Chapter 27

A PROJECTION-TYPE SOUNDER

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INTRODUCTION

The Depth sounding is the fundamental process for the investigation of sand drift on sandy beach and has been carried out by means of echo-sounders. Although it is necessary to obtain the actual variations of bottom topography under the direct action of strong waves, the data even by the up-to-date method of soundings are limitted to the case of calm sea conditions. Moreover, even in calm seas it is often difficult to measure the depth of water in the surf zone which has remarkable change of bottom topography due to wave action. The author has no information on the data of bottom topography under the direct action of waves on actual beaches in Japan, excepting those of Mr. Fujiki on the coast of Niigata along the Japan Sea, who, however, had measured the bottom profile along one fixed line which was set perpendiculaly to the beach.

At present we have no effective method of measuring the amount of drift sand, and therefore the measurement of dynamical variation of bottom topography is considered to be the possible primary and fundamental approach to the estimation of sand drift on sandy beach without any coast structure and also to be the final method of finding out the similarity law between model test and actual phenomena, through which model test may become a confiderable method of solving the sand drift problem.

In order to observe the dynamical variation of bottom topography by wave action, it is necessary to develope newly any possible method without boat and echo-sounder. This is the purpose of study of projection type sounder.

PRINCIPLE

For the above purpose of field investigation of sand drift, the following conditions should be satisfied.

(i) The observation should be carried out even in ordinary storm conditions, that is, even for the case of waves with heights of 2 or 3 meters and wind speed of 10 or 15 m/sec.

(ii) Bottom topography in the surf zone of remarkable change by wave action should be measured. Therefore, the area within 400 or 500 meters from shore line is to be necessarily observed.

(iii) The accuracy of measurement should be of the order which is sufficient to find out the change of water depth by wave action.

(Iv) Observation should be carried out as easily as possible and also the apparatus should be moved easily on the beach.

As for the methods which are available without any sounding boat and satisfy above conditions, the following three are considered to be possible.

The first is the underwater method, in which a topedo with pressure unit and a rope is to be driven into the sea, stopped and droppec down to the bottom at any required point and then pulled back by rope, measuring the statical water pressure.

The second is the water surface method, where any small boat is tc be used instead of a topedo.

The third is the aerial method, where instead of topedo or self-driving small boat a projectile is to be projected to the required point in the sea. Although any other method may be possible, only the above methods are considered to be practically possible.

In the first method, however, it is difficult to drive the topedo across the surf zone carrying a rope and also it seems to be complicated and difficult to realize from the the points of required horse power and complicated mechanism of the apparatus. The second method seems to have some possibility but it is considered to be difficult for the self-driving small boat to cross surf zone from beach to the sea, keeping any fixed direction.

From above reasons the author adopted and studied on the third method, of which the advantages are such as it is not affected by the sea surface conditions and the projection mechanism is extremely simple. However, the maintenance of conductor cable from breaking by shock of initial discharge and shock pressures which act instantaneously to the pressure unit at the time of discharge and alighting on the water surface become difficult problems.

As for the method of projection, two method may be considered. One is by means of explosive power of gun powder and the other is propulsive power of rocket. At first, the author tried the former because of its simplicity.

The Miroku-Type Rope Projector which is developed recently in Jap is applicable and the simplest one for this purpose. The method of projection is simple as shown in Figure 1. A hollow steel projectile ③ of mm in outside diameter, 40 mm in inside diameter and 820 mm in length is set on a projector ① of 40 mm in outside diameter, gun powder and cartridge case ② are charged and by firing the gun powder the projectile is thrown pulling a nylon rope and a conductor cable ⑤.

The projector is fixed by its basement ④ and a sand bag ⑥ to mai tain the angle of firing of about 35 degree. The weights of the project and projectile are 35 kg and 12.5 kg, respectively. The outside diameter of nylon rope is 3 or 4 mm and breaking strength is 280 kg. When gun pow der of 45 gr in weight is charged, initial velocity of the projectile at the instant of discharge is to be about 120 m/sec and be reached to 500 o 600 meters from the beach. Therefore, if the pressure unit is set on the projectile, variations of statical water pressure due to the change of bottom topography is to be measured by pulling back the projectile to the beach. The successive positions of the pressure unit and the statical water pressure at each position are registered continuously by recorder on the beach. And by each projection a cross-section or profile of botto topography is obtained on the recording paper.

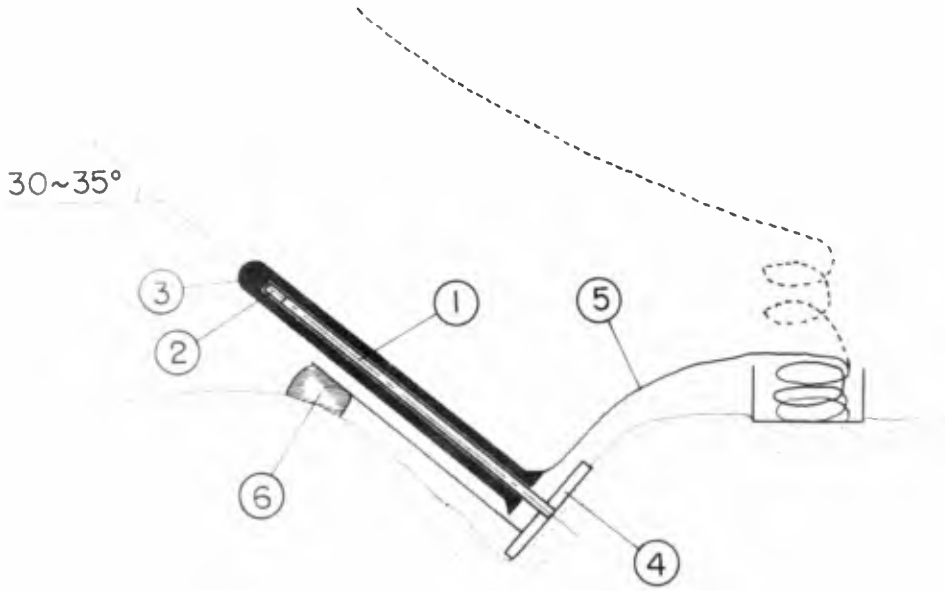

Figure 1 The Outlined Sketch of Rope Projector

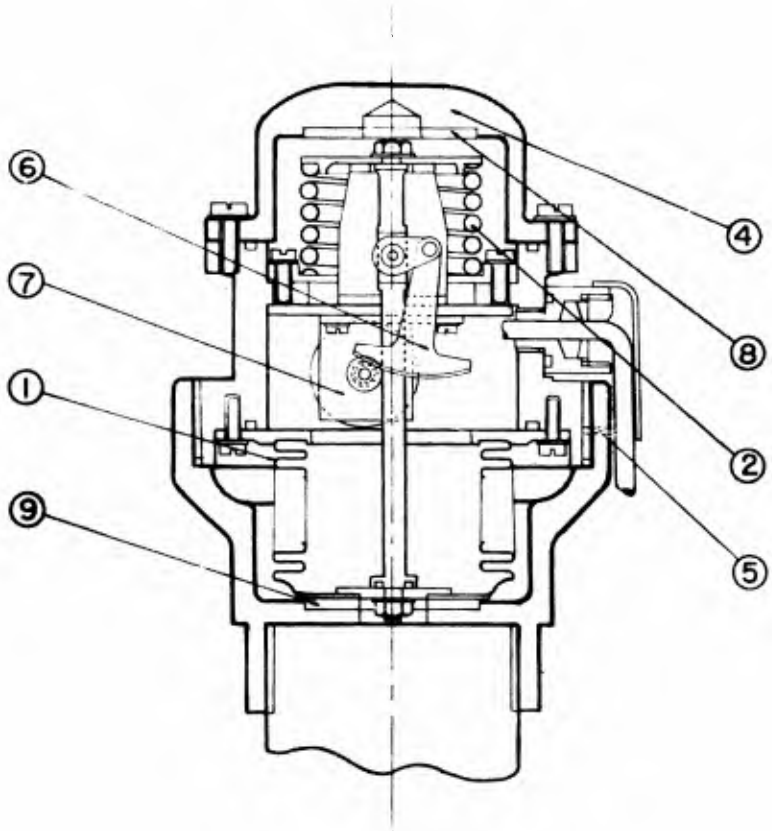

Figure 2 Mechanism of Pressure Unit

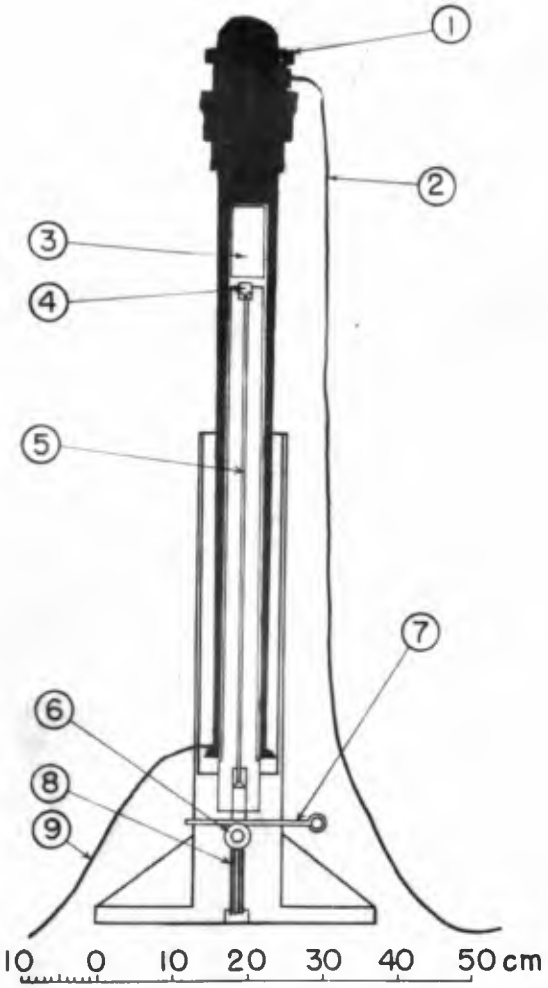

Figure 3 Projectile with Pressure Unit set on Projector

MECHANISM

The most difficult problem for this method is how to meet the shock pressure due to the acceleration at the instant of discharge of the projectile. The maximum acceleration at that instant will mainly depend on the weight of projectile and explosive power of gun powder. In case when the weight of projectile is 12.5 kg, the maximum explosive pressure inside the hollow of projectile due to explosion is said to be about 2000 kg/cm^2 and, therefore, the maximum acceleration of the projectile with the hollow of 40 mm in diameter is estimated to be about 2000 gal.

For the case of such a serious acceleration and for conductor cable with length of 500 or 600 meters, any complicated method cannot be used. Use of strain gage may be possible but the author adopted the mechanical method as shown in Figure 2 and 3, because the use of strain gage has some complicated problems on account of the necessary insulation of conductor cable.

Figure 2 shows the mechanism of pressure unit mainly made of aluminum metal, in which metal bellows ① and spring ② are connected with an axis ③. Inside of the bellows is water-tight with cap ④. When the pressure unit drops down into the sea, water flows into the unit through a small hole ⑤ and pushes the bellows. This water pressure is balanced by spring ② and bellows ①. The amount of compression due to water pressure fluctuation is directly converted into the rotation of sector gear ⑥ and the rotation of potentiometer ⑦, through which pressure fluctuation is changed into the voltage fluctuation. ⑧ and ⑨ are stoppers against shock pressures at the time of discharge and alighting on the water. Total weight of this unit is about 6 kg.

In Figure 3, ① is the pressure unit of Figure 2, ② is conductor cable, ③ the powder case, ④ the cartridge case and ⑤ is gun hammer. For the time of discharge, gun hammer is pulled down by lever ⑥, set by rock key ⑦, and powder and cartridge case are charged, then the projectile with pressure unit is set on the projector. Pulling out the rock key, the gun hammer is pushed out by spring ⑧ and strikes the cartridge case. Then the powder is fired and projectile is thrown out pulling the conductor cable and nylon rope ⑨. A few seconds after discharge, projectile is to reach at given point and drop down to the sea bottom. It is pulled back to the shore by nylon rope, sliding on the bottom and measuring the statical pressure. Recording paper is set to move in connection with the rotation of rope winch so as to be proportional to the displacement of the pressure unit. Thus the pressure record is to be nearly proportional to the cross-section of bottom topography.

EXPERIMENTAL RESULTS

After about 60 test projections, it became evident that the pressure unit in Figure 2 is strong enough against the shock at time of discharge and alighting on the sea, with only neglisible fluctuation of zero point in potentiometer. In case of pulling back the unit, the rope may sometimes be broken by the increasing earth pressure to the buried rope and projectile, especially in crossing the sand ridge in surf zone. In order to avoid this, a pully is prepared on the beach to lift up the

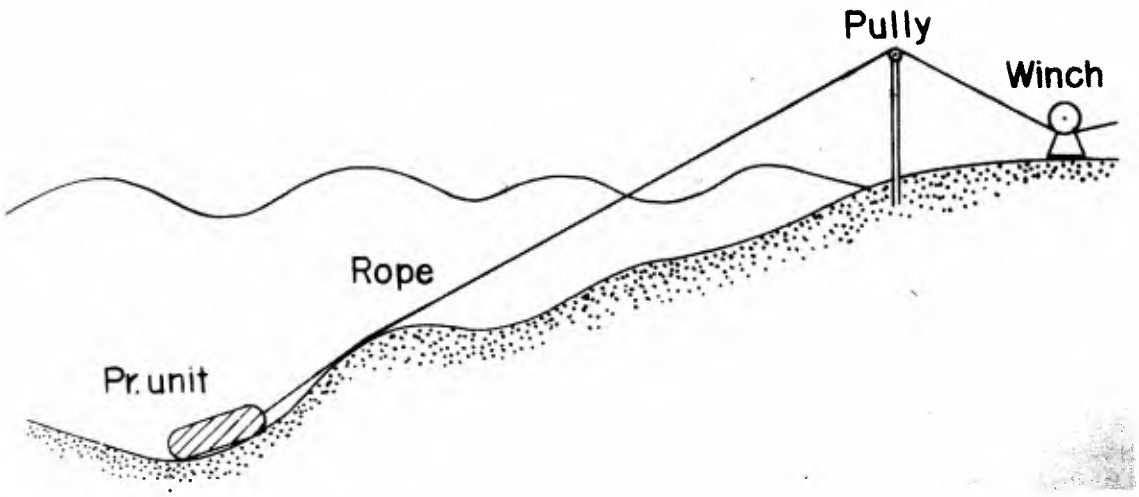

Figure 4 Sketch of Sounding

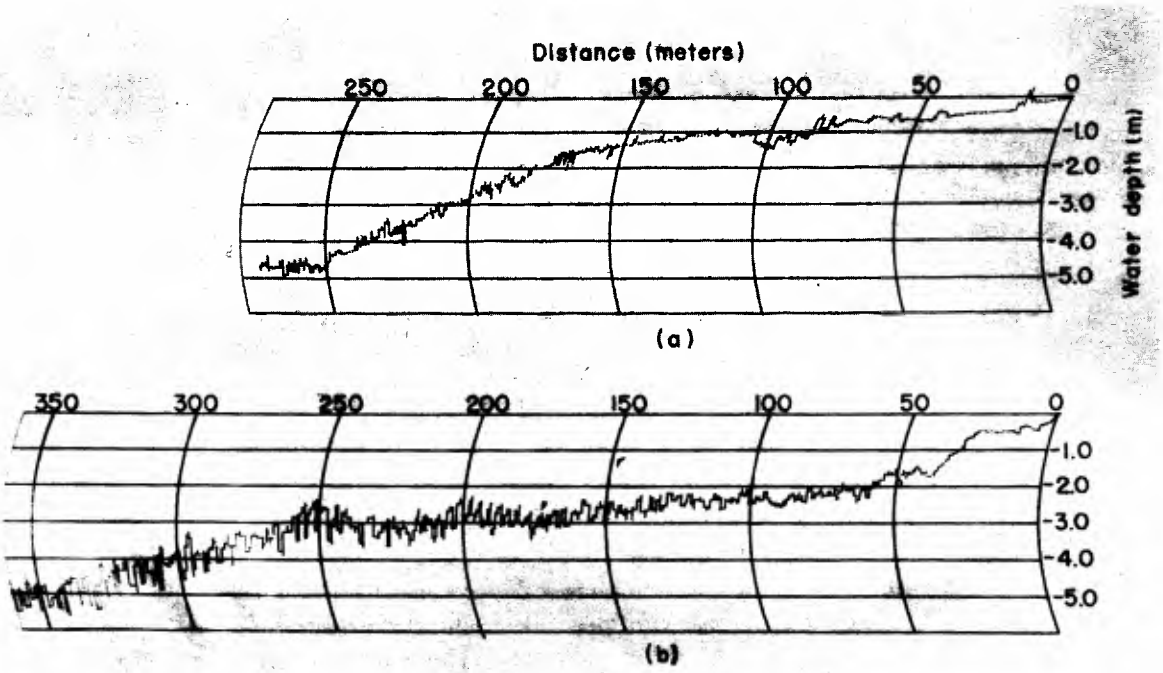

Figure 5 Examples of Records

FIG. 6 Projectile on Beach

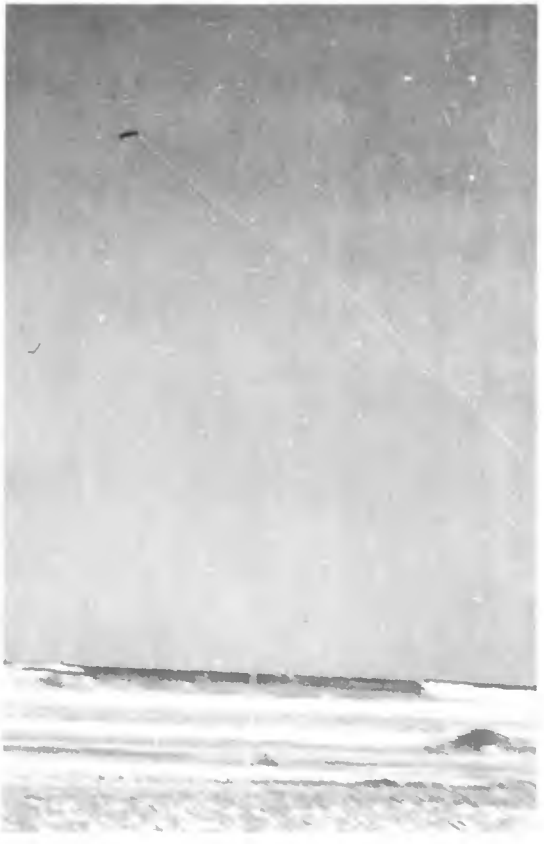

FIG. 7 Flying Projectile with Rope and Cable

rope in height of 2 or 3 meters above the ground as shown in Figure 4. Thus the pulling force to the rope was remarkably decreased.

As for the conductor cable, it became clear that the cable which has one conductor of four copper wires with 0.29 mm in diameter, reinforc by three piano wires with the same diameter and covered with polyethylene was strong enough against the breaking effect of shock at the instant of discharge. In this case, the cable should be initially winded into the shape of hollow cylinder with inside diameter of 12 cm, outside diameter of 20 cm and height of 12 cm, and total length of cable is 600 meters. When gun poeder of 45 gr is charged, the projectile reaches to more than 300 meters from shore line for wind velocity of about 10 m/sec, pulling the rope and cable. The alighting point of the projectile is easily observed using two transit-instruments like as ordinary sounding surveys, and the maximum error of alighting point measurement was expected to be less than 10 meters after several tests by three transit-instruments.

For examples, two typical records are shown in Figure 5, which were obtained on the Kashima-Nada coast of the Pacific Ocean. Figure 5(a is a record on 21st Nov. 1963 and (b) is on 3rd June 1964, in which the ruggedness of recorded curve is due to overlaps of statical water pressur and surface wave pressure fluctuations, so that the middle points of the curve is considered to be the cross-section of bottom topography.

Photograph 1 is the projectile set on projector just before firin and Photograph 2 is the flying projectile pulling a white nylon rope and a black cable just after firing.

REMARKS AND ACKNOWLEDGEMENT

Though it may be desired to increase the alighting distance of th projectile up to 400 or 500 meters, it seems to be somewhat difficult for the present type to cover such distances. The author, however, believes its applicability to the field investigation of sand movement and further data on bottom topography under the direct action of waves will be reported in the near future.

The author expresses his heartfelt thanks to Mr. Y.Suzuki, Mr. Y Abe and Mr. R.Sasage in Wave Laboratory of this Institute for their earnest coorperations to this study.

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