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High-Energy Launcher for Commercial Transportation to Space

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Abstract

THE Space Shuttle with its winged Orbiter has paved the way for a further advance toward economical space travel. Since the Orbiter and its wings are designed for the dynamic pressures and heat loads of re-entry, they could also be used for lift during the acceleration to orbit. By using lift, nearly all of the acceleration of a space transporter could be in the direction needed for Earth orbit, i.e., a horizontal direction.

In the search for methods for economical transportation to space, it is important to keep in mind the overall goal. This is to accelerate a space shuttle to about Mach 24 in a tangential (i.e., horizontal) direction to Earth as efficiently as possible. In this regard, there is one combination of methods that has not been discussed in the literature. This is the use of a high-energy, inclined, ground-based launcher to accelerate a space shuttle to a speed where ramjet engines can produce sufficient thrust to continue the acceleration up to about Mach 6. Above Mach 6, scramjet engines would be used, as long as advantageous, prior to using rocket engines for insertion into orbit.

As can be determined from Ref. 1, a ground-based launcher will increase the propulsive efficiency over that with either rocket or turbojet engines during the initial acceleration. As shown in Ref. 2, ramjet engines are considerably lighter than turbofan or turbojet engines. As discussed in Ref. 3, scramjet technology has now been developed to the point where a large vehicle application is needed as a focal point for further advance.

This combination of methods will provide excellent propulsive efficiency, and it will make maximum use of air augmentation which will greatly increase the specific impulse over that of rocket engines. This in turn means a very significant reduction in the gross takeoff mass of future space shuttles. An indication of the possible advantage of this concept can be obtained by extrapolating the conclusions of Ref. 4. This possible reduction in gross takeoff mass, along with the relatively low cost of ramjet engines and the possibility of designing a launcher with about a forty year life with low-operating costs, provides a potential for high-volume, commercial transportation to Earth orbit.

As a first step, an inclined, ground-based launcher, which would use stored, compressed air for accelerating a winged, space transporter to a speed of 0.4 km/s and an altitude of between 150 and 300 m, is described. At this speed, it is assumed that the acceleration could be continued solely by the thrust of ramjet engines.

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Launchers are not new. They have been used for many years to make the takeoffs of high-performance aircraft from ships possible. Also, the Polaris and Trident missiles are started on their way by launchers. What is new about this launcher is its much larger size and much higher launch speed.

The shortest length launcher would be obtained by accelerating at the maximum value (i.e., 3 g) throughout the launch. But at a constant 3-g acceleration, it takes a distance of 2.7 km to get up to a velocity of 0.4 km/s. By present standards, this is a long distance to have to exert such a large force.

Another consideration is the protection of the environment. If at all possible, noxious gases should not be released during or after the launch.

One way of making a long launcher, which would not release noxious gases, is to use stored, compressed air to drive pistons which are inside of pressure tubes. Relatively large pistons are needed to generate the necessary force while maintaining the maximum local pressure sufficiently low so that dynamic lubrication systems can prevent metal to metal contact. From symmetry considerations, the lowest number of pressure tubes that would be required is two. This results in the configuration shown in Fig. 1, which depicts the principal components of this 2.7 km long launcher. There are at least two methods for transmitting the required force from the pistons inside the pressure tubes to the launch bar which is outside of the pressure tubes. The launch bar would push the space shuttle up an inclined slope. The dynamic lubrication system, which would prevent metal to metal contact, is not shown in this simplified view. The support wheels, which are shown, would only be used during the initial part of the aceleration. After attaining a nominal velocity, the entire configuration would be supported by air lift, so the wheels would not be used at high speeds.

A pressure differential of 6.9×10^5 N/m^2 acting on two pistons 9 m in diameter will provide a gross force of about 90×10^6 N. This will be sufficient for a 3-g acceleration through Mach 1.0. The required amount of air would be released from the storage compartments into the pressure

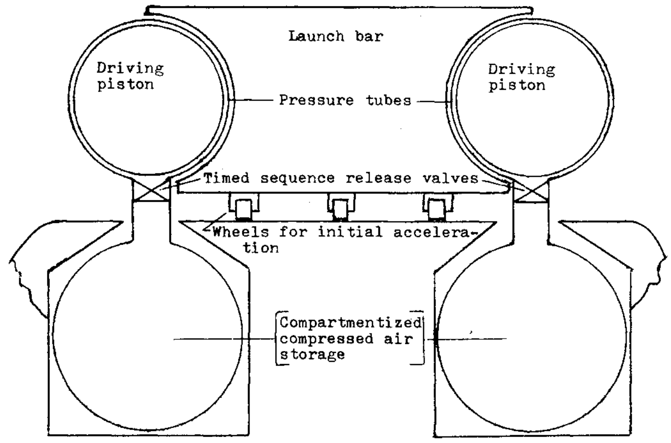

Fig. 1 Principal components of the high-energy launcher.

tubes when needed by timed sequence release valves. Enough compressed air would be stored in each compartment so that it could continue to supply air throughout the launch. In this way, a sufficient pressure differential could be maintained to accelerate the craft through the speed of sound. The situation at this point would be somewhat like a very large model in a transonic wind tunnel. The launcher structure would be designed to accommodate the forces due to transonic ground effects. In order to alleviate the ground effects on the craft after it leaves the launcher and in order to have the craft at the desired climb angle, the slope of this launcher would be upward at a constantly increasing angle up to the point where sonic velocity is attained. From that point on, the slope would be constant at a value around 15-20 deg, and the craft would be between 150 and 300 m above the ground at the end of the launcher. When the base of the launcher is at sea level, the dynamic pressure on the craft at launch will be about 96×10^3 N/m^2. This should be sufficient to insure reliable operation of the ramjet engines.

This mode of operation will make a sonic boom corridor mandatory for the first part of the acceleration and climb. Since both of the present U.S. spaceports are on a seacoast and are designed for over-the-ocean launches, this should not be a significant deterrent to this type of space shuttle operation.

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