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Installation of Ocean Wave Recorder at Trivandrum

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ABSTRACT. This paper deals with the installation of the Ocean Wave Recorder carried out by the Indian Naval Physical Laboratory. Details of the pressure type of underwater wave recorder, the choice of the site for the installation and the actual details of the installation are dealt with. A brief review of the naval applications of ocean wave studies is also given.

1. Introduction

An Ocean Wave Recorder has been installed at Trivandrum as part of the research programme in Physical Oceanography of the Indian Naval Physical Laboratory. The aim of this project is to collect data on wave heights and periods and also to correlate the arrival of long distance swell with the microseismic activity observed at Cochin. It is believed that this is the first ocean wave recorder to be installed in the country for this type of work.

Development of precision shore wave recorders and spectrum analysers has received considerable attention in recent years. The spectrum analysis of the wave records reveals what is happening in the distant ocean. In a systematic record taken at different intervals of time, the first spectrum shows peaks at the long period end of this spectrum and they persist with increasing amplitude in subsequent spectrum. This is due to the arrival of the long period swell. As time goes on, the mean period and also the amplitude of the band decreases as the swell begins to die away.

The explanation (Deacon 1949) for this is that when waves of different periods are generated by a storm, they travel independently across the ocean after they leave the storm area each with a velocity proportional to its period. Consequently, the shorter waves generated at the beginning of the storm will be overtaken by the longer waves which are generated when the storm gathers strength and these long waves arrive at a distant observation point ahead of the shorter waves. Subsequent observations reveal a slow decrease in the mean period of the wave band due to the arrival of the short period waves. This rate of decrease as also the period of the longest wave depends upon the distance and the strength of the storm. Thus it is seen that each storm provides, at the recording station, its own characteristic spectrum having a certain rate of decrease of mean period depending upon the distance of the storm. This interesting observation can be used by the meteorologist in uuderstanding the mechanism of wave generation and also in collecting valuable data on storms from wave spectra. The distance of the storm can also be estimated by taking successive wave records and studying the rate at which the different period components cease to appear in the spectrum. The period of the longest wave recorded can be used for estimating the greatest wind strength.

Observations on an interesting relationship between microseismic periods and the period of the sea waves have been made in the U.K. Simultaneous wave and microseismic records have shown in a number of cases a similarity in the spectrum and the wave period has been found to be about 2 times the microseismic period lending support to the theory that microseisms are produced in a region of interference between the similar wave trains travelling in opposite directions, either near the coast or in deep water. It is intended to carry out simultaneous wave and microseismic studies at Cochin also to investigate this relationship further.

2. Location of site

For selecting a suitable location for the wave recorder station, two considerations were kept in view. The location chosen should be such that a depth of water of 40—50 ft could be reached at as short a distance as possible from the beach and there should be facilities for locating the recording instruments ashore. From this point of view, Trivandrum was found to be a better location than Cochin where the sea bottom is very shallow. From Trivandrum, swell data in the Arabian Sea and the Indian Ocean could be gathered.

The site at Trivandrum was chosen at the Valiathura Pier which is 703 ft long with a T-head 94 ft wide. The depth of water at the farthest end of the pier was found to be 25 ft and the 40 ft water depth line was within 209 yd from the end of the pier. The site was considered to be ideal as it was easily accessible and provided good protection to the cable and shore recorder.

3. Types of wave recorder

The shore based wave recorders fall into two broad categories—(*i*) Surface type recorders and (*ii*) Underwater pressure recorders. In the surface types, parallel wire resistance wave gauge, step-resistance wave gauge and capacitance-wire wave recorders are normally used. These wave recorders give a true picture of the wave profile but they require a steady platform such as a solid pier for installation. The wave-measuring elements of these recorders have short life due to the action of the wave and surf and require frequent replacements.

The underwater pressure type recorder consists of an instrument which is placed on the sea bed and responds to the pressure changes at the sea bottom due to the waves on the sea surface. This type of installation is more elaborate than the 'Surface type' but suffers from the disadvantage that it does not give a true picture of the wave profile at the surface. If a_0 is the amplitude of the wave, the amplitude of the bottom pressure fluctuation p is given by

$$p/a_0 = \operatorname{sech} 2\pi h/\lambda$$

where h is the depth of water and λ the wave length. Thus $p/a_0 = \frac{1}{2}$ where the depth of water is equal to $\lambda/5$ and $p/a_0 = 1/10$ when the depth is equal to $\lambda/2$. Thus for a depth of recorder of 40 ft, a wave of 200 ft wave length will appear with 1/2 its amplitude and a wave of 80 ft wave length will appear with 1/10 its amplitude. This, however, is not a serious drawback as only the short period waves are affected. These are not of interest when swell from a distant storm is being studied and elimination of these on the other hand makes the wave spectrum simpler to study.

It was decided to try both these types of wave recorders. The surface type, namely, the capacitance-wire wave recorder, developed in this laboratory (Narayana Rao 1957) and the underwater pressure type (Tucker 1953) designed by the Admiralty and manufactured by the Cambridge Instrument Co. were installed at the same site. The former was modified so that it could be operated from batteries and was enclosed inside a thick steel casing fixed on the top of a pillar on which the capacitance-wire electrode was mounted. The audio frequency output, which was frequency-modulated by the sea waves, was taken to the recording room by a two-wire cable, where the audio signal was converted into an electrical current which was a replica of the sea wave. This was recorded on a recording galvanometer.

4. The underwater pressure recorder

The underwater wave recorder used was the Cambridge Pressure Recorder developed by the Admiralty (Tucker 1953) during the last war. The sketch illustrating the principle of operation of this recorder is given in Fig. 1. The chamber A, which is hermetically sealed, is inflated with the valve V_1 open, to a pressure corresponding to the mean hydrostatic

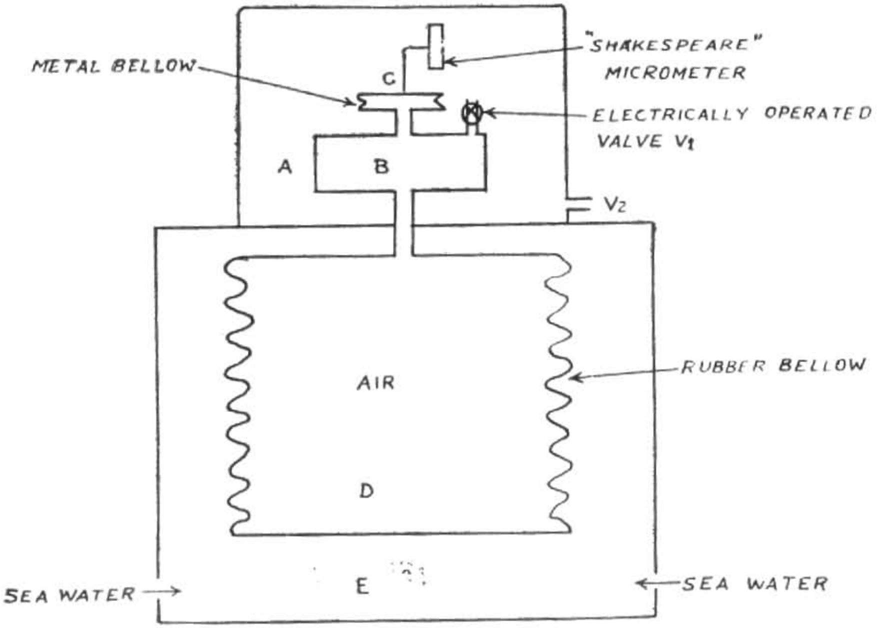

Fig. 1

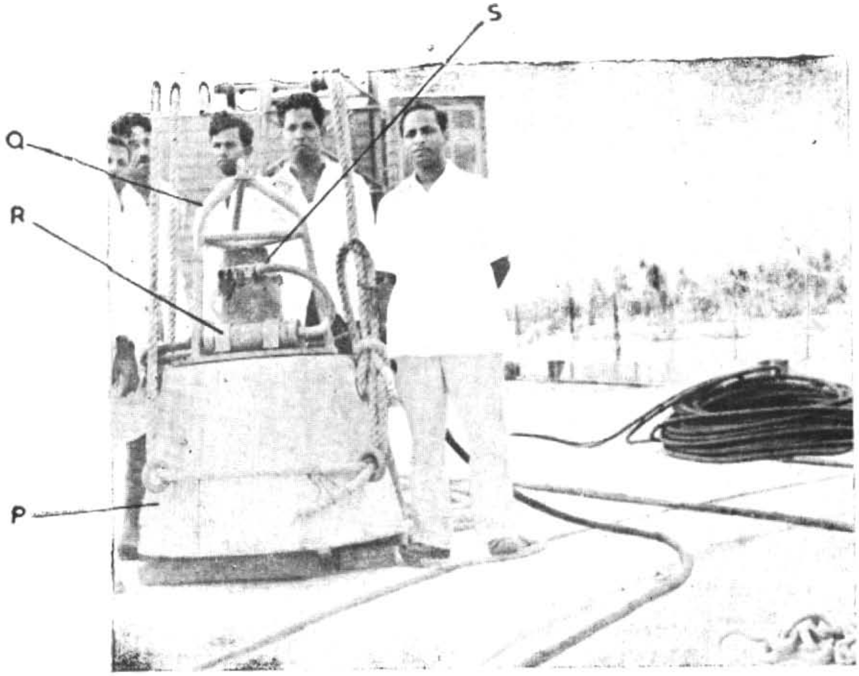

Fig. 2

P—Concrete base, Q—Steel frame work, R—Junction box, S—Pressure unit

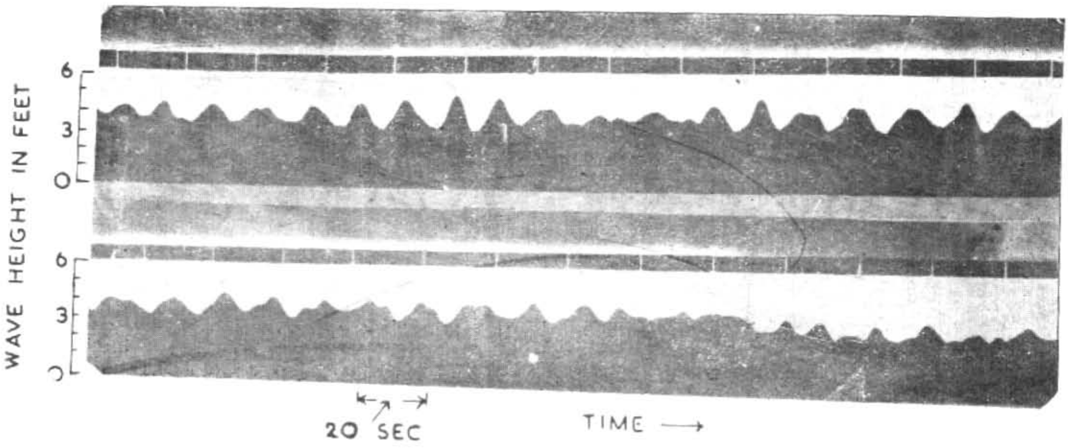
WAVE HEIGHT IN FEET
6
3
0
6
3
0
20 SEC
TIME →

Fig. 3

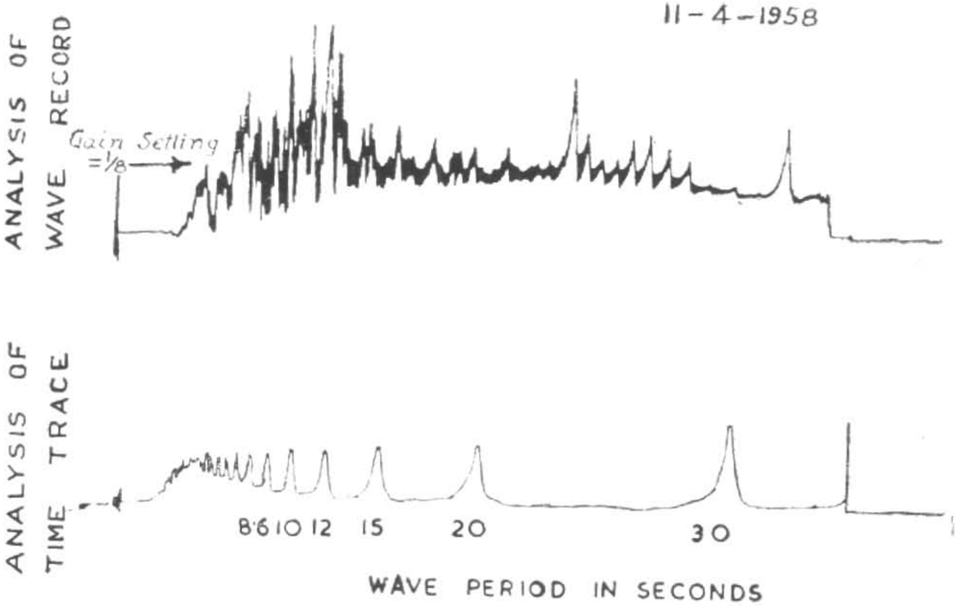
11-4-1958
ANALYSIS OF WAVE RECORD
Gain Setting =1/8
ANALYSIS OF TIME TRACE
8·6
10
12
15
20
30
WAVE PERIOD IN SECONDS

Fig. 4

pressure at the depth at which the instrument is to operate. Since the valve is open, the pressure of the air inside the metal bellow C is the same as the pressure outside, namely, the mean hydrostatic pressure outside the rubber bellow. Next the valve V_1 is closed and, due to the action of the waves, hydrostatic pressure at D will fluctuate about the mean value and this fluctuation will appear as a difference of pressure between the inside and the outside of the metal bellow. The resulting movement of the surface of the metal bellow will be transmitted by means of a lever to the "Shakespeare" micrometer. This micrometer contains four platinum spirals connected to the arms of a wheatstone bridge and it is supplied with a steady direct current to heat the spirals. Due to the action of the waves, the lever from the bellows causes one pair of spirals to get compressed and the opposite pair to be extended. The temperature of the former will increase and that of the latter will decrease resulting in a change in the resistances of the spirals and hence in an unbalance in the bridge. By proper adjustment, the out-of-balance current can be made to be an exact replica of the pressure variations and hence of the amplitude of the surface waves. Six electrical conductors are needed to provide the required supplies to the pressure recorder and to take out the output to the recording instrument. A six-conductor multicore cable 600 yd long was installed and this was taken out through water-tight glands to the recorder placed ashore.

5. Installation

It is seen from the sketch of the pressure unit (Fig. 1) that the chamber E should have free access to the sea water. This access is provided by a number of holes drilled in the metal chamber E. It is essential that after the instrument has been placed on the sea bed, these holes should not get blocked by sand and mud. Also the position of the instrument should not change due to the underwater currents. The instrument should be capable of being lifted up easily for repair, if necessary. For these reasons the instrument was mounted, through synthetic resin insulator on a platform of a steel framework Q (see Fig. 2). From the bottom of the steel framework there are three 6-inch projecting shafts at the three corners and a long 18-inch projecting shaft at the centre. This frame work is placed on a concrete base of pyramidal shape P. There are four holes in the concrete base to correspond to the four projecting shafts so that the frame work sits snugly on the concrete base. The concrete base has a hollow cylindrical portion at the bottom and the central shaft from the steel frame Q projects through this. A hole has been drilled into this shaft to carry a shearing pin. If it becomes necessary to remove the pressure unit from the sea bottom for repairs, a rope can be tied to the top ring of the steel frame Q which when pulled with sufficient force (about 2000 lb) will cause the shearing pin to break and the steel framework will be released from the concrete base. The concrete base is of a pyramidal shape of height 36″, diameter 30″ and weight 900 lb. It has three steel 3-inch diameter rings fixed on it at the sides to enable easy lifting by the ropes. The concrete base along with the framework weighs nearly 1000 lb, so that the whole unit will be stable and not drift with the current. The pressure unit mounted on the concrete base is more than 3 ft above the sea bottom and thus prevents the holes in the instrument being blocked by sand and mud.

The six-core cable from the instrument was joined to the 7-core armoured cable, A.P. 13135, which has been specially designed for underwater use, each core having 7 strands of 0·029″ diameter wire, rubber covered and well protected with jute and armouring. A specially designed junction box R (Fig. 2) capable of working satisfactorily at this depth was used for joining the armoured cable with the pressure unit. The junction box was rigidly clamped to the steel framework so that there was minimum strain on it due to the pull on the armoured cable. A certain length of the armoured cable was also coiled and tied to one side of concrete base to provide the required slack on the cable.

The pressure inside the chamber A (Fig. 1) was adjusted for the mean depth of sea water before the instrument was submerged so that the rubber bellow was not unduly compressed. With the valve V_1 closed (this is operated from a switch on the shore recorder unit) the chamber A was inflated so that the deflection on the galvanometer scale corresponded to 5 ft of water. The time in which the deflection dropped to 2 ft of water was observed. This should be at least more than half an hour as otherwise the 'slow leak' of V_1 would be too large and this would distort the wave-form. This test also enabled to assure the air tightness of the chamber A. Tests had also been carried out previously by immersing the whole pressure unit and junction box in 10 ft of water for nearly a week and ensuring no water or moisture entered the chamber A.

With the valve V_1 open. the chambers A and D (see Fig.1) were inflated to a pressure corresponding to 20 ft depth of water. The valve V_2 was securely closed by a brass cap. Ropes were tied at the three rings on the concrete base and these were secured to the hook of the 10 ton crane mounted on the pier. The unit was lifted and lowered to the sea-bed farthest away from the pier end. Two divers also were sent down to ensure that the base was resting properly on the sea bed and the cable did not get fouled. The cable from the pressure unit to the pier was allowed to rest on the sea bottom. Concrete sinkers were tied to this at intervals of 5 ft to ensure that the cable was not moved by underwater currents.

6. Shore Recorder

The shore recorder essentially comprises of a sensitive galvanometer with a lamp and scale arrangement. The image of a vertical slit on the lamp is focussed by the galvanometer mirror into a 6″ cylindrical lens fitted horizontally in the recording camera. The photographic paper which is in the form of a roll inside the camera is moved at a constant speed of 4″ per minute by a motor. The variation in the current due to the waves causes the image on the photographic paper to move up and down, *i.e.*. perpendicular to the direction of motion of the paper. A fogging lamp is dimmed momentarily once in every 20 seconds by a time-marking clock. This provides the timing marks. A typical wave record is given in Fig. 3.

7. Analysis of the wave records

It is essential that the wave records should be analysed into the component waves in order to interpret the swell data. A wave analyser developed by the National Institute of Oceanography. U.K. was procured by this department for the wave studies. This analyser gives the spectrum of a 20-minute wave record. along with the timing marks. The spectrum analysis of the wave record of Fig. 3 is given in Fig. 4. The periods of the peaks in the spectrum can be determined with reference to the time trace record and from this the swell data can be interpreted. Wave records have now been taken for nearly a month and they are being analysed.

8. Acknowledgements

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