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RESEARCH MEMORANDUM

WIND-TUNNEL INVESTIGATION OF THE BEHAVIOR OF PARACHUTES IN CLOSE PROXIMITY TO ONE ANOTHER

By Stanley H. Scher

Langley Aeronautical Laboratory
Langley Field, Va.

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SUMMARY

The results of an investigation in which the behavior of parachutes in close proximity to one another was studied by using small parachutes attached to thin wires in the Langley 20-foot free-spinning tunnel are presented. These results indicate that the parachutes when side by side generally had little effect on one another and may sometimes have had slight repelling effects. When one parachute got into the wake above another parachute, the upper parachute sometimes collapsed on top of the lower parachute. The results indicate that the collapsing phenomenon is somewhat more prone to occur for high-porosity, stable parachutes than it is for lower-porosity, unstable parachutes such as those customarily used as man-carrying parachutes, although it may occur for the latter type. The wake region in which the upper parachute may be affected adversely extends to a distance of about five parachute diameters above the lower parachute.

INTRODUCTION

The National Advisory Committee for Aeronautics has made a brief investigation to obtain some information as to the behavior of a parachute in the wake of another parachute and also to determine the behavior of two parachutes in close proximity to one another. This problem is of particular concern to the military services in connection with mass paratroop jumps and multiple-parachute cargo drops.

Tests were made with small parachutes tethered in the vertical Langley 20-foot free-spinning wind tunnel. The parachutes were free to oscillate about the attachment point in the vertically rising airstream. Low-porosity, unstable parachutes and high-porosity, stable parachutes were used in the investigation. The tests results are reported herein.

APPARATUS

The tests were made in the Langley 20-foot free-spinning wind tunnel. This facility is an atmospheric wind tunnel with a vertically rising airstream in the test section.

Small parachutes which were available from previous investigations were used in these tests. The diameter of the parachutes ranged from approximately 10 inches to 12 inches. Some of the parachutes had porosity numbers of 120 and some had porosity numbers of 400. The parachute porosity numbers used indicate approximately the cubic feet of air that will pass through 1 square foot of the canopy cloth per minute under a pressure of $\frac{1}{2}$-inch of water. The 120-porosity parachutes were unstable and are considered as small models of parachutes customarily used as man-carrying parachutes. The 400-porosity parachutes are representative of one type of stable (no appreciable oscillation) parachute. The 120-porosity, unstable parachutes had flat-type canopies and the 400-porosity, stable parachutes had hemispherical canopies, but this difference in canopy shapes is of no significance in this investigation.

METHODS AND TESTS

The high-porosity, stable parachutes and the low-porosity, unstable parachutes were tested separately. For each type, each of two parachutes was attached to a separate movable thin wire which was stretched horizontally across the tunnel. The parachute-attachment points were at the bottom of their shroud lines and the parachutes were free to oscillate in the airstream about their attachment points. The respective wires were moved slowly by hand so that the parachutes were brought side by side or so that one parachute was brought near, or into, the wake of the other parachute at various heights. Heights up to about 6 canopy diameters above the lower parachute were used. In one instance, also, two 120-porosity, unstable parachutes were attached side by side on the same wire and a third similar parachute was moved into the enlarged wake region above them.

Visual observations were made and motion pictures were taken from which a determination was made as to how parachutes brought side by side would affect one another, and as to how the wake region above a parachute would affect another parachute when moved near or into this wake. The motion pictures were made at a camera speed of 32 frames per second, and were made to provide pictorial records of the results. The relative positions of the camera and the parachutes varied during the tests and no detailed measurements were made of parachute motions from the film records.

The tests were made over an arbitrary velocity range of approximately 13 to 33 feet per second.

RESULTS AND DISCUSSION

The high-porosity, stable parachutes trimmed in an approximately vertical attitude, which was expected based on the results of previous investigations such as that reported in reference 1. When the two stable parachutes (10-inch and 12-inch diameters, respectively) were brought side by side either slowly or rapidly, they apparently had no appreciable effect on each other as illustrated by the motion-picture strip of figure 1. However, when one parachute was moved near the wake region above the other parachute, there was a very definite and consistent tendency for the upper parachute to move into the wake region and then to collapse on top of the lower parachute. This tendency appeared to be greatest when the vertical distance between the two parachutes was about 1 to 3 canopy diameters, and was still present when the distance was increased to 5 diameters. At about 6 diameters distance, the upper parachute did not collapse. A motion-picture strip illustrating the behavior of the two parachutes when one is moved near the wake of the other at a vertical separation distance of about 4 or 5 diameters is presented in figure 2.

The low-porosity, unstable parachutes trimmed at an inclination of about 25° from vertical and made occasional circling motions at this attitude, a behavior which could be anticipated based on the results presented in reference 1. When two of these inclined parachutes (12-inch diameters) were brought side by side, there appeared to be some slight tendency for them to repel one another. When one parachute was brought near the wake of the other, there was a tendency for the upper parachute to momentarily start to collapse. Then the upper parachute usually moved rapidly sidewise in space out of the wake of the lower parachute and immediately opened fully again. This phenomenon is illustrated in the motion-picture strips of figure 3. However, the upper parachute was sometimes slow in reopening and occasionally collapsed completely just as did the high-porosity parachutes. When a 120-porosity, unstable parachute (10-inch diameter) was brought into the enlarged wake region above two adjacent unstable parachutes (12-inch diameters), the tendency of the upper parachute to collapse was increased considerably. This is illustrated in the motion-picture strips of figure 4.

The behavior of all the parachutes did not appear to be affected appreciably by changes in velocity over the range covered by the tests.

The test results indicate that a parachute may collapse when it gets into or near the wake of another parachute, but that this phenomenon is less likely to occur with low-porosity, unstable parachutes than with high-porosity, stable parachutes. Inasmuch as high porosity is sometimes used for purposes of obtaining stability of a parachute (ref. 1), it is obvious that compromises may be necessary when designing a parachute to achieve desired stability and degree of reliability in remaining open. Initial opening characteristics of a packed or folded parachute and desired drag characteristics of the open parachute also have to be considered in designing the parachute (ref. 2).

Based on the results of the current tests, it appears that careful consideration must be given to problems such as determining whether a specific parachute (carrying a specific pay load) descending in close proximity above another parachute would have any undesirable behavior such as collapsing or fouling the parachute below. Such information will be necessary in order to determine how many men or other articles can be safely dropped in a given space in a given amount of time.

CONCLUDING REMARKS

An investigation has been made in which the behavior of parachutes in close proximity to one another was studied by using small parachutes attached to thin wires in the Langley 20-foot free-spinning tunnel. It was found that the parachutes when side by side generally had little effect on one another and may sometimes have had slight repelling effects. When one parachute got into the wake above another parachute, the upper parachute sometimes collapsed on top of the lower parachute. The results indicated that the collapsing phenomenon is somewhat more prone to occur for high-porosity, stable parachutes than it is for low-porosity, unstable parachutes such as those customarily used as man-carrying parachutes, although it may occur for the latter type. The wake region in which the upper parachute may be adversely affected extends to about 5 parachute diameters above the lower parachute.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., June 15, 1953.

REFERENCES

1. Scher, Stanley H., and Draper, John W.: The Effects of Stability of Spin-Recovery Tail Parachutes on the Behavior of Airplanes in Gliding Flight and in Spins. NACA TN 2098, 1950.

2. Scher, Stanley H., and Gale, Lawrence J.: Wind-Tunnel Investigation of the Opening Characteristics, Drag, and Stability of Several Hemispherical Parachutes. NACA TN 1869, 1949.

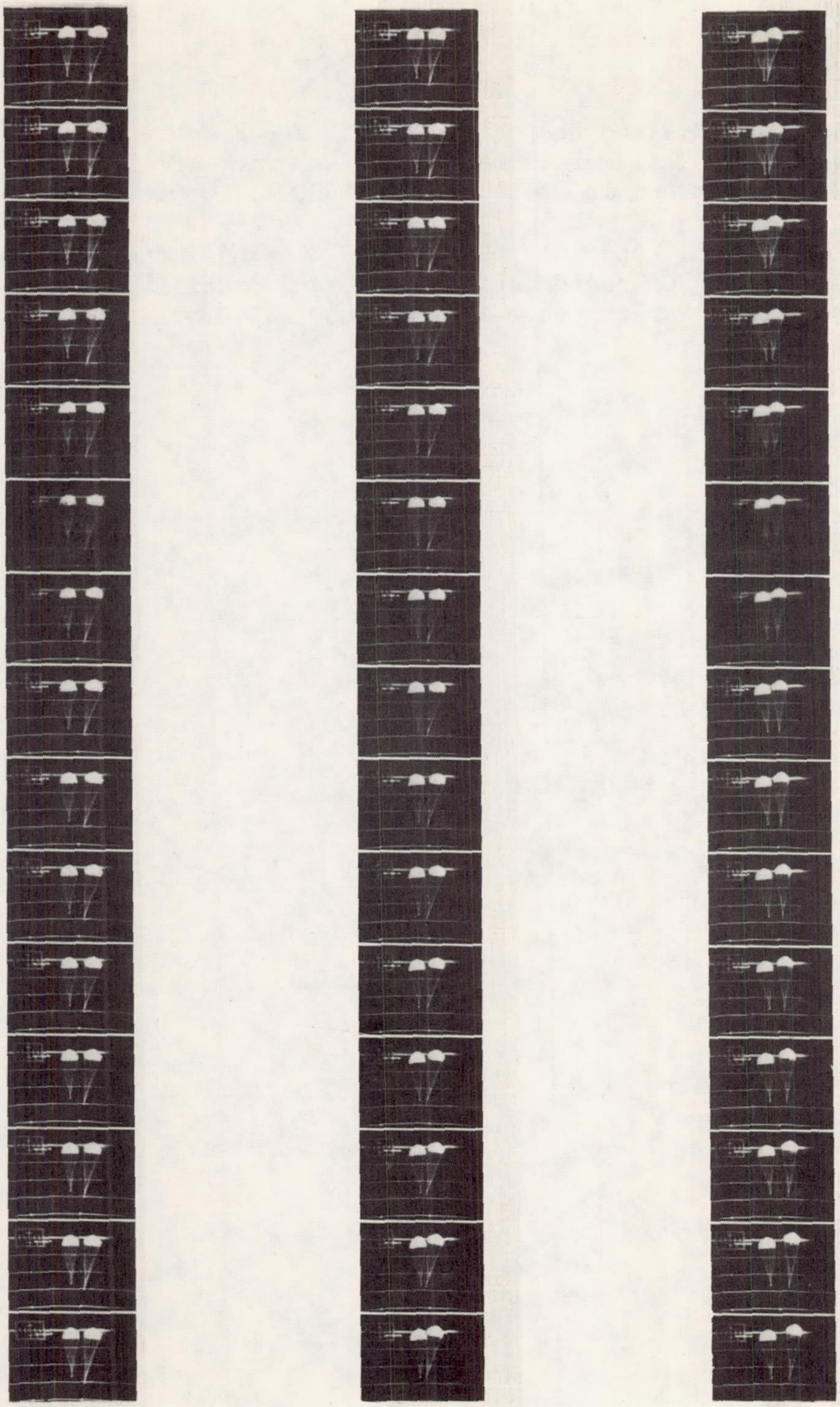

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Figure 1.- Motion-picture strip showing two 400-porosity, stable parachutes brought side by side (12-inch-diameter parachute with 26-inch shroud lines on left; 10-inch-diameter parachute with 30-inch shroud lines on right).

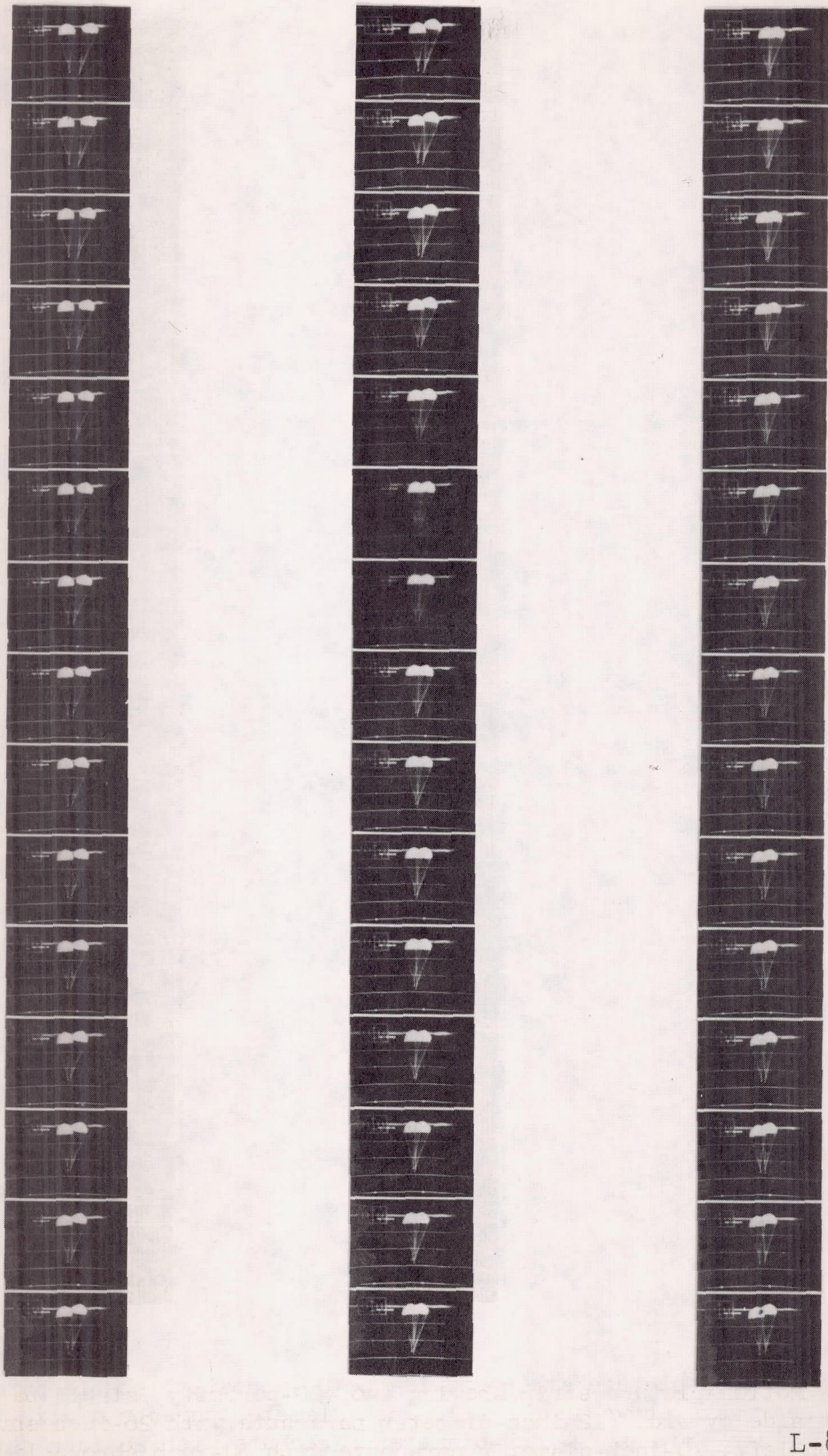

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Figure 1.- Concluded.

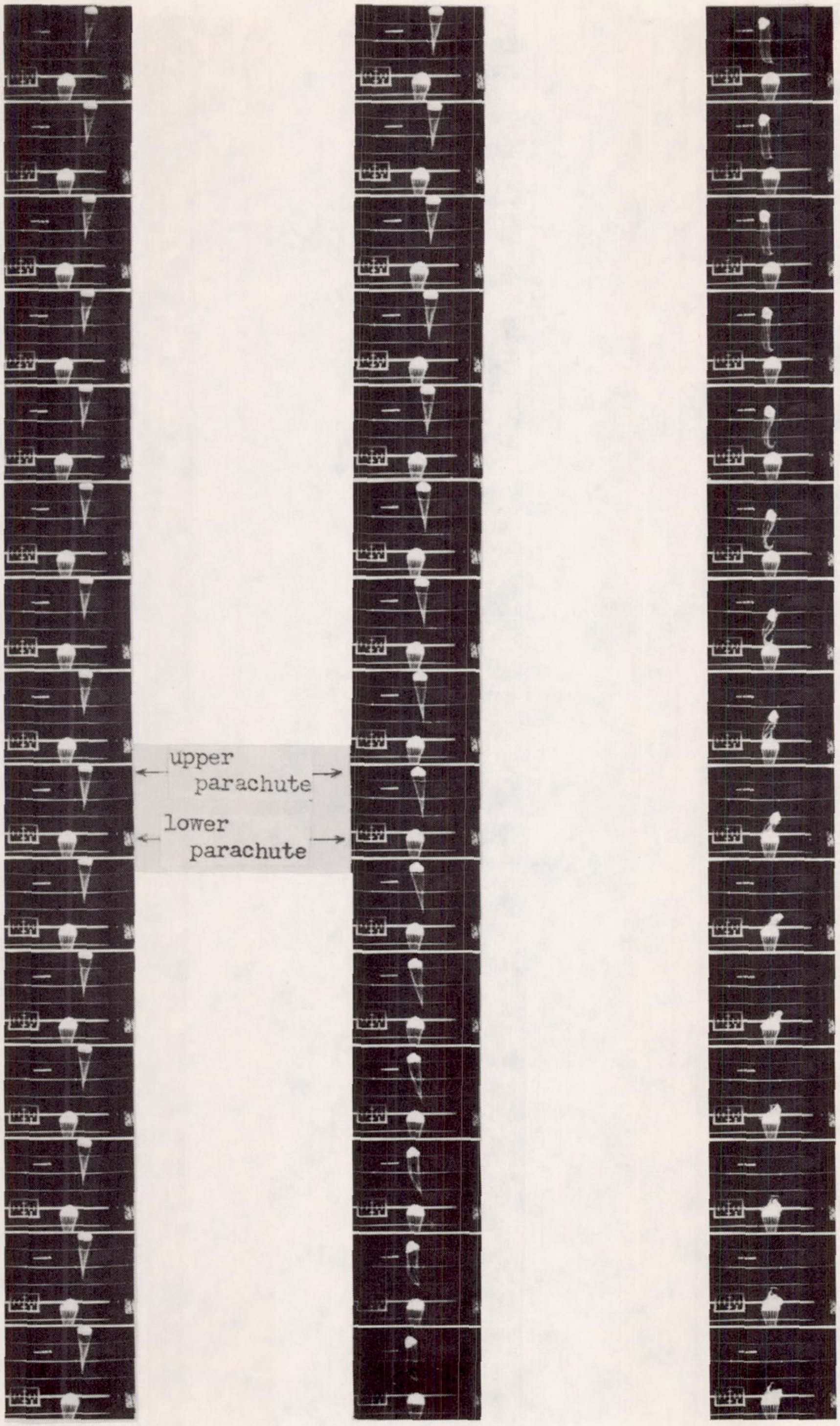

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Figure 2.- Motion-picture strip showing a 400-porosity, stable parachute moved near wake above another (10-inch-diameter parachute with 30-inch shroud lines above a 12-inch-diameter parachute with 26-inch shroud lines).

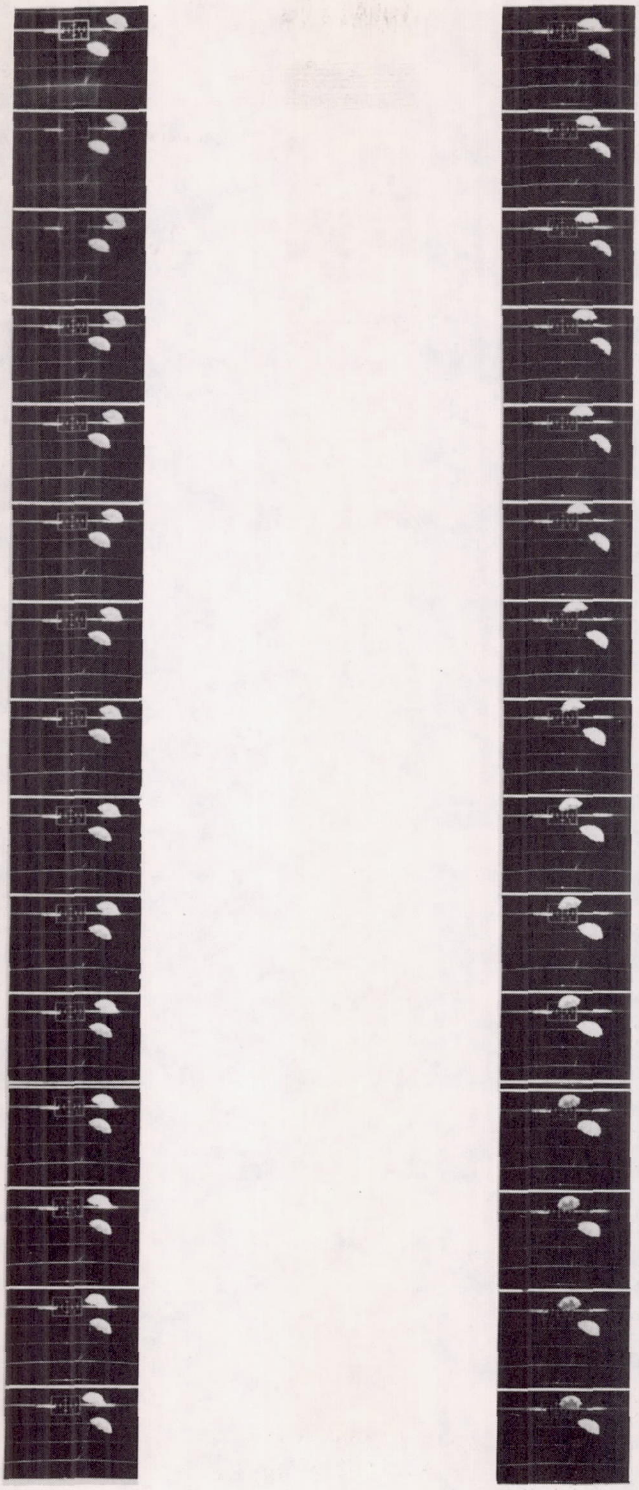

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Figure 3.- Motion-picture strip showing a 120-porosity, unstable parachute moved into wake of another (12-inch-diameter parachutes with 20-inch shroud lines and 1-inch-diameter vent cut in top of canopies).

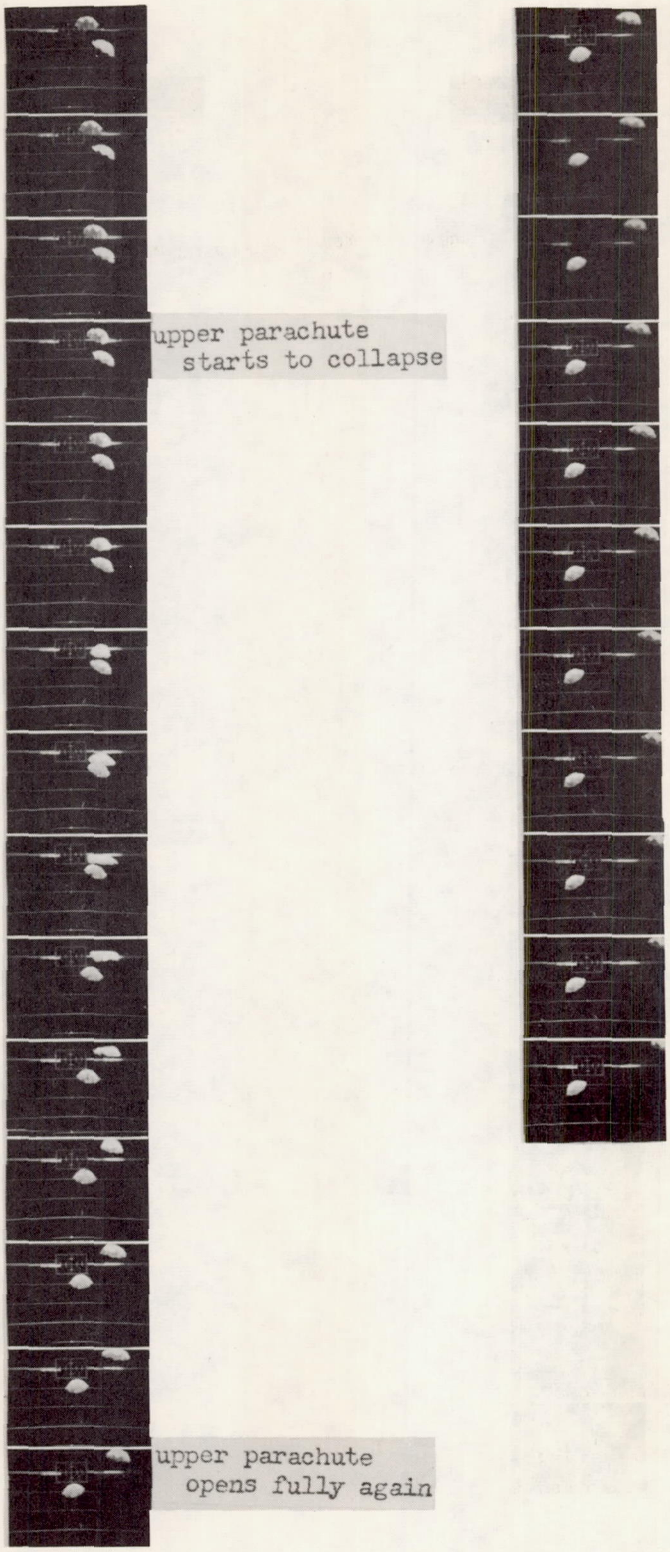

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Figure 3.- Concluded.

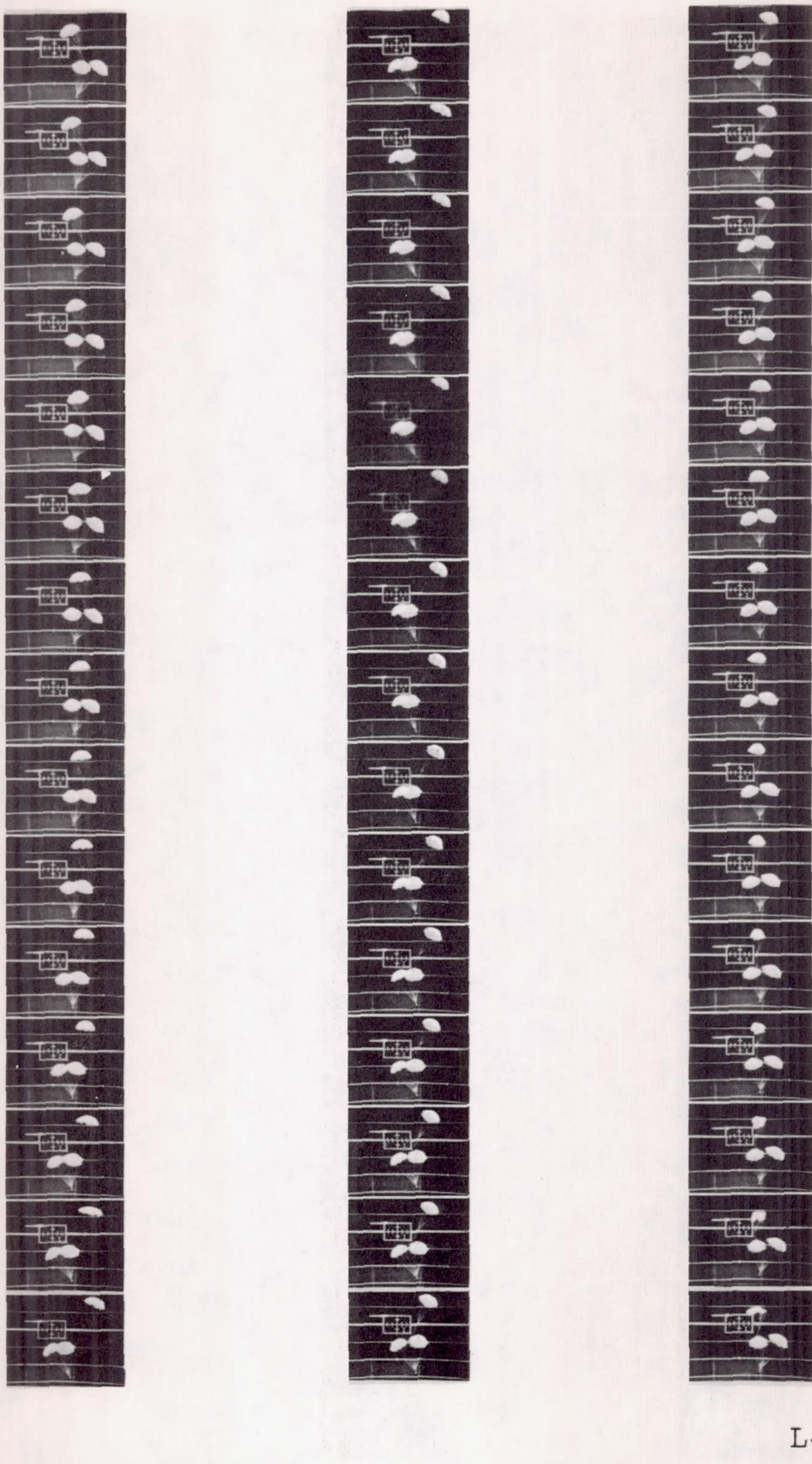

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Figure 4.- Motion-picture strip showing a 120-porosity, unstable parachute moved into wake of two others (one 10-inch-diameter parachute with 13-inch shroud lines and 0.83-inch vent moved above two 12-inch-diameter parachutes with 20-inch shroud lines and 1-inch vents).

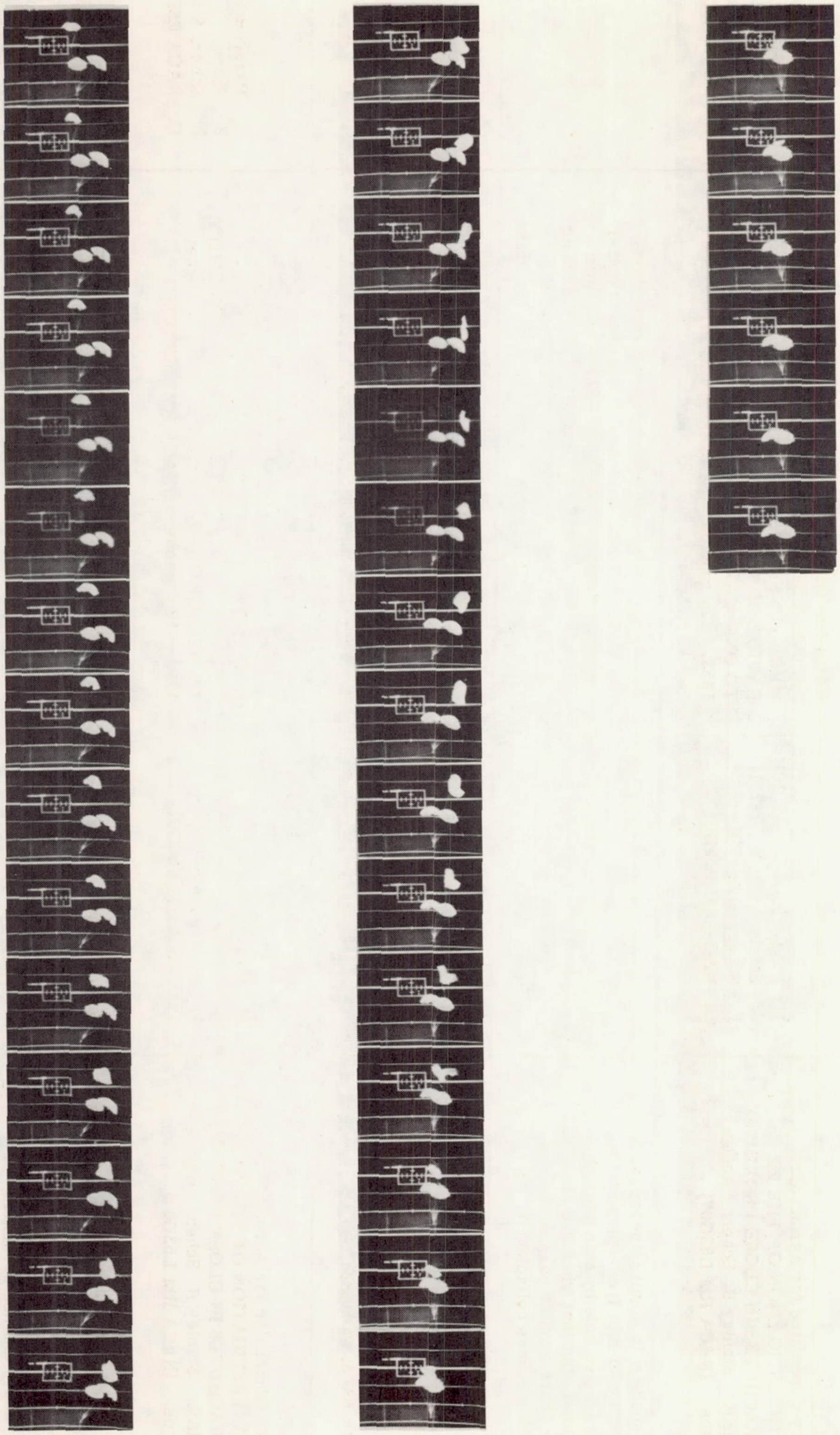

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Figure 4.- Concluded.