The Development of U.S. Missiles During the Cold War

An Online Continuing Education Course for Engineers

Course Number: M-1047

Credit: 1 Hour / 1 PDH / 1 CPD

The Development of U.S. Missiles During the Cold War

Eric Myers, BSME

Overview

This publication provides a short history of introductory information on ballistic missiles developed by the United States military including reference to the "space race" competition between the United States and Russia during the "Cold War". It features easily understood insight into the operation of rocket engines and the early stages of development of the Atlas Intercontinental Ballistic Missile System (ICBM), the first that was developed by the U.S. It also describes other U.S. missile programs and their deployment across the United States and Europe to combat the Russian threat. It concludes with a sometimes serious, sometimes humorous narrative by the author of his life as a Flight Test Engineer at Cape Canaveral, Florida. He describes his experiences working on the Atlas ICBM test stands and taking part in Atlas missile launches during its early stages of development. This publication was written for the interest and enjoyment of the average reader who might be interested in the "space race" through the eyes of a young engineer, fresh out of college, who had a small role in it. It includes eleven illustrations, several of which are full size photographs of Cape Canaveral missiles and missile launches from the author's personal collection.

Background

During World War II the United States and Russia fought as allies against Germany and Japan. After the war, the U.S., tired of the ravages of international conflict, greatly reduced its armed forces while Russia kept the bulk of its huge army active and forced Eastern European nations to join the Communist bloc. The term "Cold War" was used to describe the relationship between the U.S. and Russia because, although they regarded each other as enemies, there was no open warfare between the two. Behind the scenes both governments engaged in intense scientific research in the development of nuclear weapons and the means of delivering them over the vast distances that lie between the two countries. It was for this reason that in October 1945 the U.S. Army Air Force requested industry proposals for missile systems to deliver warheads as far as 6000 nautical miles (5200 statute or land miles).

Following the presentation of information on ballistic missiles, there is included a first person account by the author of his sometimes serious, sometimes humorous experiences as a Flight Test Engineer at Cape Canaveral, Florida on the Atlas Intercontinental Ballistic Missile System during its early stages of development.

Introduction

This publication is intended to provide introductory information on ballistic missiles developed by the United States military. The flight of a ballistic missile resembles that of an artillery piece where the projectile is given an initial thrust out the barrel and then coasts in an arced trajectory to its target. A ballistic missile used for military purposes is given an initial thrust from its engines and then coasts to its target in a similar curved path. Initially, U.S. missiles were designed after the German V2 rockets whereby a kerosene-like fuel and a liquid oxygen oxidizer were used as the propellants. Later, more advanced liquid and solid propellants were developed. The long range ICBMs have the capability of reaching most targets anywhere on the globe from bases in the U.S. The Medium Range Ballistic Missiles (MRBM) have the capability of hitting enemy targets from bases located in friendly countries in Europe. Short Range Ballistic Missiles (SRBM) were issued to combat troops for use on the battlefield. There is good reason to believe that ballistic missiles had a large part in preventing the outbreak of World War III.

Rocket Engines

A rocket is an engine that produces more power than any other engine known. The word "rocket" is also used to describe the vehicle that is powered by a rocket engine. The Chinese used rockets against enemy soldiers in the 1200s. In the war of 1812, British soldiers used rockets to attack Fort McHenry, Maryland. Francis Scott Key while watching the battle wrote "the rockets' red glare" which is contained in "The Star-Spangled Banner", the United States National Anthem. “Missile” is also used to describe the vehicle that is powered by a rocket engine. Missiles are used for military purposes as well as to carry people and scientific equipment into outer space for peaceful means.

Rocket engines are internal combustion engines that rely on the production of high pressure gases from the chemical reaction of a fuel component and an oxidizer component to provide propulsive force. There are two kinds of rockets that are used on most missiles and spacecraft today: liquid propellant and solid propellant. Liquid propellants require proportionately large tanks, pumps, and plumbing systems to store and deliver the contents to a combustion chamber where the fuel and oxidizer are mixed and ignited by an electric spark. In the case of hypergolic (self-igniting) liquid propellants, the two components ignite on contact. Solid propellants have the fuel and oxidizer mixed in granular form. The grains are packed inside a cylindrical casing that has a hollow core extending down the center where the combustion takes place. The high temperature gases from the combustion of the grains flow into a nozzle which converts high temperature, high pressure gas into very high velocity gas-the reactive force of which propels the vehicle. (See Figures 1 & 2.)

Figure 1. Schematic Rocket Engine Liquid Propellant

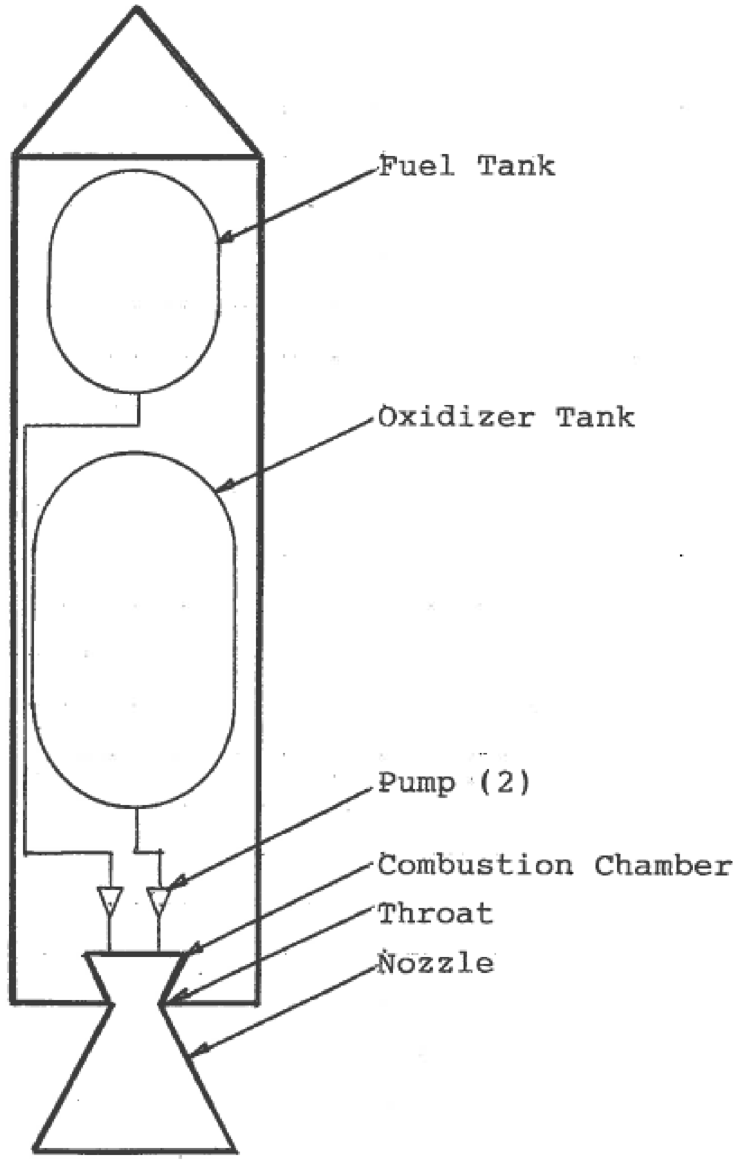
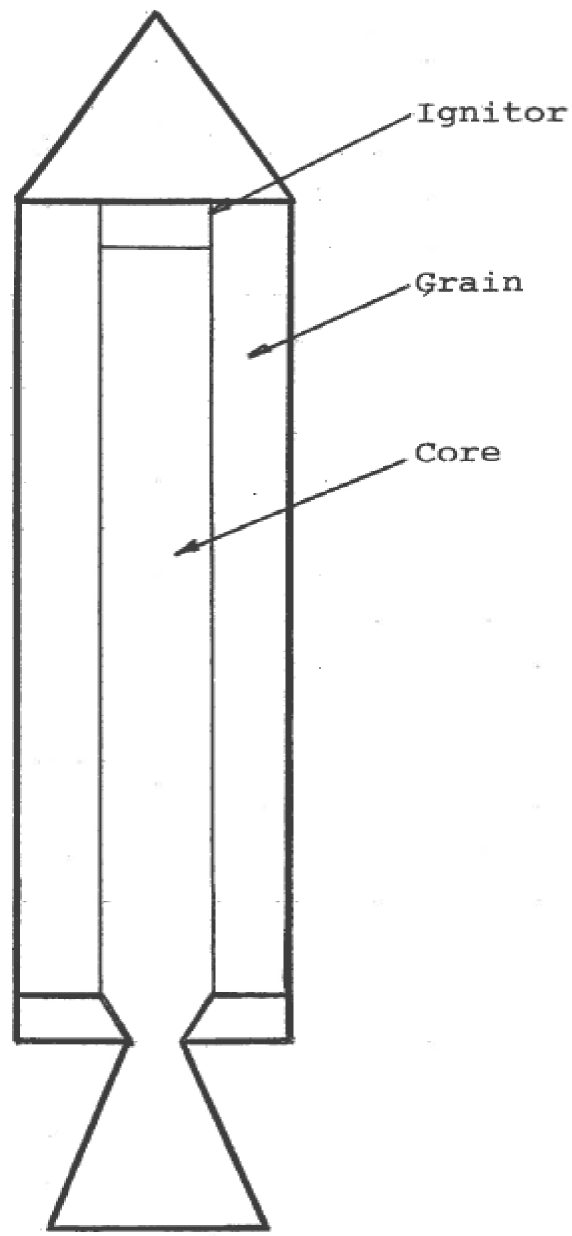


Figure 2. Schematic Rocket Engine Solid Propellant

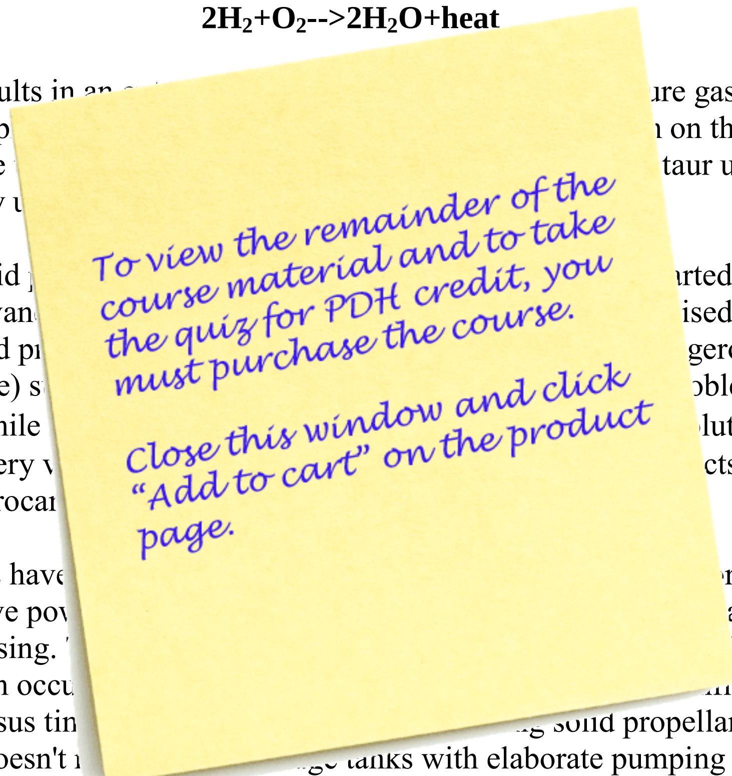


Rocket Engine Propellants

Most U.S. missiles use RP1 and liquid oxygen (LOX) as the propellants, the same used in the German V2 rockets. RP1 is similar to kerosene which is distilled from crude oil and is a mixture of various hydrocarbons. Hydrocarbons, as the name suggests, are hydrogen-carbon compounds which when mixed with LOX and ignited produce heat, carbon dioxide, and water. Liquid oxygen is obtained from distilled liquid air. Air is liquefied by lowering its temperature to minus 310Fº. The most powerful liquid propellant combination is liquid hydrogen (LH2) and LOX. Bulk quantities of LH2 are produced from natural gas. LH2 and LOX burn clean giving off only water and heat as the by-products. The chemical equation is:

$$\mathbf{2H_2+O_2\text{-->}2H_2O+heat}$$

This combination results in an ... ure gases making it the most powerful of all p... n on the moon and the space shuttle both use ... taur upper stage vehicle which was previously u...



An advantage of liquid ... rted in space while some of the more advan... ised and lowered). A disadvantage of liquid pr... gerous cryogenic (very low temperature) s... oblems. Oxygen liquefies at -316Fº while ... lute zero (-460Fº). Liquid hydrogen is very v... cts violently when in contact with any hydrocar...

Solid fuel propellants have ... rm. The grains burn with an explosive pov... acked inside a cylindrical shaped casing. ... the grain pack in which the combustion occu... figured to produce the desired thrust versus tin... solid propellants is that the engine is simple. It doesn't ... tanks with elaborate pumping and plumbing systems. The disadvantage of using solid propellants is that they don't burn as efficiently as liquid propellants and they can't be stopped and restarted in space. They essentially burn until all the fuel is consumed.

Another advantage of using liquid propellants over solid propellants is that liquid propellants have a higher "specific impulse" than solid propellants. Specific impulse can be defined as how long a rocket engine can produce a given amount of thrust using a given amount of fuel. Pound thrust is a measure of how powerful a rocket engine is while specific impulse is a measure of how efficiently it operates. An analogy can be made to an automobile engine where horsepower is a measure of engine power and miles per gallon is a measure of how efficiently it operates. In an automobile, a high powered engine is not too practical if it gets only a few miles per gallon of fuel. The specific impulse of some of the more advanced solid propellants is 265 seconds while the specific impulse of RP1/LOX is 330 seconds and the specific impulse of LH2/LOX is 450 seconds.