MULTIPLE PULSE SHOCK TUBE

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An explosively-driven shock tube designed to generate a train of airshocks for the purpose of repetitively loading model structures placed beyond the tube end is described. Shock trains can be controlled by the number, size, separation distance, and firing time interval of small explosive charges fired along the centre-line of a tube 298mm in diameter and 12m in length. Planar shocks emerging from the tube exit-plane travel initially at constant velocity by shortening in length until triangular in profile and then the blast wave tends to become spherical. Results are described for a train of five uniform pulses of 128kPa overpressure and 50 kPa-ms impulse. The report concludes that a region of constant peak overpressure can be created at the tube end where impulse diminishes with distance from the tube exit-plane. The unusual properties of this region allow model structures to be studied in response to peak overpressure, impulse, number of pulses, and pulse interval, controlled as independent variables.

Introduction

Blast waves often take the form of an extended pulse containing several distinct shocks or a train of pulses. Examples are blast waves containing pressure peaks from reflections, blast waves from multiple explosions such as linked demolition charges or military bombardment, and blast waves which might possibly occur when assessing risk hazards of distributed explosive storage sites. Pressure-impulse diagrams commonly used to predict damage to a structure in response to a simplified pulse might give invalid results when the blast load takes the form of many pulses. Factors such as the number of pulses and interval between pulses might cause damage independently of peak over-pressure or total impulse of all the pulses. To investigate the influence of such factors, a simple model structure was to be subjected to a variety of waveforms to assess whether the conventional approach to predetermine response needed to be modified. A blast generator was required for this purpose.

A parallel tube was chosen as the most practical basis for the generator with the intention that small explosive charges along the axis of the bore would create pulses of the required duration, interval, amplitude and number. This configuration could provide simplifying conditions such as one-dimensional flow or slab symmetry. However, it was not known whether the profile of shockwaves generated in this way would be suitable. In short blast simulators a plateau in pressure can often be seen behind a shock front before pressure decays. Amann[1]describes techniques to cause pressure to drop immediately behind the shock front. In spherical airblast a secondary shock often appears due to explosive/air discontinuity[2] . The degree to which explosions from points on the centre-line would cause transverse oscillations was also not known, nor whether the tube would modify the pulse train by acting as a waveguide[3].

Practicalities such as being able to use ordinary commercial blast gauges, accelerometers and strain gauges defined the minimum size of a model structure to be tested by blast pulses. The size of this model and further practicalities of the generator itself, such as the use of common hot-wire detonators and being able to interpret results within the range of well-established scaling laws, confirmed the dimensions of the tube as having to be at least several metres long. It was also desirable that the model be placed at the mouth of the tube rather than inside it to provide a relatively free or unconfined field around the model. Shocks emerging from an open tube end can take various forms depending largely on shock intensity. Glass and Sisliant[4] describe a plane shock emerging into the atmosphere, diffracting, decelerating, tending to become spherical, and being followed immediately by an annular vortex. The vortex travels slowly at first and then accelerates, with transverse shocks seen where this occurs. Pennelegion and Grimshawt[5] describe one or more enclosed threedimensional shockwave cells and the formation of a Mach disc strongly dependent on nozzle pressure ratio. Naugolnykh and Ostrovsky[6] describe pulse energy decreasing with distance due to pulse shortening rather than amplitude decay in the context of nonlinear acoustics. Analysis of such processes, complicated by the evolving profile of shock waves, was impractical. The only way to find out how such a tube would behave was to build and test it.