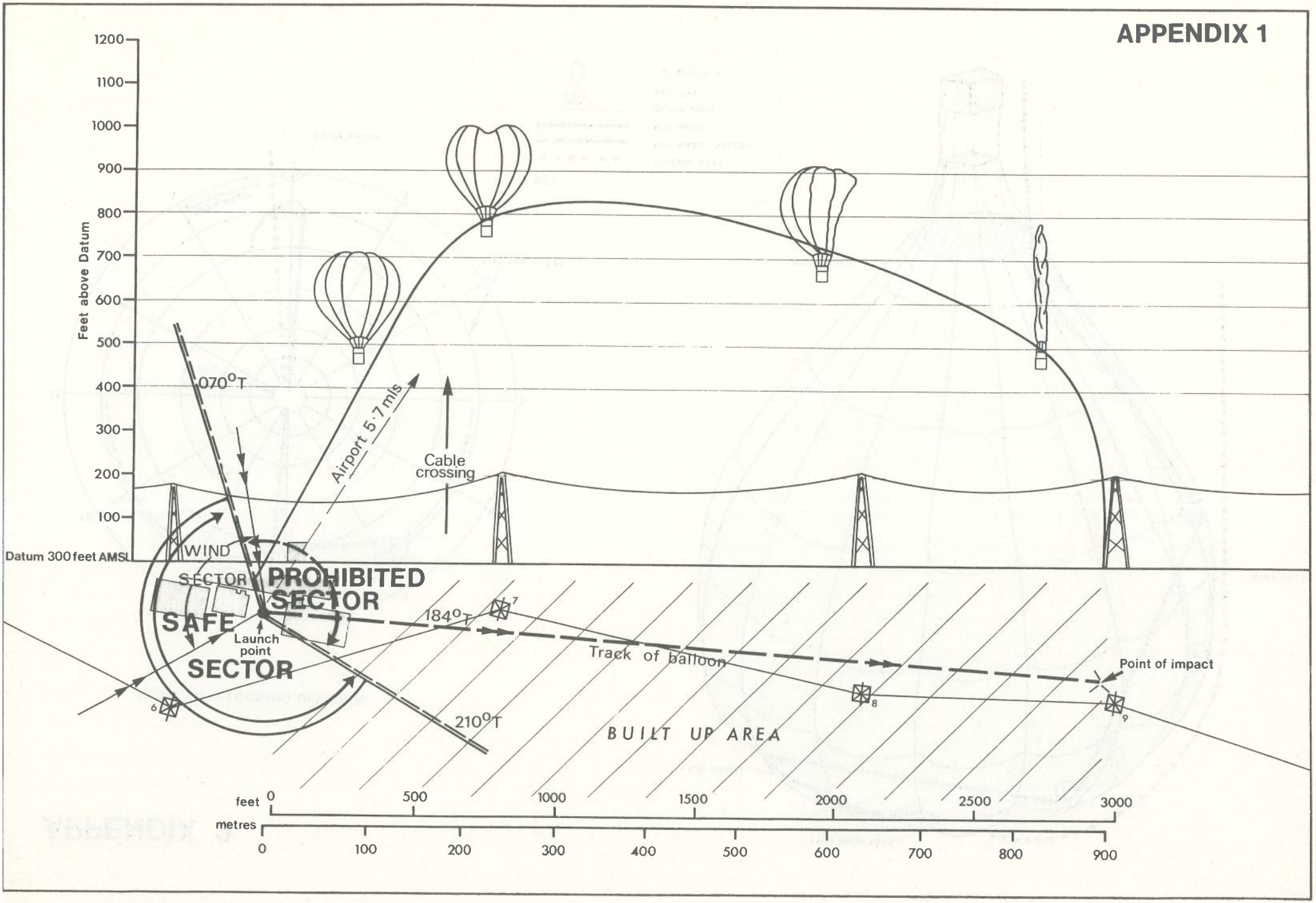
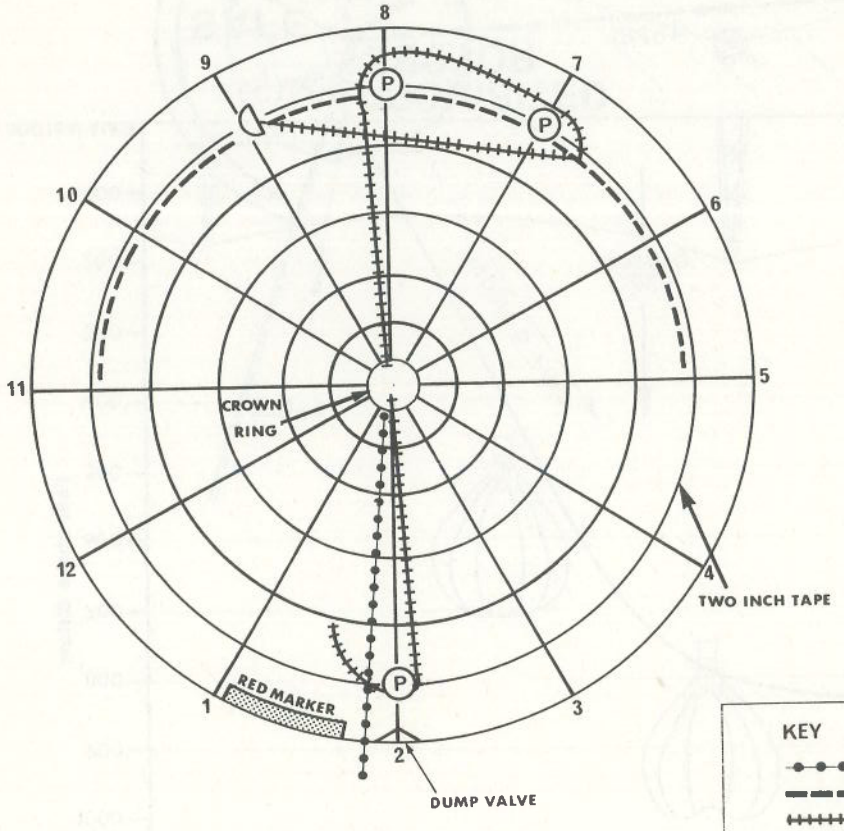
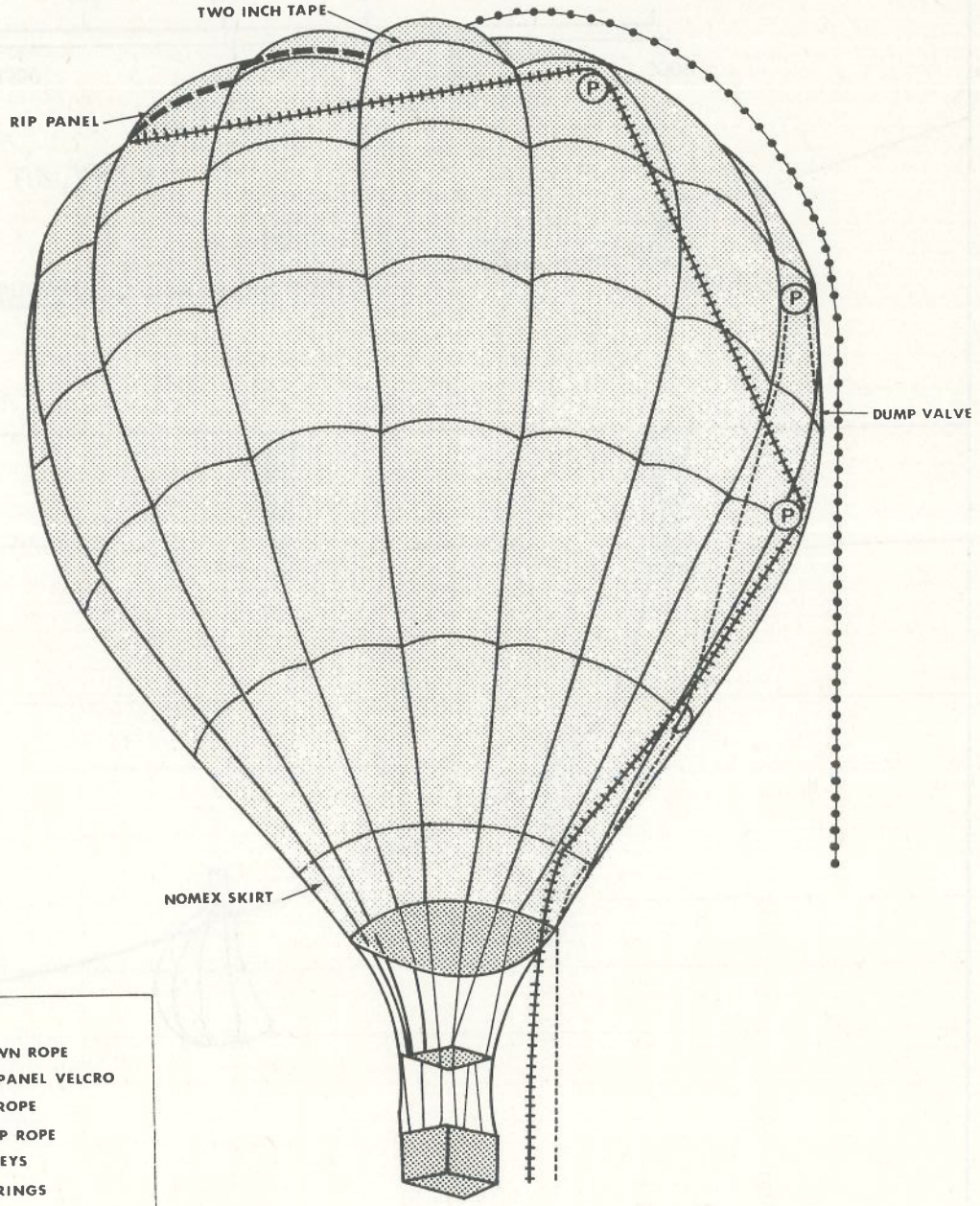
APPENDIX 1


Feet above Datum
1200
1100
1000
900
800
700
600
500
400
300
200
100
Datum 300 feet AMSL
070°T
Airport 5·7 mls
Cable crossing
WIND
SECTOR
PROHIBITED SECTOR
SAFE
SECTOR
Launch point
184°T
210°T
Track of balloon
Point of impact
BUILT UP AREA
6
7
8
9
feet
0
500
1000
1500
2000
2500
3000
metres
0
100
200
300
400
500
600
700
800
900

APPENDIX 2

PLAN VIEW LOOKING UPWARDS





KEY

- CROWN ROPE
- RIP PANEL VELCRO
- RIP ROPE
- DUMP ROPE
- P PULLEYS
- D "D" RINGS

APPENDIX 3

(i)

Material tests and research

1 Tests on Velcro

1.1 *Peel tests*

Tests were made using a new test specimen. A 12 cm length of 2.5 cm wide circular woven cordage was stitched across the centre of each of the outer faces of Velcro specimens 15 cm long so that the longer portion projected laterally on one side.

The two halves were then mated with the cordage projecting on the same side, and rolled 5 times along the seam in each direction alternately, under a pressure of 45N on a roller 3 cm diameter, over the full width of the Velcro.

The cords were then clamped in the jaws of a tensometer. Under load the specimens deformed three-dimensionally, the peel line being at about 45° to the edges of the Velcro. The force rose to a maximum as the peel line increased in length until the Velcro was torn through and the force decreased as the geometry changed to give a shorter peel line.

1.2 *Shear test*

Tails of lightweight fabric (140 g/m^2) 5 cm wide x 10 cm long were sewn on to 5 cm lengths of Velcro, which were then mated so that the tails projected in opposite directions. The specimens were then rolled as in the peel tests and the tails clamped in the tensometer jaws. The force rose to a maxim until the hooks started slipping and the width of Velcro held was diminished.

1.3 *Effect of temperature*

Tests at 100°C and 150°C were performed in a standard environmental chamber attached to the tensometer.

1.4 *Effects of water*

Both halves of the Velcro were immersed in water for some hours before mating. Tests on wet Velcro were made only at 20°C since higher temperatures would result in an indeterminate amount of drying out before a strength test could be done, and the effect of water would be replaced by the effect of temperature.

APPENDIX 3

(ii)

Velcro test results

1 *Peel with repeated peels*

No. of Peel	1	2	3	4
Max Force N	47	44	41	33
% of Original Force	100	94	87	70

Microscopic examination showed that a proportion of the hooks were displaced laterally with respect to their partners in the pairs. A reduction in strength appears, therefore, to be real.

2 *Peel effect of temperature*

Temperature °C	20	100	100 (Repeat)	150
Max Force N	33	21	20	12
% of Original Force	100	64	61	36

The results are reasonably linear and on straight extrapolation would give zero strength at 230°C.

3 *Peel effect of water*

	dry		*wet*
Max Force N	33	25	24
% of Original Force	100	76	73

4 *Shear effect of temperature*

Temperature °C	20	100	150
Max Force N/5 cm	132	85	50
% of Original Force	100	64	38

The percentage losses in shear are similar to those in peel and extrapolate similarly.

5 *Shear effect of water*

	dry		*wet*
Max Force N/5 cm	132	79	71
% of Original	100	60	54

Conclusions It is therefore concluded that the effects of repeated peel, and temperature and wetness are important, though not necessarily additive.

APPENDIX 3

(iii)

2 Tests on temperature indicators

The indicator is designed to show when an air temperature of 100°C is reached by releasing a streamer attached to the lower half of a soldered joint.

2.1 *Test 1. On indicator from accident balloon*

This was observed to have grooves along the edges of the join and some small blobs of solder on the edges. Oven tests with the indicator vertical did not result in any change of appearance nor did it break until 226°C was reached. The solder had melted at the correct temperature of 100°C but the indicator had failed to separate mechanically.

2.2 *Test 2. This and subsequent tests were conducted on new indicators*

These did not have the grooved edges, but instead a solid edge of solder. The indicator was arranged vertically in the oven but with a spring balance attached to the upper half. Up to 100°C there was no change in appearance and a load of 20N did not cause failure at 100°C. At 101°C a bubble appeared on the edge, which burst at 102°C. At 104°C a groove became visible all along the edge and some molten solder ran to the bottom. At 105°C the indicator was pulled to failure, this requiring 6N force.

2.3 *Test 3* – as for test 2 but to a higher temperature. Above 105°C there was no further change, except for blobs of solder falling from the bottom at about 115°C, some blobs remaining attached. At 150°C the indicator was pulled to failure this requiring a force of 2N.

2.4 *Test 4* This was performed with the indicator horizontal to give some peel component, and without load. Blobs of molten solder appeared at 108°C, grooves at 110°C, and drips at 115°C, but no failure or further change up to 200°C where the test was stopped to preserve the grooved indicator for examination. The indicator was similar in appearance, after test to the accident indicator before test.

2.5 *Test 5* A streamer of fabric was attached to the lower part of a new indicator, which hung from a spring balance. The force was increased from 0.05N (due to the lower part acting on the soldered joint) to 0.2N (due to the streamer in addition). The indicator and streamer were exposed to an air current from a fan (at 20°C). The force decreased to 0.15N due to lifting of the streamer. Although the spring balance would not measure dynamic loads of high frequency, it was not expected that the force would be much higher than that recorded, because of the low natural frequency of the streamer.

2.6 *Test 6* This was performed in the oven with the indicators vertical and a mass of 0.5Kg (exerting a force of 5N) attached to the lower half. Globules appeared at 99°C and grooves and drips at 100°C. Drips continued to 115°C and failure occurred at 131°C. This was probably a more accurate test than 2 or 3 since it was easier to measure temperature under a given force than vice versa.

APPENDIX 3

(iv)

Conclusions Although the solder melts at 100°C (correctly) a substantial force well in excess of what would be expected by virtue of oscillations in the balloon is required to separate the indicator even at 150°C. The indicator therefore gives a very unreliable indication that a temperature of 100°C has been reached. Even a positive (attached) load of 5N is insufficient to release the streamer below 130°C (vibrations excepted).

The grooved appearance of the indicator from the accident balloon (prior to Test 1) strongly indicates (c.f. Test 4) that it had previously been to a temperature of more than 100°C; whether this occurred on the accident flight, or on one of its previous flights cannot be deduced from these tests; visual examination of fabric and webbing near the rip panel suggests that the temperature had not been as high as 200°C.

3 *Test on Rip Cord*

3.1 The rip cord from G-BCCG measured 78 feet 4 inches between end fixings after the accident. 14 inches of cord was used at each end for the end attachments. The total length of cord was therefore 2 x 14 inches + 78 feet 4 inches = 80 feet 8 inches.

3.2 A pull of 35 lb (1 per cent load) was applied to the cord after removal from the envelope, and it stretched and when off loaded contracted until it was 8 inches longer than the initial length.

The cord had been wet prior to the accident flight and was still wet when it was examined.

3.3 A new length of rip cord, measuring 82 feet 9¼ inches, was obtained from the manufacturer.

A pull of 35 lb (1 per cent load) was applied to the cord in a dry state and it stretched. When off loaded it contracted until it was 7 inches shorter than the initial length.

3.4 The new cord was soaked for 10 minutes in water and became saturated. It was then subjected to a pull of 10 lb and after being off loaded, remained stretched 2 feet 8¾ inches longer than initially. It was then pulled every 5 minutes for 30 minutes and finally after a 15 minute period. With each pull the cord recovered to 2 feet 8¾ inches stretched condition.

Although not conclusive the indications from (b) and (d) are *that the rip cord was probably not pulled on the* accident flight, otherwise it should have remained at the 'received length' (when examined) since it had been in a wet state throughout.

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