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A Note on Side and Floor Aperture Jumping

By

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Introduction.—The occasional complete or partial failures of " X " type parachute equipment are, so far as is known, always associated with one or more of the three following faults :—

1. Somersaulting of the man.
2. Twisted rigging lines.
3. Tangled rigging lines.

Present research and development work is primarily directed to reducing or eliminating these faults.

1. *Forces Acting on Man Emerging from a Floor Aperture.*—The main forces acting on a man emerging through a floor aperture from an aircraft are as follows.

1.1. *The Wind Force Acting on the Man.*—(*a*) Since his feet enter the airstream first the initial effect is a couple tending to rotate him about a horizontal axis, regardless of which way he is facing.

(*b*) As a whole he is unsymmetrical because of the parachute pack on his back. His most stable position is that in which he is facing the wind, and his least stable position is sideways, when the wind force on his pack will tend to rotate him till he faces wind.

1.2. *The Drag of the Static Line.*—The effect of this on the man depends on which way he is facing, for the point of application of the force is altered thereby.

Three cases only need be considered :—

(*a*) *Facing forward.*—The line is blown clear behind the man, and as it pays out from near his C.G. very little couple is exerted on him. The drag applied in this way, however, increases his stability. (Fig. 1.)

(*b*) *Facing aft.*—The line is blown over one of the man's shoulders, or even round one arm (almost always on the same side as its anchorage in the aircraft). It therefore exerts a couple about a horizontal axis (which opposes that due to the wind force on his legs), and also a couple about his vertical axis. The further the last point of contact of the static line with the man is from his vertical axis, the greater the latter couple. (Fig. 2.)

(*c*) *Facing sideways.*—The line is blown clear away from the man, but a couple is exerted tending to swing the pack to the rear. (This adds to the couple due to the wind force on his pack.)

2. *Motion of Man on Leaving a Floor Aperture.*—The general tendencies towards particular motions are derived by combining the forces referred to above for any given conditions, and the conclusions for all the most usual cases agree with the analysis of ciné records of a considerable number of drops. Broadly, they are that a man leaving a floor aperture facing forwards tends to somersault forwards, a man facing aft tends to twist, and a man facing sideways tends to roll forwards onto his face.

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* R.A.E. Technical Note No. Aero. 1143 (Par.).

The above motions result from exits in which the paratroop initially falls vertically without rotation about any axis. A man may, however, impart angular momentum to himself while jumping, or may strike the side of the hole during his exit. The first experiments made with single jumps from aircraft showed no sign of these effects, and later investigations into jumps from a balloon car confirmed that they are unusual in an unhurried exit.

Ciné records taken of men jumping in sticks, however, suggest that the men do emerge from the hole with angular momentum. Certainly the general standard of exit is noticeably worse with the " quick stick " method, though this may be partly attributable to the fact that some men are not facing directly fore or aft as they jump, and as has been shown above, they are then in the most unstable condition.

3. *Methods of Reducing Unwanted Motions of the Man.*—3.1. *Somersaulting.*—While the " attention " position remains the standard way of leaving the hole, the couple due to the wind force on his legs cannot be eliminated, and it therefore becomes necessary to oppose this by another approximately equal couple. An alteration in the stowage of the static line so that its last point of contact with the man is well above his C.G. whichever way he is facing, instead of only when he is facing aft, is an obvious choice.

3.2. *Twisting of the Man.*—It is hardly possible to make the man with pack symmetrical so that he would not be unstable in any position, and hence instability due to the wind force on the pack when he faces sideways cannot be avoided. For exits facing aft and sideways the couple due to static-line drag may be reduced by ensuring that the last point of contact of the line with the man is as close to his vertical axis as possible. The only place meeting this requirement, as well as complying with 3.1 above, is just behind his neck. The simplest practical method of effecting this appears to be to stow the static line in such a way that it pays out from this point.

It will be appreciated that it is not advisable to reduce the drag of the static line by using a thin cable, because this would reduce the couple which opposes that due to the wind force on the man's legs, and somersaulting would increase.

Experiments are in hand with a design of outer pack in which the stowage of the static line is on the base (under the bag), arranged so that it pays out at the top by the nape of the man's neck. (Fig. 3.)

4. *Twists in Lines due to Rotation of the Bag.*—4.1. *Aircraft Drops.*—Twists in the lines may be produced by rotation of the bag during the deployment of the lines and canopy. In the trials conducted by the Royal Aircraft Establishment referred to in Aero. Tech. Note No. 972, the bag only once made more than half a turn in about 70 drops. Further ciné records now available suggest that it may do so more frequently than this, though more than two turns has never been recorded. Such twisting of the bag is more dangerous than twisting of the man, as it might put a tight twist in the lines near the canopy, a position more likely to cause failure.

Wind-tunnel tests have shown that the bag itself is stable in an air stream, the stability decreasing slightly with a decrease in the angle between the static line and the horizontal. Presumably, therefore, the rotation is due either to the mechanical effect of the lines deploying from loops on alternate sides, or to an initial kick if the bag leaves the outer pack at an angle to wind. Analysis of films of actual drops suggests that the latter is the more potent cause, and also confirms that the bag is less stable at smaller angles to the horizontal.

The most promising method of preventing bag rotation appears to be to alter its shape or suspension so that it is still more stable in an air stream, and to increase the angle to the horizontal by increasing the tension in the rigging lines.

4.2. *Balloon Car Drops.*—Ciné records of jumps from a balloon car already referred to showed that such twists as occurred were due to rotation of the bag and not to the man. Since there is no air stream the modification suggested above would be ineffective in this case. The inherent stability of the bag referred to above would account for it rotating far less in drops from aircraft than from the balloon. Unfortunately a method of preventing bag rotation in balloon drops appears very difficult to devise without making considerable alterations to the equipment, which would then probably be unsuitable for use from an aircraft.

4.3. *Tangled Rigging Lines.*—It has been noticed that in a large proportion of fatal accidents to paratroops tangles have been found in the lines, often locked in by twists. Many theories to explain their occurrence have been propounded, but proof is exceedingly difficult to obtain, mainly because they are so rare, but partly because the deployment of the lines can only be seen by the use of very good photography, and the personnel, equipment and lighting conditions necessary for this are seldom available.

It is, however, considered by many that the stowage of the lines on a flexible flap (*see* Fig. 4), which has to be rapidly unrolled just prior to their deployment, does not promise such consistent performance as a stowage mounted on a more rigid base. So far as is known tangling troubles have not been noticed with the latter arrangement, but most of those tried in quantity deploy canopy first, and so cannot be directly compared.

Experiments made at the R.A.E., whereby the static line and bag are pulled upwards from the back of a stationary dummy man with the same relative speed and acceleration as in an actual drop, showed that with the standard pack the lift webs did not remain above the man's head after the mouth ties broke, but descended, sometimes to his waist. It therefore appeared that the elastic loops at present used do not hold the lines sufficiently tightly to keep the first few yards under tension on every occasion. Photographs taken from the nose of the dropping aircraft using dummy men confirm this. Tests have shown that a statically applied tension of not more than 10 lb. is sufficient to pull the lines from the smallest size of elastic loops so far used.

Other experiments made at the R.A.E. which allowed very good high-speed close-up photography of the shroud lines and canopy leaving the bag under conditions exactly the same as a balloon drop, but using a 200 lb. rubber dummy, have not so far yielded very much positive information on tangling.

The most noticeable features were firstly, the large tension necessary to break the canopy tie as shown by the distortion of the bag just before the break, and secondly, the fact that the flap was sometimes horizontal, or even upside down, while the lines were pulled from it. The first of these points is dealt with further below.

A suggestion has been made that tangling may be caused by the breaking of one mouth tie before the other, thus allowing the flap to unroll unevenly. This condition will always obtain when a man rolls onto his side in the early stages of his exit, because the lift web on his under side will be pulled taut first. It has not been noticed, however, that tangles are particularly liable to occur in such cases either in ordinary live drops or when deliberately brought about in experimental drops at the R.A.E.

It has been shown by P.T.S. Ringway that a loop of rigging line, after passing through one elastic loop, may catch round another elastic loop and so become locked. Conditions then obtain which can cause tangling of the lines and mal-development of the canopy.

Another suggestion is that trouble may be caused because while the two sets of lines from each lift web are stowed together, they are not necessarily required to come out exactly together, since one lift web may be pulled in advance of the other. This would be the case if a man rolled, but, as stated above, tangles have not been found particularly liable to occur in such conditions.

A further argument for the separation of the two sets is that tangling due to other causes might be confined to only half the lines.

5. *Methods of Reducing Tangling of Rigging Lines.*—From the above it will be seen that this is a difficult problem because so little direct evidence on the underlying causes of the present troubles exists. Improvement would seem most likely to result from

(*a*) increasing the rigidity of the base on which the lines are stowed,

(*b*) increasing the tension necessary to pull the lines from their stowages, (*c*) alteration of the type of stowage loop or the arrangement thereof so that locking cannot occur,

(*d*) separate stowage of the groups of lines from each lift web.

Experiments are proceeding with a type of bag meeting the requirements (*a*), (*b*) and (*c*) above. So far they show promise, though only a very large number of drops can prove that improvement has been made. The final version of this bag is shown in Fig. 5.

6. *Deployment of the Canopy.*—Failure due entirely to the canopy itself is extremely rare, and trouble is almost entirely confined to thrown lines. These are most probably due to its deployment from the bag at right angles to the windstream, which occasionally results in part of the skirt being blown between a pair of rigging lines, so that this part of the canopy develops inside out.

With the present equipment the high steady load of 150 lb. is required to break the canopy tie (already referred to). The canopy is then entirely free to leave the bag (it will fall out under gravity) until the apex is arrested by the apex tie, which again needs the high load of 200 to 400 lb. to break it. It is felt that the deployment of the canopy under these loading conditions is used because it is convenient, but that further study is required. It seems that a steady restraint on the canopy throughout its deployment might prove superior to the present system of sudden shocks.

7. *Canopy-first Equipment and Side Exit Aircraft.*—The R.A.E. has no practical experience of these, but some information is available, and in view of the possible use of American airciaft some comments are called for.

The essential difference in the aircraft is that the men leave from the door in the side of a fuselage of oval section. The two methods, type " X " equipment in aperture exits and " canopy-first " equipment in door exits, are shown in Figs. 6 and 7 respectively.

The main differences from jumps through a floor aperture are therefore likely to be :—

(1) The man steps out, turning his back to wind as he does so. Hence his whole body becomes exposed to the air stream at once, so that no tendency to somersaulting should be produced.

(2) The man is able to step out quietly without jumping. The fact that the fuselage is of oval section means that the bottom of the door is well back and he has no feeling that he may catch on the bottom edge as he falls. This is conducive to consistently good exits.

(3) The man steps out almost directly into the slipstream of one of the engines and therefore moves backwards relative to the aircraft faster than when jumping from a floor aperture.

As a result the static line never blows past him. In fact, it is stated that the pull on the line tends to stabilise him and keep him facing directly aft.

From the above it will be seen that the exit conditions through a door in a suitable aircraft are probably greatly superior to those of a floor aperture. The conditions which lead to somersaulting and twisting of the man, whether due to static line drag, instability, or to his own action when jumping, are absent. This being so, there is no objection to the use of a parachute pack which deploys the canopy first, for the man is highly unlikely to come in contact with it. We are told, however, that some of the few cases where the man has somersaulted or become entangled with the static line have resulted in fatal accidents.

8. *Interchange of Equipment and Aircraft.*—From the foregoing it will be seen that there is probably no objection to the use of "lines-first" equipment in suitable aircraft with door apertures, but the use of " canopy-first " equipment in aircraft with floor apertures is likely to be highly dangerous, and should not be attempted without considerable previous experiments with suitable dummy men.

9. *Conclusions.*—From present theoretical knowledge of door and hole jumping the former should prove the better method. With the latter unwanted motions of the man are more likely to develop, though there are sound reasons for thinking these can be reduced by alterations to the outer pack. It is doubtful whether anything can be done to ameliorate the results of a bad exit. Little is known about the effects of higher dropping speeds, but the motions of the man may be expected to become more violent.

Certain modifications to the inner bag show promise as regards the deployment of the lines. Further investigation is required into the deployment of the canopy.

" X " type equipment should work satisfactorily with door jumping, but the use of " canopy-first " equipment from floor apertures is likely to be dangerous.

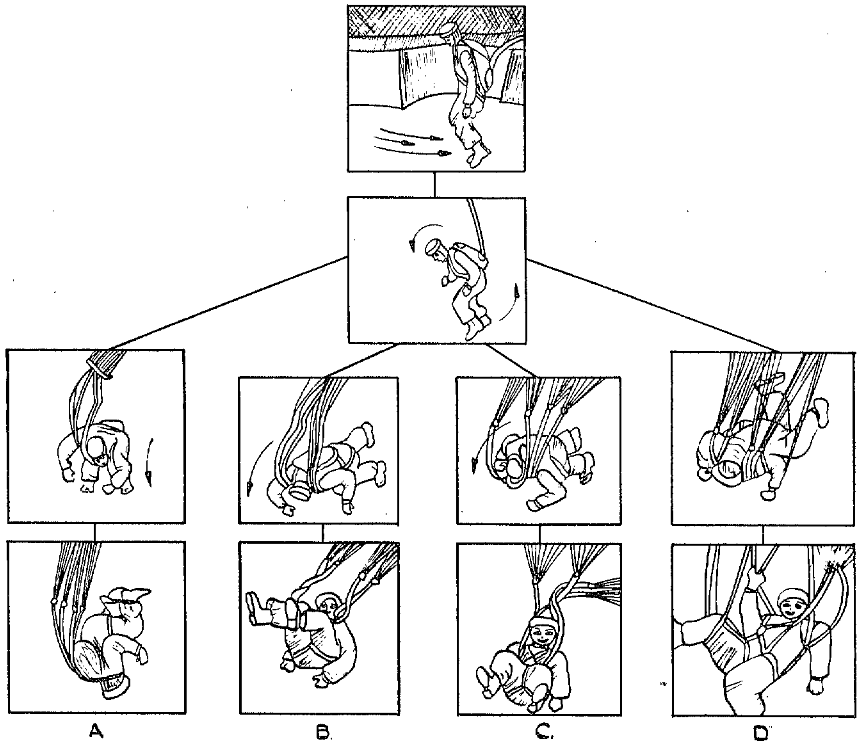

FIG. 1. Somersaulting with Type " X " Equipment.

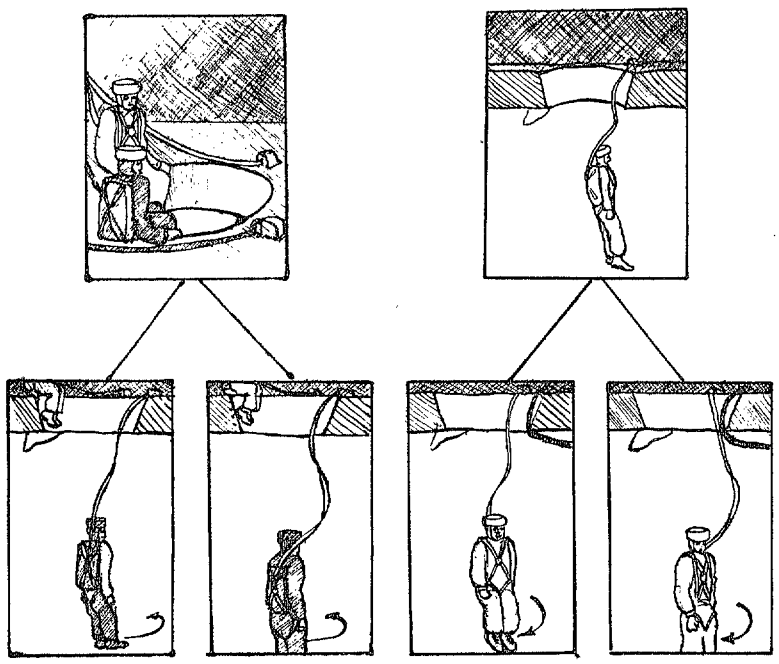

FIG. 2. Twisting with Type " X " Equipment.

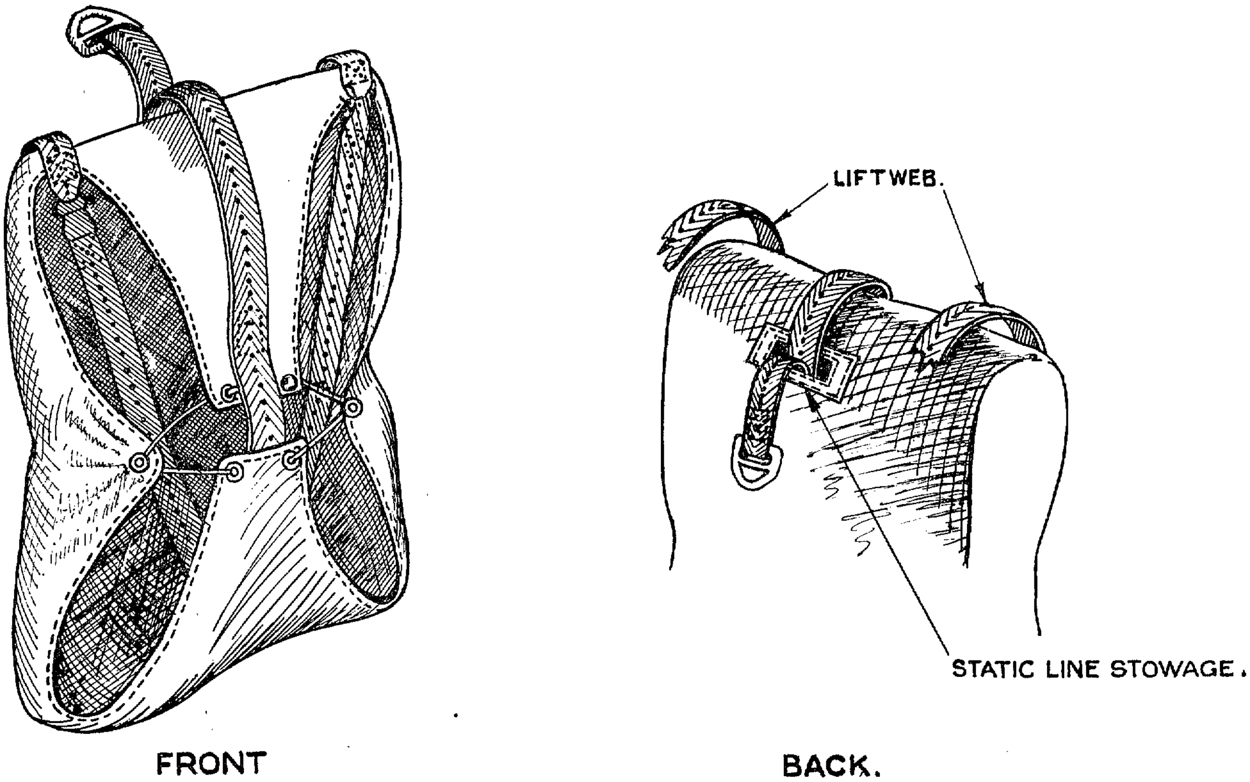

FIG. 3. Modified " X " Type Parachute Outer Pack.

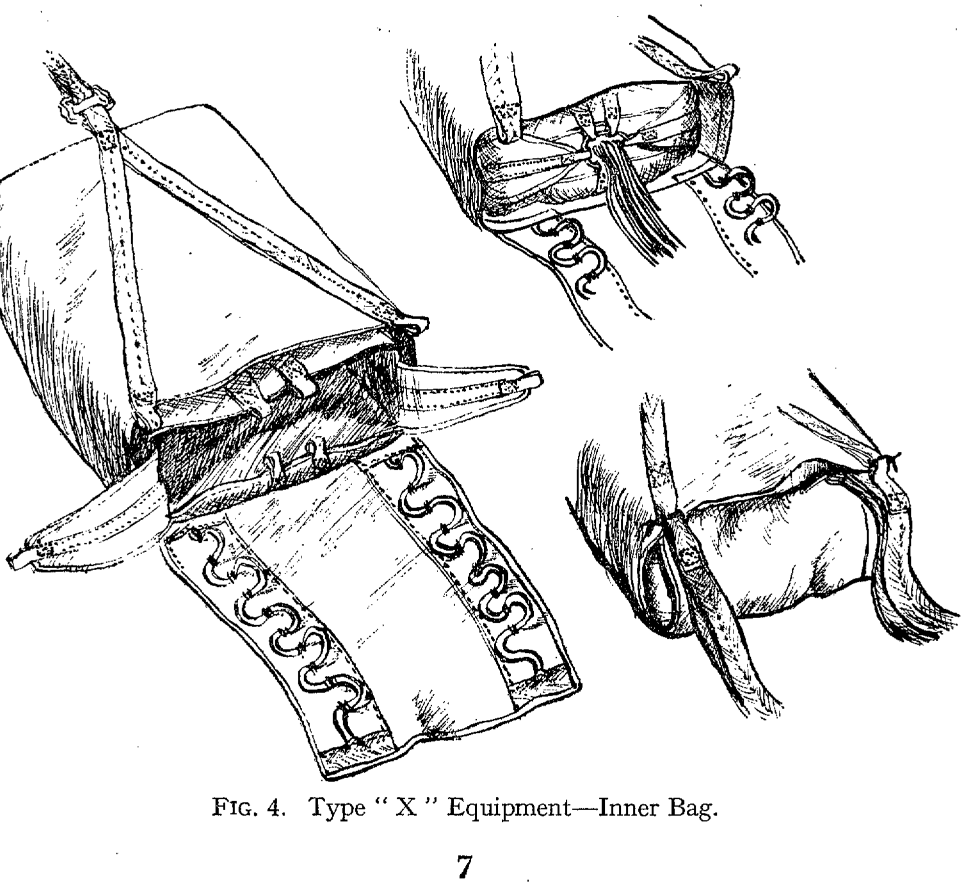
FIG. 4. Type " X " Equipment—Inner Bag.

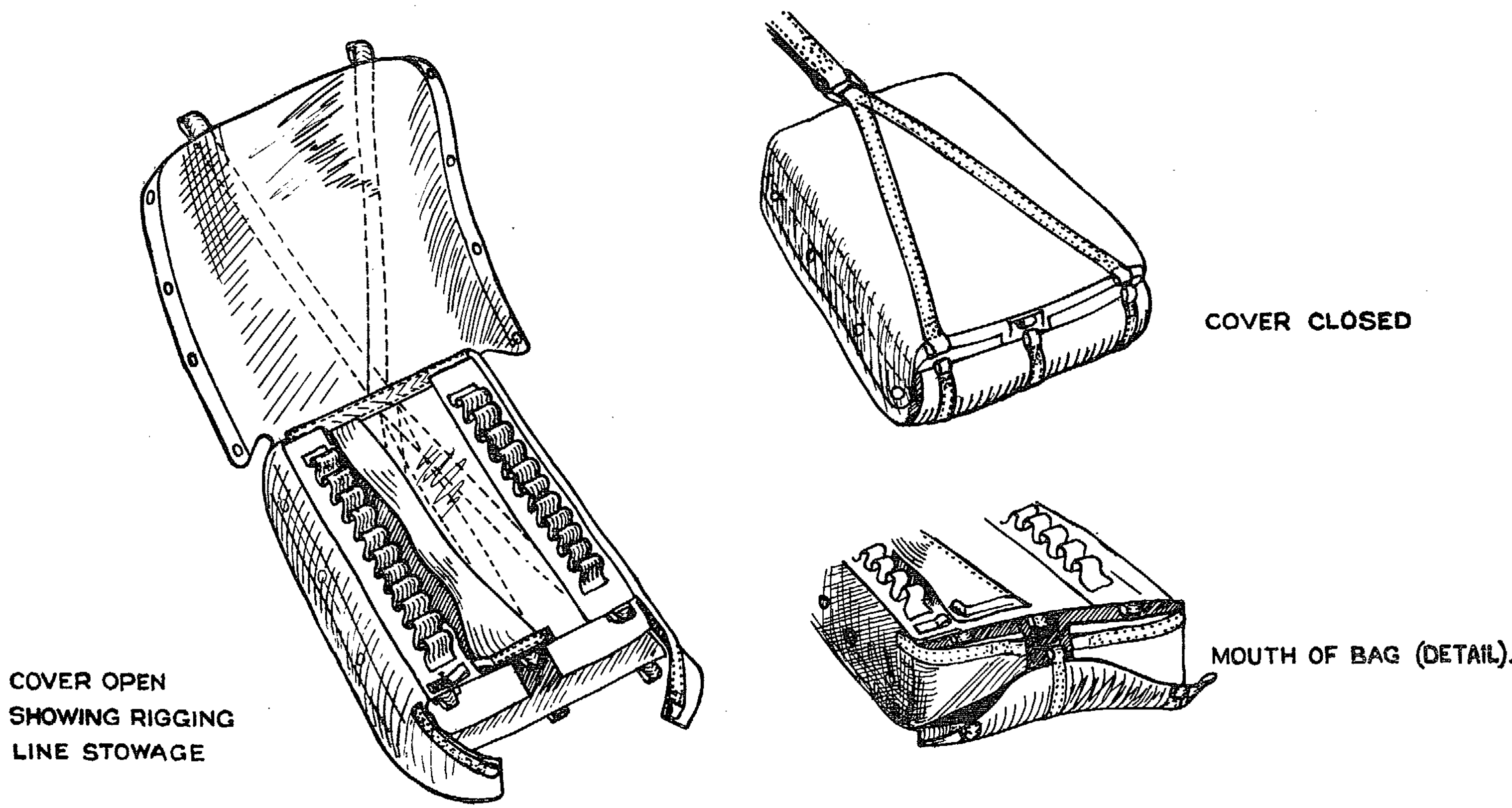

FIG. 5. B.14 "X" Type Parachute Inner Bag.

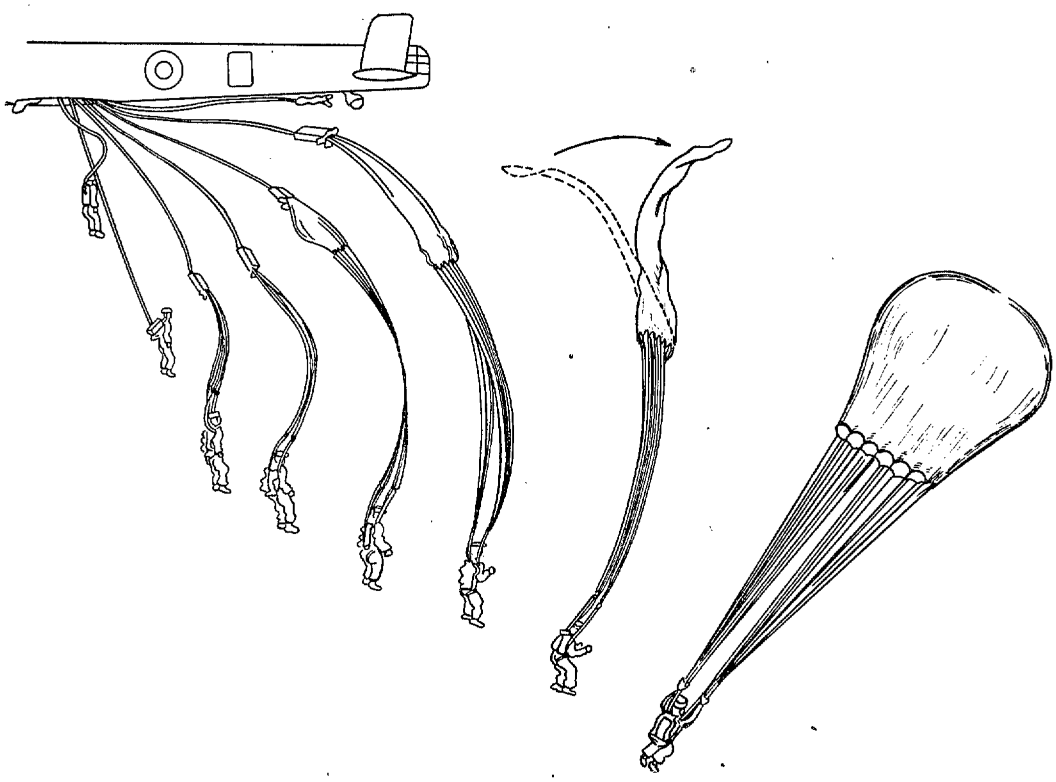

FIG. 6. Deployment of the "X" Type Parachute Aperture Exit.

(89510) Wt. 13/806 K5 2/50 Hw.

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