CHARLES R. BROWN and CHARLES F. MEYER

THE TALOS CONTINUOUS-ROD WARHEAD

INTRODUCTION

The warhead developed by APL for the Unified Talos (SAM-N-6c1) missile was a significant milestone in ordnance technology. Performance objectives were achieved with a configuration in which a double layer of steel rods, welded at the ends to form hinge joints, was accelerated by the detonation of a cast explosive. Structural damage to the target was achieved by the impact of the steel rods projected at high velocity in an expanding circular pattern (Fig. 1). This was shown to be a highly effective counter to any manned aircraft, such as a heavy bomber. An accurate fuze was employed to control burst position so that the rods would strike the target.

The continuous-rod warhead evolved from consideration of the lethality of chunky fragmentation devices and their inability to inflict a decisive kill on a manned aircraft. The optimum fragment velocity for effective target penetration was shown to be considerably higher than that of about 3000 feet per second from an antiaircraft shell. Considerable improvement in lethality was observed when the chunky fragments from a 3-inch/50 shell were replaced by small discrete rods.

A quick, decisive kill was shown to be feasible when a long rod sufficiently damaged the aircraft structure so that failure resulted from normal aerodynamic flight loads. Ordinary fragments, while adequate for damaging vital components, cannot produce such structural failure. The continuous-rod concept was born in 1952 with the suggestion that the rods be connected end to end, thereby providing the capability of inflicting a continuous "line" of structural damage over the target surface.

WARHEAD DESCRIPTION

The Mk 46 continuous-rod warhead, developed for the Unified Talos 6c1, is shown schematically in Fig. 2. Each pair of a double layer of 0.25-inch square rods, 19.25 inches long, was resistance welded at the ends to form a hinge joint. The rods were welded together in two flat sections that were connected by two heli-arc welds after assembly on the cylindrical surface. At the explosive-rod interface, two filter layers — a 0.062-inch layer of steel and a 0.025 inch layer of lead — helped to reduce the explosive shock effect on the steel rods, the steel filter being part of the basic warhead structure. Structural rigidity was achieved by a 0.035-inch steel stress skin over the rods; both rods and stress skin were welded to steel end rings.

Detonation of the explosive composition, nominally 25% RDX and 75% TNT (cyclotol), was centrally

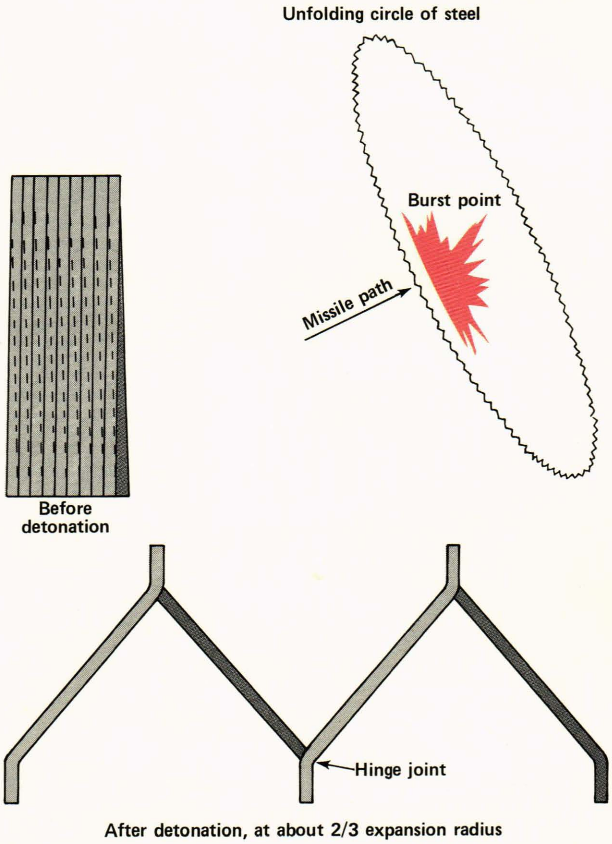

Figure 1 — The continuous-rod warhead was designed to produce an expanding zigzag ring of connected rods. The rod structure expanded like a folding rule.

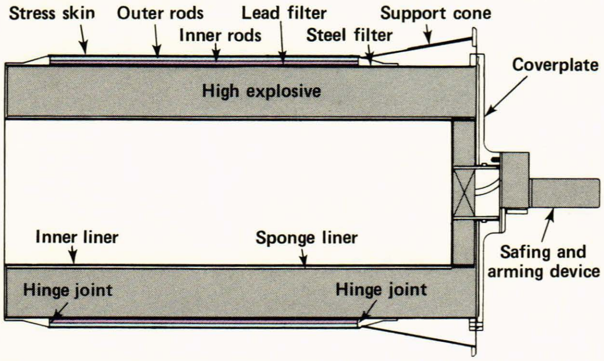

Figure 2 — The Unified Talos 6c1 Mk 46 warhead was a hollow cylindrical structure. Quarter-inch rods arranged in a double layer and surrounding the explosive charge were welded at the ends to form hinge joints. At the explosive/rod interface, two filter layers — a 0.062-inch layer of steel and a 0.025-inch layer of lead — helped reduce the explosive effect on the steel rods.

initiated at the aft end where the detonator and booster were part of the overall safing and arming assembly. A silicone sponge liner was used on the approximately 8.7-inch outer diameter steel inner liner to prevent cracking from shrinkage of the explosive caused by cooling in the casting process.

The overall weight of the warhead was about 465 pounds, and the explosive load was about 225 pounds. Warhead length, not including the end plate and the safing and arming device, was about 29.5 inches and the diameter of the section comprising the rod assembly was about 16.8 inches.

The location of the warhead within the missile structure is shown in Fig. 3. The blowthrough area is the section that has the most effect on warhead performance. Lockfoam was used between the warhead and the inner-body cowl as a cushion to prevent the rods from damaging the magnesium cowl. Coaxial cables, pitot tubes, and their fairings were designed for the most practical, circumferentially uniform distribution of mass to minimize rod breakup.

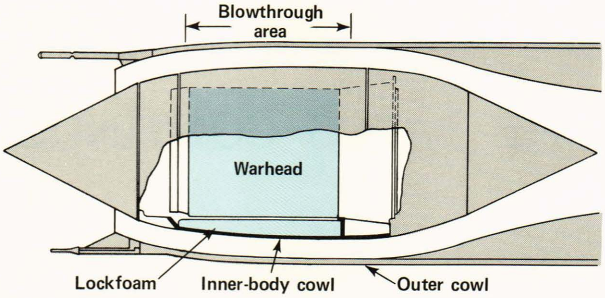

Figure 3 — The missile and warhead structure was designed to place the warhead in the inner body of the multiple-shock diffuser. Lockfoam was used between the warhead and inner-body cowl as a cushion to prevent the rods from damaging the magnesium cowl. Coaxial cables, pitot tubes, and their fairings were distributed to minimize rod breakup.

DEVELOPMENT AND PERFORMANCE OF THE TALOS WARHEAD

Problems solved during the development of the Mk 46 warhead were associated with preventing rod deformation, controlling initial rod motion so that a nearly unbroken rod pattern persisted to the maximum radius, and producing rod velocities high enough to inflict structural damage on the target.

Fastax camera coverage of static testing of the warhead in an arena of steel witness plates (Fig. 4) provided valuable performance data on rod continuity, rod pattern, and velocity. Extensive recovery of sample rod strands yielded vital information on hinge opening and the metallurgical properties of the rods.

The missile structure had a strong influence on warhead performance. About 30% of the kinetic energy of the rods was lost in the process of blowing through the substantial missile structure. The initial velocity was reduced from about 5300 to about 4600 feet per second, a useful speed. However, rod continuity seemed to be somewhat improved because gapping between inner and outer rod layers was reduced.

The maximum radius of continuity was 90 feet. Ideally the rods would produce a uniform "saw-

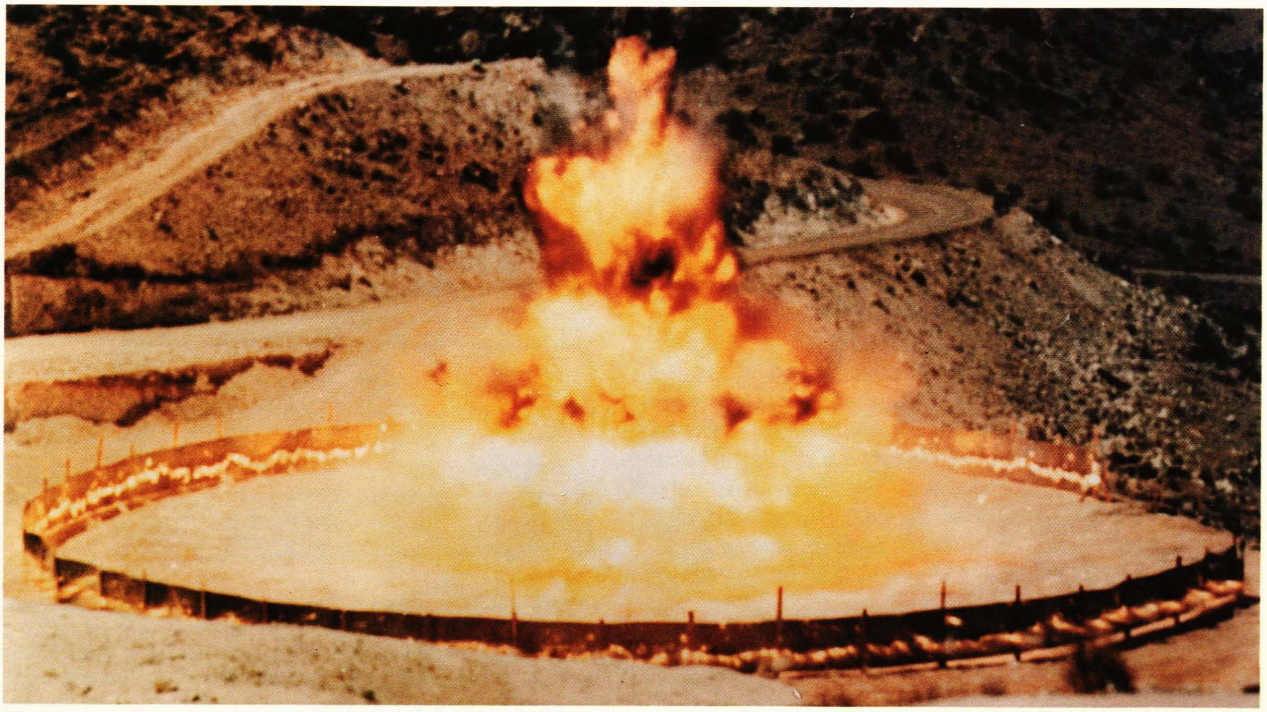

Figure 4 — A continuous-rod warhead test demonstrated an unbroken ring of continuous rods. This photograph shows the continuous rods striking steel target panels located near the maximum possible continuity radius.

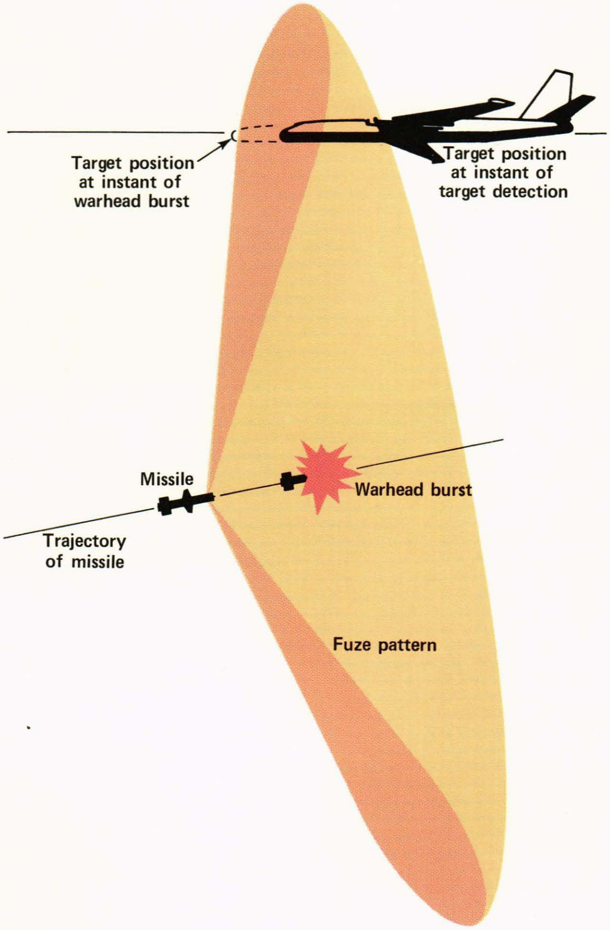

Figure 5 — Warhead burst position was controlled to obtain maximum effectiveness of the continuous-rod warhead. The target was detected by a short-pulse range-gated radar having a fixed-angle antenna pattern. The time delay from detection to burst was controlled by the missile-to-target closing speed.

tooth'' pattern during expansion in such a way that all rods would break simultaneously at the hinges when the maximum radius was reached. In practice, the expansion was not uniform, and some hinges would always break prematurely. Typical continuity performance was 100% out to a radius of 60 feet, with a degradation to 90% at 90 feet.

The hinge weld played an important role in preventing excessive premature rod breakage. It consisted of a strong weld in a primary region and a weaker weld in a secondary region. Progressive failure of the secondary weld helped to control the bending radius during the expansion process, while the primary weld remained intact.

FUZE

The final fuze version (Mk 52), designed by the Naval Ordnance Laboratory, Corona, Calif., was a short-pulse-radar, range-gated device having a fixed-angle radiation pattern (Fig. 5). A sea tracking gate was included to prevent premature firing on the sea when intercepting very-low-altitude targets. The warhead was fired by a signal originating from a valid target detection or by fuze-on-jamming action. The missile-to-target closing rate controlled the time delay of the burst so that optimum effectiveness was achieved.

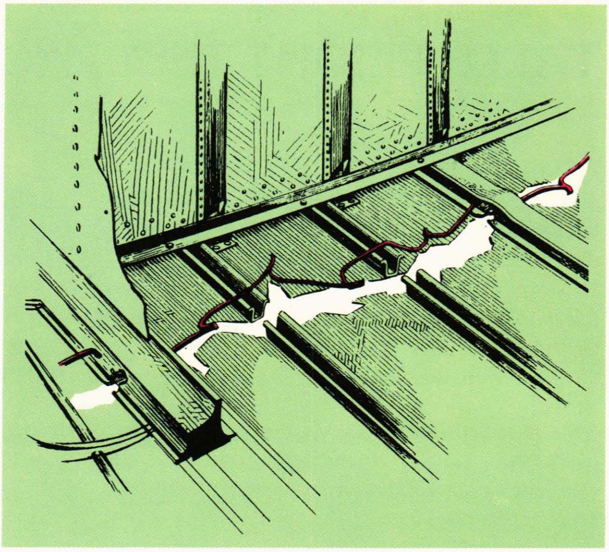

Figure 6 — Cutting action of the rods across the target surface could lead to structural failure and therefore produce a quick kill.

Analyses of time delay requirements were performed for a variety of targets, intercept-approach aspects, and altitudes. Suitable constants for the time-delay equation were thus derived for optimizing hit probability.

TARGET DAMAGE

The nearly continuous cutting action of the rods across the target surface could lead to structural failure and therefore produce a quick kill. Complete severence of the structure was not necessary. For example, if the skin and stringers of a wing were severed and the heavy spars damaged, the wing could fail under a 1g flight load (Fig. 6).

Structural damage by the impact of rods required a sufficient mass, high impact velocity, and a continuous strand of unbroken rods. For quarter-inch rods, a minimum striking velocity of about 3500 feet per second was necessary to produce structural damage to most aircraft.

Experiments showed that a rod that struck a thin target edge-on tended to break into two pieces during the damaging process. The amount of damage produced greatly depended upon the ability of the rod to resist being pulled apart. On the other hand, a rod striking a target whose thickness was much larger than the rod's thickness was broken into three pieces, the center portion contributing the most to the damage.