Development of a Two-Dimensional Ocean Wave Gauge for Surf Studies

KENNETH LEE JONES, Senior, Enid High School, Enid

(Nolen Harsh, Teacher)

Conventional ocean wave gauges are designed to measure just one maximum water level height in relation to one instant of time. The objective of this research was to develop a cross-sectional or two-dimensional instrument which would record breaking waves progressing past a fixed point. A collapsing crest and its associated cavity could then be accurately represented according to the presence of fluid at different levels extending from the subsurface to above the peak amplitude. Such wave data would prove useful in describing surf dynamics caused by underwater topography.

Design and Development

An ocean gauge was developed that would not be dependent upon an electrolyte to complete an electrical circuit. The conduction-resistance gauge requires a continuous medium in order to register the total height of a passing wave and does not record any cavity envelopes that might be contained in a degenerating wave due to the lack of a continuous medium. Therefore, a system was devised which would function according to the capacitance effect of fluids without regard to conducting characteristics (see Figure 1).

A standard Hartley radio oscillator circuit was designed to operate a few kilocycles above 455 kc in such a manner that the addition of a small amount of capacitance would lower the oscillation to 455 kc. It was found that at least a 5×10^{-5} $\mu\mu f$ capacitance change was needed to make the gauge function.

The oscillating signal was amplified ten times in the oscillator tube (6AW8) and directed into a discriminator. Current was induced in the secondary of the discriminator and distributed to a diode tube (6AL5) only when the input was 455 kc (full capacitance). The resulting current applied a positive 45-volt, d-c potential on the grid of a 12BH7 switching tube. The discriminator was adjusted to feed no voltage to the grid at minimum capacitance. The accelerated flow of electrons which resulted in the tube completed an electrical circuit through a 5,000-ohm plate relay coil with an attached drafting pen for printing. The coil operated with 4 ma and 150 v, d-c, that was derived from a transformer power supply.

A capacitor probe, consisting of two 5- by 40-mm copper plates separated by 4 mm, was connected in parallel to the tank circuit of the oscillator. These plates were coated with a marine resin to contribute insulation from the medium.

Ten identically constructed electrical sections mounted in an aluminum panel for shielding composed the two-dimensional apparatus. An array of ten relays was mounted in a line and chart paper was driven past the pens at a uniform rate. Ten sets of capacitor plates were connected to the oscillators with shielded wire and alternately positioned on either side of a miniature stand to reduce capacitive interaction between probes. The end support columns were filled with a paraffin to prevent liquid contamination.

Thus, a workable experimental instrument was developed which would write on graph paper when a fluid intervened between probes to present a graphical representation of a wave.

Performance Analysis

Since a large-scale wave generation system was unavailable, the miniature probe apparatus inserted in a long, narrow tank filled to a depth of 8 cm was selected to test the experimental gauge. As breaking waves produced in one end of the tank propagated past the capacitor plates, the recording pens responded instantaneously. The sides of the tank, which were constructed of clear plastic, allowed direct observation of the simulated ocean wave. The magnitude and time function represented by the graphed waveforms corresponded very closely to comparison photographs taken of the generated waves immediately prior to entering the probe equipment. Due to the limited size of the model, waves containing measurable cavities were difficult to obtain while destructive interference often resulted between the small wave and relatively large probe; however, sufficient data were obtained to verify the presence of a cavity and the successful operation of the two-dimensional gauge.

Applications

A two-dimensional gauge and probe unit suitable for large tank studies or actual surf usage would reveal new knowledge concerning wave structure. Additional volume, velocity, density, and energy relationships could be established for degenerating waves. Beneficial experiments could be

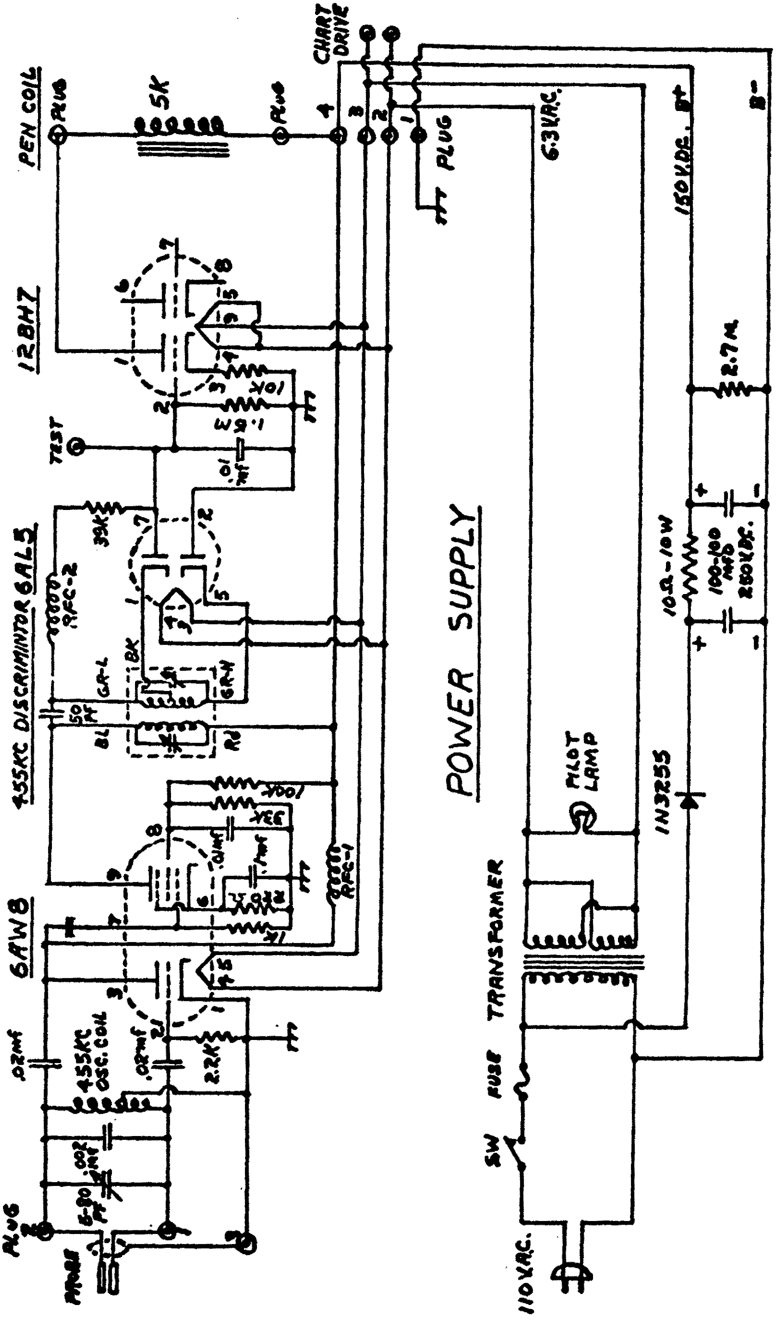

Figure 1. Guage schematic

conducted to determine what type of underwater terrain best diminishes destructive tidal waves. Although the gauge was developed specifically for surf analysis, its performance is not restricted and might be applied to many fluid mechanics problems. For example, if the upper medium of air were replaced by a liquid different from the lower, flow characteristics of the interface could be evaluated provided that the gauge response was adjusted by modifying the capacitor input values according to the dielectric constants of the fluids.

Pertinent Literature

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