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# EVALUATION OF FASTENERS FOR FLEXIBLE SHELTER APPLICATIONS

by

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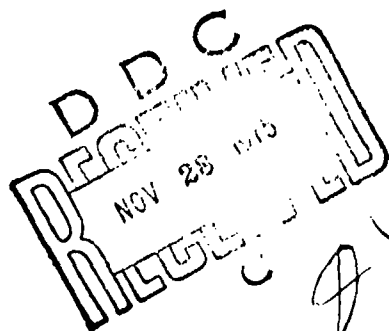
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## EVALUATION OF FASTENERS FOR FLEXIBLE SHELTER APPLICATIONS

### I. INTRODUCTION

Flexible shelters utilize a variety of different fasteners in various closure applications such as securing flaps and blackout curtains (figure 1), forming exit/entry ways (figure 2), hanging end panels and walls (figure 3), and joining complete components (figure 4). The decision as to which of the available fasteners is superior for a particular application is the responsibility of the system design engineer, who normally makes a choice based on past experience, and personnel preferences.

He may, for example, choose a slide fastener (zipper) because of its ease and convenience of closure and release, ease of assembly into manufactured items, and low cost and weight. However, the slide fastener has disadvantages in field situations. The teeth are susceptible to damage, and operation of the closure is impaired by mud and ice. Even more critical is the fact that slide fasteners are not standardized items; each manufacturer has a different design which requires special tooling and equipment to manufacture. Thus the loss of a supplier requires the selection of a new supplier with a different fastener design which is not compatible with existing shelters.

Such a situation actually occurred, and a major noncompatibility problem arose in an existing shelter system. Components containing slide fasteners manufactured by one vendor could not be joined to components containing slide fasteners manufactured by a second vendor.

A guide for selection of flexible shelter fasteners was needed to prevent a similar situation from reoccurring in future closure designs. Use of the guide would insure that an essential requirement, such as interchangeability, was not overlooked during the fastener selection process. In addition, it would make the designer aware of any tradeoffs, for example, convenience for reliability, or speed for cost, which he may be making by selecting one fastener over another.

In response to this need, an engineering study of the use of fasteners in flexible shelter closure applications was conducted. The study was concerned with determining a standard set of requirements for fabric closures, evaluating fastener/closure systems against those requirements, and selecting superior fasteners for fabric closures based on the evaluation. This report is a result of the study and is intended to be a designer's guide for selection of flexible shelter fasteners.



Figure 1. Tie Tape Flap Closure in Pop-Up Tent.



Figure 2. Zipper Exit/Entry Way Closure in Expandable Frame Tent.





Figure 3. Zipper End Panel Closure in Air-Supported Shelter.

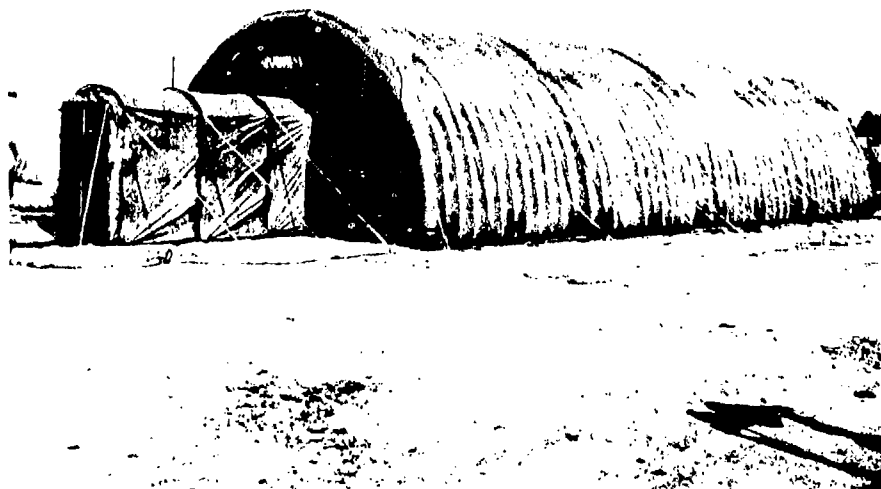


Figure 4. Complete Component Closures in Air-Supported Hospital.  
The various fasteners used to connect the four arch sections are not visible in the figure.

## II. DEFINITIONS

For the purposes of the study the following definitions apply:

A fastener is the primary device used to join two fabrics, and a fastener system is a series of fasteners used to join two fabrics along an interface. In some cases the words fastener and fastener system can be used interchangeably.

A closure is the interface formed between two fabrics after the fasteners are joined and any required ancillary operations, such as installation of a weather seal, are completed.

A temporary fabric closure is one which is capable of being opened and closed as opposed to a permanent closure, such as a stitched seam, which is not designed to be opened.

## III. DETERMINATION OF FABRIC CLOSURE REQUIREMENTS

There are six general areas involved in the fabrication and use of a temporary fabric closure system.

1. Manufacture of the fastener/fastener system
2. Assembly of the fastener/fastener system to the fabric
3. Operation (opening/closing) of the fastener/closure system
4. Effectiveness of the fastener/closure system
5. Repair of the fastener/closure system
6. Other

Each area was analyzed and a list of fabric closure requirements for each area was compiled. The requirements were categorized as either desirable (D), essential (E), or borderline (D/E), depending on their relative functional importance. Desirable requirements are those such as neat appearance and light weight which are nice qualities to have in a closure, but which are not absolutely required to perform the function adequately. Essential requirements, such as operability in inclement weather or operability with partial damage, are important qualities which are always required. Borderline requirements, such as flexibility or number of loose parts, are general requirements which can be classified as essential or desirable, depending upon the particular closure under evaluation. Following is the list of requirements compiled. It is also a

set of criteria for systematically evaluating fasteners in flexible shelter closures.

Manufacture of the fastener/fastener system - the fastener/fastener system should be

1. A non-proprietary item (E).
2. Manufactured from material which is readily available from several sources (E).
3. Interchangeable. When manufactured by different vendors according to the same plan, the resulting items should be identical (E).
4. Standard. The fastener should not be intended for one specific Government use only (D).
5. Easy to manufacture (D).
6. Manufactured without the need of specialized high cost equipment, not commercially available (D).
7. Low cost (D).
8. Capable of being manufactured from several different materials (D).

Assembly of the fastener/fastener system to the fabric - assembly of the system to the fabric should

1. Be easily accomplished (D).
2. Be low cost (D).
3. Not require specialized high cost equipment, not commercially available (D).

Operation (opening/closing) of fastener/closure system - the system should be capable of being completed

1. Even though the fasteners have sustained partial damage (E).
2. In inclement weather (snow/rain/mud/ice) (E).
3. In the dark (E).
4. While wearing arctic clothing (E).
5. Without the use of special equipment not normally available (D/E).
6. With a minimum number of loose parts (D/E).
7. Easily (D).
8. Quickly (D).
9. With minimum training (D).
10. By one man (D).

Effectiveness of fastener/closure system - the installed system should be

1. Fire resistant (fastener) (E).
2. Mildew resistant (fastener) (E).
3. Weatherproof (fastener) (D).
4. Weatherproof (closure) (E).
5. Blackoutproof (fastener) (D).
6. Blackoutproof (closure) (E).

7. Flexible as the shelter (D/E).
8. Strong as required for the particular application (fastener) (E).
9. An electrical nonconductor (closure) (D).
10. As long lasting as the particular shelter (D).

NOTE: In the above list weatherproof and blackout-proof are reported to distinguish between those fasteners, e.g., rope and chain, which have the advantage of being inherently weather/blackout-proof and those fasteners, e.g., buttons, which require an additional step to make the closure weather/blackout-proof.

Repair of fastener/closure system - the system should be field repairable

1. With a limited repair kit (E).
2. Easily (D).
3. At minimum cost (D).
4. In minimum time (D).

Other - the fastener/closure should

1. Not restrict operation of the shelter (E).
2. Not be easily damaged (E).
3. Be capable of identification marking such as start/finish points (D/E).
4. Be neat (D).
5. Be lightweight (D).
6. Be oil proof (D).
7. Require minimum maintenance (D).
8. Be reversible (e.g., not require hole and female connectors) (D).
9. Be universal (i.e., capable of being used for every closure application in a particular shelter) (D).
10. Not require stringent matching tolerances (D).

#### IV. EVALUATION OF FASTENER/CLOSURE SYSTEMS

A list of forty fasteners which could possibly be used in flexible shelter closure applications was then compiled and the list of fabric closure requirements, previously generated, was used as criteria to evaluate the fasteners. Although the study was concerned primarily with presently available fasteners, thirteen concepts (systems not presently available but which could be fabricated using existing technology) were suggested and also evaluated. The following fastener/closure systems were evaluated.

##### Intermittent Fasteners

1. Nut & Bolt
2. Quarter Turn
3. Lift-the-Dot
4. Snap I
5. Snap II
6. Equipage
7. Tie Tape
8. Loop Strap
9. Buckle
10. Snap & Ring
11. Link & Latch
12. Button
13. Toggle
14. Pin
15. Hitch Pin
16. Hinge Pin
17. Release Pin
18. Snap Slide
19. Columbus
20. Plug
21. Hedlock
22. Gravity Hanger
23. Channel

##### Continuous Fasteners

24. Zipper (Slide Fastener)
25. Removable Zipper
26. Drilok

27. Becket Loop
28. Chain Stitch
29. Rope & Continuous Hinge
30. Speed Lacing
31. Rope & Hook
32. Loop & Pin
33. Rope & Rigid Channel
34. Hasp & Wire
35. Coil & Wire
36. Hook & Pile Tape
37. Nylon Reinforced Tape
38. Friction
39. Flexible Channel
40. Catenary System

##### Concepts

41. Sectionalizing Band
42. Magnetic
43. Air Pressure
44. Interlock
45. Pressure Zipper
46. Channel I
47. Channel II
48. Channel III
49. Channel IV
50. Channel V
51. Channel VI
52. Clasp
53. Garter

Figures 5, 6, and 7 present the results of the evaluation for intermittent, continuous, and conceptual fasteners, respectively. The fabric closure requirements are listed vertically and the fasteners evaluated are listed horizontally. "Y" denotes that, yes, a fastener meets a requirement. "N" denotes that, no, a fastener does not meet a requirement. "Y-N" denotes a marginal case, or a case where with difficulty, or perhaps proper design, a fastener could meet the requirement.

Each column in the figures has a sketch of a fastener for ease of identification by the reader. In many cases, buckle or plug for example, the fastener depicted is merely one of many fasteners with the same principle of operation but with minor design differences. In these cases, the evaluation applies to the complete class of similar fasteners and is not limited to the one specific configuration depicted.

The number, in each of the figures, following the fastener name is the page number of the appendix of this report which contains additional information on the fastener.

Potential fasteners can be compared using the three figures. The Quarter Turn and Lift-The-Dot fasteners are basically similar in design and intended for similar applications. Referral to figure 5, however, shows that the Lift-The-Dot fastener is generally superior to the Quarter Turn fastener in fabric closure applications because in the only four categories in which their ratings differ, the Lift-The-Dot always ranks better. The figure shows that the Lift-The-Dot is easier to operate in inclement weather or while wearing arctic clothing, is not as easily damaged, and is more GI proof.

FABRIC CLOSURE REQUIREMENT	INTERMITTENT														REMARKS
	QUARTER INCH 19	QUARTER INCH 20	QUARTER INCH 21	QUARTER INCH 22	QUARTER INCH 23	QUARTER INCH 24	QUARTER INCH 25	QUARTER INCH 26	QUARTER INCH 27	QUARTER INCH 28	QUARTER INCH 29	QUARTER INCH 30	QUARTER INCH 31	QUARTER INCH 32	
1. NON PROPRIETARY	E	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
2. READILY AVAILABLE	E	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
3. INTERCHANGEABLE	E	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
4. STANDARD	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
5. EASY	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
6. WITHOUT SPECIAL EQUIP.	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
7. LOW COST	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
8. DIFFERENT MATERIALS	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
9. ASSEMBLY	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
10. EASILY ACCOMPLISHED	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
11. LOW COST	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
12. WITHOUT SPECIAL EQUIP.	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
13. OPERATION	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
14. WITH PARTIAL DAMAGE	E	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
15. IN INCLEMENT WEATHER	E	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
16. IN DARK	E	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
17. WITH ARCTIC CLOTHING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
18. WITHOUT SPECIAL EQUIP.	D/E	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
19. MINIMUM LOOSE PARTS	D/E	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
20. EASILY	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
21. QUICKLY	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
22. WITH MINIMUM TRAINING	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
23. ONE MAN	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
24. EFFECTIVENESS	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
25. FIRE RESISTANT (FAST)	E	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
26. MILDEW RESISTANT (FAST)	E	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
27. WEATHER PROOF (FAST)	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
28. WEATHER PROOF (CLOSE)	E	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
29. BLACKOUT PROOF (FAST)	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
30. BLACKOUT PROOF (CLOSE)	D/E	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
31. FLEXIBLE	D/E	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
32. STRONG AS REQ'D. (FAST)	E	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
33. NON-CONDUCTOR (CLOSE)	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
34. LONG LASTING (CLOSE)	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
35. REPAIR ON SITE	E	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
36. WITH LIMITED KIT	E	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
37. EASILY	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
38. AT MINIMUM COST	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
39. IN MINIMUM TIME	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
40. OTHER	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
41. NOT RESTRICT OPERATION	E	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
42. NOT EASILY DAMAGED	E	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
43. CAPABLE OF MARKING	D/E	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
44. NEAT	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
45. LIGHTWEIGHT	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
46. G.I. PROOF	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
47. MINIMUM MAINTENANCE	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
48. REVERSIBLE (FAST MYF)	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
49. UNIVERSAL	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
50. LIBERAL MATING TOLERANCE	D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	

Y=YES N=NO Y-N=MARGINAL E=ESSENTIAL D=DESIRABLE D/E=BORDERLINE

Figure 5. Evaluation Data for Intermittent Fastener Systems.

FABRIC CLOSURE REQUIREMENT	CONTINUOUS										TECHNICAL DRAWING
	ZIPPER	BUCKLE	CHAIN	LOOP	STITCH	NOTE	SPEED	NOTE	LOOP	NOTE	
	NO. 1	NO. 2	NO. 3	NO. 4	NO. 5	NO. 6	NO. 7	NO. 8	NO. 9	NO. 10	
MANUFACTURE											
1. CON. PROPRIETARY											
2. READY AVAILABLE											
3. INTERCHANGEABLE											
4. STANDARD											
5. EASY											
6. W/OUT SPECIAL EQUIP.											
7. LOW COST											
8. SPECIALLY DESIGNED											
9. EASY TO OPERATE											
10. LOW COST SPECIAL EQUIP.											
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188. EASY TO OPERATE											



FABRIC CLOSURE REQUIREMENT	CONCEPTS									
	SECTION 156	SECTION 157	SECTION 158	SECTION 159	SECTION 160	SECTION 161	SECTION 162	SECTION 163	SECTION 164	SECTION 165
MANUFACTURE										
1. NON PROPRIETARY	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. READILY AVAILABLE	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
3. NOT IRREVERSIBLE	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
4. STANDARD	D	N	Y	Y	Y	Y	Y	Y	Y	Y
5. EASY	D	N	Y	Y	Y	Y	Y	Y	Y	Y
6. WITHOUT SPECIAL EQUIP.	D	Y	Y	Y	Y	Y	Y	Y	Y	Y
7. LOW COST	D	Y	Y	Y	Y	Y	Y	Y	Y	Y
8. DIFFERENT MATERIALS	D	Y	Y	Y	Y	Y	Y	Y	Y	Y
9. EASY TO ASSEMBLY	D	Y	Y	Y	Y	Y	Y	Y	Y	Y
10. EASY TO DISASSEMBLY	D	Y	Y	Y	Y	Y	Y	Y	Y	Y
11. LOW COST	D	Y	Y	Y	Y	Y	Y	Y	Y	Y
12. WITHOUT SPECIAL EQUIP.	D	Y	Y	Y	Y	Y	Y	Y	Y	Y
13. WITH PARTIAL SAVAGE	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
14. IN CLIMATE WEATHER	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
15. IN DARK	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
16. IN RAIN	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
17. IN HOT SPECIAL EQUIP.	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
18. IN COLD SPECIAL EQUIP.	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
19. EASY TO ASSEMBLY	D	Y	Y	Y	Y	Y	Y	Y	Y	Y
20. EASY TO DISASSEMBLY	D	Y	Y	Y	Y	Y	Y	Y	Y	Y
21. MINIMUM WEAVING	D	Y	Y	Y	Y	Y	Y	Y	Y	Y
22. MINIMUM WEAVING	D	Y	Y	Y	Y	Y	Y	Y	Y	Y
23. FIRE RESISTANT (FAST)	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
24. FIRE RESISTANT (SLOW)	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
25. WEATHER PROOF (FAST)	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
26. WEATHER PROOF (SLOW)	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
27. BLACKOUT PROOF (FAST)	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
28. BLACKOUT PROOF (SLOW)	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
29. FLEXIBLE	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
30. TENSILE RESISTANCE (FAST)	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
31. TENSILE RESISTANCE (SLOW)	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
32. LONG LASTING (FAST)	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
33. LONG LASTING (SLOW)	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
34. REPAIR ON SITE	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
35. LIMITED KIT	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
36. EASY TO ASSEMBLY	D	Y	Y	Y	Y	Y	Y	Y	Y	Y
37. EASY TO DISASSEMBLY	D	Y	Y	Y	Y	Y	Y	Y	Y	Y
38. MINIMUM TIME	D	Y	Y	Y	Y	Y	Y	Y	Y	Y
39. EASY TO OPERATE	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
40. EASY TO DAMAGED	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
41. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
42. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
43. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
44. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
45. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
46. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
47. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
48. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
49. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
50. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
51. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
52. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
53. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
54. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
55. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
56. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
57. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
58. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
59. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
60. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
61. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
62. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
63. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
64. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
65. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
66. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
67. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
68. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
69. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
70. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
71. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
72. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
73. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
74. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
75. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
76. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
77. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
78. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
79. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
80. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
81. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
82. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
83. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
84. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
85. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
86. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
87. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
88. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
89. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
90. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
91. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
92. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
93. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
94. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
95. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
96. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
97. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
98. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
99. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y
100. EASY TO MARKING	E	Y	Y	Y	Y	Y	Y	Y	Y	Y

Figure 7. Evaluation Data for Conceptual Fastener Systems.

## V. SELECTION OF SUPERIOR FASTENERS

Section IV presents an evaluation and comparison of available fasteners. The final selection, however, must be based on the specific application the fastener is to be used in. The designer may be willing to accept several undesirable features in a fastener in order to take advantage of a desirable feature it possesses which he considers more important in a specific application.

With this in mind, all flexible shelter temporary closures were divided into eight categories.

1. Component closure with force transmittal
2. Component closure without force transmittal
3. End Panel or wall closure
4. Weather seal closure
5. Window, blackout curtain or flap closure
6. Floor section closure
7. Fabric to rigid member closure
8. Exit/entry way closure

And in each of the categories the following fasteners were selected as superior for use based on both the evaluation of Section IV and the specific application.

### Component Closure with Force Transmittal

1. Link & latch, snap & ring (on catenary system)
2. Hasp & wire, becket loop

### Component Closure Without Force Transmittal

1. Hasp & wire, becket loop
2. Hook & pile
3. Snap I
4. Friction

### End Panel or Wall Closure

1. Becket loop, hasp & wire
2. Hook and pile tape
3. Link & latch, snap & ring, buckle

### Weather Seal Closure

1. Hook & pile tape
2. Becket loop
3. Snap I, snap & ring

#### 4. Friction

##### Window/Blackout Curtain/Flap Closure

1. Tie tape
2. Hook & pile tape
3. Toggle

##### Floor Section Closure

1. Hook & pile tape
2. Rope & continuous hinge

##### Fabric to Rigid Member

1. Rope & rigid channel
2. Lift-the-dot, snap I, nut & bolt
3. Rope & hook, becket loop, hasp & wire
4. Hook & pile tape

##### Exit/Entry Way Closure

1. Zipper
2. Hook & pile tape
3. Tie tape

In addition, the following concepts were selected as deserving further investigation.

1. Magnet
2. Pressure zipper
3. Channels III, IV, & V
4. Removable zipper (borderline between available and concept. Listed in Section IV and appendix as available)

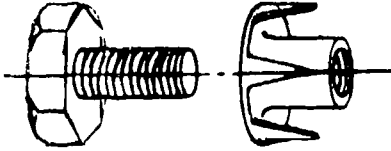
#### VI. CONCLUDING REMARKS

This report presents a standard set of criteria for evaluating fasteners in flexible shelter closure applications, summarizes the major advantages and disadvantages of numerous flexible shelter fastener/closure systems, and presents a list of available fasteners which have been classified as superior for use in specific applications.

VII. APPENDIX

DETAILS OF FASTENER/CLOSURE  
SYSTEMS EVALUATED

1. Fastener: Nut & Bolt



2. Description of Closure System:

Rigid member is threaded or threaded grommet is clinched to fabric.  
Fabrics are joined by passing bolt through grommets and tightening.  
Weather seal added as required.

3. Major Advantages:

Readily available.  
No strength limitation.  
Field replaceable.

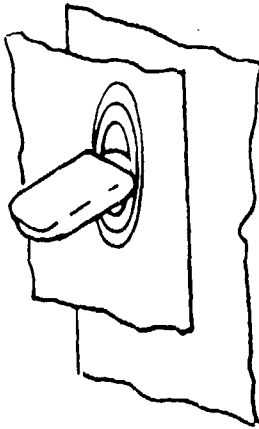
4. Major Disadvantages:

Slow opening/closing.  
Loose parts.  
Difficult operation in dark or with arctic clothing.

5. Comments:

Very unsatisfactory method of joining fabric to fabric but could be used in high strength applications to join fabric to rigid member.

1. Fastener: Quarter Turn



2. Description of Closure System:

Grommet clinched to first fabric. Stud attached to mating fabric or rigid support. Fabrics are joined by placing grommet over stud and rotating stud head 90° into locking position. Weather seal added if required.

3. Major Advantages:

Readily available.  
Quick, easy closure.  
Field replaceable.

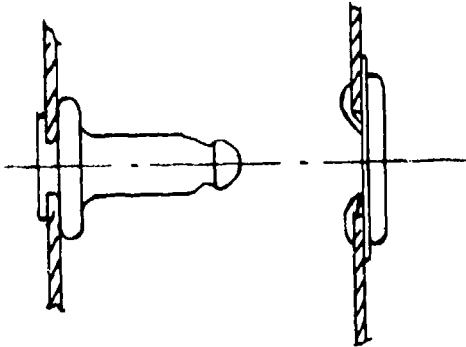
4. Major Disadvantages:

Difficult operation with arctic clothing or in icing conditions.  
Strict mating tolerance.  
Susceptible to damage.

5. Comments:

Ideal application is attachment of fabric to rigid member.  
Similar to but not as good as lift-the-dot fastener.

1. Fastener: Lift-the-Dot



2. Description of Closure System:

Stud is attached to rigid member. Grommet is clinched to fabric. Closure is effected by placing grommet over stud and pressing down. Spring in grommet holds fastener together. Closure is completed with addition of weather seal.

3. Major Advantages:

Readily available.  
Closure can be completed with partial damage.  
Quick, easy closure.

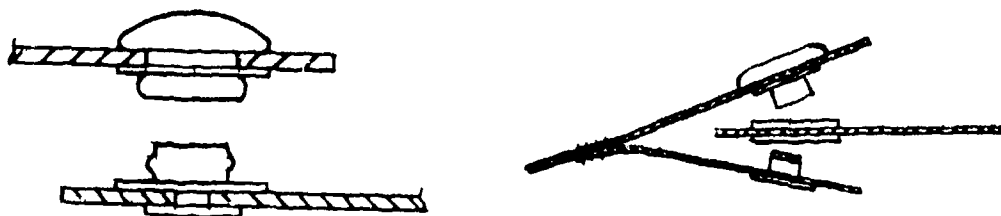
4. Major Disadvantages:

Strength limitation.  
Non adjustable.  
Difficult to manipulate in arctic clothing.

5. Comments:

Application is limited to attachment of fabric to rigid member. Closure can be assembled easily, but is somewhat difficult to disassemble.

1. Fastener: Snap I



2. Description of Closure System:

Fastener components are clinched to the respective mating fabrics or attached to rigid member. Fabrics are joined by snapping two halves of fastener together. Closure completed with addition of weather seal.

3. Major Advantages:

Readily available.  
Closure can be completed with partial damage.

4. Major Disadvantages:

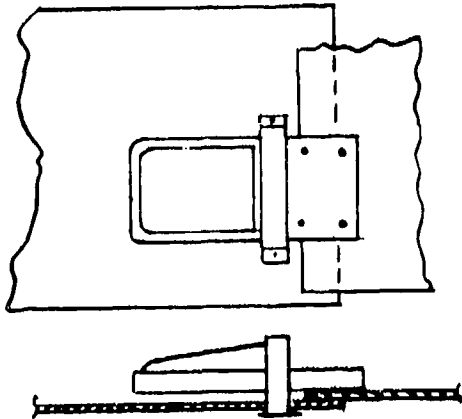
Difficult to operate with arctic clothing.  
Strength limitation.  
Non adjustable.

5. Comments:

Weatherproofing can be easily accomplished by proper closure design.  
Suitable for component closures without force transmittal and weather seal closures.



1. Fastener: Snap II



2. Description of Closure System:

Fastener components are riveted or clinched to respective fabric.  
Fabrics are joined by snapping fastener together. Closure completed  
with addition of weather seal.

3. Major Advantages:

Readily available.  
Closure can be completed with partial damage.

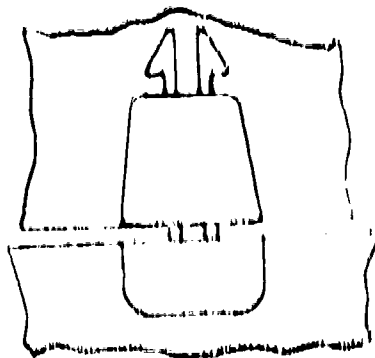
4. Major Disadvantages:

Mating tolerance critical.  
Strength limitation.  
Easily damaged.  
Slow opening.  
Possibly difficult to operate in inclement weather or with arctic  
clothing.

5. Comments:

Not suited to tentage fabric closure applications.

1. Panorama Equipment



2. Description of Camera System

Panorama components are attached to equipment taken from ship handling. Panoramas are attached to equipment that has been replaced or replaced with addition of weather work.

3. Major Advantages

Reliability available (operation of system).  
Camera can be replaced with partial backup.

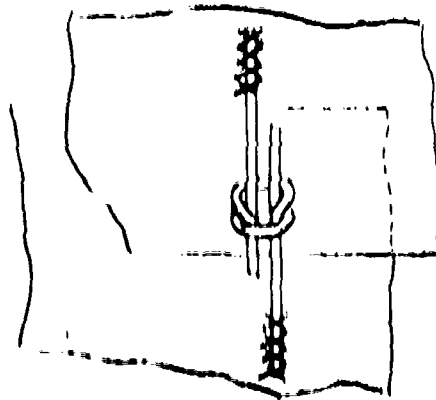
4. Major Disadvantages

Matching to camera of 1000 ft.  
Blow openings.  
Difficult operation with weather work.  
Strength limitation.  
Availability of processing in and treatment of weather.

5. Comments

Suitable for intermittent applications such as weather work in window/blackout curtain/flag clearance.

#### 1. Equipment - Tie Tape



#### 2. Description of Closure System

Tie tape is used to join fabric. Fabrics are joined by tying tapes together.

#### 3. Major Advantages

Easy to manufacture, install, operate and repair.  
No extra equipment.

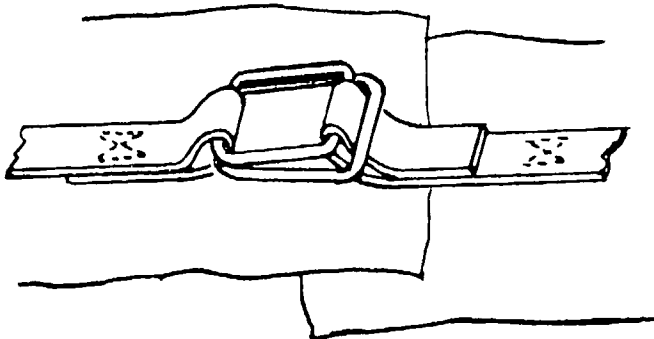
#### 4. Major Disadvantages

Not all operation with common gloves.  
Not all operation knot after load has been applied.

#### 5. Notes

Use for window/door curtain/flap and exit/entry closures.  
Not for use for any other purpose, toggle and loop should be used when  
other closures are a possibility.

1. Fastener: Loop Strap



2. Description of Closure System:

Double loop straps are sewn to tape or webbing which is then sewn to first fabric. A second tape or webbing is sewn on second fabric. Fabrics are joined by threading webbing through loop straps and tightening. Weather seal added as required.

3. Major Advantages:

Easy to manufacture, install, operate and repair.  
Good adjustability.

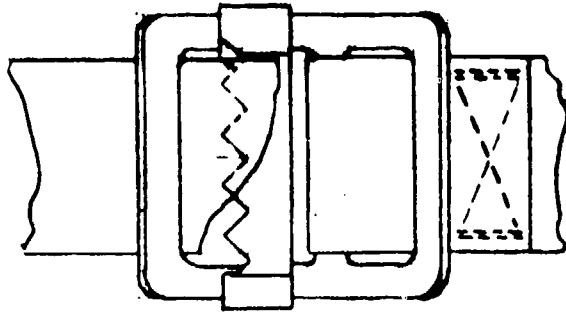
4. Major Disadvantages:

Strength limitation, but can be improved easily.  
Possibly difficult to manipulate in the dark or with arctic clothing.

5. Comments:

Good fastener suitable for intermittent applications such as flap closures, component closures, and end panels.

1. Fastener: Buckle



2. Description of Closure System:

Fastener is attached to fabric with webbing. Fabrics are joined by mating buckle and tightening. Weather seal must be added.

3. Major Advantages:

Readily available in many forms.  
Operable with partial damage.  
Not easily damaged.

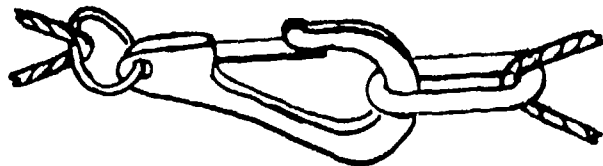
4. Major Disadvantages:

Possible difficult operation in dark or inclement weather.

5. Comments:

Suitable for high strength intermittent applications such as end panel/wall closures.

1. Fastener: Snap & Ring



2. Description of Closure System:

Fastener components are sewn to fabric via webbing or attached to catenary cables. Fabrics are joined by snapping ring into hook. Closure completed with addition of weather seal.

3. Major Advantages:

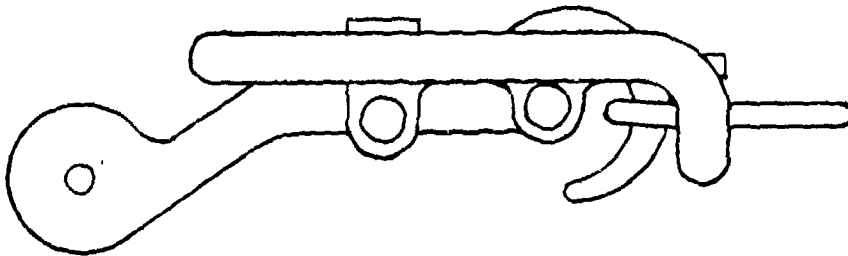
Readily available.  
Closure can be completed with partial damage.  
High strength.  
Liberal mating tolerance.

4. Major Disadvantages:

5. Comments:

Good solid high strength fastener suitable for intermittent applications such as joining major components or large end panel closures.

1. Fastener: Link & Latch



2. Description of Closure System:

Fastener sewn to fabric via webbing. Fabrics joined by linking fasteners and latching. Weather seal added as required.

3. Major Advantages:

Readily available.  
High strength.  
Field repairable.

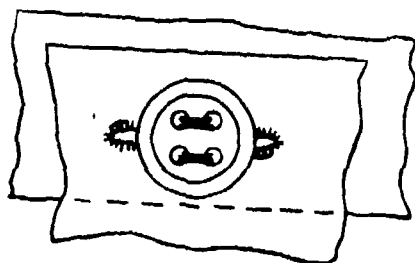
4. Major Disadvantages:

Possibly difficult to manipulate in arctic clothing.

5. Comments:

Good solid high strength fastener suitable for intermittent applications such as joining major components.  
Presently used between MUST inflatable sections.

1. Fastener: Button



2. Description of Closure System:

Button sewn to fabric. Fabrics joined by inserting button through button hole. Weather seal added as required.

3. Major Advantages:

Readily available.  
Simple.  
Field repairable.

4. Major Disadvantages:

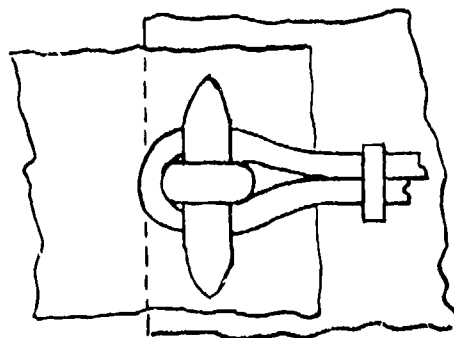
Strength limitation.  
Difficult operation with common gloves, and impossible with arctic gloves.  
Non adjustable.

5. Comments:

Not suitable for tentage fabric closures. Toggle and loop is a better closure.



1. Fastener: Toggle



2. Description of Closure System:

Toggles are sewn to one fabric. Cord or rope loops are sewn to mating fabric. Fabrics are joined by inserting toggle through loop. Closure completed by addition of weather seal if required.

3. Major Advantages:

Readily available.  
Mating tolerance not critical.  
Easily repairable.  
Inexpensive.

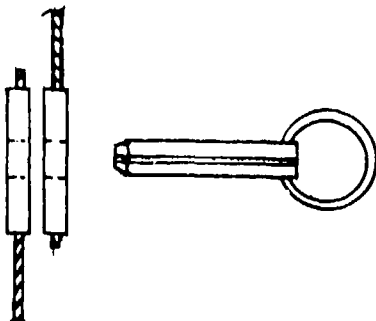
4. Major Disadvantages:

Slow opening/closing.  
Strength limitation.

5. Comments:

Simple fundamental fastener suitable for intermittent low strength applications such as window/blackout curtain/flap closures.  
Standard on General Purpose Medium Tent and others.

1. Fastener: Pin



2. Description of Closure System:

Female portion of fastener crimped or riveted to fabric and/or rigid member. Fabrics are joined by aligning holes and inserting pin. Pin held in place by grooved channel or ball indent. Weather seal added as required.

3. Major Advantages:

Readily available.  
Simple to manufacture, install, and operate.  
Easily repaired.

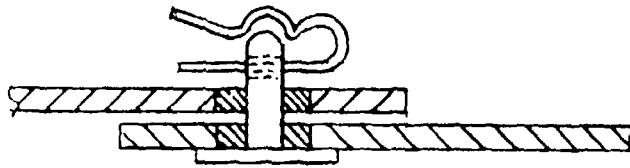
4. Major Disadvantages:

Numerous loose parts.  
Critical mating tolerances.  
Difficult operation in dark or with arctic clothing.

5. Comments:

Generally a poor fastener for fabric closures with possible exception of attachment of fabric to rigid member.

1. Fastener: Hitch Pin



2. Description of Closure System:

Fastener components can be sewn into, bonded to or clinched to fabric. Fabrics are joined by placing grommet over stud and inserting pin through stud. Spring characteristic of pin holds fastener together. Closure completed by addition of weather seal.

3. Major Advantages:

High strength.  
Readily available standard item.  
Operable with partial damage.

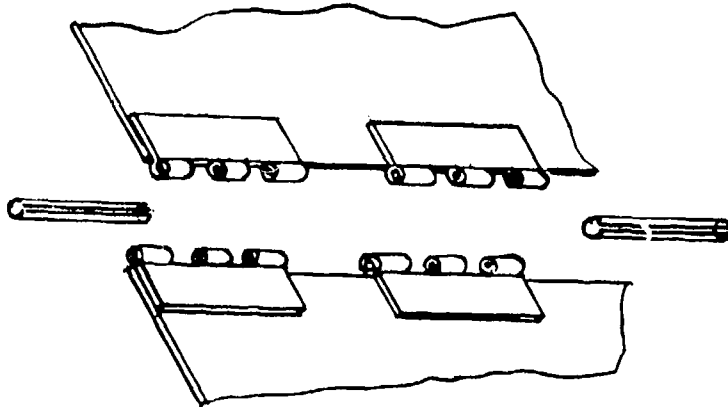
4. Major Disadvantages:

Slow opening/closing.  
Difficult to operate in dark, or inclement weather or with arctic clothing.  
Numerous loose parts.

5. Comments:

Best application is attachment of fabric to rigid member.

1. Fastener: Hinge Pin



2. Description of Closure System:

Fastener sewn or riveted to fabric. Fabrics joined by mating hinge and inserting locking pin. Weather seal added if required.

3. Major Advantages:

Operable with partial damage.  
Readily available.

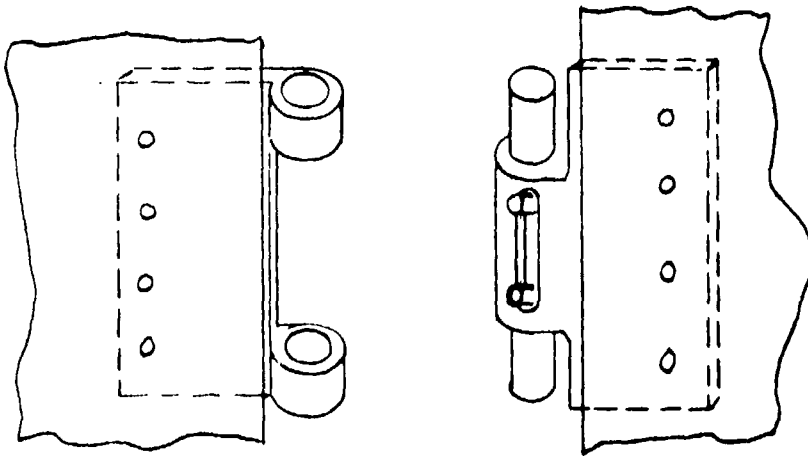
4. Major Disadvantages:

Slow opening/closing.  
Difficult operation in dark or with arctic clothing.  
Numerous loose parts.

5. Comments:

Not generally suitable to tentage fabric closure applications.

1. Fastener: Release Pin



2. Description of Closure System:

Fastener components are sewn to respective fabrics. Fabrics are joined by depressing spring loaded pins, mating two pieces, and releasing springs. Closure completed by addition of weather seal.

3. Major Advantages:

High strength.

4. Major Disadvantages:

Difficult operation in dark or inclement weather or with arctic clothing.

Misalignment critical.

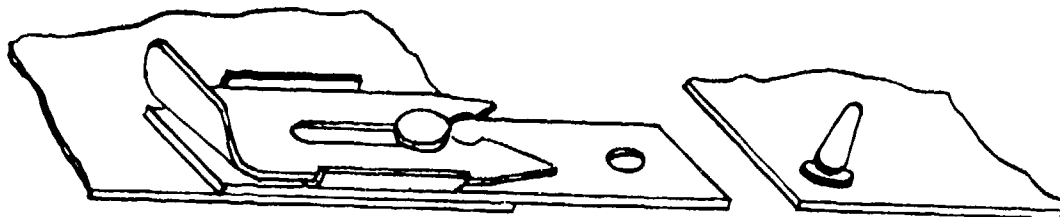
Springs susceptible to various types of failure due to adverse weather conditions.

5. Comments:

Slow opening/closing if used along continuous seam as opposed to catenary configuration.

Not generally suitable to tentage fabric closure applications.

1. Fastener: Snap Slide



2. Description of Closure System:

Snap slide fastener riveted to first fabric. Stud components assembled to second fabric. Fabrics joined by placing snap slide over stud and locking in place. Weather seal added as required.

3. Major Advantages:

Readily available.  
Operable with partial damage.

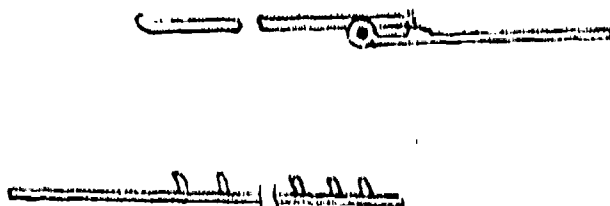
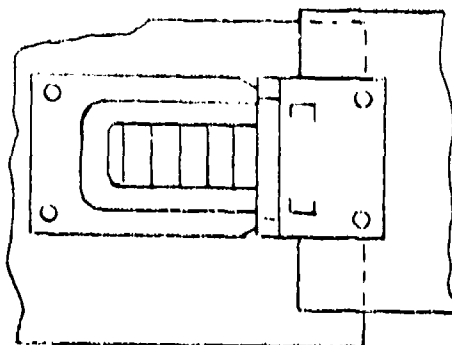
4. Major Disadvantages:

Difficult to operate in dark, or inclement weather, or with arctic clothing.  
Slow opening/closing.  
Strict mating tolerances.  
Susceptible to damage.

5. Comments:

Not generally suitable for tentage fabric closure applications.

1. Fastener: Columbus



2. Description of Closure System:

Fasteners are sewn or riveted to fabric. Fabric joined by mating male and female portions of fastener. Weather seal added as required.

3. Major Advantages:

Easy to manufacture and install.  
Field replaceable.  
Moderately adjustable.  
Readily available standard item.

4. Major Disadvantages:

Difficult operation in dark or with wet clothing.  
Easily damaged.

5. Comments:

Can be used in tension applications only. Not generally suitable to tentage fabric closure applications.

1. Postoperative Phase



2. Implication of Clinical Signs

disinfection was effected by using betadine solution. Patient was treated by wetting procedure and found the effect of treatment was not at all satisfactory.

3. Major Advantages

Readily available.  
Compatible with treatment with physical therapy.

4. Major Disadvantages

Strength reduction.  
Hyperemia, tissue death.  
Startling reaction to treatment.  
Slow opening/closing.  
Difficult operation in dark or in low light conditions.  
Clothing.

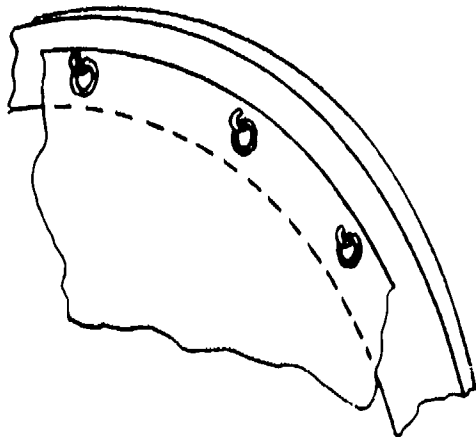
5. Comments

Not suitable for contact with the skin.





1. Fastener: Gravity Hanger



2. Description of Closure System:

Hook is attached to rigid member. Grommets are clinched to fabric. Closure is completed by hanging grommet on hook and adding weather seal if required.

3. Major Advantages:

Easily available.  
Simple, quick installation.  
Easy repair or replacement.

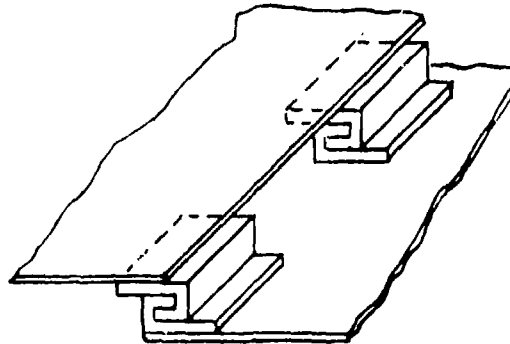
4. Major Disadvantages:

Difficult operation in dark.

5. Comments:

Limited applications, can only be used to suspend vertical fabric such as end wall to rigid member.  
Vulnerable to gusting winds unless used in combination with a conditioning system.

1. Fastener: Channel



2. Description of Closure System:

Channels are sewn, bonded, or riveted to fabric in sections.  
Fabrics are joined by interlocking channels.

3. Major Advantages:

Easily manufactured and assembled.

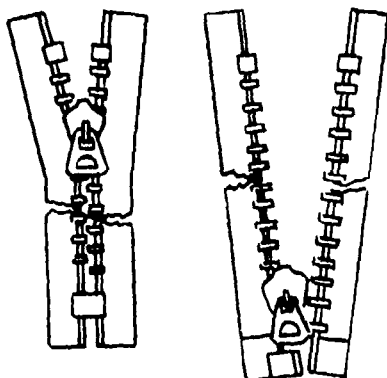
4. Major Disadvantages:

Strict mating tolerance.  
Difficult operation in dark or with arctic clothing.

5. Comments:

Suitable for small component closures without force transmittal.

1. Fastener: Zipper (Slide Fastener)



2. Description of Closure System:

Fastener is sewn to fabric. Fabrics are joined by meshing action of teeth as slider traverses closure. Weather seal added if required.

3. Major Advantages:

Very rapid opening/closing.  
Easy to install and operate.  
Operable under all weather conditions.

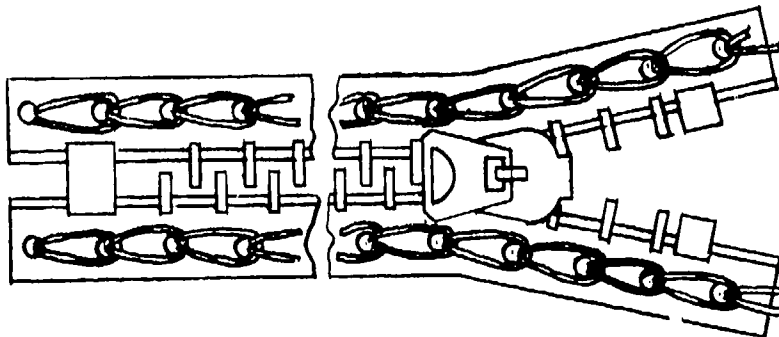
4. Major Disadvantages:

Proprietary item.  
Not operable with partial damage.  
Not field repairable.  
Stringers are not interchangeable when manufactured by different sources.

5. Comments:

Very versatile closure system. Can be used in almost any shelter application. Best application is those which require numerous openings and closings such as exit/entry closures.

1. Fastener: Removable Zipper (Slide Fastener)



2. Description of Closure System:

Fastener is attached to fabric by becket loops, or snap fasteners, etc. Fabrics are joined by meshing action of teeth as slider traverses fabric. Weather seal added as required.

3. Major Advantages:

Very rapid opening/closing.  
Easy to install and operate.  
Operable under all weather conditions.  
Field replaceable.

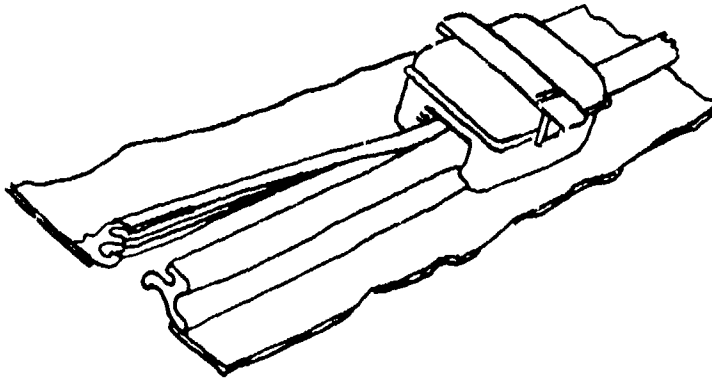
4. Major Disadvantages:

Not operable with partial damage.  
Basic zipper stringer is a noninterchangeable proprietary item.

5. Comments:

Very versatile closure system. Can be used for almost any shelter application.  
Combines advantages of zipper with field replaceability.

1. Fastener: Drilok



2. Description of Closure System:

Stringers are sewn or bonded to fabrics. Fabrics are joined by channel meshing action as slider traverses closure.

3. Major Advantages:

Quick, simple operation.  
Simple assembly to fabric.  
No additional weather seal required.

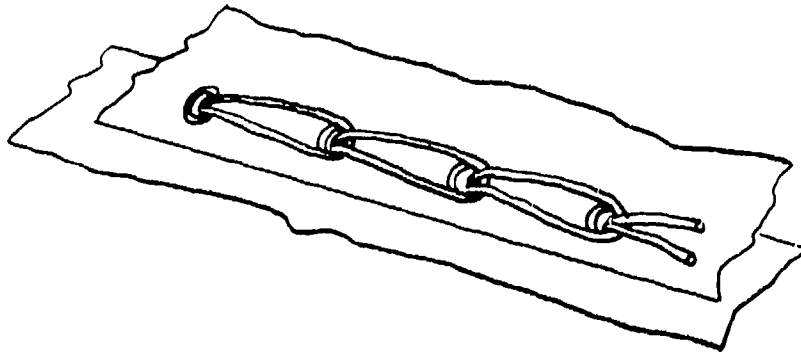
4. Major Disadvantages:

Proprietary item.  
Not interchangeable.  
Not operable with partial damage.  
Strength limitation.  
Can not be repaired on site.

5. Comments:

Strength limitation can be improved by addition of intermittent fasteners.  
Similar to zipper.

1. Fastener: Becket Loop



2. Description of Closure System:

Loops are sewn to one fabric. Grommets are clinched to second fabric. Fabrics are joined by inserting loops through grommets and then sequentially interlocking loops along length of closure. Additional weather seal not normally required.

3. Major Advantages:

Readily available.  
High strength.  
Mating tolerance not critical.  
Field repairable.  
Not easily damaged.  
Inexpensive.  
Self locking.

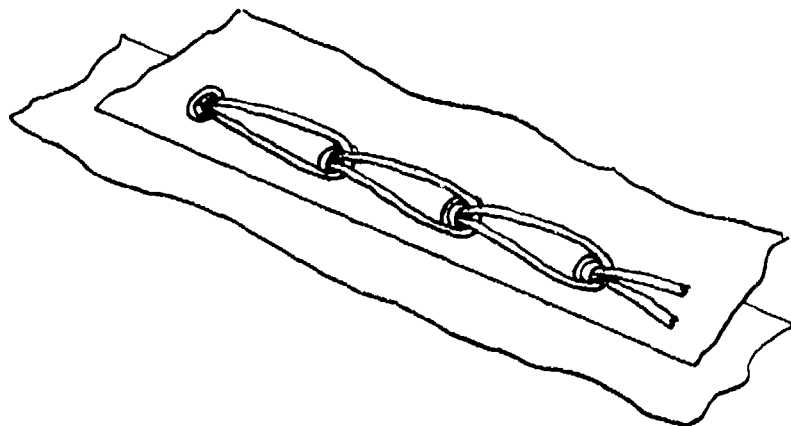
4. Major Disadvantages:

Slow closing.  
Difficult operation in dark or ice or with arctic clothing.  
Can generally be operated from one side only.

5. Comments:

Simple fundamental reliable closure suitable for many applications such as component, end panel, weather seal, floor section, and fabric to rigid member.

1. Fastener: Chain Stitch



2. Description of Closure System:

Grommets are clinched to both fabrics. Fabrics are joined by lacing cord through grommets in chain stitch pattern. Closure completed with addition of weather seal, if required.

3. Major Advantages:

Readily available.  
Operable with partial damage.  
Easily repairable.  
Not easily damaged.  
Rapid opening.

4. Major Disadvantages:

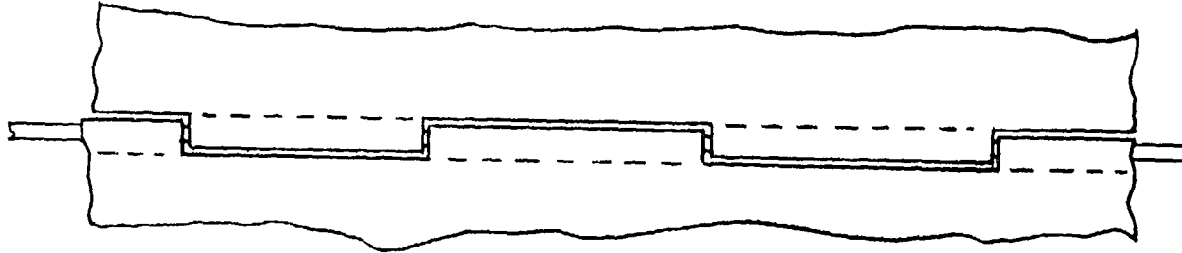
Very slow closure.  
Difficult operation in dark or inclement weather or with arctic clothing.  
Limited training required.

5. Comments:

Not suitable for closures that are continually opened/closed.  
Suitable for high strength closure where speed of assembly is not important, components will remain joined for extended period, and speed of disassembly is desirable.  
A portable stitching tool would facilitate tedious hand closing operation.



1. Fastener: Rope & Continuous Hinge



2. Description of Closure System:

Continuous flexible strip of fabric or plastic sewn to prime fabric. Fabrics joined by mating hinge and passing rope or wire through openings along length of closure. Weather seal added if required.

3. Major Advantages:

Readily available.  
Operable with partial damage.

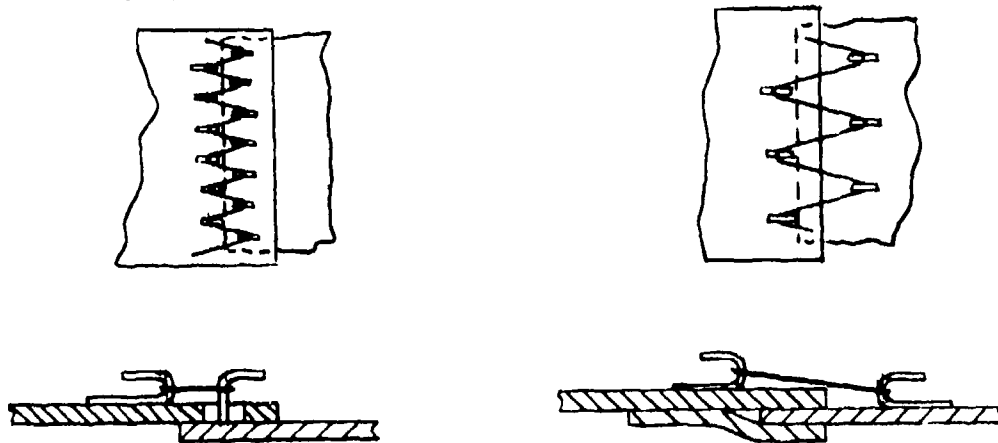
4. Major Disadvantages:

Slow closure.  
Difficult to operate in dark or with arctic clothing.  
Strength limitation.

5. Comments:

Generally suitable to component closure without force transmittal, end panel/wall closures, and floor section closures.  
Permits gathering of materials.

1. Fastener: Speed Lacing



2. Description of Closure System:

Hooks are sewn to fabric, fabrics are joined by lacing cord through alternate hooks. With proper design, no additional weather seal required.

3. Major Advantages:

Readily available.  
Operable with partial damage.

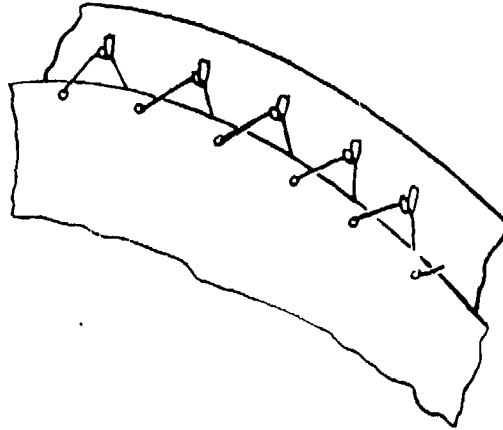
4. Major Disadvantages:

Difficult operation in ice or dark conditions.  
Operable from one side only.

5. Comments:

Not generally suited to tentage fabric closure applications.

1. Fastener: Rope & Hook



2. Description of Closure System:

Hooks are sewn to fabric or attached to rigid member. Rope is laced through grommets which are clinched to mating fabric. Fabrics are joined by running rope through hooks. Closure is completed by addition of weather seal such as hook and pile.

3. Major Advantages:

Readily available.  
Mating tolerance not critical.

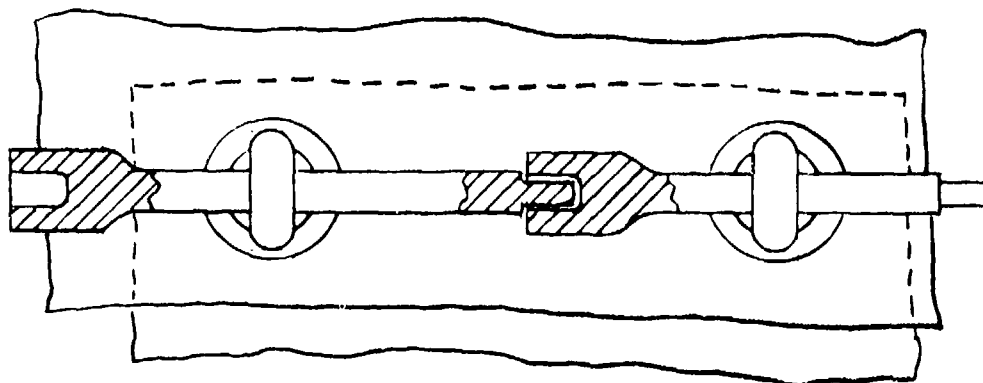
4. Major Disadvantages:

Operable from one side only.  
Possibly difficult to operate in dark or inclement weather.

5. Comments:

Suitable for fabric to rigid member closures in which the fabric is under tension.

1. Fastener: Loop and Pin



2. Description of Closure System:

Rope loop sewn and grommets clinched to respective fabrics. Fabrics are joined by inserting loop through grommet and placing pin through loop. Each succeeding pin is locked into the preceeding one. Weather seal added as required.

3. Major Advantages:

Readily available.  
Easily repaired or replaced.

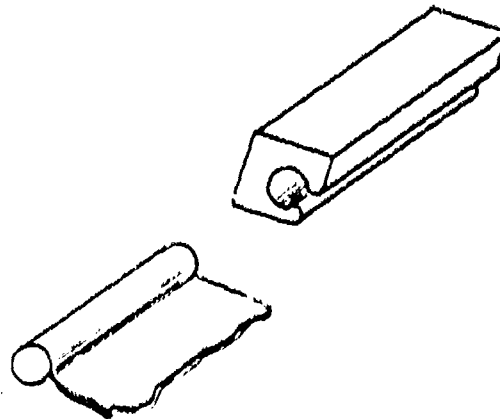
4. Major Disadvantages:

Strict mating tolerance.  
Loose parts.  
Slow opening/closing.  
Easily damaged.  
Difficult to operate in the dark, in inclement weather, or with arctic clothing.

5. Comments:

Not generally suited to fabric closure applications.

1. Fastener: Rope & Rigid Channel



2. Description of Closure System:

Channel riveted or screwed to rigid member. Fabric contains rope web along edge to be joined. Fabric is joined by pulling rope web through channel.

3. Major Advantages:

No additional weather seal required.  
Simple to manufacture, install and operate.

4. Major Disadvantages:

Not operable with partial damage. However, possibility of cutting damaged area away and replacing it with new channel exists.  
Channel generally not field repairable.

5. Comments:

Suitable for attachment of fabric to rigid member only.  
Ideal application is attachment of side walls or overhead to rigid member.

**SECRET**

1. DATE 11/11/2011

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### THE ADVERSE EFFECTS

1. The first step in the process is to identify the problem or issue that needs to be addressed. This involves gathering information and understanding the context of the problem.

10. THE UNIVERSITY OF MICHIGAN

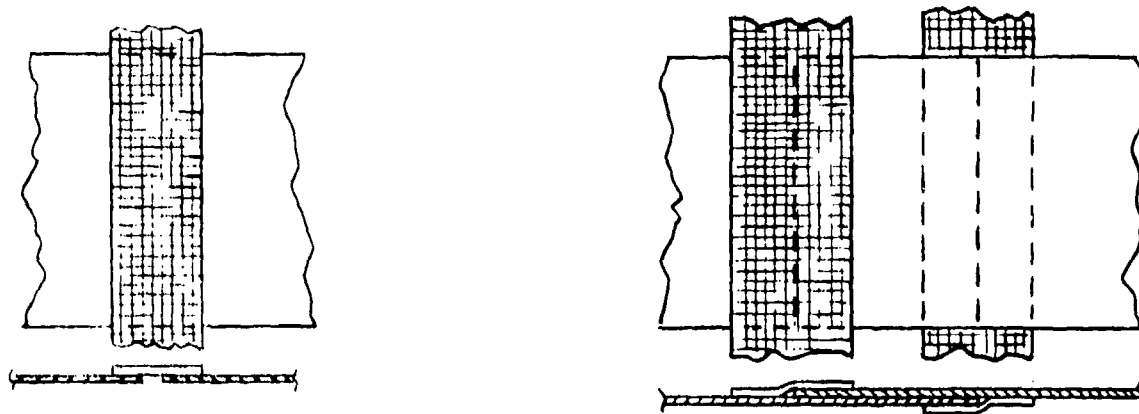
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1. Fastener: Nylon Reinforced Filament Tape



2. Description of Closure System:

Fabrics are taped together. No additional weather seal required.

3. Major Advantages:

Readily available.  
No preassembly of fastener to fabric required.  
No additional weather seal required.  
Easily repaired.

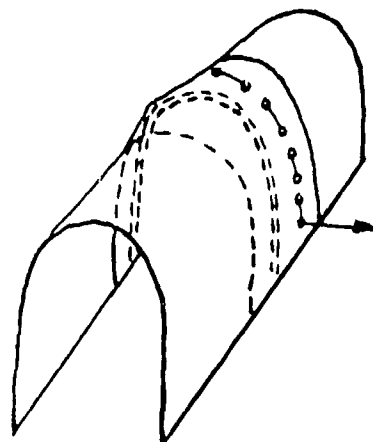
4. Major Disadvantages:

Can not be accomplished in inclement weather or in dark.  
Strength limitation.  
New tape must be used for each application.

5. Comments:

Not suitable to tentage fabric closure applications.

1. Fastener: Friction



2. Description of Closure System:

Respective fabric components are overlapped on top of a rigid frame member. Components are then secured in place by tightening ropes contained in each fabric hem.

3. Major Advantages:

Easy to manufacture, install, operate and repair.  
No additional weather seal required.

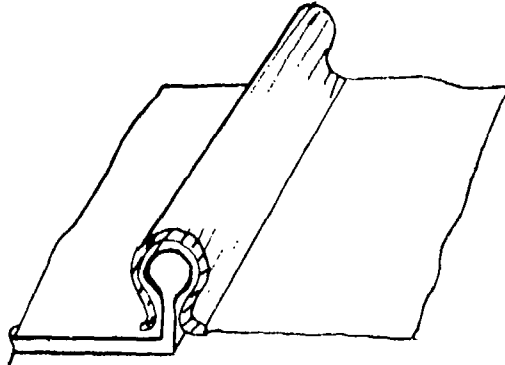
4. Major Disadvantages:

Strength limitation.

5. Comments:

Suitable for joining sections of a frame supported tent only.

1. Fastener: Flexible Channel



2. Description of Closure System:

Continuous flexible channel sewn to fabric. Continuous bead formed on rigid member. Closure completed by forcing fabric channel over rigid member bead.

3. Major Advantages:

Easy to fabricate, install and operate.  
No additional weather seal required.  
Rapid opening/closing.

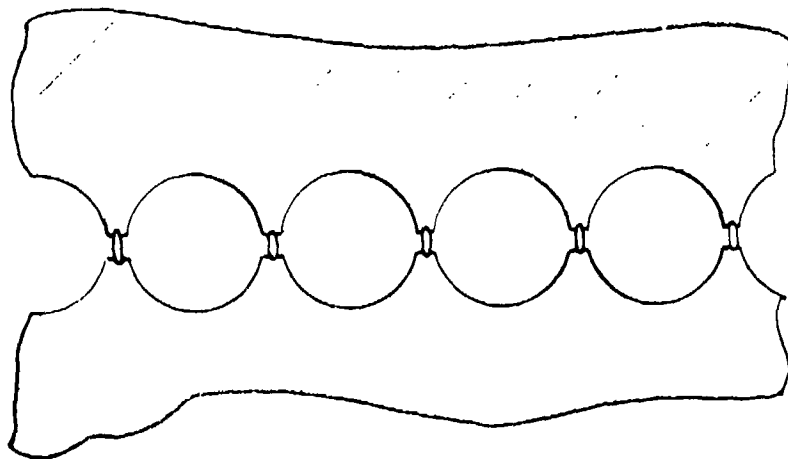
4. Major Disadvantages:

Partial damage may hinder closure.  
Not easily field repairable.

5. Comments:

Suitable for fabric to rigid member closures only.

1. Fastener: Catenary System (Note: The catenary system is not a specific fastener but a stress relieving closure method which can utilize various different fasteners.)



2. Description of Closure System:

The fabric end is sewn into a catenary configuration. Wires or ropes are also sewn into the fabric if required. The fabrics are joined by mating individual fasteners along the length of the catenary. Weather seal added as required.

3. Major Advantages:

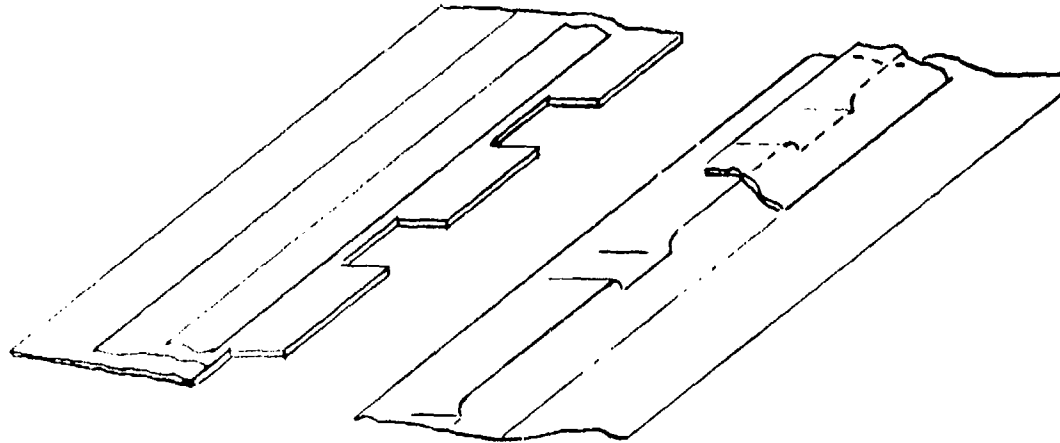
Easy to fabricate, install and operate.  
Relieves fabric stress concentration points.

4. Major Disadvantages:

5. Comments:

This system is normally used with buckle, snap and ring, or link and latch fasteners to join major components with force transmittal.

1. Fastener: Sectionalizing Band (Concept)



2. Description of Closure System:

Plastic strips are stitched at various intervals and pockets or tabs are formed. Velcro flaps and strips are stitched to cloth to hold tabs in pockets. Fabrics are joined by inserting tabs into pockets and utilizing the velcro flaps to assist in containing the tabs in the pockets.

3. Major Advantages:

No additional weather seal required.  
Operable with partial damage.  
Field repairable.

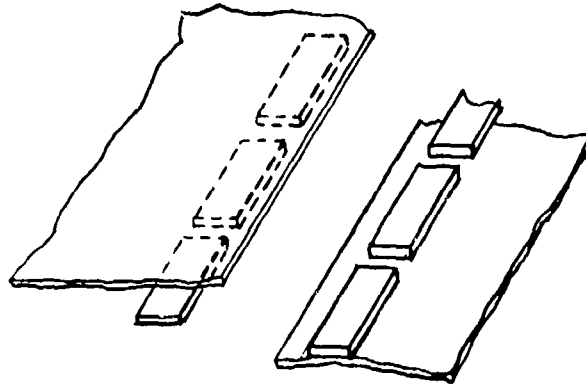
4. Major Disadvantages:

Extensive fabrication required.  
Slow opening/closing.  
Slow field repair.  
Possibly difficult to operate in dark or with arctic clothing.

5. Comments:

Designed for component, end panel/wall, and weather seal closures which are under tension.  
May not be effective in arch type application.  
This is a difficult closure to effect even under the best of conditions, i.e. clean fabrics, clean hook and pile, and comfortable temperatures. Mud, ice, and cold would make it practically impossible to complete this closure.

1. Fastener: Magnetic (Concept)



2. Description of Closure System:

Magnets riveted to fabric. Fabrics joined by matching magnets.  
Weather seal added if required.

3. Major Advantages:

Operable under all weather conditions.  
Rapid opening/closing.  
Operable with partial damage.

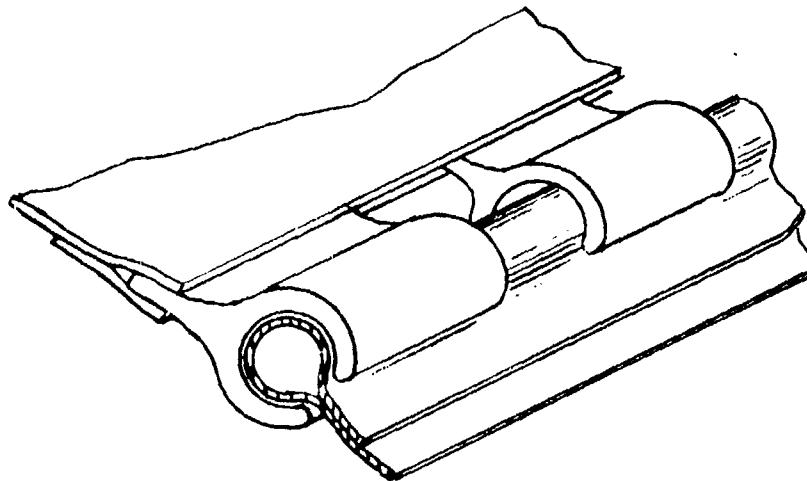
4. Major Disadvantages:

High cost.  
Strength limitation.  
High weight.  
Possibly difficult to operate in dark.

5. Comments:

Suitable for exit/entry and window applications.  
Strength of closure can be improved by proper design or by addition  
of intermittent fasteners.

1. Fastener: Air Pressure (Concept)



2. Description of Closure System:

Fasteners are sewn to fabric. Fabrics are joined by inserting deflated tube into channel and pressurizing.

3. Major Advantages:

Easily fabricated.

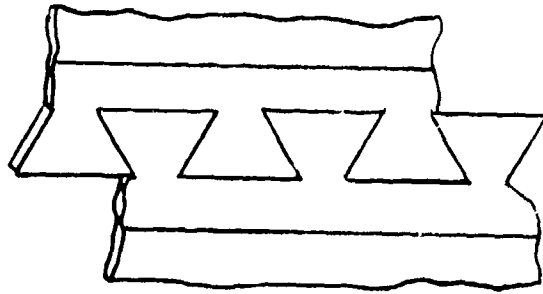
4. Major Disadvantages:

Not suitable with partial damage, in the dark or with arctic clothing.  
Easily damaged.  
Stringent mating tolerance.

5. Comments:

Applicable to air inflated structures only.  
Appears to have many disadvantages including possible damage to fabric caused by rigid member.

1. Fastener: Interlock (Concept)



2. Description of Closure System:

Flexible strips are sewn to fabric. Fabrics are joined by interlocking strips and securing with slides.

3. Major Advantages:

Easy to manufacture and install.

No additional weather seal required if properly designed.

4. Major Disadvantages:

Difficult operation in dark or with arctic clothing.

Slow opening/closing.

Stringent mating tolerance.

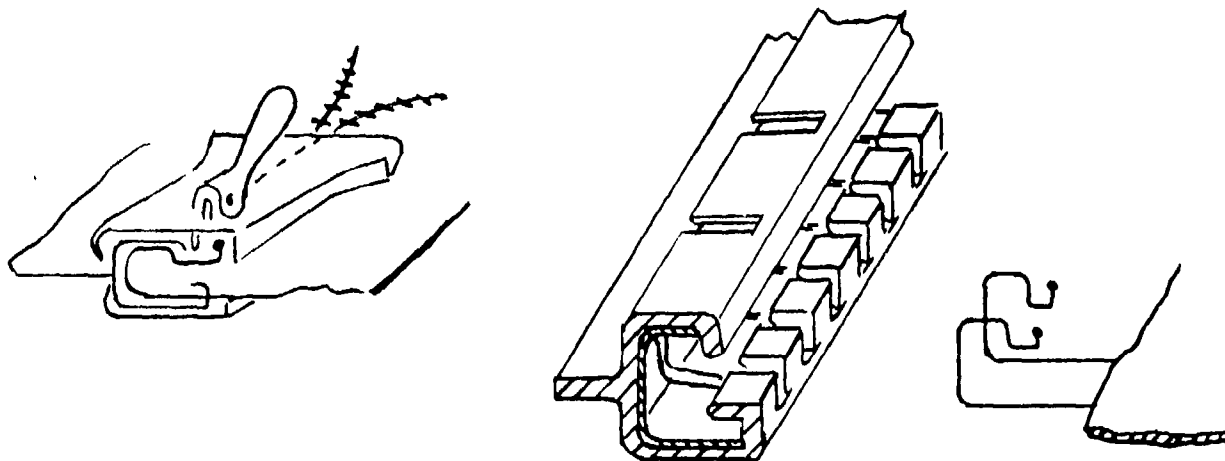
5. Comments:

Possibility of effecting closure through use of slider exists.

May not be adaptable to closures involving a radius.



1. Fastener: Pressure Zipper (Concept)



2. Description of Closure System:

Basic fastener consists of interlocking channels and wires somewhat like conventional zipper. Channels and wires are sewn to fabric and fabrics are joined by channel locking action as slider traverses closure. Weather seal added as required.

3. Major Advantages:

Easy to install and operate.  
Quick opening/closing.  
Operable with partial damage.

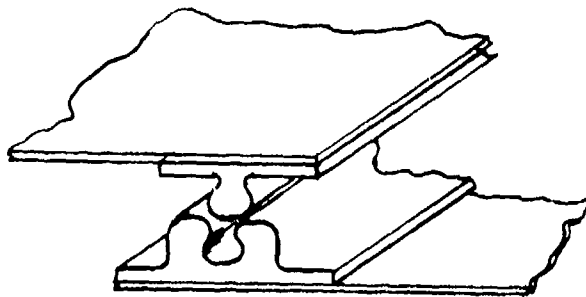
4. Major Disadvantages:

Not field repairable.  
Strength limitation.  
Possibly easily damaged.

5. Comments:

Stringers may be separated at any point along closure by properly applied pressure.  
Possible alternative to conventional zipper.

1. Fastener: Channel I (Concept)



2. Description of Closure System:

Continuous channels are sewn, bonded or riveted to fabric.  
Fabrics are joined by interlocking channels.

3. Major Advantages:

Easy to manufacture and assemble.  
Operable under all conditions.  
No additional weather seal required.

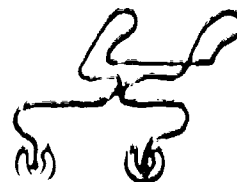
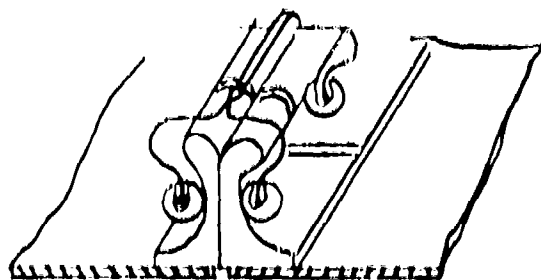
4. Major Disadvantages:

Strict mating tolerance.  
Strength limitation, but can be improved by use of intermittent fasteners.  
Not easily field repairable.  
Possibly inoperable with partial damage.

5. Comments:

Lack of flexibility may be a problem.  
Suitable for small component closures without force transmittal.

1. Fastener: Channel II (Concept)



2. Description of Closure System

Flexible extrusions are sewn to fabric. Fabric are joined by drawing ball-chain along length of closure.

3. Major Advantages:

Rapid opening/closing.  
No additional weather seal required.  
Fold retractable.

4. Major Disadvantages:

Loose parts.  
Strength limitation.  
Partly damaged.  
Difficult to operate in dark or inclement weather.

5. Comments:

Fasteners may be used individually or in a self locking chain.  
Not suitable for tentage fabric closure applications.

1. DESCRIPTION (Paragraph 1) (Continued)



2. DESCRIPTION OF DESIGN

Each component consists of a flange at the top, a central shaft, and a base. The flange is bolted to the base. The shaft is supported by bearings. The design is simple and robust, suitable for use in a variety of applications.

3. MAIN ADVANTAGES

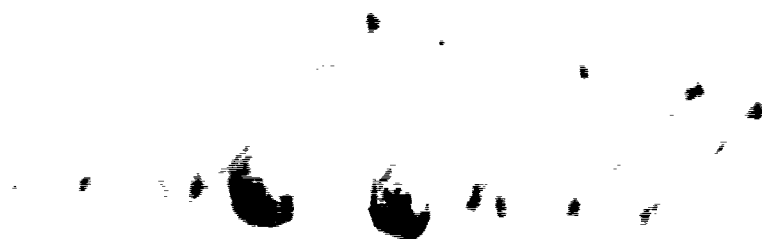
No additional features are required.  
Field maintainable with replacement of parts.

4. MAJOR DISADVANTAGES

Not operable with standard equipment. Requires special tools for assembly and disassembly. The design is simple, but the operation is complicated. The design is not really efficient.

5. CONCLUSION

Although the design is simple, it is not really efficient. The design is not really efficient. The design is not really efficient.



**Attachment V (Continued)**



**Description of Closure System**

The closure system consists of a main body and a closure member. The main body is a cylindrical component with a flange at one end. The closure member is a cylindrical component with a flange at one end and a threaded section at the other. The closure member is inserted into the main body and secured by a bolt and nut.

**Major Advantages**

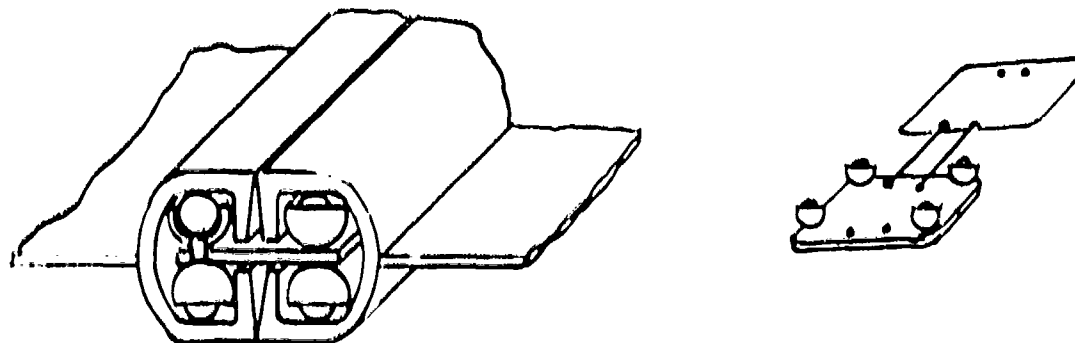
1. The closure system is simple and easy to operate.

**Major Disadvantages**

1. The closure system is not suitable for high pressure applications.

2. The closure system is not suitable for applications requiring a high degree of security.

1. Fastener: Channel VI (Concept)



2. Description of Closure System:

Flexible channels are attached to ends of both fabrics to be joined. Mating piece consists of train of interlocking rolling elements. Fabrics are joined by drawing chain through channels along length of closure. Weather seal added if required.

3. Major Advantages:

Rapid opening/closing.

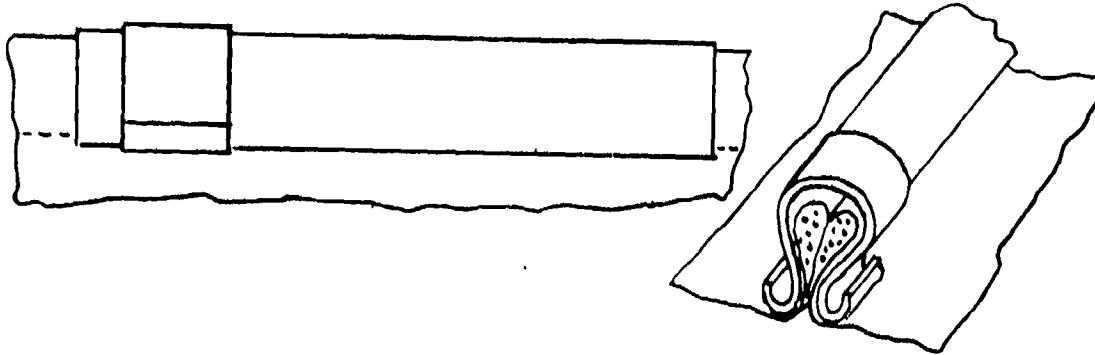
4. Major Disadvantages:

Numerous loose parts.  
Easily damaged.

5. Comments:

Not suitable for Contage fabric closure.

1. Fastener: Clasp (Concept)



2. Description of Closure System:

Ends of fabric are formed into beads. Fabrics are joined by placing two beads next to each other, covering the seam with a flexible sleeve, and adding clamps as required for strength. No additional weather seal required.

3. Major Advantages:

Easily fabricated.  
No additional weather seal required.

4. Major Disadvantages:

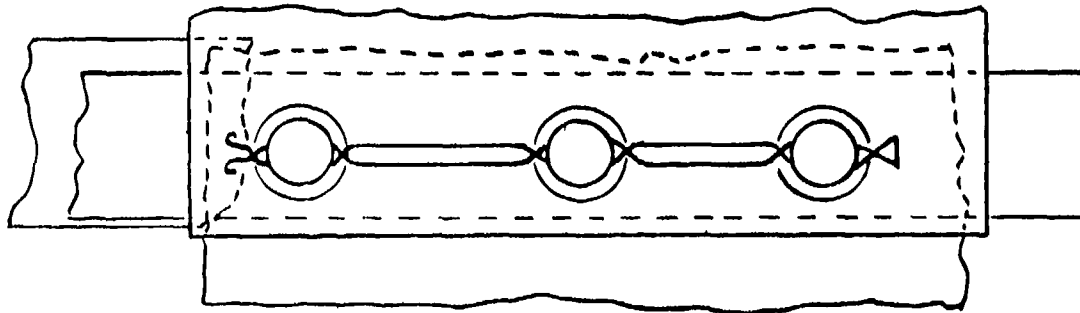
Slow opening/closing.  
Difficult operation in dark, inclement weather or with arctic clothing.  
Numerous loose parts.

5. Comments:

Not generally suited to tentage fabric closure applications.



1. Fastener: Garter (Concept)



2. Description of Closure System:

Buttons are attached to one fabric. Grommets are clinched to second fabric. Fabrics are joined by inserting buttons through grommets and securing groups of three with spring clips. Weather seal can be built into closure.

3. Major Advantages:

Operable with partial damage.  
Readily available.  
Field repairable or replaceable.

4. Major Disadvantages:

Difficult operation in dark or with arctic clothing.  
Critical mating tolerance.  
Numerous loose parts.

5. Comments:

Not generally suitable for tentage fabric closure applications.