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FIRST SUBHARMONIC OF SOUND IN DISTURBED WATER

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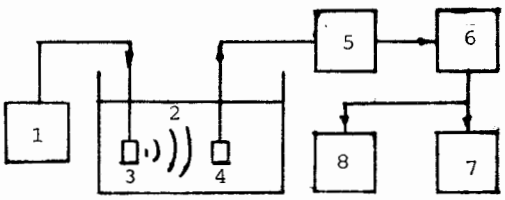
It is shown by this experiment that an appreciable first subharmonic component (one-half of driving frequency) can be observed when a travelling wave of low-intensity sound goes through the disturbed water in a tank.

When a tank containing water was vibrated vertically, Faraday[1,2] observed a standing wave on the free surface whose frequency was only half that of the tank. As other examples, surface waves being incident on a beach from the deep water can excite subharmonic edge waves having a frequency one-half that of the incident wave[3]. If the sound pressure is in excess of a threshold value, bifurcation phenomenon will appear in a vibrating bubble[4-6]. An acoustic cavitation experiment[7] showed that the deterministic chaos can be obtained by period-doubling bifurcation. Recently, experimental observations on subharmonics in liquid nitrogen as well as in air acoustic system have been reported[8,9]. However, all of above works were carried out in the conditions of the static media and high-intensity sound (i.e., the acoustic-pressure amplitude must exceed a threshold value).

Our experiment was carried out in a tank containing tap water when a travel wave of low-intensity sound was generated in it. If the medium is in static state, nothing other than a component of the driving frequency appeared. On the other hand, when the water in tank is disturbed, an appreciable first subharmonic can be observed.

Figure 1 shows the schematic diagram of the experimental system. The size of the tank is $30\times30\times100\text{cm}^3$. The rubber absorbers stand against its walls facing the driving transducer and receiving transducer in order to eliminate the echoes from them. It is shown by the measurement that the reflection losses of the absorbers are not less than 30dB at frequency of 2MHz. Two transducers with diameters of 1cm and 2cm were used as the transmitter and receiver, respectively, and the former was driven by a low-power source (cw or pulse) at frequency 1.948MHz. After passing through a notch filter of the fundamental frequency and a narrow band filter (its centre frequency being 0.974MHz with a bandwidth 39kHz then to an amplifier, the first subharmonic signals were displayed on an oscilloscope.



1. Generator cw or pulse,
2. Tank,
3. Transducer,
4. Hydrophone,
5. Notch filter,
6. Band-pass filter,
7. Oscilloscope,
8. Recorder.

Fig.1 Schematic digram of the experimental system.

Obviously, in this experiment both of the transducers operating on respective frequencies of 1MHz and 2MHz have the same directivity. The beamwidth of the major lobe (from the maximum to the first zero) is about 5°.

During measurements both cw and pulse signals are launched, and the duration of the pulses is 0.4ms. The peak voltage on the driving tranducer V_{pp}=12V in cw, V_{pp}=8V in the pulse operation. The distance between the transducers is about 20cm.

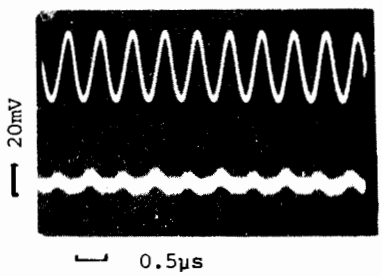


Fig.2

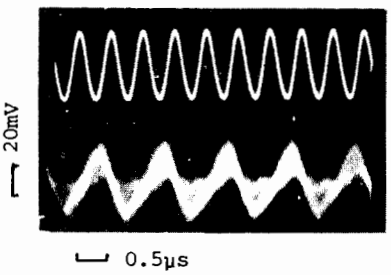


Fig.3

Figures 2 and 3 show the experimental results of the cw signals, when the medium is static (fig.2) and disturbed (fig.3), respectively, and the waveforms of the fundamental frequency and the first subharmonic are given. The ordinate scale of the fundamental and the subharmonic waveforms are 5V and 20mV per division, respectively, and the time scales of them are 0.5μs per division. It is easily seen that in the static medium there are only noise and very low-amplitude fundamental wave, which is due to the sound leak from the notch filter. On the other hand, in the disturbed water an appreciable subharmonic component can be observed. Figures 4 and 5 show the results of the pulse experiments, when the media are in static and in disturbed, respectively. It is worth to notice that there are two pairs of very narrow pulses. A pair of the higher amplitudes are caused by the leading and rear edges of the direct pulse of the fundamental wave, and another pair of the lower amplitudes are caused by those of the reflected pulse from the surfaces of two transducers. The amplitude of the reflected pulse is about 20dB

lower than that of the direct one. In order to remove the reflected pulses, the receiver was deflected a small angle from its acoustic axis. Experimental results corresponding to the static and disturbed medium are shown in the figs.6 and 7. A measurement was carried out to estimate the reduction of the receiving response caused by its off-axis with 1MHz sound signal. It is found that the receiving response decreased by a factor 1.85, when a deflection was made to eliminate the reflected pulses. Comparing fig.5 with fig.7, it can easily be seen that this estimation is in agreement with the measurements. From above results a conclusion can be drawn that a weak reflection may not make a significant contribution to the subharmonic waves.

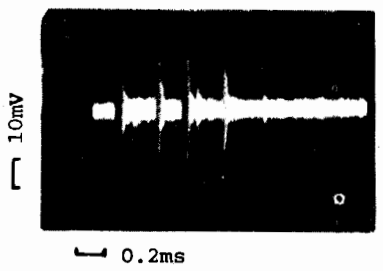


Fig.4

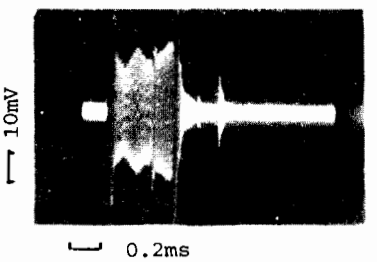


Fig.5

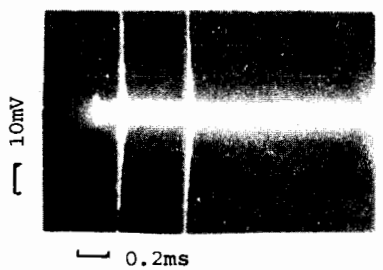


Fig.6

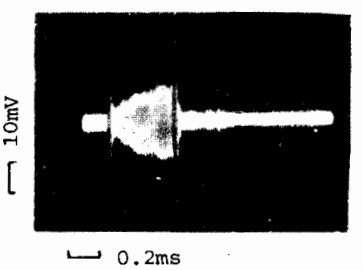


Fig.7

In conclusion the first subharmonic component can be observed in a disturbed water even though a travelling wave is emitted at low-intensity.

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