Preface

Various types of mass accelerators have been developed worldwide in the past, based on different principles. In the early 80s Professor Abe Hertzberg, at that time a professor at the University of Washington (UW) in Seattle, USA, proposed using the Ram accelerator concept for accelerating projectiles to hypersonic velocities. This concept starts with a tube filled with compressed combustible gas mixture equipped with membranes to close both the tube ends. The projectile was injected into the tube at a supersonic speed relative to in-the-tube-gases. The combustible gas was ignited by the high temperature gas generated behind the shock wave located in vicinity of the projectile leading edge. The significant temperature increase is associated with an increase in the gas pressure needed for thrust production. On the other hand, the best known accelerator is the powder gun; the maximum achievable speed while using the powder gun is moderate because of the heavy powder gases in comparison with the light gas used in hypersonic accelerators where hypervelocity speeds in the range of several km/s are reached.

In the present volume numerous descriptions of Ram accelerators are presented as well as descriptions of light gas guns and a ballistic range including explanation of shock waves in solids. These descriptions provide a good overview of the progress made and the present state of the Ram accelerator technology worldwide.

In a light-gas gun (using helium gas), projectile velocities ranging up to 7 km/s are theoretically attainable. Such facilities are mainly used for studying projectile impact on investigated material. Typical examples for impact investigations are comets or asteroids penetrating into the Earth’s atmosphere and their final impact on the Earth.

The usage of Ram accelerators is relatively new in comparison with the development of the light-gas gun and the electromagnetic accelerator, i.e., the rail gun, and its operation is still in the development stage. Many Ram accelerator facilities have been built around the globe, some having small tube calibers and some with large caliber, up to the 120 mm pipe diameter at the Army Research Laboratory (ARL) in Maryland, USA. Smaller Ram accelerators were developed at the French–German Research Institute of Saint-Louis (ISL), France: one having a

30 mm caliber and another with a 90 mm caliber acceleration tube. Additional Ram accelerators were built in Japan, at Tohoku University in Sendai with a 25 mm rectangular cross-section. In China, at the China Aerodynamics R&D Center (CARDC) a 37 mm bore accelerator was tested. Different approaches have been used: (a) where the projectile is guided by fins in a smooth pipe and (b) where the projectile is centered by rails fixed within the tube. In both cases a gap exists between the projectile and the tube.

As of today, in spite of all efforts made, the maximum projectile velocity has not exceeded 3 km/s. Therefore, the goal to reach orbital speeds has not been realized. The reason for this failure is the fact that the projectile material quickly burns up while reaching the needed high combustion temperatures required for projectile acceleration inside the Ram tube. As a result, many research institutes and companies decided to freeze their investigations of Ram accelerators at the beginning of 2000. However, some experiments have been carried out at a low level even thereafter. This lull did not involve the theoretical investigations. For example, at the National University of Seoul in Korea, numerical investigations of the combustion dynamics in a Ram accelerator are conducted and their findings are reported in this volume. Hopefully, a rebirth of the Ram accelerator concept will take place in the near future when new materials that can withstand the high gas temperatures without ablating will be found. Should this be the case, the dream of Prof. Hertzberg could be fulfilled: Using the Ram accelerator as a device to launch a capsule into orbit or to other planets. As noted, the biggest problem in reaching the desired projectile speed is the projectile material. The early projectiles were made from magnesium in order to save weight. The high combustion temperatures associated with high heat transfer into the magnesium resulted in melting and ablation. Thus, the projectile guidance became more and more difficult and eventually failed. In the next step, projectiles were made of aluminum. Ablation was lower, but still very problematic. Also, projectiles made of titanium, iron, and composite materials were tested in various Ram devices.

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