

THE OCEAN WAVES

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The buoyant effects of the waves in supporting a vessel in a rough sea are of considerable magnitude and must be taken into consideration in ship-building. Therefore, all scientific experiments are of particular interest. Such, for instance are the studies recently carried out on the *San Francisco* of the *Hamburg-Amerika Line* in 1934 under the direction of SCHNABEL during a trip in very severe weather in December 1934 which were summarized in the *Bulletin du Bureau Veritas*. The author has chosen the measurements made on a certain day at 11:40 a.m. because the wave at the moment showed an extraordinarily steep slope. Its length was about 147 metres (529 ft). Naturally measurements made aboard ship can not be as accurate as experiments in the laboratory, but they show a very close agreement on the whole nevertheless.

Two methods were employed to measure the waves: the photo-stereoscopic method which gives the dimensions and heights of the waves at some distance from the vessel in the undisturbed zone; and the direct method of WEISS, which gives the shape and dimensions of the wave outlined along the hull of the vessel with the aid of electric contacts in couples spaced at intervals of 20 metres (72 ft) the vertical distance between contacts being from 0.30 to 0.40 cm. Each of them is connected to a lamp in the central station which is illuminated on contact with the wave.

The lamps in the central station are photographed in such a manner and with such a time scale that the shape of the wave along the hull is known at every instant.

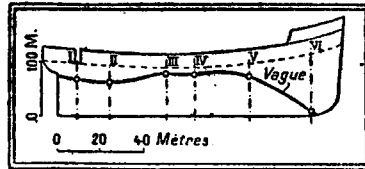


FIG. 1.
Partial profile of wave.

Fig. 1 shows the result of the measurements at a given instant. The diagram cannot represent the complete wave form when the length of the wave is greater than the distance between the two end contacts on the hull. In order then to determine the exact shape use is made of a certain number of diagrams which can be shifted by translation and rotation on the probable hypothesis that the shape of the wave will vary very slightly in a short interval of time.

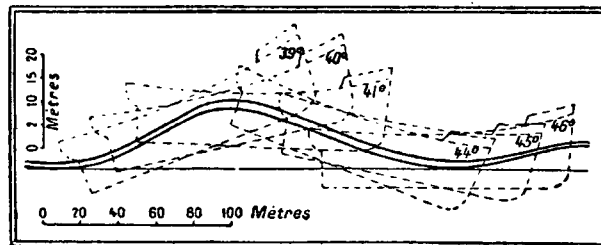


FIG. 2.
Complete profile of wave.

Fig. 2 represents a wave obtained by this process. In order to facilitate the representation the scale of the heights of the wave to length is given in the ratio of 2.5 to 1. The figure shows a wave of 186 metres (668 ft) length with depressions of 12.6 to 14.4 m.; or an average

of 13.5 metres (48.4 ft). The figure needs to be supplemented by a few explanations. Every big wave in a storm has superposed on it a few smaller waves whose velocities are different from those of the large wave, which cause a modification in the shape of the former. In fact the figure does not yield a simple curve but rather a band within which the profile of the wave is comprised.

Slight errors are also caused by the vertical and horizontal distances between contacts as well as the slight modifications due to the reflection of the waves from the hull. To be noted is the extraordinary slope of the waves and the value of the ratio of 13.8 of the length to depth.

By this method we find not only the shape of the wave but the pitching oscillations. It should be noted that in the course of this storm the values of the pitching angles were abnormal and very remarkable.

In order to check these measurements the angles of pitch were measured directly by a gyroscope which registered angles of plus 10° and minus 12°. It was noted that the difference between these two measurements was obtained when the center of gravity of the vessel passed the crest of the wave.

By using this data one may then correct the shape of the wave (Fig. 3). Its mean height is augmented to 14 metres (50 ft) and the ratio of height to length is then reduced to 13.3.

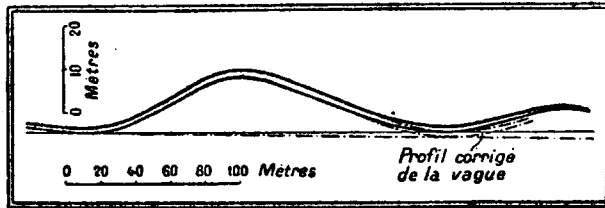


FIG. 3.
Profile corrected in accordance with gyroscopic method.

Although exceptional, such waves can exist in the Atlantic and they must be taken into consideration in the calculations of the keel and hull. It would appear that in the Pacific even larger waves are encountered but up to the present exact measurements on such waves are lacking.

