PHENOMENA OBSERVED IN CONNECTION WITH RADIO-ACOUSTIC POSITION FINDING AND ECHO SOUNDING. SHIELDING OF THE HYDROPHONES

by

JERRY H. SERVICE, *U. S. Coast and Geodetic Survey*

With reference to the article published in "*Hydrographic Review*", relative to supersonic parasite noises, the International Hydrographic Bureau has received the following communication from Mr. JERRY H. SERVICE :

Referring to the article in the "*Hydrographic Review*", vol. IV N° 2, November 1927 page 157, I am enclosing copies of a few pages from my doctorate dissertation on "*The Transmission of Sound through Sea Water*" at the Ohio State University, June of this year.

I am sending this matter in the hope that it may be of interest to the workers that were being troubled by parasite noises in their supersonic receivers, who are referred to in the article on page 157.

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SHIELDING OF THE HYDROPHONES.

In the first three seasons (winter of 1924, summer and fall of 1924, winter of 1924-25) of radio-acoustic work in the Coast and Geodetic Survey, the hydrophones were mounted so as to be fully exposed to the water and the hydrophone circuit was at most times continually being disturbed by strays of moderate intensity. The writer took part in all of this work and taxed his ingenuity to the utmost in his efforts to eliminate this trouble, which was so serious that it raised serious doubts as to the practical value of the radio-acoustic method.

These strays, or "parasite noises", received the name of "water noises", because some of the associates of the writer believed that they were caused by the roar of the surf on the beach. The writer never held this opinion, but believed that the strays were due to subsurface water currents flowing over the exposed hydrophone; these currents, in addition to the action of the water itself, perhaps cause sand. bits of shell, *etc.*, to strike the hydrophone. Also, the hydrophone current had been observed to "breathe", *i. e.*, increase and decrease slowly in value, which the writer attributed to the periodic changes in the hydrostatic pressure at the hydrophone caused by the passage of surface waves.

It was suggested by Dr. E. A. ECKHARDT that the hydrophone might well be shielded by enclosing it in a perforated metal case. This was tried and effected no appreciable improvement.

In reading "*Mechanical Properties of Fluids*", by DRYSDALE and others, the author came upon an account of the work of BRILLIÉ, in which the latter had found the acoustic resistance of certain kinds of wood to be nearly equal to that of sea water. It occurred then to the writer that if the hydrophone be enclosed in a fairly large, watertight wooden case, as for example a keg, filled with sea water, sound would pass through the wood and reach the hydrophone without attenuation, while the hydrophone would be completely shielded from mechanical disturbances. Some preliminary experiments were conducted by the writer, assisted by ALMON M. VINCENT, Chief Wireless Operator of the GUIDE. These experiments, in which two matched hydrophones were used, one exposed and one sealed in a keg full of sea water, gave very encouraging results. The shielded hydrophone was quite as sensitive to *sound* as the exposed one; the exposed one was subject to strays as usual, while the shielded one was almost entirely free from such disturbances. At the Port Orford station in connection with the 200-mile test run of August 1925, a single hydrophone was used, sealed in the keg used in the preliminary experiments. At Hunter's Cove three hydrophones in parallel were sealed into an oak box made for the purpose. In the box made for the hydrophone at Brookings several one-half-inch holes were bored; it is perhaps significant that the hydrophone circuit at that station was disturbed by strays as usual.

Since that time all the radio-acoustic hydrophones used by the Coast and Geodetic Survey have been sealed into watertight wooden cases filled with sea water, with very beneficial results on the Pacific Coast. On the coast of North Carolina the hydrophone cases did not eliminate the bad strays, because these strays were *sound* and not mere mechanical disturbances.

The writer has made a study of BRILLIÉ's original paper. (*) It is shown that where sound passes successively through three media of acoustic resistances n, n_1, n_2, then if $r_1 = \frac{n_1}{n}$ and $r_2 = \frac{n_2}{n_1}$,

$$(1) \quad \frac{\text{Energy transmitted}}{\text{Energy incident}} = \frac{4\, r_1\, r_2}{(r_1\, r_2 + 1)^2} \quad \frac{1}{1 - sin^2\, a_1\, \dfrac{(r_1^2 - 1)\,(r_2^2 - 1)}{(r_1\, r_2 + 1)^2}}$$

where $a_1 = 2\,\pi\,\frac{l_1}{L_1}$, l_1 being the thickness of the second medium.

If $n = n_1 = n_2$ as when the first and third media are sea water and the second is a material having the same acoustic resistance as sea water, the expression on the right becomes equal to unity and the sound is transmitted without attenuation.

If a_1 is nearly zero, *i. e.*, if the thickness of the second medium is sufficiently small relative to the wave length of the sound, then, as BRILLIÉ points out, we may set $sin^2\, a_1$ equal to zero, and we have

$$(2) \quad \frac{\text{Energy transmitted}}{\text{Energy incident}} = \frac{4\, r_1\, r_2}{(r_1\, r_2 + 1)^2} = \frac{4\,\dfrac{n_2}{n}}{\left(\dfrac{n_2}{n} + 1\right)^2}$$

which is as though the second medium did not exist, *i. e.*, we need not be so careful to have its acoustic resistance near to that of sea water.

It may be stated as a matter of experience that sound from TNT bombs fired under water passes without appreciable attenuation through wooden cases having wall thickness of from one to two inches of any available hard wood; the wave length of the sound is not definite but probably ranges from about fifteen feet to greater lengths. On the other hand, Dr. HERBERT GROVE DORSEY, Senior Electrical Engineer of the Coast and Geodetic Survey, found that wooden planks four inches thick were scarcely penetrable by sound of wave length about five feet.

As BRILLIÉ points out, if the thickness l_1 of the second medium is equal to an exact multiple of half wave lengths, then $sin^2\, a_1$ will be equal to zero and Eq. (2) will apply. It has occurred to the writer that this principle may serve as a means of shielding ultra-sonic receivers from "parasite noises" or strays, where these are due to mechanical disturbances; the wave

(*) H. BRILLIÉ: "*Etude des Ondes Acoustiques. La propagation des ondes vibratoires et l'écoute sous-marine*". Génie Civil, Vol. 75 pp. 171, 194 et 218, August 23rd and 30th, September 6th 1919.

lengths of ultra-sonic energy range from about one-twentieth to one-sixth of a foot, *i. e.* from a little more than one-half inch to about two inches. In the "*Hydrographic Review*, Vol. IV, N° 2 November 1927, is given an account of a considerable amount of trouble being experienced in such a receiver due to "parasite noises". The writer would suggest that if it were feasible to shield this receiver by a case of which the wall thickness is very nearly an exact multiple of the wave length, the "parasite noises", if due to mechanical causes, might be eliminated without appreciable attenuation of the ultra-sonic energy.