

## **Development of a New Non-Diaphragm Type Shock Tube for High Density Plasmas**

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### **ABSTRACT**

A non-diaphragm type shock tube is being developed for the gas-dynamic laser research. The laser medium is planned to be uniformly heated by a reflected shock wave. The shock wave heated plasma will be expanded through a two-dimensional nozzle to obtain a non-equilibrium state with respect to vibrational levels, and consequently to have the population inversion between certain levels.

### **KEY WORDS**

Shock wave, Reflected shock, Supersonic nozzle flow, Population inversion

### **1 Development of A Non-Diaphragm Shock Tube**

A non-diaphragm type shock tube is being developed for the gas-dynamic laser research.

The shock tube of this type (Fig.1) has been designed to be operated without a diaphragm which the conventional shock tube has in order to separate the high and low pressure regions. By this new scheme, several advantageous properties are expected to be obtained. The vacuum vessel of the conventional shock tube should be opened to atmosphere every time after an each shot in order to replace a diaphragm by a new one. This process always introduces impurities into the vacuum vessel. The reproducibility of experiments sometimes depends on the reproducibility of diaphragm-breaking phenomena. In the non-diaphragm type shock tube, there is no necessity for replacing a diaphragm after an each experiment. Thus, it will be possible to reduce influx of impurities in the experiment. In addition, the reproducibility and the efficiency of experiments may be expected to be largely improved.

High pressure driven pistons in the non-diaphragm shock tube are shown in Fig.2. The cylinder sections C and D are filled with a higher pressure gas than that of the driver room. Since a small pinhole ( $\phi=1\text{mm}$ ) is drilled at the center of the piston B, the pressures of cylinder sections C and D are equal at the initial stage. When the gas is released from the C part through exhaust valve, the pressure of section C quickly decreases. Because of a low conductance through the pinhole between C and D, a pressure imbalance quickly

develops and this will lead the fast movement of the piston B toward left hand side (Fig.3(a)). When the gas in the section D flows out through lateral holes (Fig.3(b)), the pressure imbalance between the section D and the driver room causes a fast movement of the piston A to the left side, and this makes the high pressure gas in the driver room flows into the driven room (Fig.3(c)). Consequently, a shock wave will occur. Several improvements have been carried out in order to have quick movement of pistons, and finally the shock wave propagation has been successfully obtained. The dynamic behaviors of pressure changes caused by the arrival of shock waves have been observed, and the shock wave velocity has been measured by using piezo electric gauges .

## 2 Rapid Cooling of Shock Heated Plasma by Nozzle Flow and Expected Population Inversion

The laser medium is planned to be uniformly heated by a shock wave. After an incident shock wave reaches to the end of the low pressure region, the reflected shock wave will re-heat the incident-shock heated plasma, and a high temperature condition will be sustained for a certain long period. In some cases, the so-called Tailored-Mode operation will be utilized in order to obtain a very long experimental time (Fig.4).

The shock wave heated plasma will be expanded through a two-dimensional nozzle and the temperature will drop rapidly. This may lead to a non-equilibrium state, where the higher vibrational level of the medium has a greater population than the lower vibrational level has. Consequently, the population inversion is generated, and the laser oscillation might be generated (Fig.5, 6).

By using this shock tube, the research for laser oscillations with various medium gases is planned.

## REFERENCES

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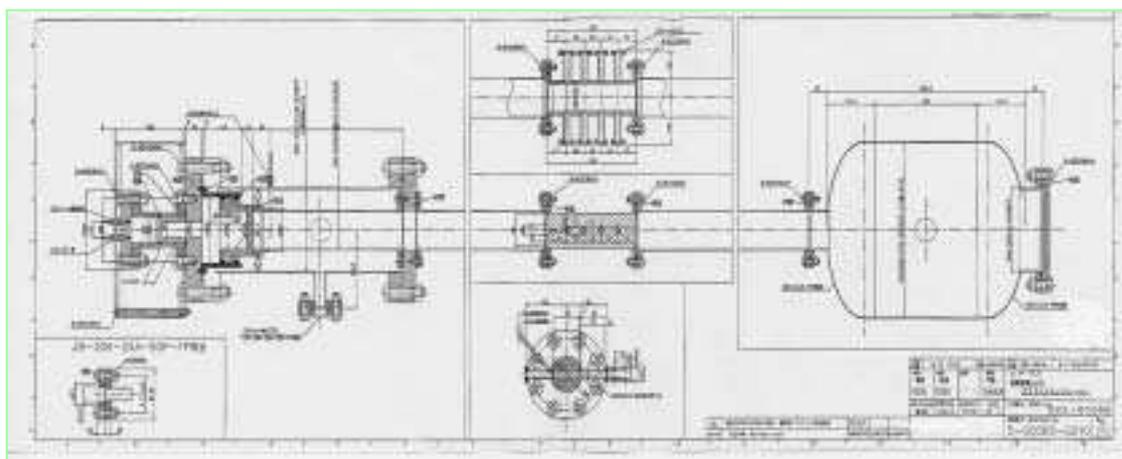


Fig.1 Non-diaphragm type shock tube being developed

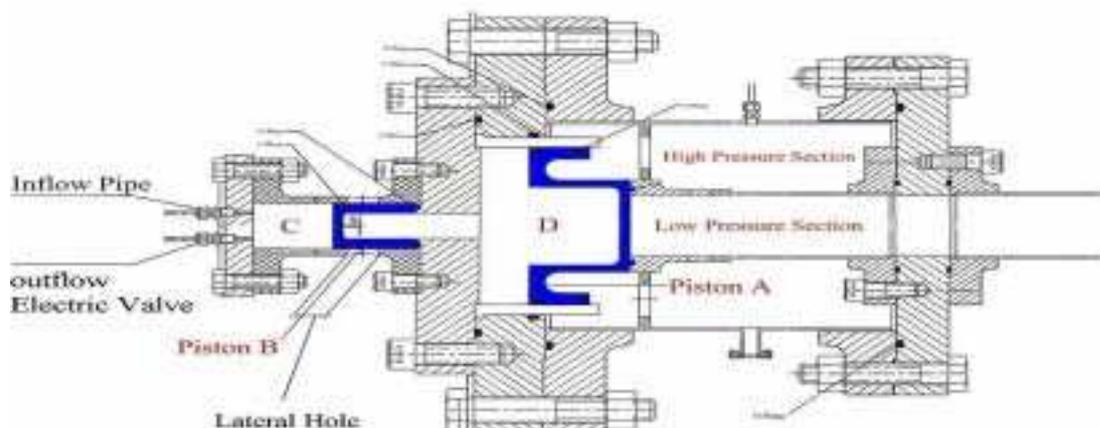


Fig.2 High pressure driven pistons in the non-diaphragm shock tube

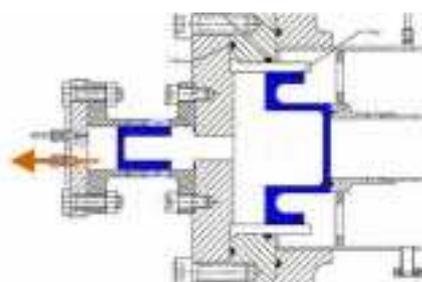


Fig.3(a) The cylinder sections C and D are filled with a higher pressure gas than that of the driver room. Since a small pinhole ( $\phi=1\text{mm}$ ) is drilled at the center of the piston B, the pressures of cylinder sections C and D are equal at the initial stage. When the gas is released from the C part through exhaust valve, the pressure of section C quickly decreases.

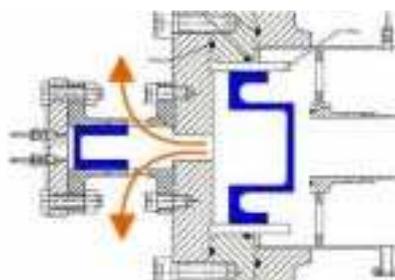


Fig.3(b) Because of a low conductance through the pinhole between C and D, a pressure imbalance quickly develops and this will lead the fast movement of the piston B toward left hand side.

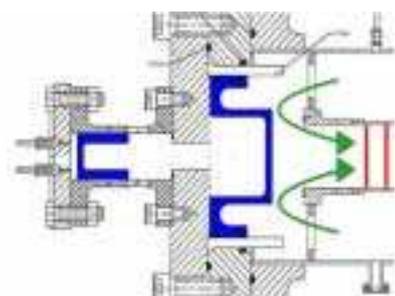


Fig.3(c) When the gas in the section D flows out through lateral holes (arrows in Fig.3(b)), the pressure imbalance between the section D and the driver room causes a fast movement of the piston A to the left side, and this makes the high pressure gas in the driver room flows into the driven room.

