SUCCESSFUL TESTS OF A
RAND-RECOMMENDED RUNWAY CRATERING DEVICE

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On 15 September 1966 an inert runway crating munition was successfully fired downward from a SUU-13A dispenser mounted beneath an A-4B flying at its maximum airspeed, 540 knots; another was discharged at 520 knots (the qualifying speed set in the contract), and two others were fired at 500 knots. Information from a pair of high-speed (300 frames per second) motion picture cameras mounted on the side of a pylon of the A-4B will be available later for study. Rex Finney, who designed the parachute system, watched the drops through binoculars and reported that the parachute opened normally. A cord linking the risers kept the parachute reefed and allowed the munition to unfold and straighten out. A reefer cutter, used for the first time on this munition on 14 September, cut the restraining cord two seconds after emergence from the SUU-13A dispenser. By that time the horizontal component of movement had been reduced to the point where there was no damage to the payload. A double length of cable, perhaps 8 or 9 inches long and capable of elongation to 50%, had been inserted between the payload and the parachute, in order to absorb some of the energy. This was stretched. Al Janeikas, of Harvey Aluminum Inc., is taking these energy absorbing cables to the plant for laboratory study. He will attempt to deduce the tensile force to which it was subjected, probably in excess of 1700 pounds. The inert ordnance items were picked up from the desert floor in good enough condition to be re-used. The only damage was to the three light metal arms that hold a piezoelectric crystal in front of the device which have served their purpose as soon as the piezoelectric crystal sends out its signal on impact.

The explosive effects of this ordnance item have been demonstrated, successfully, in static tests and in drops from a balloon tethered 100 feet above a slab of concrete. It now remains to drop live runway-cratering-devices from an aircraft on a strip of unused runway in order to prove out the weapon. No doubt problems will arise in completing the demonstration. Considering the problems that have been solved already, it is possible to be quite optimistic about the eventual outcome.

Marv Schaffer and Bernie Jaeger said that as far as they knew, this is the first ordnance item on which the Air Force has taken the sole responsibility for
requirements, design, development, and tests, which has been brought this close to completion. They said that development of this item presented substantially greater difficulties than do most ordnance developments. It seems to me that the mounting of two high-speed motion picture cameras on the side of the pylon made it possible to recognize the cause of a difficulty which might otherwise have forced the termination of the entire project.

Over a year ago, when the project was stalled because of technical problems and shortage of funds, RAND recommended (in L-8317 dated 19 April 1965) that the Air Force assign a high priority to this munition. The Air Force did so, and the AF Armament Laboratory awarded a one-year contract to the Harvey Aluminum Company, of Los Angeles. Performance of the contract was delayed for 5-1/2 months through failure of the Government to supply the high explosive it had contracted to supply.

On 8 September 1966, when Marv Schaffer, Bernie Jaeger, Jack Ellis and I visited the Naval Air Facility at El Centro, California, where parachute tests were in progress, only three weeks remained before termination of the contract and the project was plagued by difficulties. A parachute had been developed by Rex Finney of the Naval Air Facility, which appeared to produce satisfactory trajectories when dropped with weights approximately those of the ordnance item. When inert munitions were fired downward from the SUU-13A dispenser at 200 knots the parachute opened normally, the ordnance item unfolded with a snap sufficient to cause visible undulations in the cable on which the elements of the munition are strung, but not enough to cause physical damage. When the munition was fired from the cylindrical dispensers of the SUU-13A at 300 knots, the abrupt deceleration induced by the sudden opening of the parachute induced a whiplash effect of sufficient intensity to snap the 5/32-inch braided steel wire cable linking the several parts of the munition. Failure occurred in two other structures in at least one instance each.

Marv Schaffer has requested Harvey Aluminum Inc. project personnel to send him one of these test items, and it is probable that very soon he will have an
item on display in his office. Instead of attempting to describe the hardware, let me try to outline the functions.

This munition is designed to be carried in, and fired from, tubes in the SUU-13A dispenser which are 4-1/2 inches inside diameter and eight or ten inches long. Everything is space-limited. The munition is ejected from the dispenser by a small explosive charge. The units may be fired sequentially by an intervalometer. The intent is to produce a line of craters on the ground track of the aircraft, whose spacing can be controlled by the intervalometer setting.

This ordnance is intended to be fired from an aircraft flying in straight and level flight at relatively low altitude. The lower the altitude one specifies, the greater the difficulties one creates in design. I, for one, believe that the release altitude specified in the contract is unrealistically low.

A parachute is needed to insure that the munition approaches the target with an angle from the vertical of less than 30°. Obviously, it also reduces the horizontal component of movement.

The first element of the munition to touch the ground or target is a Lucky crystal, a piezo-electric crystal mounted on a species of light toggle joints such that it snaps (and is locked) into position about two inches in front of the base of the shaped charge. This crystal, as it is crushed, generates an electric current which (1) arms the device, (2) ignites the shaped charge, (3) ignites a delay fuze on a follow-through charge, and (4) ignites a delay fuze on a tiny rocket motor at the upper end of the follow-through charge.

The shaped charge is adequate to punch a hole nearly two inches in diameter through 12 inches of seasoned concrete. Oddly enough, the shaped charge has so little recoil that the follow-through charge remains in place and in line with the hole punched through the concrete and into the subsoil.

The follow-through charge consists of four aluminum-cased high-explosive charges strung, like beads, on a length of 5/32-inch stainless steel braided wire cable. While packed in the launcher, these four segments rest side-by-side. The steel cable on which they are strung is spring loaded to about 40 pounds, so that there is a tendency for it to straighten (and put the four charges end-to-end) when
the lateral restraints of the launcher walls are removed. It is under a tension of about 12 pounds when it is fully straightened; enough to hold the four aluminum-cased segments together semi-rigidly while the DuPont Detal Sheet propellant in the tiny rocket motor exerts thrust at the top, which will push the follow-through charge into the space below the runway. This is the cable which was thrown into undulations, gentle or violent, if the braking effect of the parachute was exerted before the cable was fully extended.

When the tiny rocket motor thrusts the follow-through charge into the hole punched into the subsoil, the follow-through charge is detonated. In D-14338-PR, "A Runway Interdiction Weapon and a Modular Fire Bomb: Development and Tests in Progress at Eglin AFB," I have described and illustrated the effects of this bursting charge on a runway. It appears to produce an adequate amount of structural damage; too much to permit use of a runway by high-performance aircraft in fragments too large to be removed by man or by draft animals.

Let me call attention to two kinds of instrumentation which are being helpful in these developmental tests.

The fall of the munition is being followed by an Askania photo-theodolite which takes five photographs a second on 35-mm film. This, of course, is the pre-War German-made instrument in fairly wide use at proving grounds. Contraves photo-theodolites which operate at 30 frames per second are available at El Centro (and elsewhere) as needed. Askania cameras yield only a blurred image of the critical first few seconds of fall of this munition. We were shown print-outs of data obtained the week before which showed, among several other measures of performance, the angle of fall, measured from the vertical, of the ordnance item, as a function of the number of feet below the release altitude, and the horizontal and vertical components of velocity. From the former, one can ascertain how many feet of fall it is necessary to allow before the munition is within 30° of the vertical. From the latter, Marv Schaffer and Jack Ellis showed the project personnel how to calculate G-loadings.

As noted earlier, two 16-mm motion-picture cameras operated at 300 frames per second were mounted on the side of a pylon to scan the space below and to the
rear of the SUU-13A dispenser. One was equipped with a 5.3-mm lens, the other with a 13-mm lens. They were so mounted as to be capable of enregistering events from the emergence of the munition from the dispenser up to the point that the munition was fully extended and falling under the control of the parachute. These films clearly showed the violent stresses set up in the munition when the parachute opened abruptly before the load was fully extended. If it had been necessary to deduce the cause of the malfunction from the old-fashioned method of picking up pieces from the desert floor, it might have taken so much time to check out the several hypotheses, by the usual trial-and-error processes, that the contract would have terminated long before the correct hypothesis could be proved out.

I believe the RAND party contributed substantially to the solution. I can say this because I contributed least.

The Armament Laboratory had chosen to fund this as a test project, rather than as a development project. Armament Laboratory personnel were confident that a year's testing would suffice (I believe this is traditional) and this kind of funding allowed them to retain control of the project. Major Ronald Opfell, who had managed this project resourcefully throughout its early stages, was promoted from Captain last March, and the Laboratory re-organized during the summer. There are far fewer billets for a Major than for a Captain, and he was removed from the project in the process. His successor, Paul Briere, ATWD, is a young man who came to the Armament Laboratory only six months ago from Inyokern. He apparently decided, reasonably enough, not to commit himself until the four men from RAND had made their position clear.

The Department of Defense has a Joint Parachute Test Center as one of the four tenant organizations at the El Centro Naval Air Facility. The parachute work was done by a civilian employee of the Navy Department. Apparently, he is a very competent man. Interactions between a new Air Force civilian project officer, working at Eglin AFB, a contractor in Los Angeles, a civilian employee of the Navy and USAF military personnel at El Centro actually were much better than one might have supposed. I think the four of us were able to overlook some
jurisdictional lines which create difficulties in communication for the others and, during the afternoon, to get a discussion started to which each person present contributed. Marv Schaffer, Bernie Jaeger, and Jack Ellis were able to recognize the principles of mechanics which were represented by the bizarre movements of the linked components of the parachute-weapon system and to suggest efficient methods for putting the several hypotheses to test. The results of the tests on the 14th and 15th seem to indicate we were operating on the right hypotheses.