Net-Skirt Addition to a Parachute Canopy to Prevent Inversion

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Abstract

THIS paper gives a historical account of the circumstances which led to the invention of the net-skirt extension as a device to eliminate parachute canopy inversions, in particular, partial inversions known as "blown peripheries." The phenomenon has been completely eliminated in parachutes modified in this way. Whereas the net-skirt extension solved the difficulties with the Airborne Forces' parachuting system, it does not appear to be essential for all deployment systems if adequate line tension can be maintained. Because previous papers do not give a precise account of the mechanism causing the phenomenon it is re-analyzed.

Contents

One of the successful developments relating to a parachute assembly has been the addition of a net-skirt to the canopy to eliminate abnormal behavior during opening such as inversions and partial inversions, the latter being known as blown peripheries. The phenomenon of the blown periphery occurs when a section of the parachute canopy skirt hem passes under the skirt hem of another section and between the suspension lines, and inflates inside-out or inverted. Uneven inertial and aerodynamic forces can cause the hem to become out of line and, during random movement of the skirt hem, part of the canopy can be blown between the lines and carry a portion, or all, of the remaining canopy with it. The blown periphery appears as an irregularly inflated canopy with two or three lobes. Figure 1 clearly shows an example of a two-lobed blown periphery. Figure 1a looks up into the canopy and shows the uninflated material as a bundle inside the right-hand lobe. Figure 1b is a side view of the same parachute taken a few seconds after it has rotated through 90 deg. The phenomenon was referred to in the early days as a "thrown-line" because, in the process, lines roll over the canopy and have been known to have become caught up in the fabric folds. Blown peripheries were conducive to parachute damage because of the friction between slipping fabric and lines and hem and to a faster rate of descent, which increased risk of landing injuries, even to a fatality in the absence of a reserve parachute.

During the 1950s this phenomenon was experienced on paratroop assemblies and on some escape parachute assemblies for aircrew without ejection seats. Although the observed incidence of blown peripheries from recorded statistics of paratroop jumps was not particularly high, slightly less than 0.2%, it was known that there would be a number of complete inversions that would pass undetected, and a number of instances when partial inversions disappeared and the parachute canopy opened with the right side out. Yet some damage was incurred by the parachute. Some experimental work on escape parachutes deployed by a small auxiliary pilot parachute showed an even more serious situation because, at a release speed of 175 knots, the incidence of blown peripheries was 1.1% and 3 of 100 parachutes dropped failed completely. These observations stimulated research at the Royal Aircraft Establishment, Farnborough, to eliminate the phenomenon.

If the lower part of the canopy near to the hem was made much more porous, then, when one part protrudes below another, there would be less force to drive material between a pair of lines. However, at the time, there was limited knowledge of the dynamic strength of a parachute near to the hem, so an 18-in.-wide strip of strong net, woven on a bobbin-lace machine from 210 denier nylon yarn at 19 holes per inch, was added as an extension to the canopy without removing the existing hem and making a similar hem to finish the extension (Fig. 2). Extensive trials[1] showed that this net completely stopped blown peripheries, but it also increased the inflation time of the parachute. In trials to develop the design to production standard, it was found that the opening performance of the parachute was very sensitive to detail in design. For example, the removal of the reinforced hem between the "solid" fabric and the net substantially increased the rate of inflation and caused minor bursts of the canopy. Thus it was impossible to generalize on the design, and the recommendation to fit a net extension had the proviso that it is applied in one of the forms actually tested.

It is important to note that there are applications of parachutes without net skirts that always open normally because the line tension is adequately maintained. In the Martin-Baker and the Folland ejection seats the seat drogue always applies a substantial tension on the main parachute canopy. This does not happen in the paratroop parachute deployment system which is operated by a static line attachment to the aircraft which pulls the deployment bag off

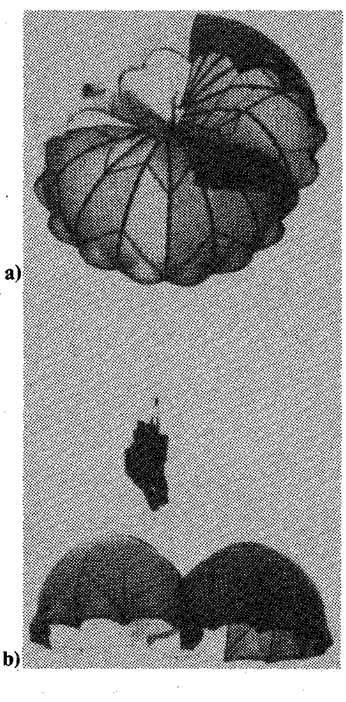

Fig. 1 Illustration of a blown periphery.

Received Oct. 14, 1981; presented as Paper 81-1927 at the AIAA 7th Aerodynamic Decelerator and Balloon Technology Conference, San Diego, Calif., Oct. 21-23, 1981; synoptic received July 20, 1982. Copyright © Controller, Her Britannic Majesty's Stationery Office, London, 1981. Full paper available from AIAA Library, 555 W. 57th St., New York, N.Y. 10019. Price: Microfiche, $4.00; hard copy, $8.00. **Remittance must accompany order.**

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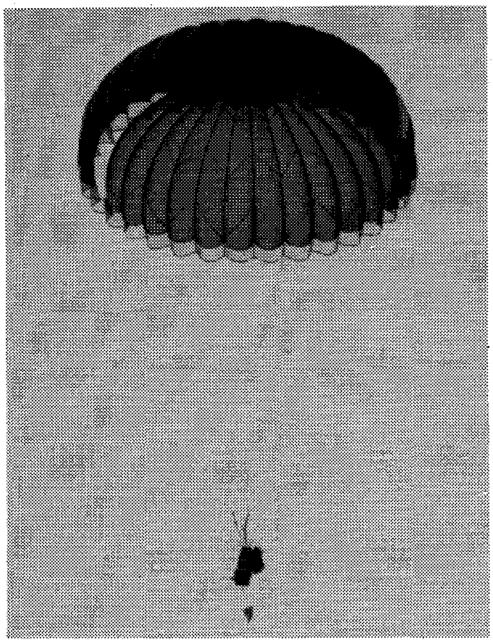

Fig. 2 32-ft-diam flat parachute with a 10-in. net extension.

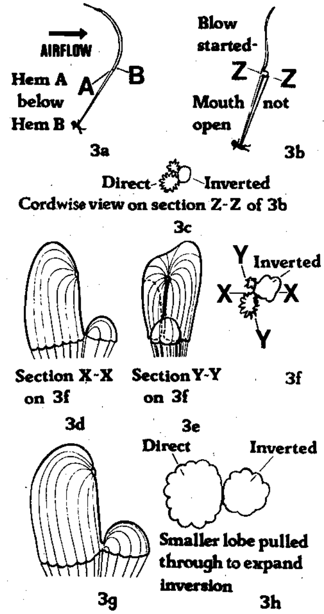

Fig. 3 Illustration of the development of a partial inversion on a paratroop parachute.

the man's back after he has jumped. The lines are deployed first and then the canopy, all stretching out in an arc across the airstream. The apex of the parachute is held to the deployment bag by a breaktie until the increase in tension in the lines causes the tie to break. The parachute then swings away and inflates (Fig. 3).

The critical stage that decides whether a blown periphery develops is immediately after the apex tie breaks (Fig. 3a). At this moment, with the parachute still uninflated, there will be elastic retraction in the lines and the tension decreases momentarily to zero. If, at the same time, the man has turned over and pulled one of the attachment points at the confluence of the suspension lines below the other, one set of lines will pull one part of the hem below the remainder. If the panels on the windward side are lower than those on the leeward side, and since there is insufficient tension in the lines to restrain the fabric, some can blow through between the lines, and form a cap (Fig. 3b). This cap quickly attains an attitude in which the full air blast strikes it, and with the remainder of the canopy still substantially uninflated, contrary to the illustration by Brown,[2] the inverted portion of the canopy can expand rapidly. Fabric can blow through randomly in more than one place, but the most developed blow will take control and arrive at the situation of Fig. 3c. In this condition the canopy is divided into two direct lobes and one inverted lobe, as seen in the plan view of Fig. 3f. The inflation may remain in this state as a three-lobe blown periphery, but if the direct lobes are substantially different in size, the larger one can pull the smaller one through and cause a two-lobe blown periphery (Figs. 3g and 3h). The indirect lobe can continue to expand, if the relative sizes of the lobes and the dynamics of the situation are right, causing the canopy of the parachute to invert completely.

A net extension was added to the Irvin I32 canopy by retrospective modification action and introduced to the British service on the PX1 Mk4 assembly in 1971. A polyester, rather than a nylon, net was used. To date, this modified parachute has been in regular use and several hundred thousand drops have been made without the recording of abnormal deployments of the type described.

References

[1] Jolly, A.G. and Stevens, G.W.H., "The Net-Skirt Extension on Man-Carrying Type Parachutes," RAE Tech. Note, Mech. Eng. 389, 1963.

[2] Brown, D.W., *Parachutes*, Pitman, New York, 1951, p. 226.