

VI. PHYSICAL ACOUSTICS*

Academic and Research Staff

Prof. K. U. Ingard
Prof. L. W. Dean III

Graduate Students

R. H. Katyl
J. L. Macon

W. M. Manheimer

J. A. Ross
H. M. Schulz III

A. POSSIBILITY OF ION-WAVE AMPLIFICATION IN A PLASMA

The energy-transfer mechanism proposed by Ingard¹ for the amplification of acoustic waves in a weakly ionized gas has been applied to the amplification of ion-acoustic waves in a fully ionized gas. Of importance in the calculation is the assumption, supported by recent experimental observations,² that the electron temperature remains constant during the period of an ion-acoustic oscillation. If the ions are treated adiabatically except for the coherent heating by the electrons, and if the various possible ion-acoustic loss terms are ignored, an amplification is discovered which is of order T_i/T_e (i. e., of the order of the ion-electron temperature ratio) times the amplification calculated for acoustic waves in a weakly ionized gas having the same electron density and temperature. This result can be understood from elementary considerations, and a note discussing the calculation in somewhat more detail has been submitted for publication in The Physics of Fluids.

H. M. Schulz III

References

1. U. Ingard, Phys. Rev. 145, 41 (1966).
2. I. Alexeff and W. D. Jones, Phys. Rev. Letters 15, 286 (1965).

B. SOUND AMPLIFICATION IN PLASMAS

Preliminary experimental evidence has been obtained in support of the theory advanced by Ingard¹ that sound waves are amplified as they pass through a plasma. This results from an in-phase heating of the neutrals by the hot electron gas. The experimental configuration is the following. A cold Helium discharge at a pressure of 16 mm Hg was maintained in a long cylindrical tube, 2" in diameter, which contains a speaker at one end and a microphone at the other. The speaker is so constructed that the maximum

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(VI. PHYSICAL ACOUSTICS)

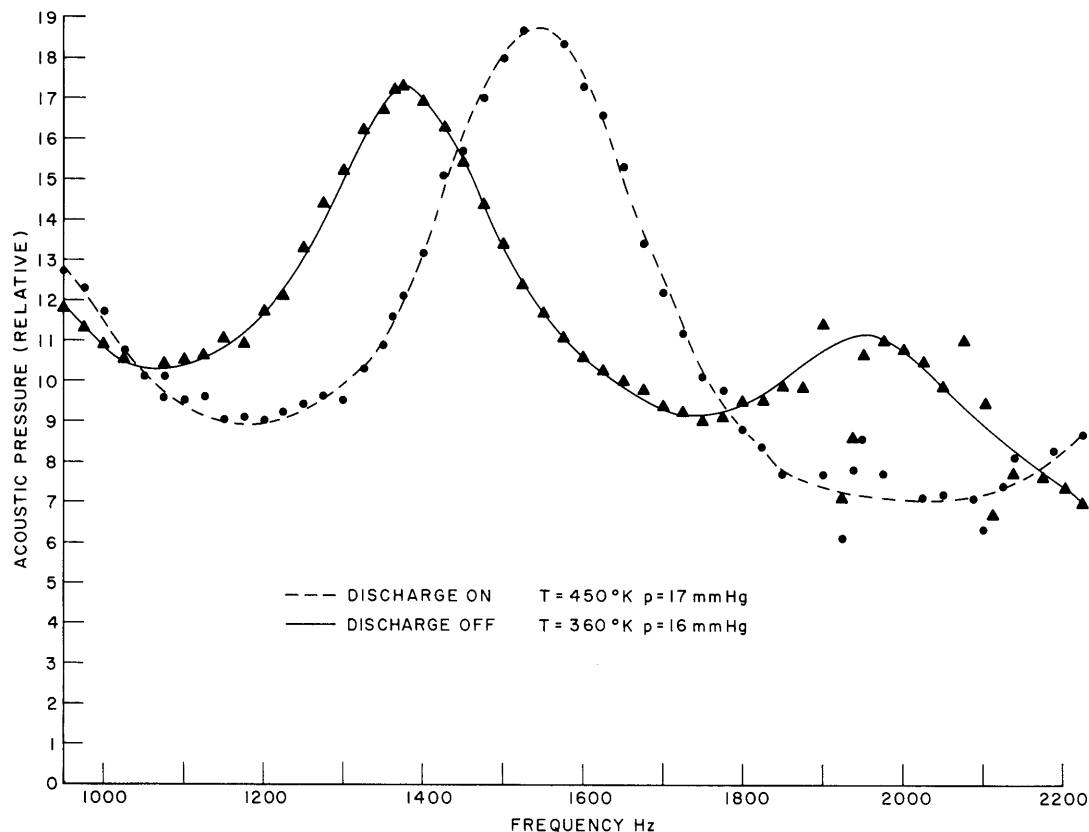


Fig. VI-1. Cavity response vs frequency for a discharge power of 340 watts ($E=1600$ V, $I=210$ ma). Pressure is not calibrated.

displacement of the diaphragm can be measured electronically while it vibrates. This known sound pressure source is then used to excite vibrations within the cylindrical cavity, and the resulting pressure at the other end of the tube is measured. The frequencies used are in the 1-2 kc range.

Figure VI-1 gives the results of a typical set of measurements. With the discharge on, the resonance peak for the second normal mode shifted from 1325 Hz to 1540 Hz. This is caused by the increase in neutral temperature when the discharge is turned on. Of significance is the fact that the peak is higher and the preceding trough is lower for the discharge ON curve. This indicates that the net attenuation rate is smaller with the discharge ON than it is with the discharge OFF. This is presumed to result from the electron amplification.

Details of these results are given in the author's thesis.²

J. L. Macon

References

1. U. Ingard, Phys. Rev. 145, 41 (1966).
2. J. L. Macon, S.M. Thesis, M.I.T., September 1966.