The present invention relates to improvements in balloon construction.

The type of balloon which embodies the features of the present invention is used primarily for high altitude flights. It is usually formed of a light weight thermoplastic material such as polyethylene which has the properties of being gas-proof, retains its flexibility in the very cold temperatures of the higher altitudes, and is relatively strong and can be used very thin so as to be light in weight.

Although this material is capable of withstanding considerable stress when the forces are distributed over a large area, concentrations of stress will damage or tear the material. For this reason the balloon load cannot be attached directly to the material but a harness must be provided to distribute the load over the balloon surface. Heretofore this harness has consisted of a series of tapes adhesively attached to the balloon material and supporting the load at the bottom of the balloon. The tapes are evenly spaced, in effect form a basket surrounding the balloon envelope, and the force of the lifting gas within the balloon envelope supports the harness to support the load.

The load supporting tapes have heretofore been adhesive backed to maintain their position on the surface of the balloon envelope and are commonly adhered over the seams between the gores to add strength thereto. Disadvantages are encountered with this structure both in the structure itself and in manufacturing the components. In the fabrication of the balloon, care must be taken to prevent accidentally touching the adhesive surface of the tape to the balloon material in the wrong location or the tape will stick to the material and may endanger the material in removal. At best it is awkward handling adhesive tapes especially in long lengths.

Another disadvantage is the additional weight necessary with this type of tape. Commercially available adhesive backed tapes often have filaments for longitudinal strength and add considerable weight when the tapes are placed over each of the balloon seams, especially in comparison to the light weight of the thin plastic balloon envelope.

A major disadvantage in these tapes lies in the inability of ordinary adhesives to withstand cold. When the balloons rise to a high altitude the tapes frequently loosen from the balloon surface becoming displaced and unequalizing the distribution of the weight of the load on the balloon surface. At times the tapes have loosened to such a degree that the entire balloon envelope has slipped out from the tape harness resulting in a complete failure of the flight.

Therefore, an objective of the invention is to present a balloon structure having a tape harness over the balloon envelope which has adequate strength for carrying the load and yet which adds little additional weight to the balloon.

Another objective of the invention is to provide a tape and means of attaching the tape to the balloon surface which obviates many of the inherent difficulties of an adhesive backed tape.

It is a further object of the present invention to provide an improved seam between the gores of balloons.

Another object of the invention is to provide a seam which may be quickly and easily made and will not add useless weight to the balloon.

Other objects and advantages will become apparent in the following specification taken in connection with the appended drawings in which:

- Figure 1 is an elevation view of a balloon in flight;
- Fig. 2 is a plan view illustrating a typical gore pattern used in goared balloons;
- Fig. 3 is a perspective view illustrating a method of forming a heat weld between gores of balloons;
- Fig. 4 is a perspective view illustrating a method of attaching the strengthening tape to the seam;
- Fig. 5 is an enlarged sectional view taken through the balloon seam illustrating the appearance of the seam with the attached strengthening tape;
- Fig. 6 is a sectional view taken through the balloon seam illustrating an alternative steam according to the present invention; and,
- Fig. 7 is a sectional view taken through the balloon seam illustrating the structure with the tape on the gore center.

In Figure 1 a high altitude balloon, which has a gas containing envelope which is formed of a plurality of gores, is shown in flight. The gores are joined at their adjacent edges to form seams which lie beneath tapes extending the length of the balloon and joined at the balloon top.

The balloon gores extend from the bottom to the top of the balloon where a cap may be attached to cover the juncture of the upper ends of the gores. At the lower end of the balloon where the gores terminate an appendix may be attached to prevent air from entering the balloon and mixing with lifting gas.

At the base of the balloon a load is carried supported by a load line which is suitably attached to the balloon by a rigging. The rigging is suitably attached to the tapes so that the weight of the load is carried by the tapes. As may be seen from the drawing, the tapes form a harness or a basket over the balloon envelope which functions to distribute the weight of the load over the balloon surface. The harness surrounds the envelope which exerts a lift due to the lifting gas contained within. This load could not be attached directly to the balloon material at the bottom of the balloon because the light weight plastic could not withstand the concentrations of stress and the tapes are therefore necessary.

The tapes also add strength to the seams as will be later described in greater detail. The tapes, however, do not necessarily have to be placed over the seams but may be placed between the seams as is shown in Fig. 7 and as is shown in the co-pending application, Serial No. 389,104, filed October 29, 1953 for Balloon with Load Supporting Tapes, James J. Ryan.

Fig. 2 illustrates the pattern of a balloon gore. The gores extend from the top to the bottom of the balloon and have their widest portion toward the top end so that the balloon has a rounded top and tapers to a narrow lower end. The gores may be formed of any type of material that is light weight and strong. An excellent material is a thermoplastic such as polyethylene which meets the above requirements and does not become brittle with severe cold. The material being thermoplastic can be readily and simply welded by the application of heat.

An illustration of this welding is shown in Fig. 3 where the gores are being joined to each other. In this figure the material is laid on a balloon table and a first gore
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28 is positioned on top of a second gore 30. The first gore has already been attached to an adjoining gore 32 by a heat weld or seam 34.

To form the new seams to attach gores 28 and 30, a heated welding device shown generally at 36 is moved along the material forming the seam as it moves. The heat seaming or welding device may be of any preferable type and as shown has a heated resistance wire 38 which melts the thermoplastic as it is advanced to cut a strip 40 of material from the gores and creates a weld bead 42 which joins the gores. The wire 38 is moved along a path which corresponds to the proper shape of the gore.

The wire is bent in a U shape with the base extending downwardly at the points of supports 44 suitably connected to a source of electricity to heat the resistance wire. The support is carried on a block 46 mounted on a plate 48 which guides beneath the material as it is moved along. An opening 50 is provided in the plate 48 so that the wire may extend through it. When the seam is formed between the gores they are spread out on a table or platform 52 as is shown in Fig. 4. With the gores and the seam in this position the strengthening tape 54 is applied. The tape is supplied from a roll 56 which is moved ahead of the tape attaching device shown generally at 58 and the tape is fed off the roll and laid over the seam.

Tape applying device may assume any suitable form which is capable of affixing the tape by attaching its edges to the gores. In attaching the edges, one edge 60 is attached to the gore 30 while the other edge 61 is attached to the adjoining gore 28, the finished product being illustrated in Fig. 5. It will be noted that the bond 62 between the edge 61 of the tape and the gore 28 is relatively narrow and the bond 64 between the edge 60 of the tape and the gore 30 is also narrow leaving an area between the edges which is unattached to the gores. The horizontal stresses on the balloon, which are indicated by the sectional arrows 66 and 68, are withstood both by the bonds 62 and 64 between the tape and the gores, and by the seam 42. As will be apparent from the drawings, failure of any one of these bonds singly will not result in a failure of the union between the gores. For example, if the seam 42 should fail, the bonds 62 and 64 will hold the gores together. Further, since the central portion of the tape is unattached to the seam 42, the tape may shift with respect to each other when the material stretches with the application of force and this construction reduces the possibility of the stress being locally concentrated.

Another reason why the tape greatly strengthens the seam is because tension on the gores creates a shear stress on the bonds 62 and 64 parallel to the bond. The stress on the seam 42 is a tensile stress and it will be obvious from Fig. 5 that the pull on seam 42 has a tendency to separate the seam.

Another important advantage in leaving the central area of the tape unattached is that it is not always possible to exclude all the air from between these layers, i. e., between the tape and the gores, when the tape is applied to the seam. This is especially true since the weld bead 42 projects up above the surface of the gore material and the tape cannot be positively flattened to the seam and force out all the air. When the balloon ascends to high altitudes any small particles of air left between the seam and tape will expand greatly with a decrease in air pressure. If no space is provided to assimilate this expansion, it will tear the tape from the material or perhaps, the material may eventually create a leak. With the large unattached area between the seam and tape any small air bubbles may expand and the surfaces can separate to accommodate expansion without endangering the security of the seam.

There is a disadvantage in using an adhesive backed tape in that air bubbles may be entrapped and later expanded to loosen the tape. With a heat weld the bubbles are easily forced out, especially with a narrow weld.

By using a carrier tape 14 with the strengthening filaments embedded in the center of the tape and welding the tape to the balloon at the tape edges, there is no danger of the heat weakening the filaments during welding. In any event when the tapes and balloons are of thermoplastic a narrow weld has more than adequate strength to keep the tape in place during flight and unlike adhesive secured tapes, does not weaken with severe cold.

Returning now to Fig. 4, the method of attaching the tape to the gores will be explained. As the tape 54 is withdrawn from the roll 56, it is pressed tightly against the gores by the plate 70 which has a curved front edge to prevent damaging the tape as it is guided against the material. The plate has a pair of openings 72 and 74 which correspond in location to the position of the tape edges 60 and 61. The tape is a thermoplastic material and is heat welded to the gores. Projecting through the openings are heated rollers 76 and 78 which are suitably biased against the material and are supported on vertical supports 80 and 82. Electrical leads 84 and 86, connected to a suitable supply of electricity, are connected to the rollers which are heated by conventional resistance elements.

The tape application plate 70 and rollers 76 and 78 are moved over the tape together and apply the tape over the seam 42 and heat seal it to the gores along the edges 60 and 61. The balloon material is of a light weight thermoplastic and the strengthening tapes are also of thermoplastic so that a heat seal is rapid and easy to make and results in a secure seam.

The mechanism for attaching the tape is for the purpose of illustration and other methods and devices could be used. For example, on long lengths of material seam rollers create difficulty in that they push the material forward and may bunch it ahead of them. Instead of a heated roller, jets of heated air could be directed against the material to form the weld.

It will be noted in Fig. 5 that the strengthening tape 14 has filaments 88 embedded therein. These filaments extend longitudinally parallel to the tape and vertically along the balloon to carry the load.

The tapes are suitably attached to the load carrying rigging 24 at the base of the balloon and the tapes cooperatively act together as a harness to support the load and distribute its weight over the upper surface of the balloon envelope. The filaments 88 may be of nylon or cotton or other suitable strong light weight material. The filaments may be embedded in the tapes at the manufacture of the tape or the tape may be fabricated by laminating two tapes of thermoplastic material with filaments between as is shown in Figs. 5 and 6.

Fig. 6 illustrates another seam which may be used. In this seam, the left gore 90 is positioned with the right gore 92 having its edge overlapping the edge of the left gore. Between the overlapping surfaces the strengthening tape 14 is positioned. The overlap is of a width equal to that of the tape so that the edges 94 and 96 of the tape correspond respectively to the edges 98 and 100 of the gores. The seam is then secured by forming narrow heat welds 93, 95, 97 and 99 along the edges of the tape to secure it both to the overlapping and underlying gore.

This seam construction also has the advantage that the failure of either of the welds will not cause the failure of the entire union between the gores. The tape likewise has the embedded strengthening filaments 88 which serve to carry the balloon load and the tape 14 is not to be placed over the seam it may be secured to the center of the gore as is shown in Fig. 7. In this case, the seam 108 between gores 102 and 104 and seam 110 between gores 102 and 106 will be formed in the manner shown in Fig. 3. The tape 14 will be attached to extend axially down the center of the gore and may be secured to the gore either before or after it is joined to the other gores of the balloon.
To attach the tape it may be laid over the gore in much the same manner as it is laid over the seam in Fig. 4. It is attached to the gore by two narrow weld strips 112 and 114 which are formed by applying heat to the thermoplastic strip along the narrow areas to be welded.

In this instance as in the other structures shown in Figs. 5 and 6, the tape is securely fastened to the balloon by the strong heat welds. Because the strength of these welds exceeds that of the adhesive, they can be very narrow and consume a very small amount of material. They do not interfere with the strengthening elements 88 and permit some degree of freedom in allowing the elements to shift with respect to the gore.

Thus it will be seen that we have provided a new and improved seam for joining the gores in the balloon which is easy to fabricate and which forms a superior gas seal and also gives horizontal strength to the balloon.

By using a thermoplastic carrier for the strengthening elements and heat welding a thermoplastic to the balloon, we have eliminated the necessity of heavy tapes and the use of adhesives which add extra weight. The use of a heat weld obtains a strong bond between the balloon and tape and requires attachment over only a very small area permitting the remainder of the tape surface to be free for slight movements with respect to the balloon.

We have, in the drawings and specification, presented a detailed disclosure of the preferred embodiments of our invention. It is to be understood that the invention is susceptible of modifications, structural changes and various applications of use within the spirit and scope of the invention and we do not intend to limit the invention to the specific form disclosed but intend to cover all modifications, changes and alternative constructions and methods falling within the scope of the principles taught by our invention.

We claim as our invention:

1. A balloon for carrying a load at high altitudes comprising a gas containing envelope having a plurality of elongated gores extending vertically of the balloon envelope and each gore joined to the adjacent gore along a seam, means to support a load from the balloon, and load bearing tapes, only the marginal portions of which are secured to the gores, said tapes extending from the top of the balloon to the lower end to be joined to said load supporting means.

2. A balloon for carrying a load at high altitudes comprising a balloon envelope for containing a lifting gas and formed of a plurality of gores extending side by side from one side to the other of the balloon, a seam joining the adjacent edges of each of the gores, a load bearing tape positioned over each of the seams and attached to the load supporting means by being sealed to the gores along outer edges with the central portion remaining free and separate from said gores and seams, and means for supporting a load from the balloon and attached to the tapes.

3. A balloon for carrying a load at high altitudes comprising a balloon envelope formed of a plurality of elongated gores of light weight balloon material being joined to each other at their edges by seams, load bearing tapes of light weight material having strong fibers embedded therein to give the tapes longitudinal strength for supporting the load, the tapes extending from the top to the lower end of the balloon and the only marginal edges of tapes attached to the gores with the central portions of the tapes serving as connecting means between the adjacent edges, and load carrying means attached to the lower ends of the tapes for supporting the load from the balloon in flight.

4. A seam between the edges of the gores of a balloon which is formed of multiple gores comprising a first gore edge and second gore edge positioned in abutment and tape positioned over the abutting edges and joined to the gores in two thermally welded strips, each of said strips being adjacent and parallel to said seam.

5. A seam between the edges of the gores of a balloon which is formed of multiple gores comprising a first and second gore each brought into abutment and joined by a weld, a strengthening tape positioned longitudinally over the seam and joined at its edges to the first and second gore by a weld along a narrow strip at the edges of the tape, said gores and attached tape forming an air-tight passageway.

6. A seam between the edges of the gores of a balloon which is formed of multiple gores comprising a first and second thermoplastic gore brought together so that the edges are in abutment, a heat weld joining the edges between the gores, a thermoplastic tape positioned over the seam so that it lies with half its area on either side of the seam, the tape having load carrying filaments embedded therein, a first and second heat welded seam joining the tape to the first and second gores along respective edges of the tape and spaced from the seam between the gores.

7. A seam for a high altitude load carrying balloon having a plurality of gores joined together to form a gas containing balloon envelope, the seam comprising the edges of a first and second adjoining gore balloon gore being positioned in overlapping relationship with the first gore overlapping the second gore, a load bearing tape positioned between the gores with its respective edges corresponding in position with the first and second gore edges, narrow welds between the first edge of the tape and the edge of the first gore balloon and also the second gore balloon, and narrow welds between the second edge of the tape and the edge of the second gore balloon and also the first gore balloon, said narrow welds being of a width to leave an unwelded portion between them.

8. A balloon for carrying a load at high altitudes comprising a balloon envelope for containing a lifting gas and formed of a plurality of gores extending from the base to the top of the balloon, the gores positioned so that the edge of one gore overlaps the adjoining gore by a given width to form a seam, a load supporting tape positioned between the surfaces of the overlapping gores and being equal to said given width, the seam formed by adhering the tape edges to overlying and underlying gores along narrow areas at the edges of said tape with the center portion of the tape being unadhered, and means for supporting a load from the balloon being attached to the balloon at its base.

9. The method of attaching a load bearing tape to a balloon which comprises forming a balloon envelope from a plurality of gores of thermoplastic material and joining the gores to each other by a heat-welded seam, positioning a load bearing thermoplastic tape over each of the seams and heat welding the tape to the gores by applying heat to each edge of the tape adjacent the seam between the gores to avoid applying heat to the gore seam and to permit the gore seam to remain unattached with the central portion of the tape remaining unattached to the seam.

10. The method of forming a seam for joining the edges of a multiple gore balloon which comprises welding the abutting edges of adjoining gores, positioning a tape over the weld and joining the tape to the gores by thermally welding two strips of the tape to the gores, each of said strips being parallel and non-contiguous to the welded abutting edges of the gores.

11. A method of forming a seam between the gores of a multiple gore balloon which comprises bringing the gore edges into overlapping relationship, positioning a tape between the overlapping edges, forming a first weld down one edge of the tape and joining it both to the overlying and underlying gore, and forming a second seam down the other edge of the tape joining it both to the overlying and underlying gore.

12. A balloon for carrying a load at high altitudes comprising a balloon envelope formed of a plurality of elongated gores of a light-weight thermoplastic balloon material joined by thermally welded seams at the edges of adjacent gores, load bearing tapes of light-weight thermoplastic balloon material thermally welded along
their marginal edges to adjacent gores, the central portion of said tape acting as a connecting means between the two welded portions formed between the marginal portions of the tape and the gores and overlapping the welded seam between the two gores, thereby relieving the stress on said seam, and means for supporting a load from the balloon attached to the tapes.

13. A balloon as in claim 12 in which the light-weight thermoplastic material of both the gores and the tapes is polyethylene.

14. A balloon for carrying a load at high altitudes comprising a balloon envelope for containing a lifting gas formed of a plurality of elongated gores of a light-weight thermoplastic balloon material, load bearing tapes of light-weight thermoplastic balloon material thermally welded along their marginal edges to adjacent gores, the central portion of said tape acting as a connecting means between the two welded portions formed between the marginal portions of the tape and the adjacent gores, and means for supporting a load from the balloon attached to the tapes.

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