# THE NEW SEAKEEPING BASIN OF THE UNIVERSITY OF TOKYO

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### ABSTRACT

A new basin for seakeeping and manoeuvring studies has been under construction at the Chiba Campus of the University of Tokyo and the main part was completed in May 1969. The principal dimensions of this basin are 50 m x 30 m attached to a 30 m x 3.5 m approach way with 2.5 m of water depth. The most unique feature of this basin is that it is installed with a set of X-Y carriages, i.e., a main carriage which has a 30 m span moves the longitudinal way of the tank, and a sub-carriage which is hanging down from the main carriage moves the transverse way. Therefore, like an X-Y recorder, the sub-carriage can chase the model ship whatever its motion. The basin is also fitted with a hydraulic wave-maker of 50 m length.


## 1. INTRODUCTION

Tokyo University has been planning to construct a new basin to be used for seakeeping and manoeuvring studies. Due to possible allowable limits of funds, the size of the tank was supposed not larger than 50 m x 30 m. Then the size of models suitable for this tank size would be 2 m–2.5 m. Such a size of models will be usually too small to be self-propelled by batteries or a gas-engine. It would be desirable to feed power source to the model by cables. Moreover, it would be very convenient to have a platform always chasing the model which can be used as a reference level in measuring ship motions or ship translations. Taking these conditions into account, it was decided to install a set of x-y carriages: i.e., a main carriage which has a 30 m span moves in the longitudinal direction of the tank, while a sub-carriage which is hanging down from the main carriage moves in the transverse direction of the tank, so that the sub-carriage can chase the model and supply power source or take out signals from the model by connecting wires. This is the most unique feature of this basin. A detailed explanation will be given in the following sections.

## 2. ARRANGEMENT OF THE TANK

The arrangement of the tank is as shown in Fig. 1 and Fig. 2. A square basin (50 m x 30 m) is connected with an approach way (30 x 3.5 m) forming an 80 m straight part. The depth of the tank is 2.5 m and the bottom is precisely levelled for shallow water experiments. On the 50 m (south) side of the tank, a hydraulic wave-maker is installed to create two-dimensional regular and irregular waves across the basin. A line of beach-type wave absorbers is installed on the opposite side of the tank. Two 80 m rails are set on the north side and one 50 m rail on the south side.

A canti-level type high-speed carriage which is mounted on two rails on the north side runs along the longest side of the tank for experiments of high-speed boats. A bridge-type main carriage of 30 m span which is now under construction will be mounted on two rails on the north and the south sides and will run in the longitudinal direction. A sub-carriage which hangs down from the main carriage will move in the transverse direction, forming a set of X-Y carriages. The sub-carriage will be automatically controlled to chase the model or to move

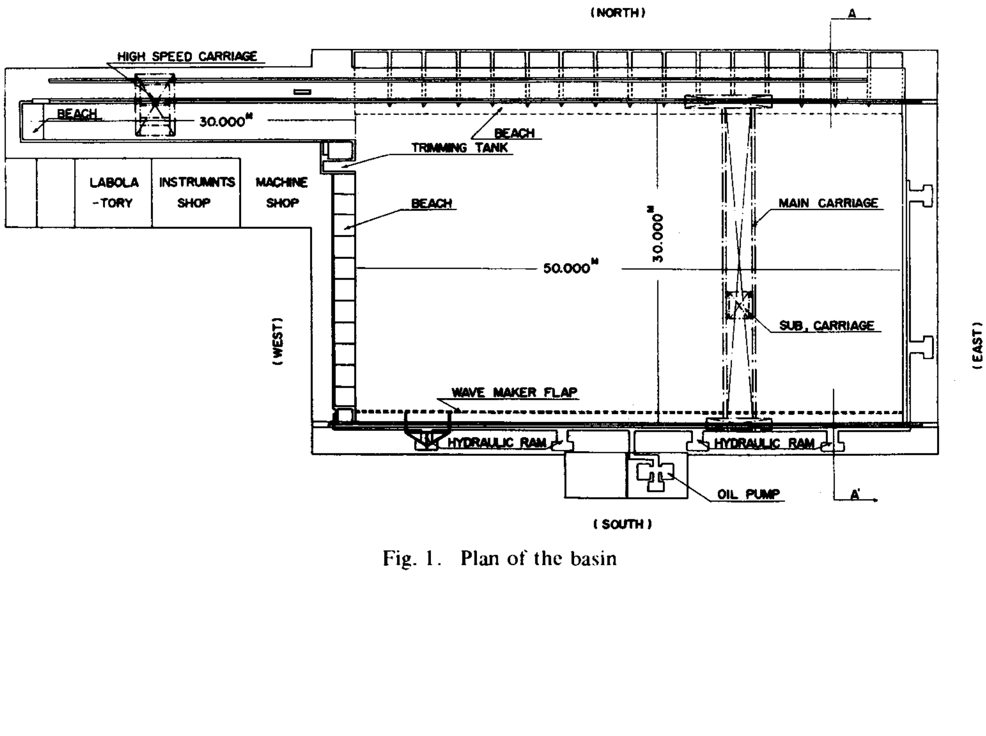


Fig. 1. Plan of the basin

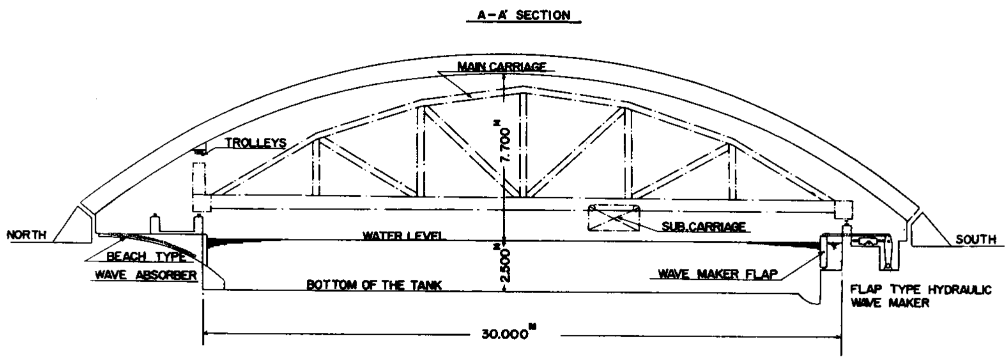


Fig. 2. Side view of the basin

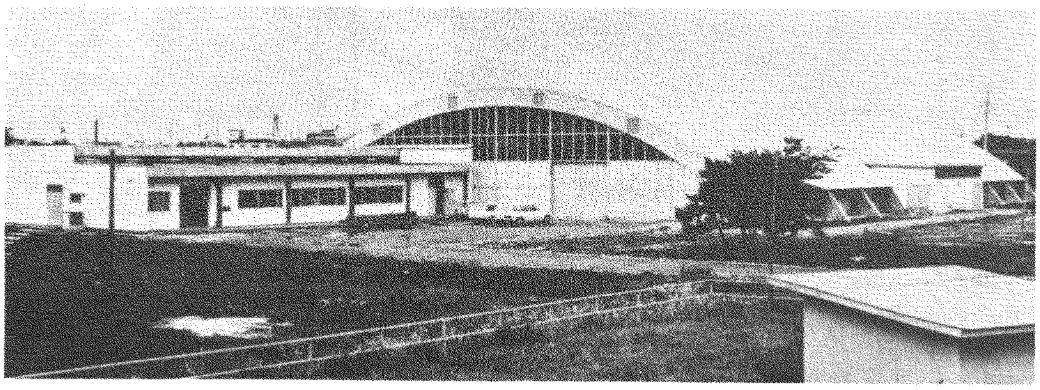

Fig. 3. Outside of the basin

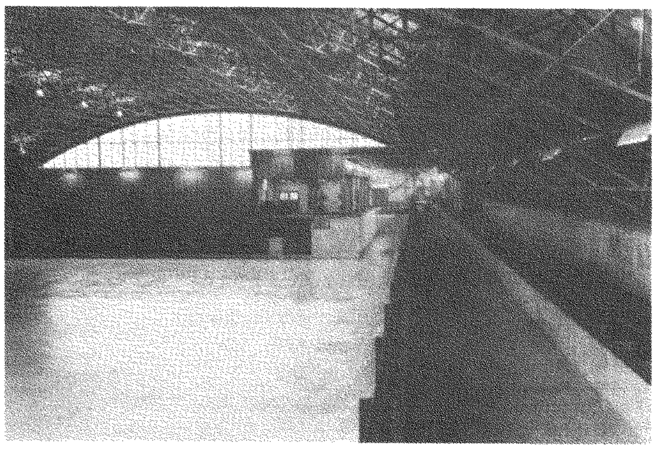

Fig. 4. Inside of the basin (looking west)

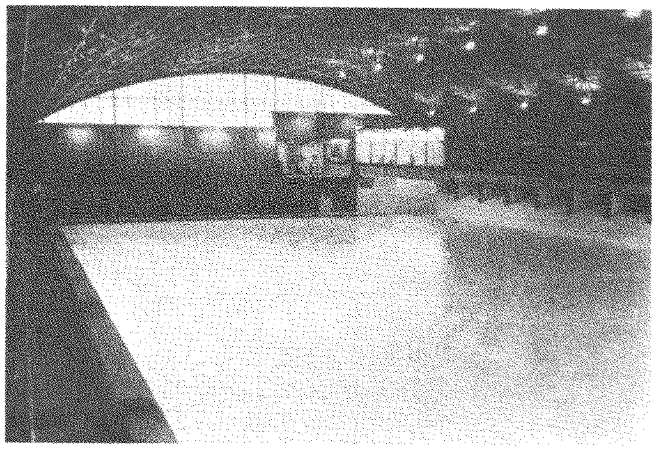

Fig. 5. Inside of the basin (looking north west)

through pre-determined loci. Power source and control signals will be fed to the model by connecting wires and the position and motion of the model will be measured in reference to the sub-carriage. An outside view of the basin is shown in Fig. 3.

The inside of the basin is shown in Figs. 4 and 5. Fig. 4 is a picture looking west. Two rails extending into the approach way can be observed, and the high-speed carriage is at the west end of the rails. Below the rails is the beach-type wave absorber. The space between the two rails can be used for a channel model. Fig. 5 is a picture looking north west. A part of the flap-type wave-maker is observed on the south side. At the north side a part of the beach-type wave absorber can be observed. On the west side another wave absorber for cross waves is observed. This wave absorber will be covered by hinged lids when only two-dimensional waves are created.

## 3. The Main and the Sub-carriages (X-Y Carriages)

The main and the sub-carriages are now under construction, and will be fitted by the end of February, next year.

Particulars of the carriages are as follows:

Table 1.

| | Main carriage | Sub-carriage |
|---|---|---|
| Rail span | 30 m | 2.6 m |
| Length (max) | 7.5 m | 2.4 m |
| Height | 7.7 m | 1.8 m |
| Max. speed | 1.8 m/sec | 1.8 m/sec |
| Max. acceleration | 0.06 g | 0.06 g |
| Control system | SCR analogue control | SCR analogue control |
| Weight | 35 tons | 1 ton |
| Motors | $9_{KW}$ 300 r.p.m x 4 | $0.8_{KW}$ 1,150 r.p.m x 2 |

An outline of the main carriage is shown in Fig. 2. To keep the quick response ability of the carriage, the weight of the carriage is limited as light as possible. Therefore, the deflection of the main girder is about 0.4 mm for the live load of the sub-carriage. This amount is deemed to be unavoidable for the light construction of the carriage. The natural frequency of the vertical vibration is about 8.5 cps and that of the horizontal vibration is about 4 cps. These rather low frequencies are also deemed to be unavoidable for such a light construction. The sub-carriage will be fitted with a small X-Y positioner as shown in Fig. 6. The positioner is designed to chase the model

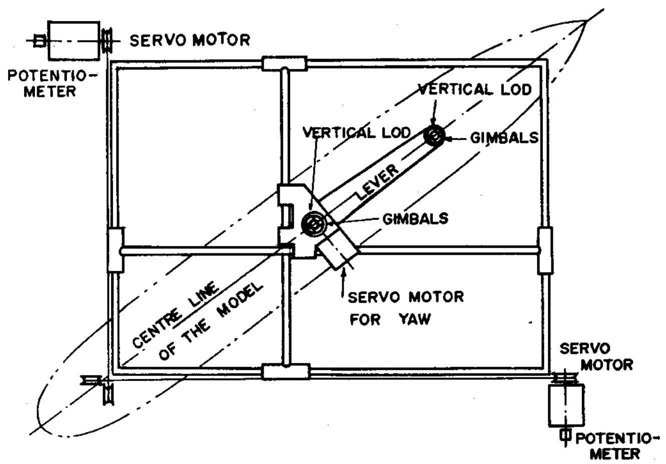


Fig. 6. X-Y positioner

automatically for any motion of the model. In Fig. 7, suppose X is the position of the centreline of the main carriage and Y is the position of the centre of the sub-carriage. Therefore O(X,Y) is the position of the centre of the XY positioner on the sub-carriage. $P(x_1,y_1)$ is the position of the head which chases the model. C.G.$(x_2,y_2)$ is the position of the C.G. of the model in respect to the centre of the positioner. From the head of the positioner (P), a light lod supported by a gimbals hangs down connected to the model at its C.G., allowing angular motions.

If C.G.$(x_2,y_2)$ deviates from $P(x_2,y_2)$, the error signals $(x_2\text{-}x_1)$ and $(y_2\text{-}y_1)$ will be picked up by the angular displacement of the lod and fed into the servo-system of the positioner so that the head (P) follows the C.G. of the model. At the same time, $x_2$, $y_2$, picked up by potentiometers

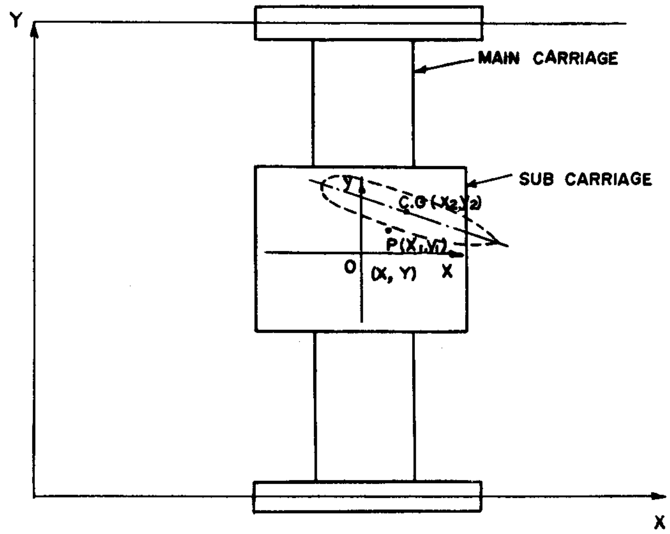


Fig. 7.

attached to the positioner are fed into the control system of the main and the sub-carriages so that the carriages will move to bring $P(x_1,y_1)$ towards C.G.$(x_2,y_2)$. Signals $x_2$ and $y_2$ will be fed into the carriages through filters so that heavy carriages will not be forced to respond to signals of higher frequencies. The XY carriages can also be controlled manually. It will also be possible to drive the XY carriages so that the sub-carriage moves through a predetermined locus.

A horizontal lever which rotates around the vertical lod and is automatically controlled to follow the yaw angle of the model is also fitted to the positioner and feeder cables, and connecting cords are led into the model through this lever without disturbing the motion of the model. $x_2$, $y_2$ as well as X, Y, are picked up by potentiometers and added by an analogue computer and will be displayed in an XY recorder. Heave, pitch, yaw, and roll are also picked up by potentiometers and are recorded in oscillographs.

## 4. High-Speed Carriage

This carriage is designed for testing high-speed craft in waves, particularly in beam seas. As seen in Fig. 4 this carriage is of a canti-level type. Its main particulars are as shown in Table 2.

Table 2.

| | |
|---|---|
| Rail span | 2.0 m |
| Max. speed | 5 m/sec |
| Max. acceleration | 0.08 g |
| Motor | $3.5_{KW}$, 1,150 r.p.m x 2 |
| Control | SCR analogue |
| Weight | 3.8 tons |

## 5. The Wave-Maker

In an earlier stage of design, the wave-maker was designed as a snake-type one driven by low inertia servo-motors. However, due to shortage of funds and some technical difficulties, a hydraulic system was adopted finally. Particulars of the wave-maker are as shown in Table 3.

Table 3.

| | |
|---|---|
| Length | 50 m |
| Depth of flap | 1.55 m |
| Thickness of flap | 0.40 m |
| Power (hydraulic out-put) | 120 KVA |
| Max. thrust | 12 tons |
| Frequency range | 0.3 – 3cps |

Irregular waves can be created by feeding irregular signals by a tape recorder, and linear frequency sweep can be applied automatically to create transient waves. The outline of the side view of the wave-maker is as shown in Fig. 2. To keep the effective breadth of the basin as wide as possible, no wave absorber was fitted behind the flap. Clearance between the flap and the wall of the basin is chosen as 0.60 m. This amount was decided on through a series of experiments. At this amount of clearance, the water pressure due to level change of water contained in this clearance cancels the inertia force of the flap best at a frequency most commonly used.

### 6. Wave Absorber

The wave absorber is of Wageningen beach-type as shown in Fig. 2. To keep the effective area of the water surface as wide as possible, the wave absorber is placed underneath the two rails for the main and the high-speed carriages.

## ON THE ENCOUNTER WAVE RECORDER FOR FREE RUNNING MODEL AND FOR ACTUAL SHIP

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### 1. Introduction

In order to get complete information on the characters of ship responses to the waves, including their phase relations, it is desirable to measure the waves at the position of the ship, namely, to measure the encountering waves from the running ship.

The seakeeping data of actual ships under service on the ocean have been accumulated in our Institute through a series of performance tests of actual ships, the test techniques and instruments being developed and improved gradually, to enable us to get the simultaneous records of many items of responses with increasing accuracy and reliability. However, the most important information on the waves that can be regarded as the input to all of the responses of the ship has not been obtained, as no practical encountering wave meter has been available.

Of course, the Tucker's Wave Recorder[1], which is installed on almost all British Ocean Weather Ships[2] now, is a ship-borne type, and has been used very successfully, the accumulation of the continuous records obtained by this system affording to the oceanographers a precious source from which to establish the wave production theory by winds[3], as well as the spectrum formulation[4] of the ocean surface. However, this wave meter was originally designed to measure the waves from the drifting ship without advance speed, and it is very natural from its working principle to have erroneous results if the measurement is carried out while the ship has an advance speed larger than a few knots. It has been our sincere wish to have some kinds of instrument completed that can measure the waves from the running ship.

It has also been the case with the free-running model ships used in our seakeeping basin, where we have no over-bridge with a following carriage on it, that can be used as the standard to measure the encounter waves.

In this situation, we have been making an effort to develop the techniques that can be used to realize these types of instrument. The supersonic relative wave height sensor[5] used in some actual ship tests, and also a special type of towed raft with rotating wheels with vane, that followed rather nicely to the change of the slope of the surface of the waves, are examples of this effort. The latter was found rather unsuccessful, however, as many difficulties were predicted in realizing the practical instrument to be towed behind a ship at rather high speed, so we gave up this type on the way.

The urgent demand for an encounter wave meter in our seakeeping basin made us realize some types for the models first. After getting a new type of very light, non-contact capacity probe for the wave sensor, we carried out a trial to make one system. After having pretty nice results on this system, we proceeded to develop a system for actual ship use, and after completion we mounted it on the newly built Training Ship "Seiun-Maru", of the Institute for Sea Training, Ministry of Transport. This report on this encounter wave recorder is a preliminary report for information, as the final precise calibration for both systems is not yet completed.

In the course of developing these systems, we found that a very similar wave recorder for ships has also been developed by the U.S. Navy[6], although it has not been published.