

## THE TALOS BOOSTER ROCKETS

Major problems had to be solved before solid booster rockets could be produced in the size required for Talos. Five years after booster rocket development was started, booster technology had reached a level where propellants and metal parts could be tailored confidently to meet the Bumblebee Program needs. The first Talos missile was launched in 1952.

As with other parts of the Talos program, the development of rockets to accelerate a 2000-pound ramjet missile to supersonic flight speed in a few seconds required major strides into unexplored areas of technology. In 1945, only the newest types of military rockets in production were capable of attaining supersonic speeds, with payloads generally a minor fraction of rocket weight. With the freedom then available to engineer, plan, and carry out development programs, it was possible to accomplish the ramjet booster rocket objectives in only 2½ years.

As an interim measure, existing rockets were used for launching the 6-inch-diameter Cobra ramjet, the Control Test Vehicle, and the Supersonic Test Vehicle. A group of rockets, arranged in a cluster and manifolded at the forward end to equalize thrust, was used in each application. For example, four (and later six) high velocity aircraft rockets were used to launch the Cobra, four British UP-3 rockets for the Control Test Vehicles, and four T10E1 rockets (developed by Division 8 of the National Defense Research Center) for the Supersonic Test Vehicles. On the whole, these clustered boosters proved adequate, although their low impulse-to-weight ratio and the necessity of relying on the uniformity of thrust of the individual units made extension of this design to the larger vehicles and service missiles highly undesirable.

### INDIVIDUAL PROBLEMS

Three major problems required solution before solid rocket boosters could be produced in sizes required by the missiles envisaged in the Bumblebee Program. The status of rocket development in 1945 is summarized in Refs. 1 and 2. The problems were: (a) the development of techniques for producing propellant grains<sup>3</sup> in sizes five to ten times larger than those used in the ongoing production of rockets,<sup>4</sup> (b) the development of special propellant granulations and compositions to achieve maximum loading density and increased overall specific impulse,<sup>5,6</sup> and (c) the development of propellant compositions having a greatly reduced dependence of burning rate on rocket chamber pressure to permit the use of lighter metal parts with a corresponding increase in the propulsive efficiency of the system.<sup>7</sup>

In addition, it was considered essential to strengthen the existing organizations engaged in solid-fuel rocket development and to establish new facilities for the experimental production of developed units.

### TECHNICAL PROGRESS

The development of solid-fuel rockets five to ten times as large as those then available was a task of major magnitude. To ensure an early solution of the problem, parallel programs were initiated at Aerojet Engineering Corporation and Allegany Ballistics Laboratory (ABL), with the objective of establishing the techniques and facilities necessary for the production of large rockets.

In the fall of 1945, the decision was made to develop for use with the ramjet test vehicle (RTV) a single booster rocket having a diameter that would permit it to be inserted and attached to the 18-inch ramjet combustion chamber. Separate tasks were assigned to Aerojet and to ABL to provide a unit capable of accelerating a missile weighing 1000 pounds to a velocity of about 1800 feet per second in approximately 2 seconds.

Jet-assisted takeoff rockets that used a castable propellant made of a mixture of potassium perchlorate and asphalt had been developed previously by Aerojet. By replacing the asphalt with a polymeric resin and the potassium perchlorate with ammonium perchlorate, a propellant with a satisfactory specific impulse and reasonable physical properties was produced. The work at ABL was to be based on smokeless powder, either in the conventional extruded granulation or, preferably, in large single grains. A process for preparing grains of double-base powder<sup>8</sup> by the casting technique had been developed but had not been established as reliable.

### AEROJET DEVELOPMENT OF BOOSTER FOR RTV

Initial emphasis was placed on development of the Aerojet booster, which was accomplished quickly. Full-scale units suitable for boosting the RTV were produced in early 1946. These rockets used a charge of two 400-pound tubular grains that were supported in the rocket chamber by circumferential tie rods. Al-

though it was known that insufficient development had been carried out to establish reliable performance of these units, the time scale of the ramjet development necessitated launching an RTV at the earliest practicable time. Therefore, five units were ordered from Aerojet and, at the same time, a program of propellant research was instituted to improve the product and to establish reproducible controls in its fabrication.

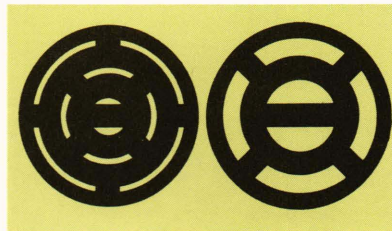
The Aerojet booster was used successfully in firing two RTV's. The first cold round to test stability and separation was fired on May 23, 1946. The second round, which successfully demonstrated ramjet operation on an 18-inch scale for the first time, was fired on September 24, 1946, 22 months after the program was started.

A third RTV and a redesigned 18-inch burner test vehicle (BTV) of reduced weight and improved airflow were launched with Aerojet boosters in January 1947. In neither instance did the rocket perform satisfactorily. Failures of the rear propellant grain occurred before the end of burning, which, in the second round, resulted in blowup of the rocket. In view of these propellant failures, it was decided to interrupt the BTV program until either the Aerojet booster could be redesigned or the ABL booster could be proved in. The discouraging results of these tests led to a vigorous effort to analyze the source of the failure. It was concluded that the tubular grain design and mode of support, combined with the marginal strength of the propellant, were inadequate to withstand the high accelerations and vibration loads imposed on the propellant during boost.

## ALLEGANY BALLISTICS LABORATORY DEVELOPMENT

Although the Aerojet booster for the BTV was considered to satisfy the immediate need of the ramjet propulsion program in the original plan, the smokeless powder booster development at ABL was pursued with the objective of producing a thoroughly reliable unit with higher performance. Three alternative designs were considered to maximize the likelihood of producing at least one fully satisfactory unit. Two used extruded smokeless powder grains, and the third used full-diameter grains of cast double-base powder. The progress made in developing the casting process made it possible to terminate the two less efficient alternatives in mid-1946.

At ABL, it became apparent that there were inherent advantages in the design of a booster rocket that used a propellant bonded to the rocket case. The uniform support at the circumference greatly reduced the maximum grain stresses and also protected the case from the high temperature of the propellant gases. Thus, a more efficient and more reliable booster could be made with this design. Accordingly, after the Aerojet booster failures, all effort was turned to the development of the cast double-base booster rocket.



**Figure 1** — Cross-section geometry of two types of powder grain used in Allegany Ballistics Laboratory (ABL) 51,000-pound thrust units. These grain geometries were designed to provide approximately constant surface area during the burning process and thus provide a constant level of thrust.

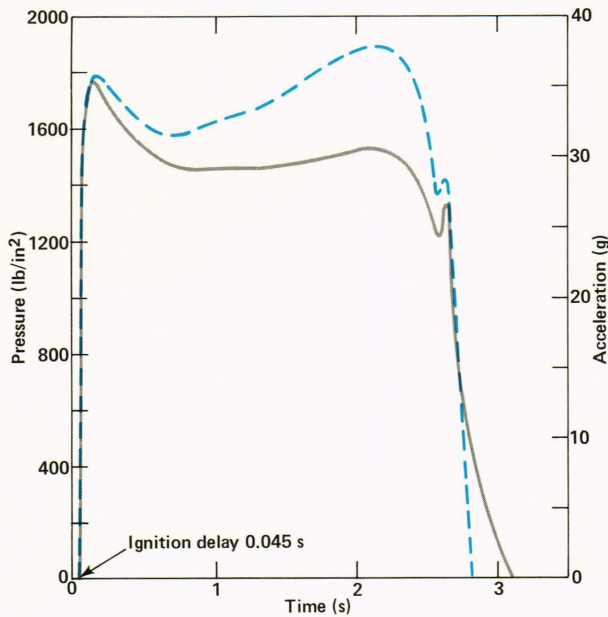
In Fig. 1, cross sections of two types of powder grain are illustrated. As a by-product of one of these, a 7-inch-diameter rocket with an aluminum case was developed that had an extraordinarily high overall specific impulse. This rocket, designated the "Deacon," was used to launch aerodynamic test vehicles for APL and for the National Advisory Committee for Aeronautics.

The development of the cast double-base booster for the BTV was completed in the spring of 1947. After five successful static tests at ABL, five launching test vehicles (LTV) with attached fins and a nose cone were flown successfully in June and July of 1947. To compensate for the absence of the BTV, a lead weight was placed in the nose cone of the LTV, which gave it a total weight that would result in about 20% higher acceleration than the BTV launch configuration to ensure a margin of safety for its use as a BTV booster.

Telemetry showed that the rocket chamber pressure during flight duplicated the static results, indicating that no propellant breakup was caused by booster acceleration and flight-induced vibrations. It was possible then to proceed confidently with adoption of the ABL booster for further ramjet testing. This confidence was fully justified by later developments. An interesting account<sup>4</sup> of the first 10 years of cast double-base propellant developments states that in 1956, when many thousands of boosters had been flown, not a single booster failure caused by the propellant had been recorded.

Because work leading to an improved Aerojet booster had not been completed at that time, it was decided to standardize on the ABL unit for subsequent BTV flights. The work at Aerojet was redirected along more fundamental lines. The ABL rocket performed in a highly satisfactory manner in the first BTV flight test in August 1947. A typical record of pressure and acceleration as a function of time is shown in Fig. 2. Figure 3 is a drawing of the launch configuration. This unit demonstrated a high degree of reliability and yielded telemetered pressure-time records in flight corresponding to those obtained in static firings.

On the basis of experience obtained in development of booster rockets for the BTV, work was

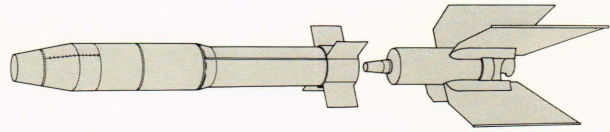


**Figure 2** — Typical telemetered record of pressure (solid line) and acceleration (broken line) versus time for ABL burner test vehicle (BTV) booster shows nearly constant pressure during the rocket burn. Rocket chamber pressure is directly related to the thrust. The acceleration curve shows the effect of weight loss during the burn.

begun in January 1948 on a scaled-up version suitable for launching the XPM, the prototype Talos missile. Fabrication of the larger propellant grain, tests to tailor the thrust and burning time to the desired values, and a series of prove-in tests were completed by the end of June 1948. Increasing the size of grains produced by the casting process involved no basic difficulties and established the procedures for subsequent booster rockets for the Talos series of missiles. The first flight test of the XPM booster was made on July 1, 1948. This LTV weighed 3000 pounds and provided 90,000 pounds of thrust for 3.5 seconds. Three additional LTV's were flown between July and December while construction and tests of the XPM (dummy) airframe were in progress, and on December 2, 1948, the first flight of the booster rocket attached to the XPM airframe occurred.

That test and the following one were unsuccessful because flight instability of the launching configuration led to failure of the booster fins, although the rocket performed as predicted. This trouble was prevented on the third flight on March 30, 1949, in a flight without missile wings that demonstrated successful booster and ramjet operation. The stability problem and other program work delayed the next flight until March 6, 1950, when completely satisfactory operation was demonstrated.

With these flights, booster rocket technology had reached a state in which the propellant and metal parts could be tailored with confidence to meet new program needs, and further booster research and development turned to improvements in the specific impulse and reductions in hardware weight and cost.



**Figure 3** — BTV and launching carriage after separation. This configuration was flown successfully in 1947.

Modifications to the XPM in the spring of 1949 led to the need for a larger booster rocket, and on June 6, 1949, an LTV was launched with 105,000 pounds of thrust (average). It weighed 3720 pounds and contained 2063 pounds of propellant. Although the XPM was a prototype, the Talos missile required a still larger booster. Development of this booster, which also needed a significant reduction in the weight of the booster case and thorough prove-in of its reliability, was carried out at ABL during 1950 and 1951.

On October 28, 1952, the first Talos missile was launched. The total weight of the launching configuration was 7455 pounds. The booster alone weighed 4425 pounds. Further minor modifications were made to the booster to accommodate the requirements of the various versions of Talos over the years, but Talos booster development was essentially complete at this point. At least 1400 tactical Talos boosters were flown without a single failure during the lifetime of the Talos program.

## LIQUID-FUEL BOOSTER ROCKETS

In view of possible limitations in the ultimate size of solid-fuel booster units, the development of liquid-fuel systems for short duration use was initiated at the M. W. Kellogg Company early in 1947. The objective of this work was to provide all the engineering data required to evaluate the relative merits of solid- and liquid-fuel boosters as a function of thrust and total impulse required.

Preliminary work indicated that it would be possible to design an efficient liquid-fuel rocket having thrust and duration comparable with those of the solid-fuel booster for BTV. However, the success of the solid booster development eliminated the need for liquid boosters, and further development was discontinued.

### REFERENCES and NOTES

- <sup>1</sup>Rockets and Underwater Ordnance, Office of Scientific Research and Development, National Defense Research Council, Washington, D.C. (1946).
- <sup>2</sup>R. E. Gibson, "Personal Reflections on the Origins of CPIA," *CPIA Bull.* (Oct 1981).
- <sup>3</sup>A rocket propellant grain is a single piece of propellant of a particular geometrical configuration, developed to produce a specified rate of production of propellant gases or burning.
- <sup>4</sup>L. G. Bonner, 12th Meeting, Joint Army, Navy, Air Force Solid Propellant Group, NOL, White Oak, Md. (7 May 1956).
- <sup>5</sup>Specific impulse is thrust divided by weight.
- <sup>6</sup>W. H. Avery and J. Beek, *Propellant Charge Design of Solid Fuel Rockets*, OSRD Report 5890, ABL Report 13-4, George Washington Univ. (Jun 1946).
- <sup>7</sup>W. H. Avery, R. E. Hunt, and M. N. Donin, *Burning Rate Studies of Double Base Powder*, OSRD 8527, ABL 8-1, George Washington Univ. (Jan 1946).
- <sup>8</sup>Highly nitrated guncotton plasticized with nitroglycerin.