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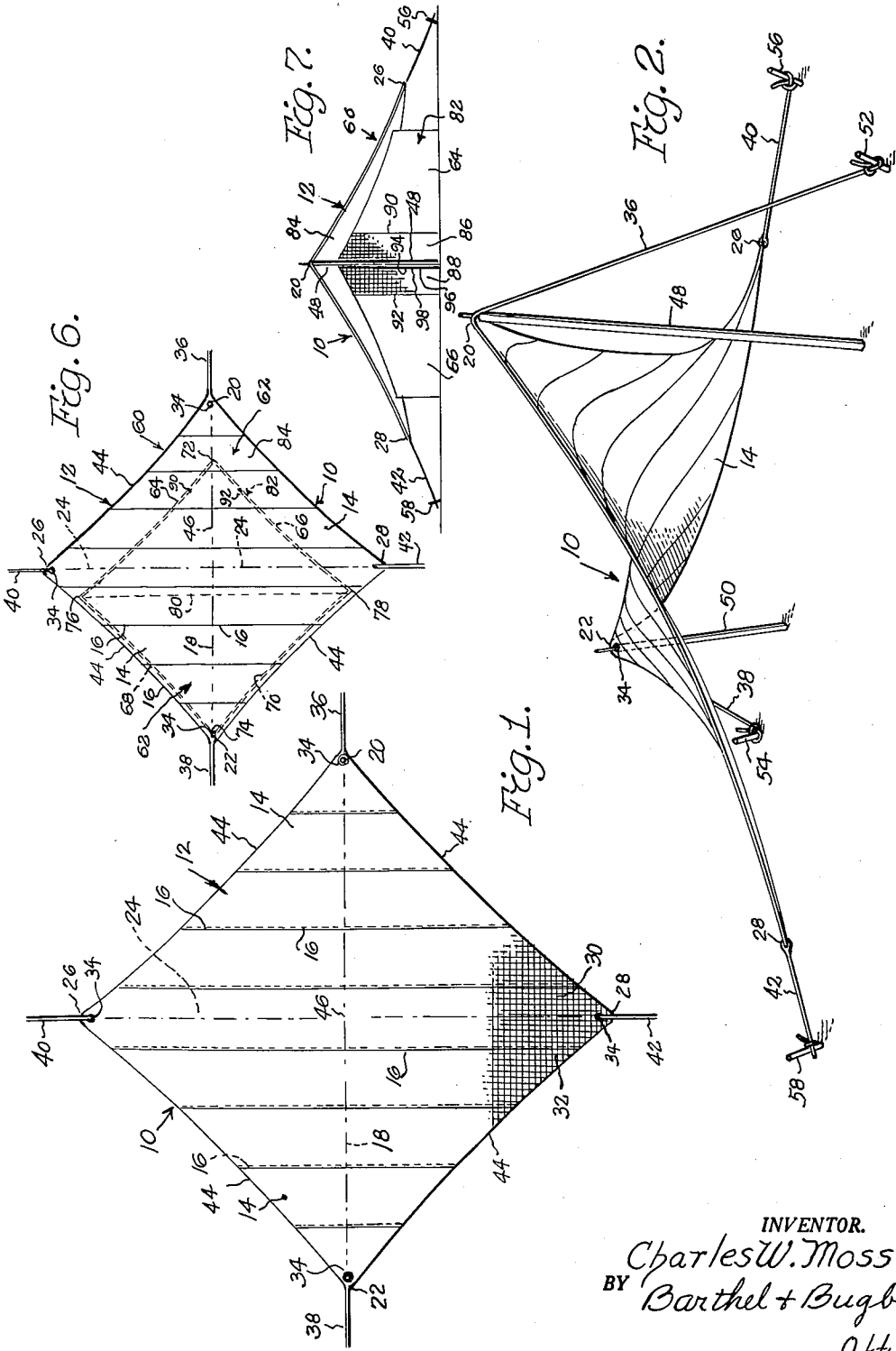
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FLEXIBLE HYPERBOLIC PARABOLOID SHELTER

Filed Jan. 30, 1957

2 Sheets-Sheet 1



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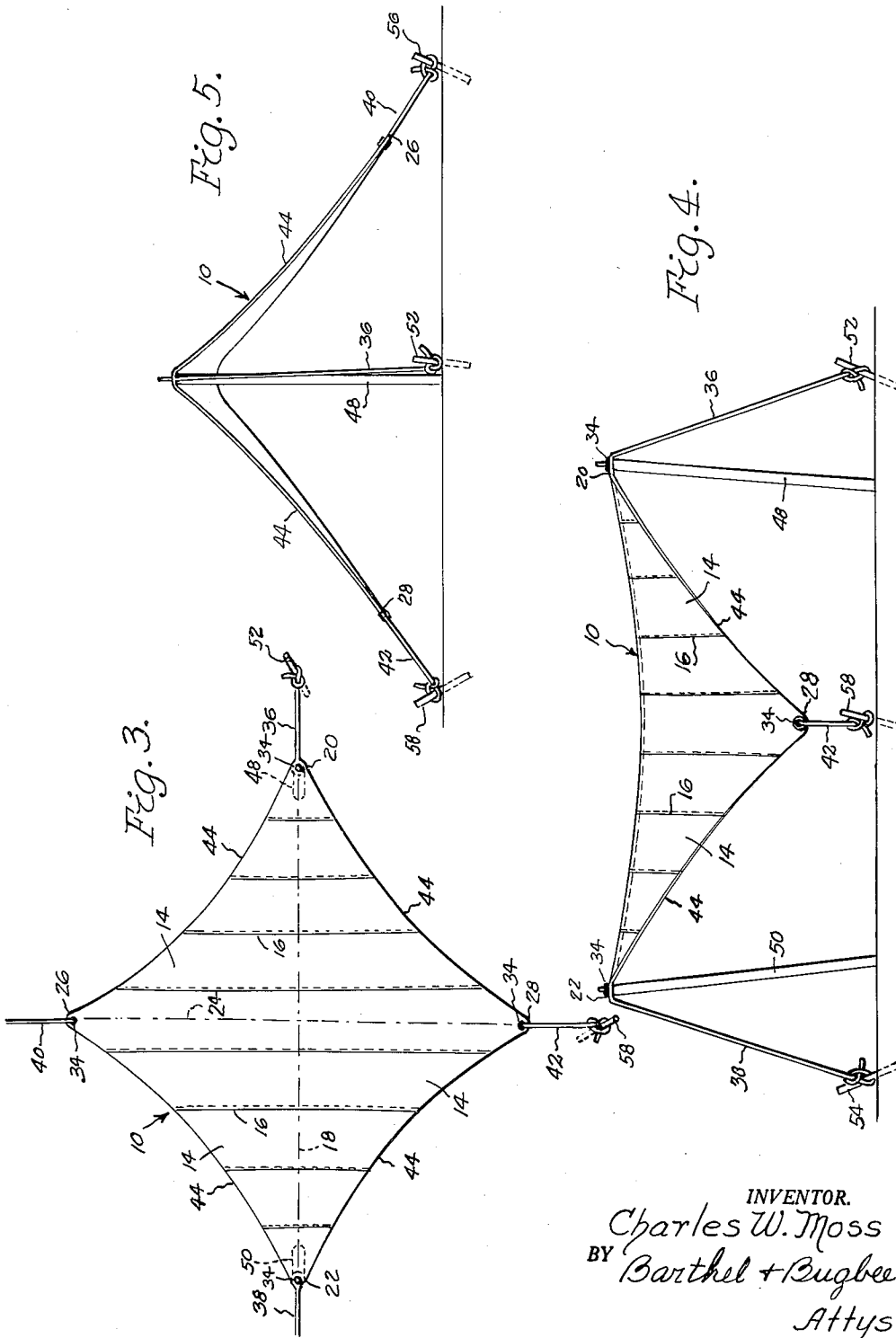
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FLEXIBLE HYPERBOLIC PARABOLOID SHELTER

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11 Claims. (Cl. 135—1)

This invention relates to shelters and, in particular, to shelters of flexible material, such as woven fabric or the like.

One object of this invention is to provide a portable flexible shelter, which, when laid out on the ground is substantially flat but the roof structure of which, when pitched between tent poles, trees, car roofs or other upright anchorages, assumes an approximately hyperbolic paraboloid shape which forms a roof structure possessing superior stability in high winds without collapsing or blowing away, which sheds rain and snow exceptionally well and which is quickly and easily pitched, yet folds into a small space for storage and transportation.

Another object is to provide a portable flexible shelter of the foregoing character which is useful not only as a tent or roof structure thereof but also as a shelter for a picnic table, camping stove or other similar purpose when the shelter is used either alone or in connection with another sleeping tent.

Another object is to provide a portable flexible shelter of the foregoing character which is formed from a four-sided and four-cornered sheet of woven fabric or textile material, the edges of the shelter being cut obliquely to the warp and weft of the fabric of the sheet, so that all four edges of an approximately square sheet of material with the guy lines at the corners thereof are disposed obliquely to the warp and weft of the fabric, which are therefore disposed respectively parallel and perpendicular to the two mutually perpendicular diagonals extending between the opposite pairs of corners.

Another object is to provide a portable flexible shelter, as set forth in the object immediately preceding, wherein the approximately rectangular sheet, preferably approximately square, is made up of fabric strips with parallel seams joined edge to edge and oblique ends in which the warp and weft are disposed respectively parallel and perpendicular to the parallel seams between strips and oblique to the ends of the strips and to the edges of the sheet formed collectively by the ends of the strips.

Another object is to provide a portable flexible shelter, as set forth in the two objects immediately preceding, wherein the edges of the sheet are concavely arcuate or inwardly curved before pitching, and become more strongly arcuate under the tension applied thereto by pitching, so that the shelter assumes a hyperbolic paraboloid shape wherein the main ridge or longitudinal diagonal is concave from above and the cross ridge or lateral diagonal is convex from above.

Another object is to provide a portable flexible roof structure as set forth in the preceding objects, wherein side walls are additionally provided extending from the roof-like shelter downward to the ground so as to partly or fully enclose a part or all of the ground area under the shelter.

Other objects and advantages of the invention will become apparent during the course of the following description of the accompanying drawings, wherein:

FIGURE 1 is a top plan view of a shelter sheet from which a portable flexible shelter with a roof structure of approximately hyperbolic paraboloid or saddle shape is adapted to be erected, according to one form of the invention;

FIGURE 2 is a front perspective view of the shelter erected from the shelter sheet shown in FIGURE 1;

FIGURE 3 is a top plan view of the shelter shown in FIGURE 2;

2

FIGURE 4 is a side elevation of the shelter shown in FIGURE 2;

FIGURE 5 is a front elevation of the shelter shown in FIGURE 2;

5 FIGURE 6 is a top plan view somewhat similar to FIGURE 4, but showing a slightly modified enclosed shelter having side walls; and

FIGURE 7 is a front elevation of the enclosed shelter shown in FIGURE 6.

10 Referring to the drawings in detail, FIGURES 2 to 5 inclusive show an open portable flexible shelter with a roof structure of approximately hyperbolic paraboloid or saddle shape, generally designated 10, formed by pitching and thereby placing under tension a substantially flat shelter sheet or cloth, generally designated 12, with a specially arranged warp and weft of the fabric, as described below and shown in FIGURE 1. The shelter sheet or cloth 12 is preferably an approximate quadrilateral of approximately rectangular shape, preferably approximately square but optionally kite-shaped or diamond-shaped. It is preferably formed of strips 14 of fabric or other suitable sheet material with parallel edges sewed or otherwise secured to one another along seams 16 which are substantially parallel to one another but are substantially perpendicular to the longitudinal or main ridge line or diagonal 18 between the longitudinal or front and rear corners 20 and 22 respectively, and parallel to the lateral or secondary ridge or cross line or diagonal 24 between the lateral corners 26 and 28.

25 The opposite ends of each strip 14 are cut obliquely to the fabric warp 30 and weft 32 which are, however, respectively perpendicular or parallel to both the seams 16 and the diagonals 18 and 24 of the sheet 12. The corners 20, 22, 26 and 28 are preferably provided with grommets 34 for the reception of guy lines, the grommets 34 at the main corners 20 and 22 receiving front and rear guy lines 36 and 38, and the grommets 34 at the side corners 26 and 28 receiving side guy lines 40 and 42 respectively. The shelter sheet or cloth 12, when laid out flat before pitching (FIGURE 1) has edges 44 which are slightly inwardly concave toward the center point 46 at the crossing of the longitudinal and lateral diagonals 18 and 24 respectively.

30 In pitching the shelter sheet or cloth 12 of FIGURE 1 to form the portable flexible shelter 10 of FIGURES 2 to 5 inclusive, front and rear tent poles 48 and 50 are preferably provided although either or both the front and rear corners 20 and 22 may be anchored to and supported by another upright object, such as a tree, side or end of an automobile or truck or the like. For convenience, the poles 48 and 50 are used, with their upper end spikes projecting through the grommets 34 at the front and rear corners 20 and 22 and with their front and rear guy lines 36 and 38 leading downwardly in oblique directions away from one another to front and rear stakes 52 and 54 respectively. The lateral guy lines 40 and 42 are also preferably secured to lateral stakes 56 and 58. Each of the guy lines is preferably equipped with a conventional guy line tightener (not shown) for purposes of simplification.

35 The tent poles 48 and 50 at their upper ends preferably lean slightly away from one another and sufficiently high to pull the front and rear corners 20 and 22 upward above the center point 46 while the side corners 26 and 28 are pulled downward by their respective guy lines. This procedure stretches the bias-end shelter cloth 12 in the directions of the main and secondary diagonals 18 and 24, the central portions of which thereupon become concave and convex respectively, viewed from above—in other words, so that the roof structure becomes of approximately hyperbolic paraboloid shape or approximately saddle-shaped. The curving of the edges 44 inwardly toward the center 46 of the shelter cloth 12 becomes more strongly

arcuate (FIGURE 3) as tension is increased, so that the edges 44 of the shelter 10 are more strongly concave inwardly than the same edges 44 in the flat shelter cloth 12 before pitching, as is indicated by the contrast between FIGURE 1 of the shelter sheet or cloth 12 and FIGURE 3 of the pitched shelter 10. At the same time, also, it will be observed from FIGURE 3 that the seams 16 under tension also become slightly arcuate in a direction concave toward their nearest front and rear corners 20 and 22, the bias-end fabric in the strips 14 bringing about this stretching and curving of the seams 16 and edges 44.

The curving of the edges 44 in the flat untensed shelter cloth 12 causes the tensed edges 44 of the pitched shelter 10 to remain taut and substantially free from ripples, which tend to occur in a shelter cloth 12 wherein the side edges are straight or rectilinear. Such ripples tend to set up corresponding ripples in the body of the shelter, from the slackness created in certain portions thereof, so that the shelter flutters or flaps in the wind. The preliminary curving or concaving of the edges 44 in the untensed shelter sheet 12 prevents such ripples and consequently prevents such fluttering or flapping in the wind when the shelter cloth 12 is pitched under tension as the shelter 10.

The modified enclosed shelter, generally designated 60, shown in FIGURES 6 and 7 includes the open shelter 10 shown in FIGURES 2 to 5 inclusive which is therein generally designated as the roof 62, similar parts being designated by the same reference numerals as are used in FIGURES 2 to 5 inclusive. The enclosed shelter 60, however, differs from the open shelter 10 by additionally providing front side walls 64 and 66 and rear side walls 68 and 70 with their front and rear corners 72 and 74 located along the main ridge line 18 and their side corners 76 and 78 located along a tertiary ridge line or diagonal 80 which is approximately parallel to but spaced rearwardly of the secondary ridge line or diagonal 24. The walls 64, 66, 68 and 70 collectively form a substantially vertical-walled enclosure, generally designated 82. The purpose of this construction is to space the rear walls 68 and 70 closely adjacent the rearward side edges 44 but the front walls 64 and 66 a greater distance away from the forward side edges 44 so as to provide in effect an awning or marquee portion 84 between the front corner 20 of the roof 62 and the front corner 72. This awning or marquee portion 84 provides additional protection from the sun or rain, especially when the front walls 64 and 66 are provided with open-mesh netting door panels 86 and 88 having their outer edges secured along seams 90 and 92 to the adjacent front walls 64 and 66. The inner or adjacent edges 94 and 96 of the netting panels 86 and 88 are preferably separably secured to one another by means of a conventional slide fastener 98 to facilitate entering and leaving the shelter 60.

Experience with this portable flexible shelter of the present invention under actual high wind and rain storm conditions has shown it to possess extraordinarily high stability as compared with conventional shelters or tents of flexible material, even though the shelters 10 and 60 possess a minimum of guys and consequently a minimum of tent stakes or tent pegs to secure them to the ground. At the same time, the hyperbolic paraboloid or saddle roof shape sheds rain well without leaking. The approximately square or rectangular shape of the shelter cloth 12, with or without the enclosure 82, enables it to be quickly and easily folded into a small bundle by inexperienced persons, and as quickly and easily unfolded or unrolled, laid out on the ground and pitched. One or both ends of the shelters 10 or 60 may be secured to trees or one end secured to an automobile or truck, as by running the guy line over the roof of the car or truck. A so-called station-wagon is an especially convenient form of vehicle for use as a support for one end of the shelter.

The enclosed shelter 60 of FIGURES 6 and 7, in addition to providing overhead protection, also provides

lateral protection because of the enclosure 82 formed by its substantially vertical side walls 64, 66, 68 and 70. This gives privacy and lateral protection against wind and rain as well as affording greater protection against intruders than the open shelter of FIGURES 2 to 5 inclusive. It will be obvious that the strips 14 of material may be of different colors so as to increase the attractiveness of appearance of the shelter and enhance its salability.

What I claim is:

1. A portable flexible fabric shelter comprising a roof structure formed of a sheet of flexible woven fabric of quadrilateral outline with four roached edges and four corners, said sheet having a ridge extending between one pair of opposite corners and a cross-line extending between the other pair of opposite corners generally perpendicular to said ridge, the fabric of said sheet having a warp and a weft disposed obliquely to all of said four edges and parallel respectively to said ridge and said cross-line, said sheet in a stretched condition from tension simultaneously applied obliquely upward to the opposite ends of said ridge and obliquely downward to the opposite ends of said cross-line forming a stretched fabric roof structure having a hyperbolic-paraboloid-like shape with side flaps declining from said ridge on opposite sides thereof and with said ridge curved convexly upward relative to the supporting surface and with said cross-line curved downward relative to the supporting surface, and upright side walls of flexible sheet material secured to said roof structure in depending relationship therewith to form a side enclosure therefor, said side walls being disposed in a quadrilateral formation with forward and rearward corners disposed in a substantially vertical plane containing said ridge and wherein the line connecting the lateral corners of said enclosure is disposed rearwardly of the cross-line of said roof structure so as to provide an awning area in the roof structure forward of the forward corner of said enclosure.

2. A portable canopy or shelter comprising a sheet of flexible flat woven material of roached quadrilateral outline and with the diagonals at right angles to each other, said sheet having a set of warp threads running parallel to one of said diagonals and a set of weft threads running parallel to the other of said diagonals, attachment means connected to said sheet at the opposite ends of said one of said diagonals so as to directly tension certain of said warp threads, and additional attachment means connected to said sheet at the opposite ends of said other of said diagonals so as to directly tension certain of said weft threads.

3. A portable canopy or shelter comprising a sheet of flexible flat material defining four corners with diagonals extending between nonadjacent corners and being approximately at right angles to one another and the edges joining said corners being roached, said sheet having sets of crossed threads with the threads of one set being parallel to one of said diagonals and the threads of the other set being parallel to the other of said diagonals, attachment means connected to said sheet at the opposite ends of one of said diagonals so as to directly tension certain of the threads of said one set, and additional attachment means connected to said sheet at the opposite ends of the other of said diagonals so as to directly tension certain of the threads of said other set.

4. A portable canopy or shelter comprising a generally square sheet of a flexible flat woven material having sets of warp and weft threads running at substantially right angles to each other, the warp threads running parallel to one diagonal of said generally square sheet and the weft threads running parallel to the other diagonal of said generally square sheet, the edges of said sheet being curved inwardly toward the center of said sheet, and attachment means at the corners of said sheet for securing and tensioning said sheet.

5. A portable canopy or shelter comprising a sheet of

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6

a flexible flat woven material having sets of warp and weft threads running at substantial angles to each other, attachment means connected to said sheet at the opposite ends of certain threads of one of said sets so as to directly tension said certain threads, and additional attachment means connected to said sheet at the opposite ends of certain threads of the other of said sets so that tension applied through said additional attachment means directly tensions said certain threads of said other set and draws said certain threads of said one set into bowed form, said sheet having side edges which run generally diagonally relative to said threads from each of said additional attachment means to each of said first-mentioned attachment means, said side edges being curved inwardly toward the center of said sheet.

6. A portable canopy comprising a sheet of woven fabric having four roached edges defining an equal number of corners, the warp threads of said fabric when said sheet is laid flat extending generally parallel to a straight line joining two nonadjacent ones of said corners so that when said sheet is stretched by tension applied between said nonadjacent ones of said corners it forms a ridge extending in the line of the tension, the weft threads of said fabric when said sheet is laid flat extending generally parallel to a straight line joining the other two nonadjacent ones of said corners so that tension applied transversely across said ridge and downwardly therefrom at the last-mentioned corners is then effective to stretch said sheet into a wrinkle-free form which is bowed downwardly in the direction of the last-mentioned tension.

7. A tent structure including a generally rectangular fabric surface formed by joining a plurality of fabric strips along their side margins, the side edges of said rectangular fabric surface being roached inwardly toward the center thereof, the lines of junction of said strips being parallel to one diagonal of said rectangular fabric surface, means for supporting and exerting tension on the corners of said fabric surface disposed at the ends of the diagonal which is transverse to said strip junctions, and means for supporting and exerting tension on the corners of said fabric surface disposed at the ends of said one diagonal, whereby said tent structure is provided with a smooth doubly curved upper surface and the interior thereof is free of supporting poles.

8. A tent structure, as claimed in claim 7, which includes a fabric side wall connected to and suspended from said surface.

9. A tent structure including a generally rectangular

fabric surface formed by joining a plurality of fabric strips along their side margins, the side edges of said rectangular fabric surface being roached inwardly toward the center thereof, the lines of junction of said strips being parallel to one diagonal of said rectangular fabric surface, means for supporting and exerting tension on the corners of said fabric surface disposed at the ends of the diagonal which is transverse to said strip junctions, means for supporting and exerting tension on the corners of said fabric surface disposed at the ends of said one diagonal, the support for said last-mentioned corners being at a lower level than the support for said first-mentioned corners, whereby said tent structure is provided with a smooth doubly curved upper surface and the interior thereof is free of supporting poles.

10. A portable canopy or shelter comprising a sheet of flexible flat material having two sets of crossed threads with the threads of one set being parallel to one another and the threads of the other set also being parallel to one another and with the threads of one set being at a substantial angle to the threads of the other set, attachment means connected to said sheet at the opposite ends of certain threads of said one set of threads, and additional attachment means connected to said sheet at the opposite ends of certain threads of said other set of threads so that the tension applied through said additional attachment means directly tensions said certain threads of said one set and draws said certain threads of said one set into bowed form, said sheet having side edges which run generally diagonally relative to said threads from each of said additional attachment means to each of the first-mentioned attachment means, said side edges being curved inwardly toward the center of said sheet.

11. A portable canopy or shelter, as claimed in claim 10, which includes a flexible side wall connected to and suspended from said flat material.

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