SELF-ERECTING MISSILE FIN

During wartime fleet operations there is a problem of defense against high-performance enemy aircraft attacking in large numbers from several directions and at varying altitudes. In order to meet attacks of this kind successfully, missile ships must be able to launch large numbers of missiles at high firing rates. To do so it has been suggested that in addition to existing launchers missile ships be equipped, at strategic locations on board, with one or more multiple-unit "tube" or "box" missile launchers having rapid-fire capability. An important factor in designing this type of launcher is the size of the box or tube needed to accommodate the span of the missile fins; this in turn determines the number of missiles that can be carried for immediate launching. It is clear that it would be desirable for the missiles to be equipped with self-erecting folding fins so that they could be stowed in the launcher with fins in the folded position.

There have been studies, made by APL and by missile contractors, aimed at devising a box- or tube-type launching system for Tartar or Tartar-type missiles.* As can be surmised, however, each proposal has run up against the problem of the volume required for storing missiles with fins erected. In the case of the Tartar missile with fins extended, for example, a box with an end opening approximately 36 in. square is required. On the other hand, with fins folded, the same missile can be contained in a box of the same length that has only a 24-in.-square opening, representing a volume saving of 55%. It is therefore obvious that if the missiles can be stored in launcher cells with fins folded, the number of cells in a given launcher can be significantly increased.

To achieve this, automatic fin erection immediately after the missile leaves the launcher cell is essential. Several methods of erection have been studied in the past, which require the use of external hardware that is ejected from the missile when fins are erected. Such concepts have not proven to be desirable solutions because of both their inherent unreliability in operation and the presence of loose parts that are exposed to rocket blast and may be thrown back on the launching ship at high velocity, with possible damage to equipment and injury to personnel.

At APL five engineering models of a self-erecting folding fin have been developed by S. Kongelbeck, W. F. Williams, and J. M. Snapp, which provide the self-erecting capability necessary for box- or tube-launch installations.† A number of tests of these fins have been conducted successfully to establish operational characteristics as well as functional reliability. As a result, the feasibility of the concept has been thoroughly demonstrated.

The APL-designed, spring-loaded, self-erecting

* The Tartar missile is among those developed for the U.S. Navy at the Applied Physics Laboratory.

† S. Kongelbeck is supervisor and W. F. Williams is assistant supervisor of the Central Laboratory Facilities Group. J. M. Snapp is a design engineer in the same organization.

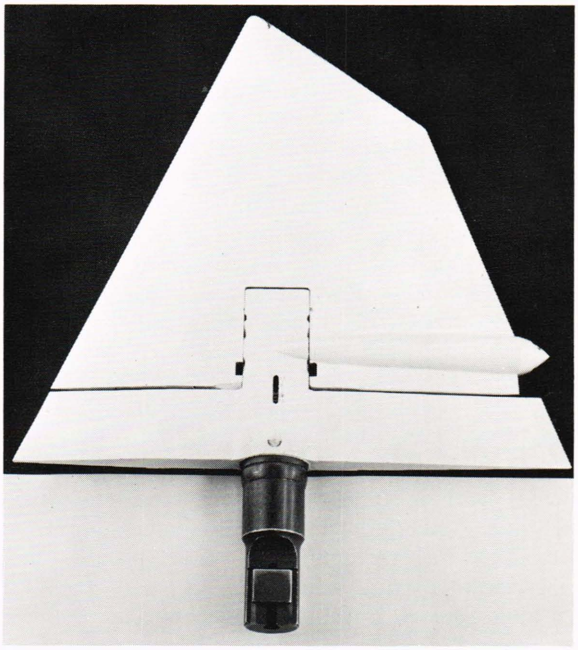

Fig. 1—Self-erecting missile fin engineering prototype.

fin (Fig. 1) fulfills the requirements for a compact, fully automatic, self-contained erection unit that does not depend on external springs or other erection mechanisms. This fin is an adaptation of the folding fin now in use on Tartar missiles.

In principle the folding and latching mechanism of the self-erecting fin is the same as that employed on the Tartar folding fin, except that such recent design changes as the improved latch and hinge-pin design, stronger latch pin, and positive stops have been incorporated. The detent mechanism has been eliminated since it is not required for a self-erecting fin. In its place an external means for holding the self-erecting fin in the folded position must be provided, and with a suitable release mechanism that depends on missile motion at launch or triggering at a predetermined time during the launch cycle. Several acceptable release mechanism designs have been studied.

Figure 2 shows the details of the erection spring and latch mechanism. The upper fin panel has been modified to include a torsion-spring housing along the hinge-pin centerline. The housing is an integral part of the upper fin panel and is aerodynamically faired to the fin at the forward and aft ends, as can be seen in Fig. 1. The torsion-coil-spring subassembly consists of the spring, with a keying ring attached to its forward end, and a housing-enclosure plug attached to the aft end. In the fin assembly the aft-hinge pivot is attached to the fin lower spar by a roll pin, and the aft end of the pivot is slotted to receive the key in the keying ring on the forward end of the torsion spring. Assembly of the torsion spring to the fin is very easily done by sliding the spring into the housing from the aft end until the spring key engages the slot in the end of the aft-hinge pivot and the housing closure is in position. The housing closure is pinned in place and, with the fin erected, the torsion spring is pre-loaded to 20-in.-lb torque by rotating the aft plug and pinning it in position. With a 20-in.-lb pre-load, the spring will develop approximately 70 in.-lb of torque when the fin is in the folded position.

A number of tests have been run to establish functional operability and reliability of the mechanism. The engineering prototypes have been subjected to repetitive folding and spring-erection cycles, with no indication of mechanical weakness or failure. Laboratory bench tests have determined the unfolding cycle times for four different fins; the results of 10 measurements on each fin showed a variation of unfolding time ranging between 0.17 and 0.20 sec.

In the box-launch concept the fins automatically erect just after the missile has left the launcher

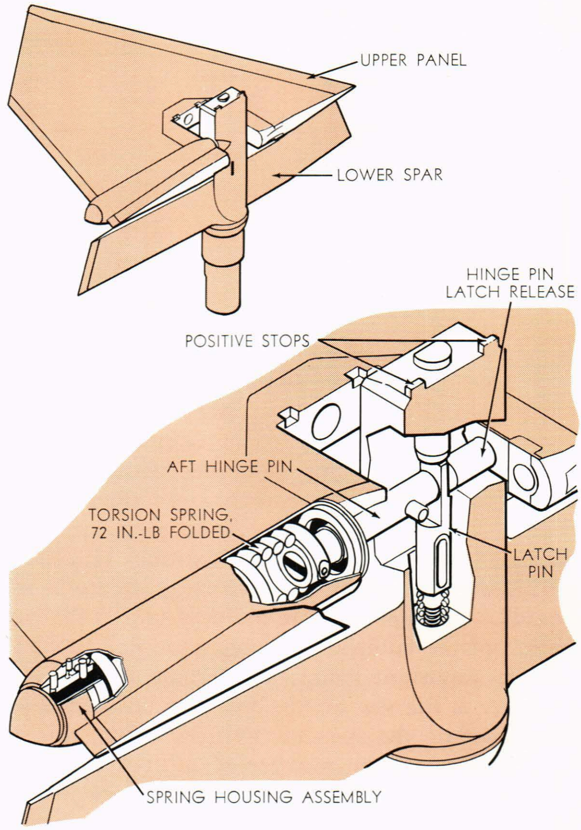

Fig. 2—Cutaway drawing of the self-erecting missile fin shown partially folded.

cell. At this time the missile is traveling at a relatively low speed and may be subjected to high-velocity winds, either broadside or at some intermediate angle to the flight path. To determine the effect of this type of wind loading on the erection-cycle time of the self-erecting fins, tests were run in which such a wind-load condition was simulated. Four self-erecting fins were installed in a missile boattail section, and means were provided for triggering the release of the fins from the folded position. The boattail was mounted on a pedestal at one end of a framework, with a high-speed camera mounted at the opposite end. This assembly was then mounted on an elevated wooden structure on a flat-bed truck in order to be exposed to the undisturbed wind stream when the truck was in motion. With the truck moving at 60 mph, the fins were triggered and erected, and the erection cycle was recorded by the camera. Several runs were made, with the boattail axis perpendicular to the air stream or facing into it at angles of 30° and 60°. No difficulty was experienced in erecting the fins during any of the runs, and analysis of the films showed only a negligible increase in erection time ($\approx$ 0.03 sec) caused by crosswind loading.