159

A wave damping device for model sea-motion tests

Z-159

Dr. Baumann

Schiff und Hafen, 6, 12 (December, 1954) 771

(From German)

Investigations on the behaviour of ships in sea motion can be carried out more cheaply and rapidly by model tests than at sea. Such tests also have the advantage that the desired wave can be produced at any time. In order to provide reproducible conditions, it is very important to be able to destroy the waves at the end of the tank. With the means so far employed (beach installations, damping screens, bars, etc.), however, the effect obtainable is inadequate, since such obstacles reflect a large proportion of the energy. Consequently, there is little agreement between the results of different authors. Allowing the waves to run out into a larger tank is likewise merely an expedient, since damping is no better, the waves are stored in the larger tank to a considerable extent, and after some time return to the experimental tank. In addition, there is reflection at the mouth of the experimental tank into the large tank.

The problem of reflection-free absorption of waves can, however, be solved in a theoretically exact and practically satisfactory manner. For this purpose, the experimental tank should be closed by a mechanism which with respect to the impinging waves behaves like the tank extended to infinity ("matching"). In the hydrodynamic respect, therefore, this mechanism must have a purely dissipative reaction and in addition it must be watertight so that no water can run out.

The simplest construction of such a mechanism consists of a transverse bulkhead mounted on the bottom of the experimental tank and arranged to tilt to-and-fro, the top of the bulkhead being connected to appropriate mechanical elements (springs, weights, damping means). Since the bulkhead cannot be made watertight at the sides without giving rise to troublesome friction, a stationary wall must be fixed at some distance behind it. Adjustment to the incident wave is to be effected as follows:
First the natural frequency of the mechanism (resultant of all inertias and elasticities of the bulkhead, oscillating mass of water, volume of water between bulkhead and back wall and the arbitrarily selected springs and weights) must be made equal to the wave frequency. The sum of all the conservative forces thus disappears and the effect of the system for the wave in question is purely dissipative. Secondly, the damping must be of such proportions that the movement of the bulkhead consumes just as much energy as would be required for wave production in an infinitely long tank.

Such a mechanism (called "wave damper") has been built in the Shipbuilding Institute of Hamburg University in an experimental tank or trough 1 metre wide with a depth of water of 40 cm. The distance between the swing bulkhead and the back wall is 16 cm. Frequency adjustment is effected by hooking cylindrical springs to the bulkhead fixing the frequency of the wave the absorption of which will be optimum. This wave is then adjusted on the wave-maker by means of a stepless gear. Damping is by means of an eddy-current brake consisting of a few copper plates connected to the bulkhead and swinging in the gap of a permanent magnet. The engagement in the magnet gap is adjustable.

The function of this wave damping device has been verified by measurements and hydrodynamic calculations, the details of which may be passed over. The absorption of waves between 1.15 and 1.50 metres long is more than 98%, i.e. due to inaccuracies of a mechanical nature, a wave of less than 2% of the original height is reflected. To improve on this value would require considerable effort not only in the precision of the entire installation but also in the measuring technique.

The physical operation of the wave damping device having now been confirmed experimentally and theoretically, it is possible to proceed to the technical development of an experimental tank for model sea-motion tests and the like. As compared with the provisional damping arrangements mentioned at the commencement, which are theoretically wrong on account of defective matching, three advantages are obtained, namely short experimental tank, any length of test and short adjustment interval between tests. In the practical development, the following will have to be borne in mind:

1. There should be a wave-damping device not only at the end of the tank but also at the beginning, since secondary waves are radiated on both sides from the test object. It is therefore necessary to use a wave-maker, which at the same time will also absorb incident waves. This can be formed from a wave damping device if, for example, the fixed damping magnets are set in periodic motion.

2. In practical operation, not only must the adjusted wave be satisfactorily absorbed, but also waves of adjacent frequency, so that the accuracy of adjustment of wave-maker and damper need not be too high, and so that the long waves always associated with the starting and stopping of the wave-maker will disappear rapidly enough. The method of doing this is to avoid all unnecessary inertias.

SJC/CCB.24.