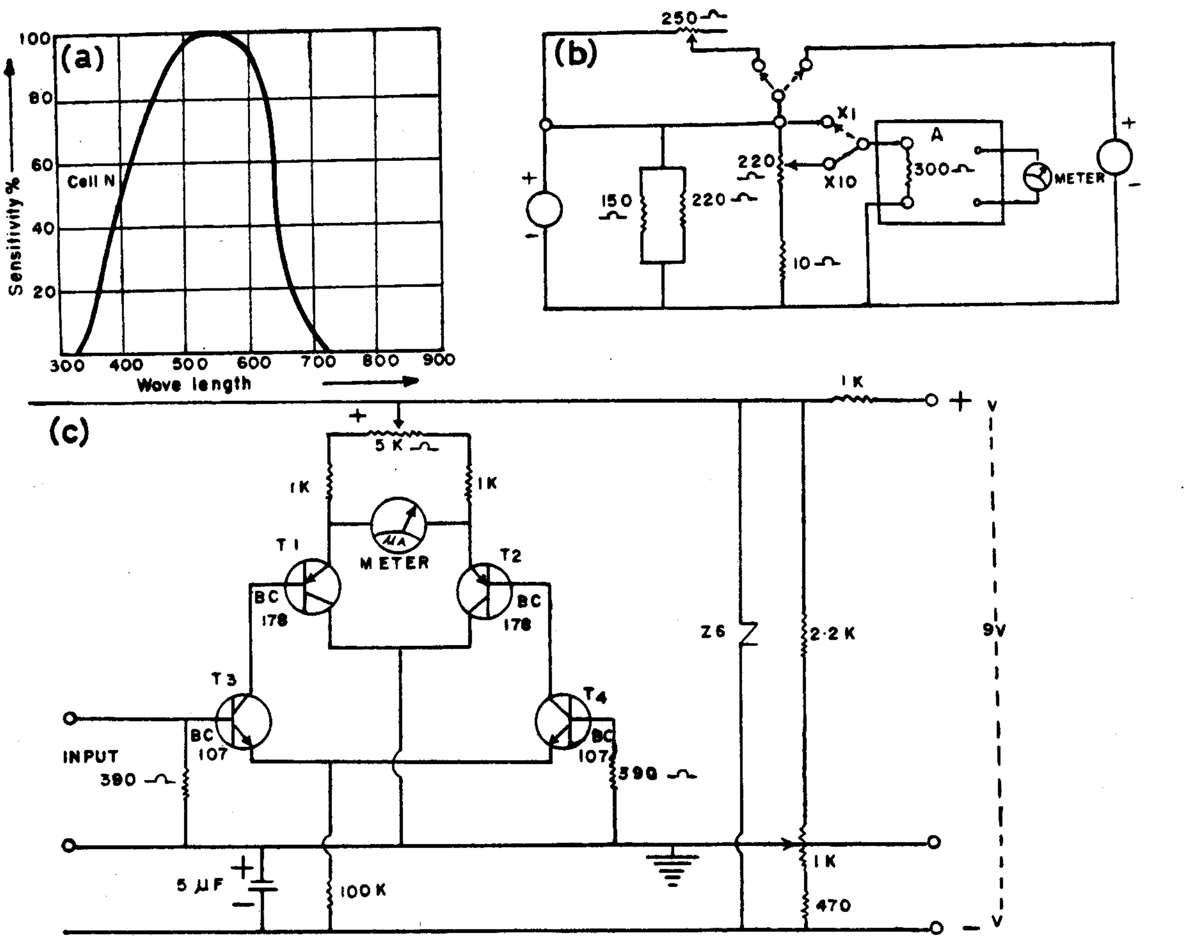

Fig. 1 — (a) Characteristic curve of the selenium photocell 'N' type [wavelength in nm], (b) circuit details, and (c) differential amplifier circuit

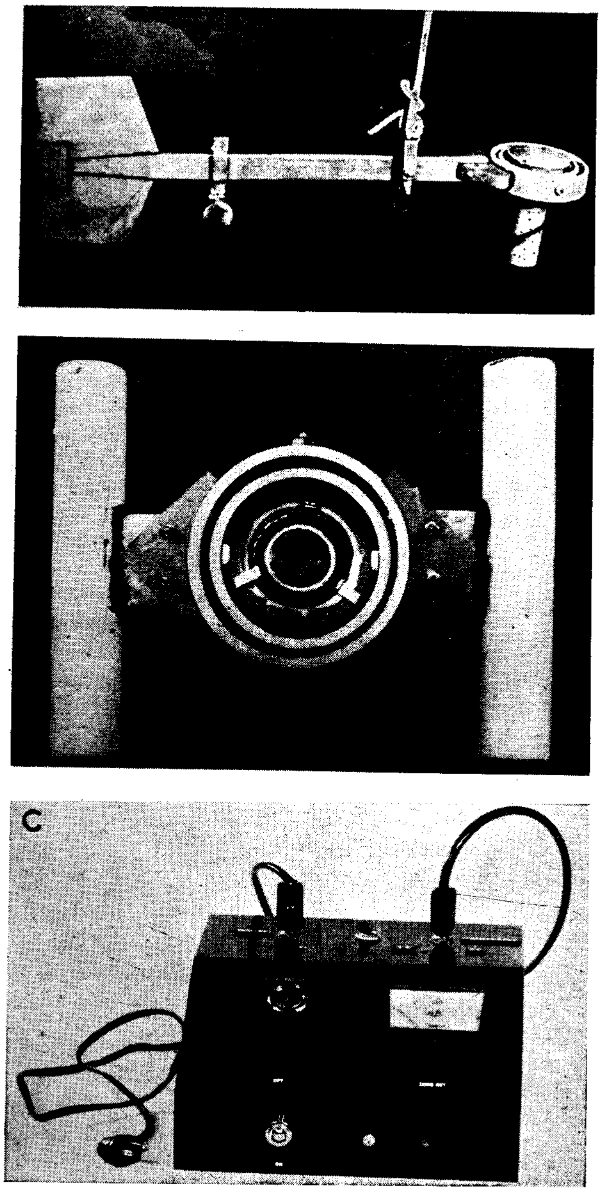

Fig. 2 — (a) Submersible transparency meter, (b) surface unit, and (c) deck unit

In the transparency meter described in this paper 2 similar selenium photocells (N type khandelwal Herrman) are used. The characteristic curve in the visible range is given in Fig. 1a.

The selenium photocells chosen were checked for comparable sensitivity[2] using B. Lange's luxmeter.

The instrument consists of the sea going unit, the surface reference unit and the deck unit.

Sea-going unit — The underwater cell was potted (Fig. 2a) in a clear perspex container and the empty space completely filled with araldite. The connecting lead is a 2 core cable 100 m long. It is taken through the side of the cell housing and connected to the cell before potting. Thus the cell and the connecting cable which is covered with PVC are completely sealed and made waterproof. The unit is then mounted on gimbals and the cell housing has an extension which can be weighted suitably to keep the cell always horizontal. The assembly is carried on a pivoted and counterbalanced arm made of rigid PVC. It has a vane at the other end to prevent under water currents from upsetting the position of the cell. The arm is supported in the middle and an adjustable weight (total weight of 3·5 kg) is used to balance it. The total weight of the sea-going unit is 3·5 kg.

The complete assembly is carried by a tough nylon rope to which the connecting cable is also tied and these are wound on a feeding drum.

Surface reference unit — The unit (Fig. 2b) is a similar selenium photocell mounted in the same manner as in the sea-going unit. Two floats are attached on either side of the gimbal system. Under the carrier of the photosensitive element adjustable lead weights are attached so as to make the surface unit always immersed in water keeping approximately 5 mm water column above the surface of the sensing element. The error due to the immersion effect[6,7] can be thus avoided.

The noon intensity of light is approximately 100000 lux above the sea surface. The output of the selenium photocell is linear up to a maximum of 1000 lux only. Therefore, it is found necessary to use a filter (neutral diffuser). Number of discs made of different materials have been tried as filters and a milky plastic disc[2] easily available in market is found useful. It gives a reduction in light intensity of approximately 1/100. Identical covers made of this material are slipped over the 2 cell housings.

Measuring circuit — To obtain linearity, photocells were loaded with a low resistance. Because of this and because of the neutral diffuser it was found necessary to use an amplifier (5 times amplification) for showing the output of the underwater cell at greater depths. To compare the surface intensity and the underwater intensity it is necessary to use the same amplifier. Hence a potential divider is used to read the levels of the surface cell and also the underwater cell when the latter is near the surface. The complete circuit details are given in Fig. 1b. DC amplifier using differential pair arrangement (Fig. 1c) was used. One of the inputs is shorted and to the other input, the signal to be measured is given. The differential pair arrangement makes the amplifier stable and free from drift. Common mode effects such as those due to ambient temperature, fluctuations in supply voltage, etc. affect both transistors equally and their effect will be nullified at output stage. The input impedance of T3 in parallel with 390 Ω will give approximately an effective input resistance of 300 Ω across the amplifier. Thus, the cell faces a load consisting of 150 Ω, 220 Ω and 300 Ω all in parallel. Across this the potential divider is also in parallel. In this condition the effective load is roughly 50 Ω. In the X10 position, the 300 Ω in the amplifier will come in parallel with only 1/10th of the potential divider. Hence the effective load will go slightly above

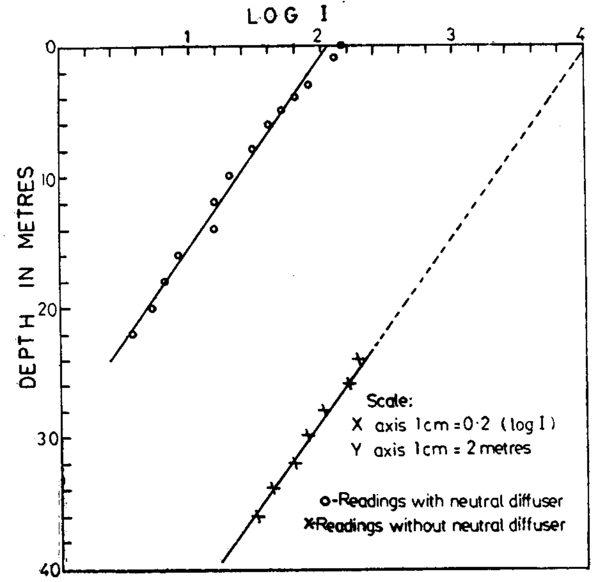

Fig. 3 — Typical set of observations taken with the instrument

50 Ω. In all cases the effective value will be below 100 Ω ensuring good linearity.

Measuring is done by connecting the surface unit and the underwater unit in turn by a changeover switch. The surface unit has a preset resistance in series to make its output equal to that of the submersible cell when both are placed in equal levels of illumination at the deck level. As the depth becomes greater the potential divider switch is thrown into the maximum position, marked x1. The response of the photocell can be read on the index meter to a minimum of 1 μA. The measuring deck unit is shown in Fig. 2c.

The instrument has been tested for its satisfactory working several times and is found good. A typical set of observations is shown in Fig. 3.

Reduction by the neutral diffuser calculated from the graph (Fig. 3) is about 95%. This value can be made use of in all calculations in order to eliminate the effect of neutral diffuser.

For the calculation of the extinction coefficient the percentage of reduction of light can be calculated at each depth.

There are many advantages of the new transparency meter. Thecost of the instrument excluding its cable is only about Rs 1000. Its light weight renders its operation easy at sea. Its linear response for illumination simplifies its calibration. The surface unit is a special facility of the transparency meter. With the aid of this, percentage changes of illumination at various depths in the sea relative to the surface could always be determined irrespective of cloud condition.

The authors are grateful to Dr E. G. Silas, Director, for his encouragement. They are thankful to Prof. M. N. Nambudiripad, St Albert's College, Cochin, for his discussions and help especially on electronic circuits. They are also thankful to Shri P. Balakrishna Menon, Proprietor of Krishna Plastics, Cochin, for fabricating the instrument.

References

1. Jerlov, N. G., *J. mar. biol. Ass. India*, **14** (1972), 335.
2. Jerlov, N. G., *Optical oceanography*, Vol. 5 (Elsevier Oceanographic Series, London), 1968, 94.
3. Tyler, J. E. & Preisendorfer, R. W., in *The sea*, Vol. 1 edited by M. N. Hill (John Wiley & Sons Inc., New York), 1962, 397.
4. Tadayoshi, S., Gohachiro, O. & Motoaki, K., *J. Oceanogr. Soc. Jap.*, **22** (1966), 123.
5. Cooper, L. H. N., *J. mar. biol. Ass. U.K.*, **41** (1961), 535.
6. Raymond, C. S., *J. mar. Res.*, **27** (1969), 341.
7. Tyler, J. E., Richardson, W. H. & Holmes, R. W., *J. Geophys. Res.*, **64** (1959), 667.