# WAVE MEASURING APPARATUS

## STATEMENT OF GOVERNMENT INTEREST



## BACKGROUND OF THE INVENTION

This invention relates to wave measuring apparatus for determining information relating to waves on the surface of a liquid.

When ships go to sea during extensive sea trials, considerable data is collected which is used in laboratory analysis to determine exactly how the ship behaved during the trials. One of the parameters which must be taken into account is the condition of the sea in which the ship is located. The ship's performance is, of course, affected by the roughness of the sea and thus it is desirable to know the particular Sea State during the trial.

## SUMMARY OF THE INVENTION

Accordingly the present invention provides wave measuring apparatus for determining information relating to waves on the surface of a liquid comprising: a wave buoy capable of providing a signal representative of the motion of the buoy when floating on the liquid; receiving means for receiving said signal; discriminator means having an input terminal connected to an output terminal of said receiving means; integrator means having an input terminal connected to an output terminal of said discriminator means; and indicator means connected to an output terminal of said integrator means to provide an indication of the input therefrom indicative of the said wave information.

## OBJECTS OF THE INVENTION

It is an object of the present invention to provide wave measuring apparatus which may be utilized in at least one embodiment of the invention to determine the condition of a sea, particularly the height of the waves thereon.

## BRIEF DESCRIPTION OF THE DRAWINGS

One embodiment of the present invention will now be described, by way of example, with reference to the accompanying drawings in which:

FIG. 1 is a diagrammatic representation, in block form, of wave measuring apparatus according to the present invention;

FIG. 2 is a diagrammatic representation, in greater detail than in FIG. 1, of the wave buoy used in the apparatus of FIG. 1;

FIG. 3 is a typical static calibration curve for the buoy of FIG. 2;

FIG. 4 is a diagrammatic representation of the noise limit circuit for the receiver of FIG. 1;

FIG. 5 is a diagrammatic representation of the equivalent circuit at the output terminals of the frequency meter unit of FIG. 1;

FIG. 6 is a graphical representation of the transfer characteristics of the frequency meter unit of FIG. 1; gives:

FIG. 7 is a diagrammatic representation of a single integrator stage used in the integrator unit of FIG. 1;



FIG. 8 is a graphical representation of the frequency response of the integrator unit of FIG. 7;

FIG. 9 is a typical wave table of the wind waves at sea;

FIG. 10 shows typical response curves for the integrator stage of FIG. 1;

FIG. 11 is a representation of a typical circuit for the integrator stage of FIG. 1, shown in greater detail;

FIG. 12 is a graphical representation of the results of actual experiments using a function generator, as opposed to the theoretical curves of FIG. 10;

FIG. 13 is a diagrammatic representation of the profile of a trochoidal wave; and

FIG. 14 is a graphical representation of typical wave records.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1 a free-floating accelerometer wave buoy 2 transmits burst of RF signals at an average rate of about 30 bursts/second. The burst or pulse repetition rate, PRR, varies directly as the acceleration applied to the buoy as it moves up and down on the waves 4 of the sea on which it is located. The pulsed CW transmission is received by the associated equipment on an attendant vessel and this is indicated in FIG. 1 as including an antenna system 6 feeding into a receiver 8 for amplitude modulated signals. The receiver 8 provides two outputs, one to an aural monitor 10 and another output along connection 12, the latter output being fed to a frequency meter and discriminator unit 14 and also to an FM tape recorder stage 16. The output of the frequency meter and discriminator unit 14 is fed to a double integrator unit 18 which supplies an output to a wave height indicator unit 20. If desired, the FM tape recorder 16 can be connected, by way of a connection 22 to the output of the double integrator unit 18.

The wave measuring apparatus in FIG. 1 for determining the desired information relating to waves on the surface of the sea is used to receive and record the pulses which are transmitted from the buoy 2. The receiver 8 demodulates the signal and produces DC pulses at the same pulse repetition rate, PRR, as was transmitted from the wave buoy 2. The aural monitor 10 connected to an output of the receiver 8 indicates the presence or loss of the respective RF signal.

The output pulses from the receiver 8 are recorded on the FM tape recorder 16 so as to enable detailed laboratory analysis of the Sea State data to be made at a later time in the shore-based laboratory, since the equipment illustrated in FIG. 1 after the antenna 6 is located on a vessel floating on the sea which is to be analyzed.

The frequency meter and discriminator stage 14 standardizes the width of the DC pulses from the receiver 8 so as to provide real-time monitoring and a simple RC filter at the output of the discriminator converts the standardized pulses to a continuous DC voltage. The amplitude of this DC voltage is thus proportional to the total acceleration of the wave buoy 2. The double integrator 14 converts this analog acceleration signal into a signal which is proportional to the height of the particular waves and the wave displacements are then observed on the output meter 20. If desired, this displacement information could also be recorded in the tape recorder 16 by the connection 22.