Engineering Notes

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Wind-Tunnel Tests of Small Decelerator Stabilizers

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Introduction

A LIGHTWEIGHT, efficient, stable decelerator was desired for a small 5-lb munition. Since no comparative data were available on small decelerators, wind-tunnel tests were conducted in the LTV Aerospace Corporation 7 × 10-ft low-speed wind tunnel[1] (LSWT) at velocities from 100 to 300 fsp. Configurations tested were guide surface, ring slot, cross, slotted solid, bare streamers, and streamers with pockets. Parachute diameters from 1 to 2 ft were used. Decelerator drag force was measured by means of the wind-tunnel balance system, and stability was recorded by cameras.

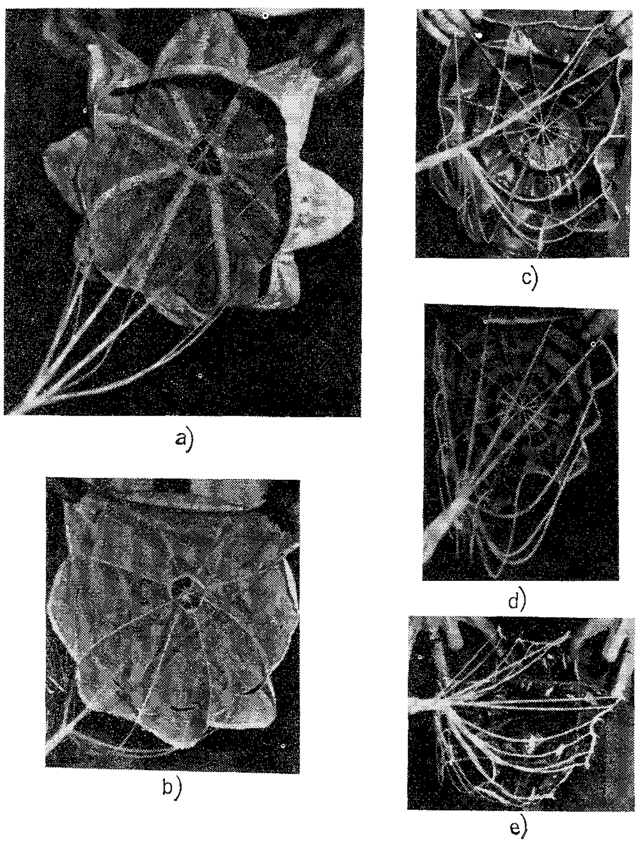

Fig. 1 Photographs of parachutes tested; a) guide surface canopy, b) slotted solid canopy, c) less porous ring-slot canopy, d) more porous ring-slot canopy, and e) cross canopy.

Apparatus and Tests

The model decelerators, listed in Table 1 and shown in Figs. 1 and 2, were fabricated from all-nylon material in the Sandia Laboratories parachute laboratory. The canopies were made of 1.6 oz/yd^2 material, and the lines were made of 160-lb breaking strength cord. The 2-in.-wide ribbon, MIL-T-5608E, was used to make the streamers shown in Fig. 2. Three weights of ribbon were tested, 0.044, 0.066, and 0.091 lb/ft^2, corresponding to ribbon tensile strengths of 460, 1,000, and 1,500 lb. The red pockets were made of 1.6 oz/yd^2 nylon, and treated to produce near-zero porosity.

The models were attached to a 4-in.-diam body located on the LSWT centerline. The body was supported by a vertical strut attached to the balance turntable in the test section floor. To prevent line rollup if the decelerator rotated, all decelerators were attached to the vehicle to be retarded by a small fishing-line swivel.

Two series of tests were conducted in the LSWT in April 1969. Drag loads were recorded at tunnel speeds of 100, 150, 200, and 300 fps. The body and support system tare drag was measured without decelerators attached, and the tare drag value of 0.195 ft^2 drag area was subtracted from the measurements with decelerators attached.

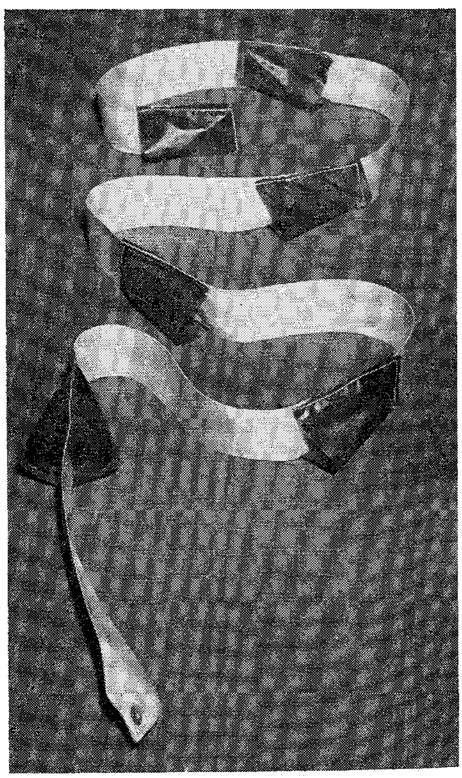

Fig. 2 Double pocket streamer.

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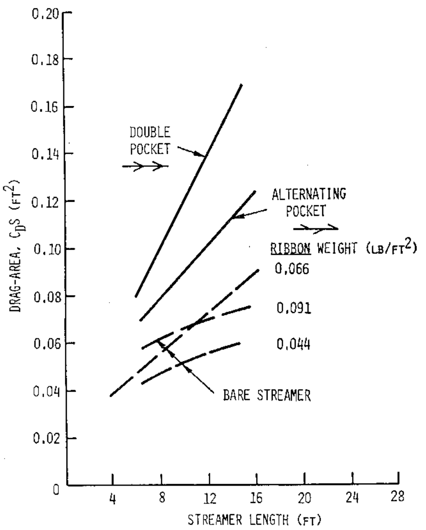

Fig. 3 Comparison of bare, alternating pocket, and double pocket-streamer drag area with length.

Results

Comparative drag coefficients for the various decelerators tested are listed in Table 1. These data were taken at a speed of 200 fps. Data taken at 100, 150, and 300 fps gave almost identical drag coefficients, as would be expected. The slotted solid parachutes had the highest drag coefficient of 0.69 but showed the usual instability of a solid chute (15°–20° oscillation).

The guide surface parachutes gave an average drag coefficient of 0.6, and they were stable with no oscillation. The less porous ring-slot parachutes had an average drag coefficient of 0.5; and the more porous, 0.36. All ring-slot chutes had a high rate of rotation, necessitating the use of a swivel, as did the cross chutes. No drag measurements could be obtained on the cross-type because they rolled up. The ring-slot chutes exhibited canopy closure at the highest velocity of 300 fps.

Figure 3 shows the variation of flat, alternating pocket, and double pocket 2-in.-wide streamer drag area as a function of streamer length. The flat 2-in.-wide, 15-ft-long ribbon streamer produced a drag coefficient of 0.084, based on 1 ft² reference area. The addition of double-opposed pockets every foot, as shown in Fig. 2, raised the drag coefficient to 0.164, or 95% more than without the pockets. This configuration was chosen for the initial stabilization of the unstable shape. A 1-ft-diam guide surface parachute was chosen as the final decelerator stage because of its excellent stability and high-drag coefficient.

Table 1 Summary of decelerator tests in low-speed wind tunnel

Decelerator type	Model number	D Constructed diameter (in.)	$C_D{}^a$
Guide surface	P_1	12	0.55
	P_2	18	0.65
	P_3	24	0.58
	P_4	12	0.64
Slotted solid	P_5	15	0.69
	P_6	18	0.69
Ring slot (more porous)	P_7	9	0.36
	P_8	12	0.28
	P_9	15	0.36
	P_{10}	18	0.41
Ring slot (less porous)	P_{11}	12	0.53
	P_{12}	15	0.47
	P_{13}	18	0.50
Streamer		Length	
	S_1	15 ft	0.084 (flat 2-in.-wide ribbon)
	S_2	15.75 ft	0.164 (double pockets)

^{a} C_D for items P_1 through P_{13} are based on constructed area $(\pi/4)D^2$; and for the streamers S_1 and S_2, the reference area is 1 ft².

Conclusions

From low-speed wind-tunnel tests of small guide surface, slotted solid, ring-slot, cross, and streamer decelerators, the following conclusions can be made: 1) The guide surface canopy design was most favorable, having a high-drag efficiency ($C_D = 0.6$) and excellent stability for all sizes tested from 1 to 2-ft diam; and 2) The new alternating pocket streamer design is a cheap, reliable method of providing a small drag increment for initial body stabilization.

Reference

[1] Holbrook, J. W., "Low Speed Wind Tunnel Handbook," LTV Publication AER-AOR-12995-B, May 1968, LTV Aerospace Corp.

Measurements of Particulated Gas Flow Pressure on Cascade Nozzles

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Cascade Tunnel and Model Description

A SPECIAL subsonic cascade tunnel was built which incorporates a device for injection of solid particles (Fig. 1). The cascade dimensions and the pressure probe locations are shown in Fig. 2. Further test facility information may be obtained from Ref. 1.

Instrumentation

Manometer readings were recorded by camera after a steady state was reached. The primary mass flow was measured by an orifice meter located ahead of the settling chamber. The primary flow temperature was measured with a standard thermocouple located in the settling chamber. An electronic counter was employed to record the time of par-

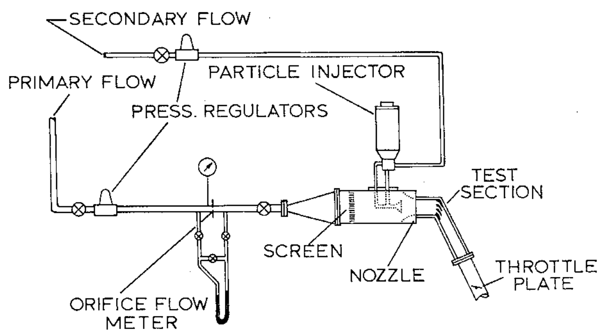

Fig. 1 Cascade tunnel schematic.

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