FIRST APPROXIMATION TO A CONFUSED SEA IN A CIRCULAR MODEL BASIN

by

R. E. Glover

Prepared for David Taylor Model Basin
under
Contract Nonr 1610(02)

Technical Report No. 2

Colorado A and M College
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ABSTRACT

The stresses that a ship undergoes in simple head, following and oblique seas are briefly discussed. The predicament of a ship in a confused sea and the need to model such a situation is mentioned. Subsequently the advantages of a circular wave basin over a rectangular basin for generating a confused sea are emphasized. A typical first approximation to a confused sea, generated in a circular tank, is presented.

A ship is an expensive piece of equipment and for this reason model studies are of value because they enable the designer to determine many of the performance characteristics of a proposed design before funds for its construction must be committed.

If the evaluation of performance is to be useful, it will not only be necessary to build a scale model of the ship which is true to dimensions, but also to provide a model tank and to produce upon the water surface therein waves which will act upon the model in the same way that waves upon the open sea will act upon its prototype. It seems essential also to try to select from among the myriads of wave configurations to be met in the open ocean those which will test the important strength and stability characteristics of the hull most severely. It is important to identify the characteristics which need to be tested and, if possible, to arrange the tests to isolate them in a manner that will not be obscured by irrelevant factors. A type of sea combined with a manner of navigation which will tax most severely a certain strength or stability factor will hereafter be referred to as a "predicament".

It will be worthwhile to list some well known cases as examples:

Predicament 1:- A sea with parallel crests and a wave length approximately equal to the length of the ship combined with a heading which causes the ship to cross them at right angles. This predicament produces the "sagging" and "hogging" condition which puts a severe strain upon the beam strength of the hull.

Predicament 2:- A sea with parallel crests and a wave length somewhat less than the length of the ship combined with a heading which takes the ship across them at an angle. This predicament tests the torsional strength of the hull. At certain combinations of wave length and ship speed it provides a severe test of the rolling stability of the ship as well as a test of the coupling between roll and pitch.

Predicament 3:- A sea with parallel crests and a wave length which has a period equal to the natural rolling period of the ship combined with a heading transverse to the direction of wave travel. This predicament provides a severe test of the rolling stability of the ship.

THE CONFUSED SEA

A type of sea met at times in the open ocean is characterized by a lack of apparent order. It is described as being produced by violent and sustained winds and it is supposed that it is, or can be, produced by a storm of the hurricane type whose winds are violent, sustained and changing in direction. Because of its lack of apparent order it has been described as "confused" although some success has apparently come from efforts to explain its undulations on the basis of a random superposition of waves occupying an entire spectrum of wave length and amplitude as well as a range of orientations. Waves of great height can be encountered in such seas and it is obvious that they can test the structure and stability of a ship severely. It is the belief of this writer, however, that this type of sea can present a predicament which is not met at all or only in milder forms in the regular types of seas. This can be labeled:

Predicament 4:- A confused sea presenting a profusion of surface configurations and a ship heading through them and experiencing violent motions of the type described as pitch, roll and heave so that a fortuitous combination of ship motion and sea surface configuration can conspire to produce situations in which the hull of the ship is brought into simultaneous contact over considerable areas with a portion of the sea surface.

When this happens a very great mass of water must be set into motion. The result is a sudden blow of great violence delivered to the ship. Some idea of the violence of these blows can be obtained from the fact that water pressures up to about 147 ft of water can be developed for each foot per second of relative velocity which must be obliterated at the instant of contact. This is equivalent to about 64 lbs per sq in. for each foot per second of relative velocity obliterated. Such pressures enjoy only a very brief existance but this may be long enough to damage the plating and to set the hull into violent vibration. Estimates based upon the equivalent masses which could reasonably be set into motion in this way indicate that the transient stresses associated with these hull vibrations may approach the magnitude of the bending stress due to the sagging condition previously described. It is possible, of course, that these transient stresses could be added to bending stresses which were already high. An attempt to maintain high ship speeds through such seas could aggravate these difficulties.

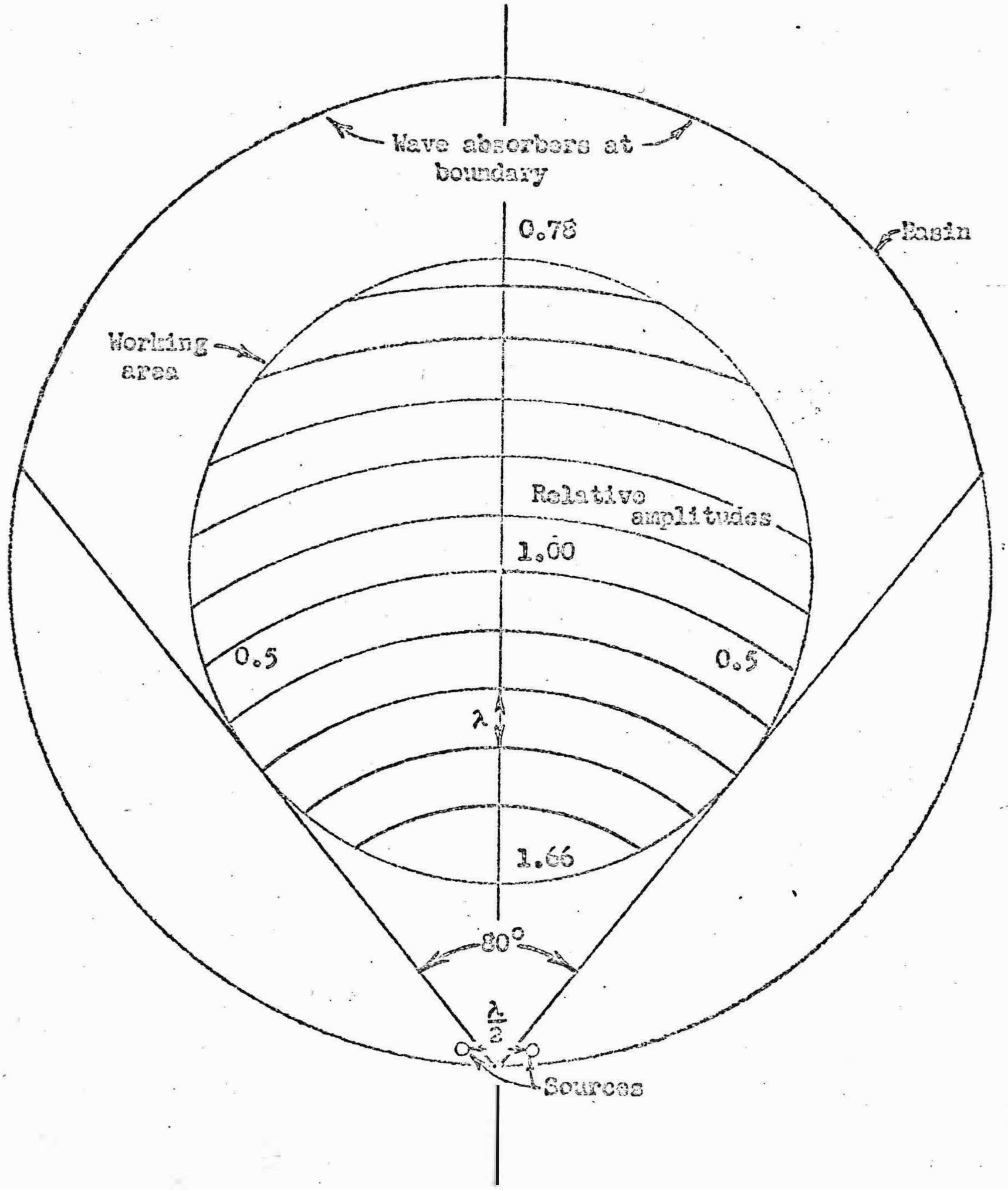
MODEL TESTS FOR THE CONFUSED-SEA CONDITION

It seems obvious that the confused sea condition is an important one and one in which model results would be very valuable if the tests can be properly made. A difficulty arises, however, when an attempt is made to specify and to generate a confused sea in a model tank. Fortunately, it is probably unnecessary to try to reproduce the exact sequence of configurations found at some time on the ocean. The requirements for model testing purposes should be met by a wave combination which will produce dynamical situations on the model scale which are comparable to those to be met by the prototype at sea. A wave system that can be clearly and completely specified is also an essential for model work in order to permit results to be checked.

A circular wave basin offers advantages for making tests of this kind because of the facility with which wave generators can be arranged to command the test area. A sufficiently confused sea can possibly be obtained by superposition of the waves from three wave generators propagating sinusoidal or irregular patterns across the test area which, in this case, would be a circular area in the middle of a model basin.

Computation of the wave pattern from a single wave generator, Fig. 1, shows the type of coverage attainable.

Fig. 2 shows the approximation to a confused, short-crested sea obtained by superposition of three sinusoidal wave patterns. This is the type of sea surface that could be expected over the center area of a circular basin, assuming the three line source generators occupy about 120° of the periphery of the tank and wave absorbers are located along the walls of the basin. This figure shows only the very simple case of three monochromatic waves, one being generated by each generator. A much more irregular sea surface can be generated by programming a less simple but periodic function through each generator. Furthermore, a circular basin is desirable for the generation of short-crested waves because the orientation of the various wave trains can be changed with ease.



Note: Amplitudes are inversely proportional to the square root of the distance traveled.

Fig. 1 Wave amplitudes in a circular tank due to a single wave generator of length $\lambda/2$.

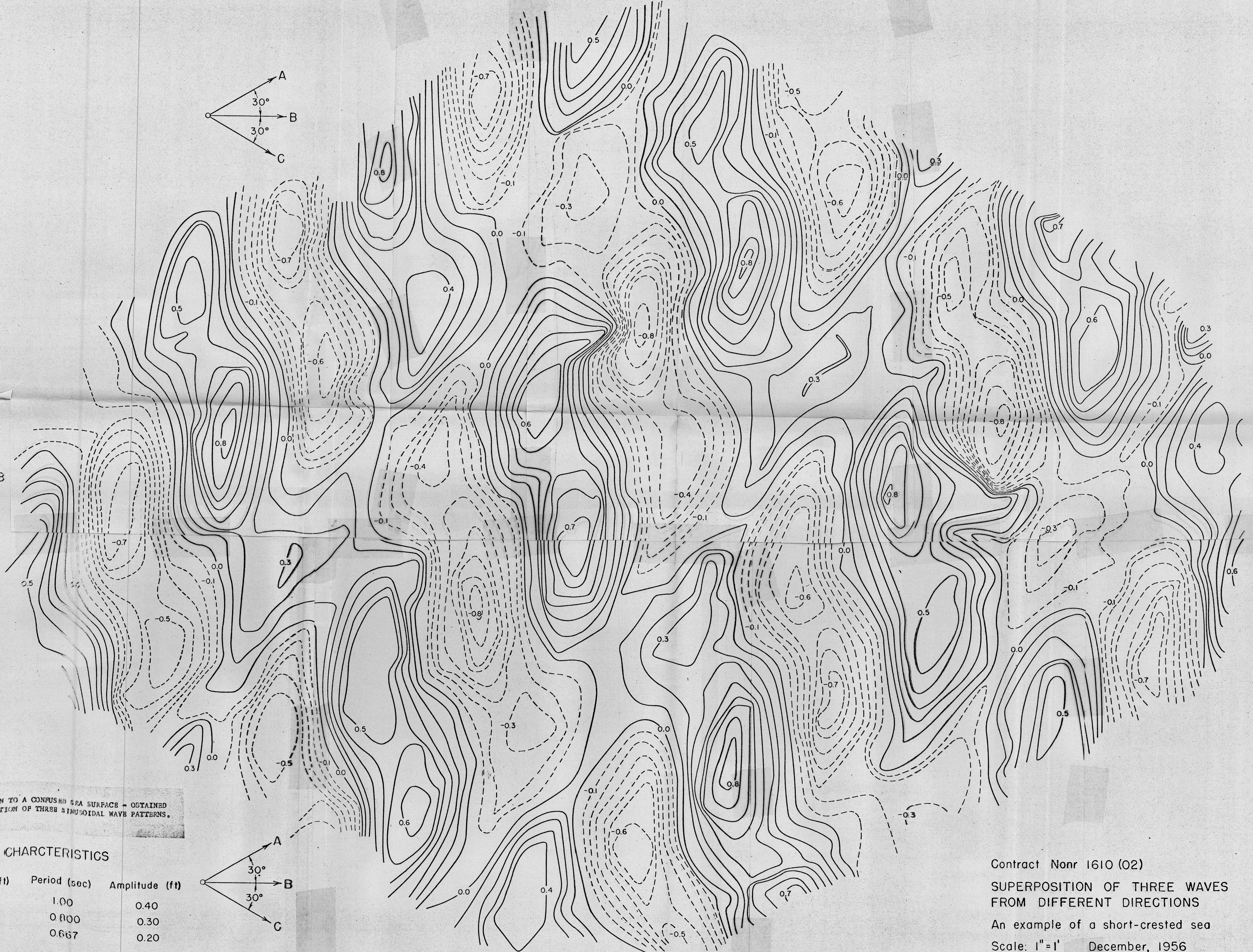


FIG. 2 APPROXIMATION TO A CONFUSED SEA SURFACE - OBTAINED BY SUPERPOSITION OF THREE SINUSOIDAL WAVE PATTERNS.

WAVE CHARCTERISTICS

Wave	Length (ft)	Period (sec)	Amplitude (ft)
A	5.12	1.00	0.40
B	3.28	0.800	0.30
C	2.28	0.667	0.20

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SUPERPOSITION OF THREE WAVES FROM DIFFERENT DIRECTIONS

An example of a short-crested sea

Scale: 1" = 1'   December, 1956